March 17, 1942. F. KREIENFELD 2,276,617

TUNING ARRANGEMENT

Filed Nov. 10, 1939

Fig. 1

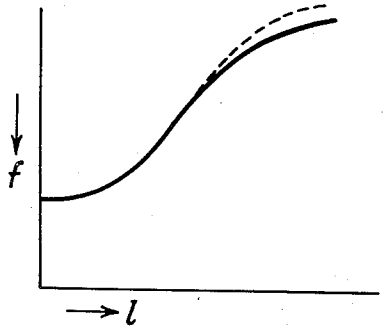


Fig. 2

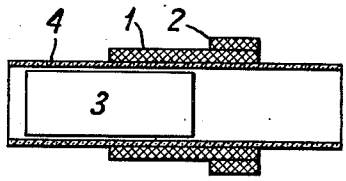
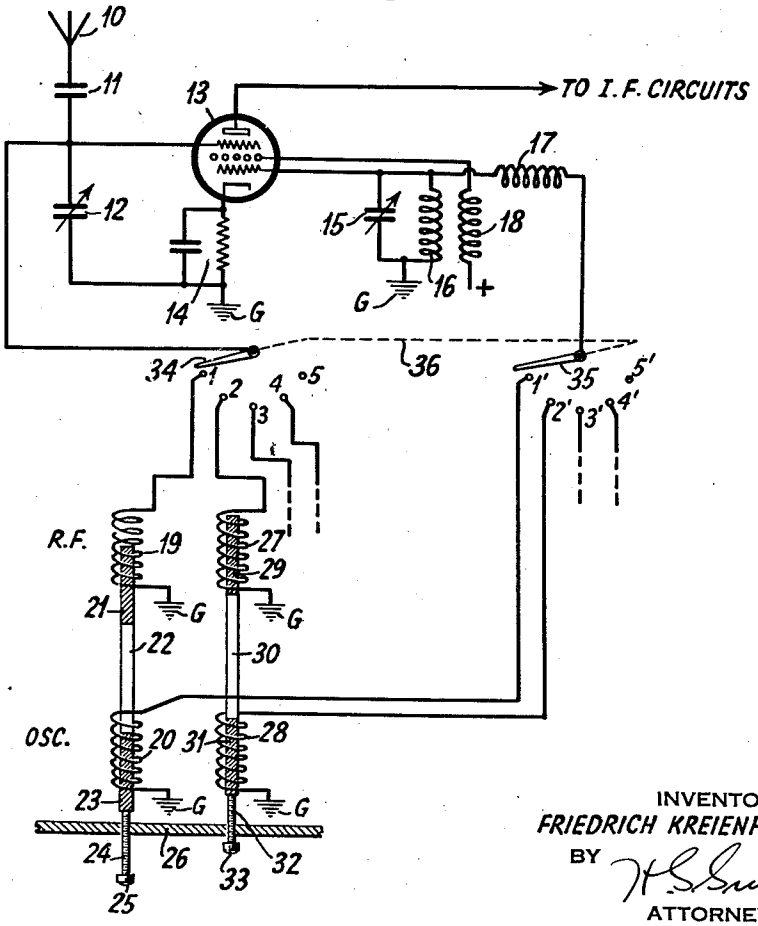


Fig. 3



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TUNING ARRANGEMENT

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1 Claim. (Cl. 250—40)

It is known that oscillatory circuits of receiver apparatus may be tuned by the shifting of dust cores of the coils contained in the oscillatory circuits. This method is used not only for the steady and continuous tuning in lieu of a rotary condenser, but it is also used in connection with oscillation circuits which are cut into circuit in automatically tuned receivers by actuation of push buttons. These oscillatory circuits, to be sure, are pre-tuned, but they are often tunable inside a larger range or frequency band in order that for each push button any desired transmitter station of the wave band may be selected.

In order that synchronism of several tuning circuits throughout the whole frequency band may be more readily realizable it is known to be desirable that the frequency curve which gives the inter-dependence between the frequency and the shifting of the core should be as straight as feasible. For all that is then necessary is to take care that the frequency characteristics of the various circuits will present the same slope, for by parallel shifting they can be made to register or coincide, and this is not feasible when the curves are not linear. In the case of capacitive tuning with straight line frequency condensers equal slopes are obtainable by balancing the inductances and parallel shifting by mutual turning of the rotors. Relative departures of differences of the inductance values, as will be seen, have the result that the frequency characteristics diverge as the frequency grows because the frequency difference of the two circuits, in the presence of a difference in the inductance is not constant throughout the band. In fact, it is only the percentage frequency difference that is constant (because of the constant percentage inductance difference); and the result is that also the frequency difference is correspondingly higher as the frequency increases.

Identical considerations apply in an analogous manner to inductance tuning which is here of interest. In this case, synchronism is securable for a straight line frequency tuning characteristic by causing the slope of the characteristics to coincide or register by balancing the capacity which remains unaltered during the tuning, and by causing the characteristics to coincide by mutual shifting of the interlocked dust cores. The advantages inherent in this method are as follows: No additional circuit element is required to the end of balancing or trimming the initial inductances, in fact, relative shifting of the dust cores suffices. Moreover, because of the absence of such an additional or accessory circuit element for balancing the initial inductances, the range of variation of the tuning is not restricted.

For a better understanding of the invention reference will be had to the accompanying drawing wherein, Fig. 1 represents curves depicting the relation between frequency and core displacement which will serve to explain the invention, Fig. 2 shows a coil arrangement according to the invention for obtaining increased linearity between core displacement and the frequency of the tuned circuit, and Fig. 3 shows the application of the invention to a circuit of the superheterodyne type.

The invention is predicated upon the fact that the curve which gives the inter-dependence between the frequency of the oscillatory circuit and the shift of the dust core has a form similar to that shown by the solid graph in Fig. 1. Along the rectilinear portion of the graph the dependence of the frequency upon the shifting of the dust cores follows a straight line law. The straight portion in Fig. 1, however, is too limited, in fact, it is desirable to extend this range. This is attained by the invention.

According to the invention the cylindrical coils, comprised in the oscillatory or tuning circuits of a receiver apparatus in which the tunings are interlocked by shifting dust cores, are provided, at their ends which are reached last by the cores as they are shifted in, with additional layers of turns over a distance so that there will be an increase in the tuning range through which a straight line frequency law is followed.

Referring to the drawing, Fig. 1 shows the interdependence between the shift distance or length l of a dust core and the frequency f of the oscillatory circuit. The beginning of the graph below on the left hand side shows the frequency of the tuning circuit when the dust core is removed. As the core is approached, the frequency initially drops slowly and later at a growing rate. Now, this drop follows a straight line law inside a limited range. At the upper end, the curve bends over. By the invention the top bend is shifted further out, at the same time it becomes sharper, with the result that the rectilinear portion of the curve is extended.

Fig. 2 shows how this end is attained according to the invention. There is first wrapped upon the form **4**, a coil **1** which comprises a single layer of spires or turns. Over a portion equal to about one-third of the length of the coil, one or several additional layers of turns **2** are wrapped. Thus, as the core **3** is inserted the inductance grows more rapidly as the iron core

at the end of the coil comes to act upon a greater number of turns. Inside the portion of the graph shown in Fig. 1, as will be noticed, the inductance of the coil grows in accordance with a square law.

The invention is not only useful in connection with equally tuned circuits, but it will be found suitable also in superheterodyne receivers in the input circuit and the oscillator circuit. The difference in frequency between the two circuits which is equal to the I. F. may be obtained in various ways. For instance, the two interlocked cores may be so shifted relative to each other that at one end of the range or band the desired frequency difference is obtained. Then, provided that the capacities are correctly adjusted it will prevail throughout the entire range. However, such shifting of the dust cores is practicable only when the I. F. is low, for otherwise the range of variation would be unduly restricted. In order to avoid this, dust cores of dissimilar permeability may be employed, or else one of the coils may be wound with greater pitch or be made of a larger diameter. But it is also possible to use like coils and cores for both circuits, but then a coil should be connected in parallel and another, small coil be connected in series relative to the coil contained in the circuit oscillating at the higher frequency, in line with what is done in case of capacitive tuning where a parallel and a series condenser are provided. Where this last suggestion is adopted in receivers of the automatic or push button type there results the advantage that for all of the oscillatory circuits conjointly only a single parallel inductance and a single series inductance need be provided, seeing that the oscillatory circuits are cut in circuit alternately. Such an arrangement is shown in Fig. 3 of the drawing.

In said figure the invention is shown incorporated in a receiver of the superheterodyne type which employs a combined oscillator and first detector tube **13**. Signals from the antenna circuit **10**, **11** are impressed upon the third grid of said tube and used to modulate, so to speak, the oscillations generated by the portion of the tube comprising the cathode, the first grid and the second grid. With such an arrangement the plate circuit contains the products of the combined local oscillations and the received energies from which the so-called intermediate frequency is selected. The signal input circuit of tube **13** is tuned by means of the condenser **12** and whichever one of the coils **19**, **27**, etc. happens to be shunted across the condenser **12** by the switch **34**. In other words, if the switch **34** is in position **1** the inductance coil **19** is connected across the condenser **12** and the two form a tuned input circuit for the tube **13**. However, if switch **34** is in position **2** the inductance coil **27** is shunted across condenser **12** and forms with the condenser a tuned signal input circuit for the tube **13**. Only two of the inductance coils have been shown in Fig. 3 since it is obvious that any number thereof may be provided and suitably connected to the positions **3**, **4**, **5** etc. of the switch **34**. The frequency determining circuit for the local oscillator portion of the tube **13** includes the condenser **15** and whichever one of the inductance coils **20**, **28**, etc. happens to be connected across condenser **15** by switch **35**. Here again only two coils have been shown. However, it is to be understood that any number of coils may be provided depending upon the number of stations desired to be tuned in automatically and the number of oscillator coils will correspond to the number of coils employed in the input circuit.

The switches **34** and **35** may be uni-controlled by means **36** shown schematically. The single parallel inductance **16** and single series inductance **17** are associated with the oscillator circuit and these two inductances cooperate with whichever one of the inductance coils **20**, **28** etc. happens to be in the circuit. Coils **19** and **20** are provided with cores **21** and **23** respectively which may be of the powdered iron core type. These two cores are connected by a suitable piece of insulation material **22** and are uni-controlled by means of the screw thread **24** cooperating with the plate **26** to facilitate adjusting the cores **21** and **23** within their respective coils by operation of screw head **25**. By turning the screw head **25** in one direction the cores enter into their respective coils whereas turning the screw head in the opposite direction withdraws the cores. The same sort of arrangement is used for the two coils **27** and **29** which are associated with the cores **29** and **31** respectively. To set the device so that the first position of switches **34** and **35** tunes to a particular station all that need be done is to place switches **34** and **35** into the first position by operating the uni-control means **36** and then manipulating screw **24**, **25** until that station is tuned in. Then the switch **34**, **35** is placed into its second position and screw **32**, **33** operated so as to tune to some other desired station and so on for all the various circuits provided. Thereafter, all that need be done to tune to any desired station which has been previously set to is operate the device **36** so as to move switches **34**, **35** to the desired position. It is, of course, to be understood that the coils **19**, **20**, **27** and **28** may be constructed like the coil shown in Fig. 2 in which case the inductances **16** and **17** are not absolutely necessary.

I claim:

In a resonant circuit, a variable tuning instrumentality comprising an inductance winding provided with a core of substantially the same length as said winding, said core being adapted to be substantially completely inserted into said winding from one end thereof, means for extending the rectilinear portion of the characteristic curve of said resonant circuit relating the resonant frequency of the circuit to the displacement of the movable core within the winding comprising an auxiliary winding connected in series with said first named winding, the turns of both said windings being in the same direction, said auxiliary winding being superimposed upon a portion of the winding which is in the vicinity of the other end thereof.

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