May 15, 1945. D. E. FOSTER 2,375,911

VARIABLE INDUCTANCE TUNING

Filed July 16, 1942

Fig. 1.

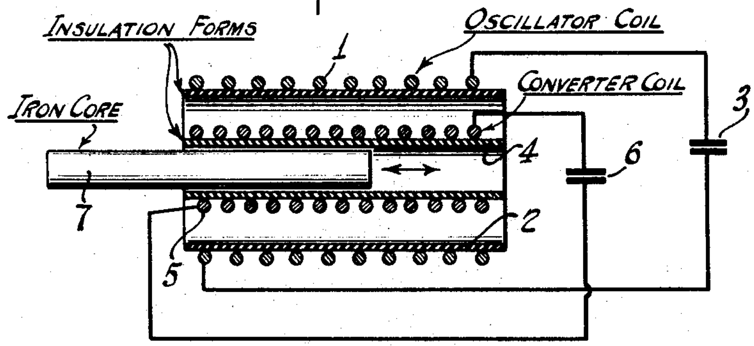


Fig. 2.

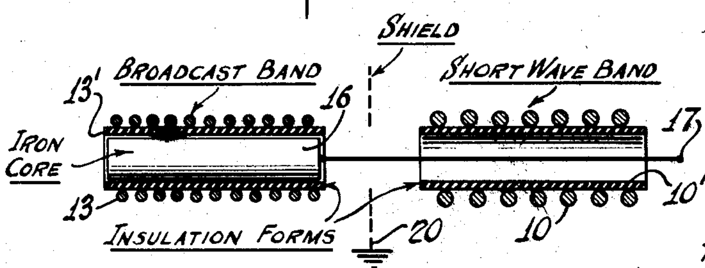


Fig. 2a.

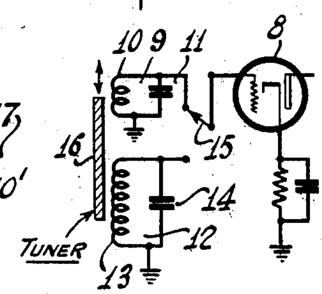


Fig. 3.

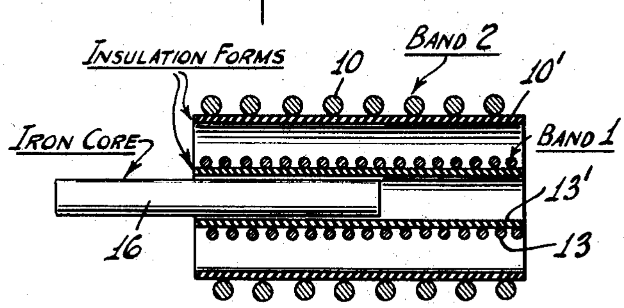
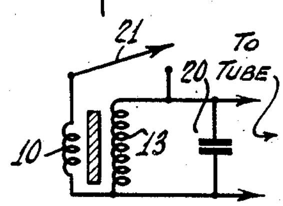


Fig. 3a.



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VARIABLE INDUCTANCE TUNING

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6 Claims. (Cl. 250—40)

My present invention relates to so-called permeability tuners for radio receivers.

One of the objects of my invention is to provide a heterodyne circuit wherein the oscillator and converter circuits utilize iron core tuners; the coils of the two circuits being concentrically wound with respect to a single, common adjustable iron core.

Another object of the invention is to provide an oscillator-converter network wherein the oscillator and converter coils are concentrically wound, and a single core of comminuted magnetic particles is used for concurrently adjusting the inductance of said coils.

Another object is to provide a multi-range receiver wherein the coils of the tuned circuits of the different ranges are adapted to be varied in inductance by a single adjustable iron core.

Yet another object of my invention is to provide a multi-range receiver wherein inductance tuning is employed, and a single iron core element being employed to vary the inductance in either tuning range.

Still other objects are to improve generally the simplicity of permeability tuners, and more especially to provide multi-range inductance tuners which use a single core element for economy of construction.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows an embodiment of the invention applied to an oscillator-converter network; the tuner being shown in section,

Fig. 2 shows the invention applied to a multi-range receiver,

Fig. 2*a* shows the tuner of Fig. 2 applied to an amplifier,

Fig. 3 shows a modified multi-range tuner construction, and

Fig. 3*a* shows the circuit connections for the tuner elements of Fig. 3.

Referring, now, to the accompanying drawing, wherein like reference characters in the figures designate similar circuit elements, the numeral **1** denotes the oscillator circuit coil of a heterodyne receiver. The coil **1** is wound on an insulation form **2**. The form is cylindrical, and the coil **1** is wound in the usual manner. The condenser **3** shunts coil **1**, and is chosen in magnitude so that proper variation of the inductance of coil **1** will result in a variable tuning range of the desired frequency coverage. The cylindrical insulation form **4** has the coil **5** wound along the external surface thereof. The condenser **6** shunts coil **5**. The coil **5** and condenser **6** provide the converter, or first detector, tunable input circuit. The manner of keeping the forms spaced is well known to those skilled in the art.

The numeral **7** designates an iron core element which is axially located relative to form **4**. Core **7** is preferably composed of comminuted particles of magnetic material, such as iron, bound together by any well known insulating adhesive binder. Reciprocation of the core **7** within the concentric coils **1** and **5** results in concurrent variation of the inductances thereof. My invention is specifically intended for a superheterodyne receiver wherein the resonant circuit **5—6** is located between the input electrodes of the converter tube, and the circuit **1—3** is the tunable tank circuit of the local oscillator. One or more radio frequency amplifiers may feed the tuned circuit **5—6**.

The local oscillations are fed to the first detector tube; the intermediate frequency (I. F.) energy is produced in the plate circuit of the first detector. Assume, by way of specific illustration, that the frequency range of circuit **5—6** is desired to be 550 to 1700 kilocycles; this is the standard amplitude modulation broadcast band in this country. The oscillator frequency is usually operated over a higher frequency range, and differs by the I. F. value. Assume the I. F. value to be 465 kilocycles (kc.). Then, the oscillator circuit will be tunable over a range of 1015 to 2165 kc.

The oscillator and converter resonant circuits **1—3** and **5—6** are each adjusted over the respective frequency ranges by movement of the common, compressed comminuted ferromagnetic core **7** relative to the inductance coils **1** and **5**. This is so-called permeability tuning. In the past it was deemed necessary to use a separate adjustable core for each resonant circuit. The change in permeability, hence inductance and frequency, is a function of the ratio of winding diameter to core diameter. In a superheterodyne receiver, with the local oscillator frequency higher than signal frequency, the ratio of maximum to minimum frequency over a given band is less for the oscillator than for the signal frequency.

The signal frequency ratio is

$$\frac{f_{max.}}{f_{min.}}$$

whereas the oscillator frequency ratio is

$$\frac{f_{max.}+\text{I. F.}}{f_{min.}+\text{I. F.}}$$

According to my invention the oscillator coil 1 is located externally of the converter coil 5. The diameter of coil 1 is substantially greater than the diameter of coil 5. Further, the oscillator coil turns are spaced at greater intervals than the converter coil turns. The diameters of the coils 1 and 5 are so chosen that the common core 7 may concurrently vary the signal frequency tuning from $f_{max.}$ to $f_{min.}$, while the oscillator frequency is varied from $f_{max.}$+I. F. to $f_{min.}$+I. F. Reference is made to "Measurement of iron cores at radio freqencies" (Equations 6 and 7) by D. E. Foster and A. E. Newlon (I. R. E. May, 1941, page 266) for the required ratio of diameters. The core 7 is to be sufficiently long to be able to nest within the form 4 at one end position, and be entirely outside the form 4 at the opposite frequnecy limit. When core 7 is completely withdrawn, then both circuits are tuned to maximum frequencies.

In Fig. 2 I have shown another use to which the present invention can be put. In the case of multi-range receivers it is necessary to switch the input electrodes of an amplifier from one tuned circuit operating in one frequency range to another tuned circuit operating in a different frequency range. For example, considering Fig. 2*a*, the amplifier 8 is a radio frequency amplifier of the usual type. For short wave reception it is provided with a resonant circuit 9 which consists of a coil 10 shunted by condenser 11. For broadcast reception there is provided a different resonant circuit 12 which consists of a coil 13 shunted by condenser 14. The switch 15 is arranged to connect either of the two resonant circuits in electrical circuit with the input electrodes of amplifier 8, depending on the frequency band in which the multi-range receiver is operating. Each of the resonant circuits 9 and 12 is of the permeability tuning type. A common iron core 16 is employed for tuning either of the circuits 9 or 12. In the prior art each resonant circuit used its own iron core tuning element.

In Fig. 2 there is shown the specific manner of constructing the tuning mechanism. The short wave coil 10 is wound on an insulation form 10'. In axial alignment therewith there is provided a second insulation form 13' upon which is wound the coil 13. The iron core 16 has secured to it a mechanism 17 which may reciprocate the iron core within the insulation forms 13' and 10'. An electrostatic shield 20 is provided intermediate the coils 13 and 10 so as to shield them from each other. It will, of course, be understood that in actual practice there will be sufficient physical space between the insulation forms 13' and 10' to permit the iron core 16 to be entirely withdrawn from form 13' without entering into form 10'.

It will, therefore, be seen that in Fig. 2 the same iron core 16 is used to tune through two different frequency bands with the same travel. The shield 20 prevents coupling between the coils even though one is not in use; this is the prevention of "dead-end effect." In Fig. 2 the direction of core motion which decreases inductance in the broadcast band will increase inductance in the short wave band and vice versa. Of course, by increasing the travel of the core added frequency bands may be used at either end of the core travel.

In Fig. 3 I have shown a further modification of the manner of using the same core for two or more frequency bands. In this case the short wave coil 10 is wound concentrically with the broadcast band coil 13. Of course, the insulation form 10' is concentric with the insulation form 13'. The core 16 is reciprocable within insulation form 13'. Of course, only one of the concentric coils will be effective during motion of the core 16. As shown in Fig. 3*a*, the inductance of coil 10 is thrown in parallel with that of coil 13 for operation in the short wave band. The inductance coil 13 of the broadcast band is assumed to have a high inductance. The inductance of the short wave band is determined mainly by coil 10. The "dead-end effect" of the coil 13 on coil 10 is avoided by the parallel connection of the two coils. Only a single condenser 20 need be used for either of the bands. The switch 21 when open permits tuning by core 16 in the lower frequency band. When closed, tuning is accomplished in the higher frequency band. Here, again, the aforesaid article is referred to for data on design of the coils.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In combination, an oscillator network comprising a coil shunted by a condenser and adapted to be tuned over a range of frequencies, a converter network comprising a second coil shunted by a second condenser and adapted to be tuned over a different range of frequencies, said coils being disposed in concentric relation, and a single ferromagnetic core movable within said coils to concurrently vary the inductances of said coils to thereby adjust the tuning of both networks.

2. In combination, a permeability tuner for a superheterodyne receiver, said tuner comprising a first coil included in the oscillator network, a second coil of less diameter than the first coil concentrically disposed relative to the latter and included in the converter network, and a single ferromagnetic core movable axially with respect to said coils for simultaneously adjusting the tuning of said oscillator and converter networks.

3. A tuning system for a superheterodyne receiver comprising a pair of circuits which are tunable through frequency ranges of different widths, a variable permeability-tuned inductance included in the circuit that is tunable through the wider frequency range, a second variable permeability-tuned inductance included in the circuit that is tunable through the narrower frequency range, said inductances being in the form of coils disposed in concentric relation, and a single ferromagnetic core movable within said inductance coils for effecting the simultaneous adjustment thereof in the tuning of said circuits through their respective frequency ranges.

4. A tuning system for a superheterodyne receiver comprising a signal frequency circuit and an oscillator circuit, a variable permeability-tuned inductance included in the signal frequency circuit, a second variable permeability-

tuned inductance included in the oscillator circuit, said inductances being in the form of coils disposed in concentric relation, and a single ferromagnetic core movable relatively to said inductance coils for effecting the simultaneous adjustment thereof in the tuning of said circuits through their respective frequency ranges.

5. A tuning system for a superheterodyne receiver comprising a pair of circuits which are tunable through frequency ranges of different widths, a variable permeability-tuned inductance of predetermined winding pitch and diameter included in the circuit that is tunable through the wider frequency range, second variable permeability-tuned inductance of greater winding pitch and diameter than the first inductance included in the circuit that is tunable through the narrower frequency range, the two inductances being disposed in concentric relation, and a single ferromagnetic core movable coaxially within said inductances for effecting the simultaneous adjustment thereof in the tuning of said circuits through their respective frequency ranges.

6. A tuning system for a superheterodyne receiver comprising a signal frequency circuit and an oscillator circuit, a variable permeability-tuned inductance of predetermined winding pitch and diameter included in the signal frequency circuit, a second variable permeability-tuned inductance of greater winding pitch and diameter than the first inductance included in the oscillator circuit, the two inductances being disposed in concentric relation, and a single ferromagnetic core movable coaxially within said inductances for effecting the simultaneous adjustment thereof in the tuning of said circuits through their respective frequency ranges.

DUDLEY E. FOSTER.