Oct. 1, 1940. M. J. KIRK ET AL 2,216,370

VARIABLE INDUCTANCE MECHANISM

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Fig. 1,

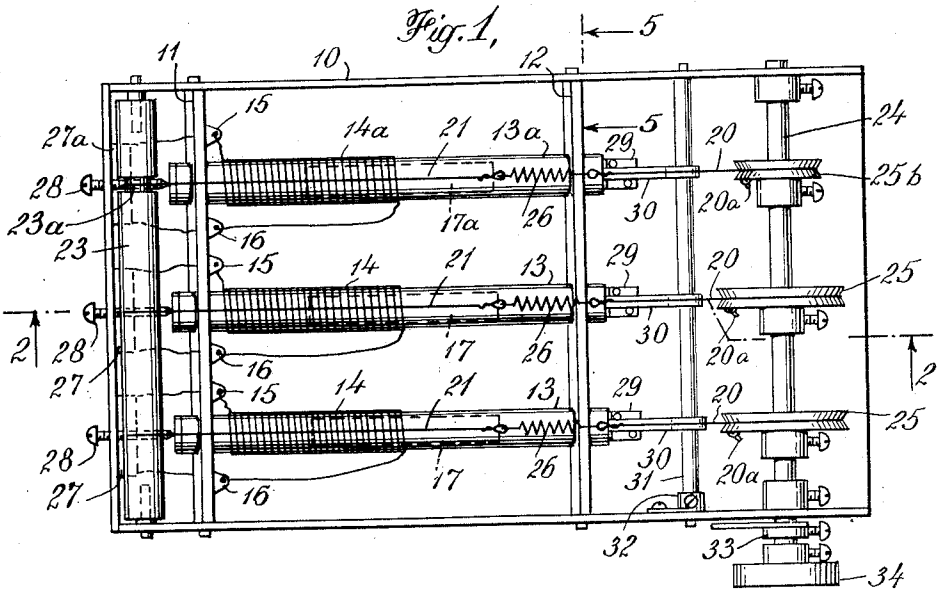


Fig. 2,

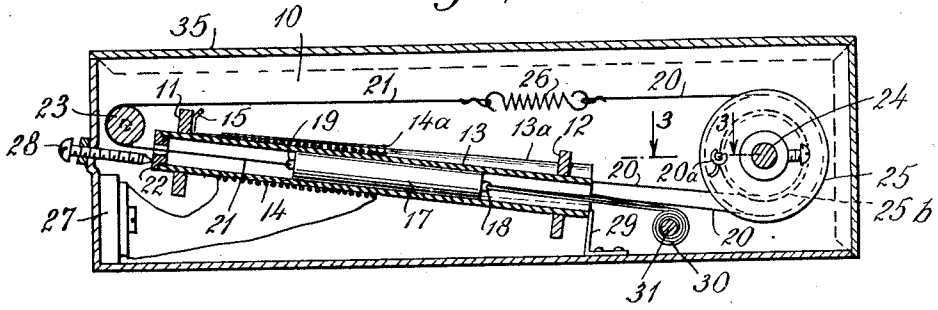


Fig. 3,

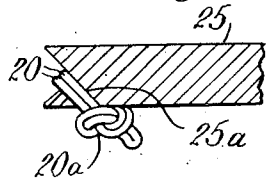


Fig. 4,

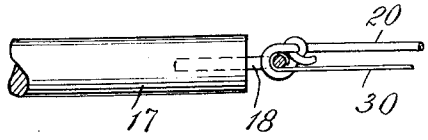
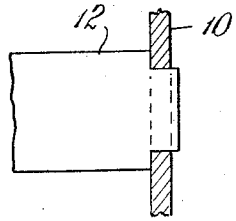


Fig. 5,



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Fig. 6.

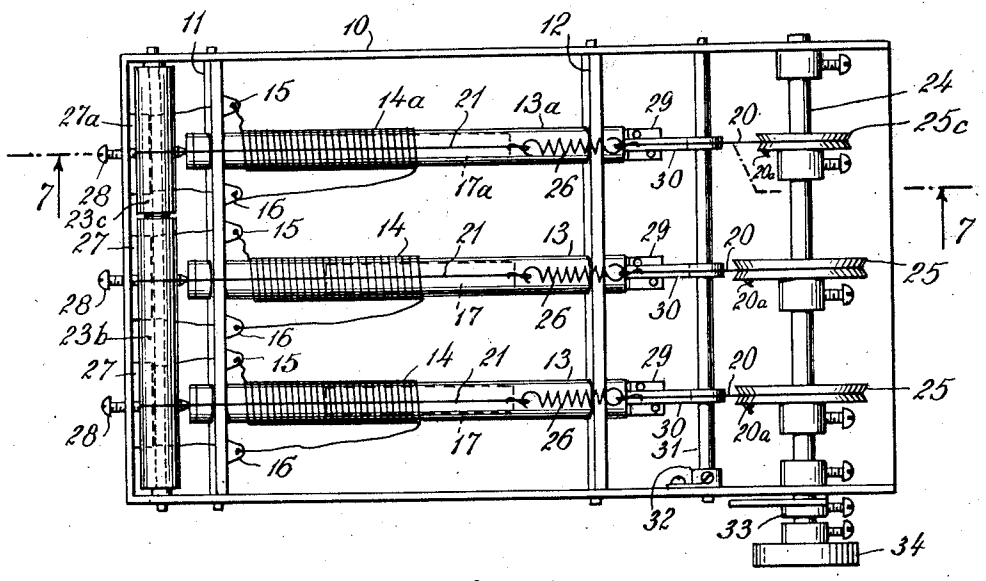
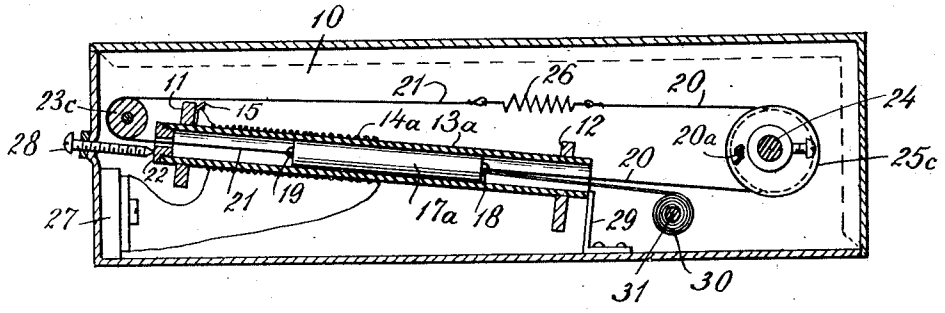


Fig. 7.



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VARIABLE INDUCTANCE MECHANISM

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Application July 5, 1938, Serial No. 217,404

4 Claims. (Cl. 171—242)

Our invention relates to an improved operating mechanism for variable inductance devices, and particularly for that type of devices in which the variation in inductance is secured by moving a core relatively to an inductance coil to change the permeability of the magnetic path of the coil. Our invention is particularly adapted to variable inductances of the kind referred to, which are intended for use in connection with high-frequency apparatus, such as the radio-frequency portions of radio transmitting and receiving apparatus.

This application is a continuation in part of our copending application Serial No. 197,222 filed March 21, 1938, and is particularly directed to systems of the type there disclosed which are especially adapted for use in superheterodyne radio receivers.

By our invention we employ flexible cables connected with the ends of the cores and a common operating mechanism for the cables, such as an operating shaft and drum structures, carried by the shaft, so that all of the cables may be simultaneously operated by rotating the shaft, and so that by properly designing the operating structure, the cores may be simultaneously moved for tuning purposes in connection with high-frequency resonant circuits. In this manner, we eliminate intermediate carriage structures of all kinds between the operating shaft and the cores, and by employing the insulating tubular mounting of each inductance coil as the support for the corresponding core for all of its positions, we produce a structure that is at once effective, extremely simple, and cheap to manufacture.

Our invention is admirably adapted to the gang operation of a plurality of variable inductance units, since it provides for the simultaneous operation of as many magnetic cores of such units as may be desired, and regardless of the number of cores so operated, the operation of each core is accurately effected and is in no way modified by or dependent upon the operation of any other one of the cores. Thus one core may move through a different distance and at a different rate from the remaining cores, to thereby tune one of the resonant circuits over a different frequency range. For example, in a superheterodyne receiver the oscillator circuit, which generally covers a narrower frequency range than that covered by the other resonant circuits, may be made to "track" with the other circuits by slightly modifying the means for actuating the oscillator core.

Our invention also provides means for continuous tuning over a plurality of frequency ranges in succession, since each movable core may be arranged to cooperate successively with a plurality of coaxially mounted inductance coils.

Our invention will be best understood by reference to the accompanying drawings illustrating preferred embodiments thereof, in which:

Fig. 1 illustrates in plan view a three-coil tuning mechanism;

Fig. 2 is a horizontal, sectional view taken along the line 2—2 in Fig. 1, excepting that in this figure the cover of the device is shown in place, whereas in Fig. 1 the cover is removed;

Fig. 3 is a horizontal, sectional view of a part of the structure shown in Fig. 2, taken along the line 3—3 in that figure;

Fig. 4 shows in side elevation and to an enlarged scale, one end portion of one of the magnetic cores shown in Fig. 2;

Fig. 5 is a vertical, sectional view to an enlarged scale of a part of the structure shown in Fig. 1, taken along the line 5—5 in that figure;

Fig. 6 shows in plan view a modified form of our three-coil tuning mechanism; and

Fig. 7 is a horizontal, sectional view taken along the line 7—7 in Fig. 6, except that in this figure the cover of the device is shown in place, whereas in Fig. 6 the cover is removed.

Similar numerals refer to similar parts throughout the several views.

As shown in Figs. 1 and 2, the tuning mechanism consists of a casing 10 between the side walls of which strips of insulating material 11 and 12 are supported vertically by having their ends shouldered and fitting in corresponding slots in the side walls of the casing, as illustrated in Fig. 5.

The strips 11 and 12 are provided with aligned apertures through which tubes 13 and 13a of insulating material extend with a sliding fit. Each of the tubes 13 and 13a has wound thereon near the strip 11 an inductance coil 14 or 14a, the ends of the winding of each coil being connected with terminal clips 15 and 16 supported by the strip 11.

It is within the scope of the invention to employ, instead of the single-layer solenoidal coils shown, coils of the universal-wound type in which the radial depth usually equals or exceeds the axial length. It is also comprehended that one or more additional windings may be wound on each tube 13 or 13a adjacent, or at any desired spacing from, the inductance coils 14 or 14a. Each tube 13 or 13a contains, with a sliding fit, a magnetic core 17 or 17a. Each of the cores

17 and 17a has formed in its ends staples 18 and 19 connected respectively with cables 20 and 21, the latter extending through the end portions of the corresponding tube 13 or 13a.

As shown in Figs. 1 and 2, the left-hand end of each of the tubes 13 or 13a is provided with a tubular plug 22 of insulating material through which the corresponding cable 21 extends. Adjacent the plugs 22, a sheave roller 23 is pivotally supported by the side walls of the casing 10, so that its lower surface is substantially in line with the axes of the tubes 13 and 13a. In the other end of the casing 10, an operating shaft 24 is supported by the side walls of the casing, substantially parallel with the strips 11 and 12 and also with the roller 23, which shaft carries drums 25 and 25b secured thereto. Drum 25b is somewhat smaller in diameter than are drums 25, and tube 13a is therefore not quite parallel with tubes 13, as clearly shown in Fig. 2, in order that the cable 20 which cooperates with drum 25b may be substantially centered in tube 13a. Each of the cables 20 extends axially from the corresponding tube 13 or 13a around one of the drums 25 and 25b and has its end secured to a tensioning spring 26. Each of the cables 21 extends axially from the plugged end of the tube 13 or 13a to and around the roller 23, and has its end secured to the other end of the tensioning spring 26. As shown in Fig. 3, each cable 20 is secured to its drum 25 or 25b by being doubled and passed through an inclined aperture 25a in the wall of the drum, the doubled projecting portion of the cable being knotted adjacent the side wall of the drum as indicated at 20a. Roller 23 has a reduced diameter at 23a to receive the cable 21 which is attached to core 17a.

As a result of the construction described, the spring 26 maintains a tension at all times on the cables 20 and 21 with which it is connected, this tension preferably being much greater than the force required to move the core 17 or 17a in the tube 13 or 13a, and as a result any rotary movement of the shaft 24 will correspondingly move each core 17 or 17a in its tube 13 or 13a, and therefore move the core relatively to the coil 14 or 14a carried by the tube, and thereby correspondingly change the permeability of the magnetic path of the corresponding coil 14 or 14a.

Since drum 25b is somewhat smaller in diameter than drums 25, core 17a is moved less with respect to coil 14a than are cores 17 with respect to coils 14. Coil 14a thus is advantageously employed in the oscillator circuit of a superheterodyne radio receiver. By way of example, in a particular receiver covering the frequency range between 540 and 1600 kilocycles and having an intermediate frequency of 455 kilocycles, drum 25b has a diameter approximately 0.67 that of drums 25.

Each of the coils 14 or 14a is illustrated as having its terminals connected with a tuning capacitor 27 or 27a having such an amount of capacitance when adjusted as to produce, with the inductance of the coil 14 or 14a, a resonant circuit tunable over a desired range of frequencies by moving the core 17 or 17a into and out of the coil 14 or 14a. To align the several resonant circuits which are tuned by movement of the cores 17 and 17a, so that they may be simultaneously tuned by the operating mechanism, the cores 17 and 17a may first be aligned mechanically by correspondingly setting the drums 25 and 25b relatively to the shaft 24 by the set screws indicated; then after the capacitors 27 and 27a have been given the proper adjustment to produce the desired resonant frequency at or near the high-frequency end of the tuning range, any one of the coils may be adjusted as a whole relatively to its core, by a screw 28 threaded through the front end wall of the casing 10 and engaging at its inner end the outer end of the plug 22 of the corresponding inductance unit, a light spring 29 being secured to the bottom of the casing and engaging the other end of each tube 13 or 13a to hold the plug 22 in engagement with the corresponding adjusting screw 28. The inner end of the screw 28 is preferably pointed or rounded and in engagement with a corresponding depression in the outer end of the plug 22, to prevent displacement of the end of the screw from the end of the plug. If preferred, the coils and cores may be given fixed predetermined positions.

It will be understood that capacitor 27a and inductance coil 14a may have values different from those employed in the remaining circuits in order to secure, in cooperation with the smaller drum 25b, the desired oscillator-circuit frequency range together with proper tracking between the oscillator circuit and the other circuits of the receiver.

Where it is desired to ground the cores 17 and 17a, that result is readily accomplished without in any way interfering with the construction and operation described, by providing a thin and narrow strip of metallic conductor 30, one end of which is electrically connected with the corresponding staple 18 of each core 17 or 17a which is to be grounded, after which the operating cable 20 is also secured to the staple 18, as illustrated in Fig. 4. The outer end portion of the conducting strip 30 is preferably wound into a spiral form with its end electrically connected with a metal rod 31 extending between the side walls of the casing 10 and connected therewith by a clamping member 32 which not only electrically connects the strips 30 with the casing 10, but also prevents angular movement of the rod 31 to disturb the adjustment of the conducting strips 30 relatively to the rod. It will be observed that any desired number of inductance units may be mounted as described and operated by a single operating shaft in the manner described, and furthermore, that the inductance units may be given any desired lateral spacing, since the casing 10 may have any desired size, the shaft 24 may have a corresponding length, and as many drums 25 and 25b may be provided on the shaft as there are inductance units, since the mounting of each inductance unit and the drum structure employed on the operating shaft to move the core of each unit are not dependent in any way on any other inductance unit or any other part of the drum structure used to operate another or others of the inductance units.

As illustrated, the shaft 24 is shown as carrying a pointer 33 for indicating the particular frequency to which the system is receptive at any moment, and an operating knob 34 is also shown secured to the projecting end of the shaft 24. The drums 25 and 25b are preferably of such a diameter that a single rotation of the shaft 24, or even less than one rotation, will effect such movement of the cores as to cover the desired band of frequencies for which the inductance devices are designed, and where this is the case, the portions of the cables 20 and 21 connected with the tensioning springs 26 may readily be located substantially above the tubes 13, so there will be no interference between the cable portions

and the inductance units. It is obvious, however, that any desired proportions in this respect may be used, and that the cables may be provided with additional cable-directing rollers or drums in particular cases, if preferred, without in any way modifying the operation of the invention.

In Fig. 2 we illustrate a cover **35** enclosing the casing **10**, the cover being removed in Fig. 1 to disclose the parts contained in the casing.

In Figs. 6 and 7, we illustrate a different embodiment of our invention from that shown in Figs. 1 and 2 and described in detail above. In this modification, the construction and operation are in general similar, but drum **25***c*, instead of being round and somewhat smaller in diameter than drums **25**, is of special shape. In this way, the motion which is imparted to core **17***a* by rotation of shaft **24** is different from that imparted to cores **17** by means of drums **25**. The spring **26** serves to maintain nearly the same tension on the cables **20** and **21**, for different angular positions of the drum **25***c*. The exact shape of drum **25***c* is determined in any particular case by the electrical requirements for example, for securing tracking between the oscillator circuit and the other circuits of the receiver, and it will be understood that the shape shown in Figs. 6 and 7 is merely illustrative and is not to be taken as in any way limiting the scope of the present invention. By properly coordinating the shape of drum **25***c* with the values of capacitor **27***a* and of inductance coil **14***a*, and with the oscillator core **17***a*, it is readily possible to secure substantially exact tracking throughout a wide frequency range. In one particular receiver, for example, the effective radius of drum **25***c* was slightly greater than that of drum **25***b* of Figs. 1 and 2 at the low-frequency end of the tuning range and slightly less at the high-frequency end of the range. Instead of a single roller **23** as shown in Figs. 1 and 2, two coaxial and independently rotatable rollers **23***b* and **23***c* are employed, to allow for the difference in rate of travel of the cables **21** attached to cores **17** and **17***a*.

In addition to its use in superheterodyne radio receivers, the present invention may be employed wherever it is desired to provide a plurality of ganged variable inductance devices, one or more of which is to cover a different inductance range from the remaining units, and also wherever with such ganged variable inductance devices, whether the inductance ranges of the units thereof are the same or not, it is desired to change the inductances of different ones of said units according to different laws of variation. It will be understood that the use of the invention in a superheterodyne radio receiver is referred to herein by way of illustrative example only, and that the invention is by no means limited to this particular application of its principles.

Where in the specification and claims we use the term "cable," we include within the meaning of that term any connecting medium having the strength and flexibility requisite for effecting the operation of the cores in the manner above described, whether the connecting medium be fibrous, metallic or otherwise; it will be understood that where the cores are required to be electrically insulated from other parts of the mechanism, the cable material should be of an insulating nature; although where it is desired to electrically connect the cores with other parts of the structure, as, for example, in cases where the cores should be grounded, the cable may be of material that is electrically conductive. In practice we find cables of braided or woven silk cords quite effective for the purpose described.

Our mechanism above described is adapted for use wherever it is desired to simultaneously vary the inductance of a plurality of inductance units, particularly where it is desirable that the mechanism shall be compact and of light weight. It is thus well adapted for radio apparatus generally, where it is desired to simultaneously tune resonant circuits by inductance tuning as distinguished from capacitance tuning, since it provides a self-contained compact and multiple-stage tuning mechanism which may be assembled as a self-contained unit, in any desired relation and location relatively to the other parts of the transmitting or receiving apparatus, even though the wiring connecting the tuning mechanism with the other parts has substantial length and appreciable capacitance which is added to the fixed capacitance incorporated in the tuning mechanism. For in any such case of fixed assembly of apparatus, the capacitance of the connecting wiring referred to is no disadvantage, since it is made a part of the fixed capacitances required in the resonant circuits of the tuning mechanism to cooperate with the variable inductances employed; in fact, such an arrangement in a radio receiver or transmitter has the desirable advantages of materially reducing interaction between the component parts of the apparatus that would otherwise appear in the operation of the apparatus. These advantages are particularly important, for example, in mobile radio receivers for automobile and other uses, where it is desired that the tuning mechanism shall have a location convenient to the operator, and the remainder of the apparatus, such as the tubes and audio-frequency amplifier, shall be at some distance for remote operation and control by the tuning mechanism.

While we have shown our invention in the particular embodiments above described, it will be understood that we do not limit ourselves thereto as we may employ equivalents without departing from the scope of the appended claims.

Having thus described our invention, what we claim is:

1. Operating mechanism for variable inductance tuning mechanism having a plurality of inductance coils around corresponding mounting tubes, and having magnetic cores associated with said coils and respectively movable longitudinally in and guided by said tubes to vary the inductance of said coils for the purpose of station selection from a band of frequencies, which operating mechanism comprises the combination of flexible cables connected directly with the ends of each of said cores to move the same relatively to the corresponding coil, and an operating shaft carrying drums coacting with said cables to simultaneously operate said cores to thereby simultaneously vary the inductances of said coils for tuning purposes at different frequencies, said drums having differently shaped peripheries differently moving the corresponding cores, the differences in movement of said cores being a curvilinear function of the movement of said operating shaft, whereby by rotary movement of said shaft the inductances of said coils are changed according to different laws of variation.

2. Operating mechanism for variable inductance tuning mechanism having a plurality of inductance coils around corresponding mounting tubes, and having magnetic cores associated with said coils and respectively movable longitudinally

in and guided by said tubes to vary the inductance of said coils for the purpose of station selection from a band of frequencies, which operating mechanism comprises the combination of flexible cables connected directly with the ends of each of said cores to move the same relatively to the corresponding coil, and an operating shaft carrying drums coacting with said cables to simultaneously operate said cores to thereby simultaneously vary the inductances of said coils for tuning purposes at different frequencies, said drums having differently shaped peripheries of different lengths differently moving the corresponding cores, the differences in movement of said cores being a curvilinear function of the movement of said operating shaft, whereby by rotary movement of said shaft the inductances of said coils are changed according to different laws of variation.

3. Variable inductance tuning mechanism including in combination a plurality of mounting tubes, a plurality of inductance coils respectively around said tubes, a magnetic core associated with each of said coils and movable longitudinally in and guided by the corresponding tube to vary the inductance of said coils for tuning purposes at the different frequencies of a tuning band, flexible cables extending respectively and directly from the ends of said cores to simultaneously operate the same relatively to their respective coils, an operating shaft, a first drum carried by said shaft and having its periphery connected with the flexible operating cables extending from a first one of said cores, a second drum carried by said shaft and having its periphery connected with the flexible operating cables extending from a second one of said cores, said first drum having a different peripheral shape radially from said second drum, whereby the movement of said first core is a function of the movement of said shaft differing in kind from the function of movement of said second core relatively to movement of said shaft.

4. Variable inductance tuning mechanism including in combination a plurality of mounting tubes, a plurality of inductance coils respectively around said tubes, a magnetic core associated with each of said coils and movable longitudinally in and guided by the corresponding tube to vary the inductance of said coils for tuning purposes at the different frequencies of a tuning band, flexible cables extending respectively and directly from the ends of said cores to simultaneously operate the same relatively to their respective coils, an operating shaft, a first drum carried by said shaft and having its periphery connected with the flexible operating cables extending from a first one of said cores, a second drum carried by said shaft and having its periphery connected with the flexible operating cables extending from a second one of said cores, said first drum having a different peripheral shape radially and a different peripheral length from said second drum, whereby the movement of said first core is a function of the movement of said shaft differing in kind and extent from the function of movement of said second core relatively to movement of said shaft.

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