June 22, 1943. C. WENTWORTH 2,322,722

PERMEABILITY TUNING SYSTEM

Filed May 29, 1942

Fig. 3.

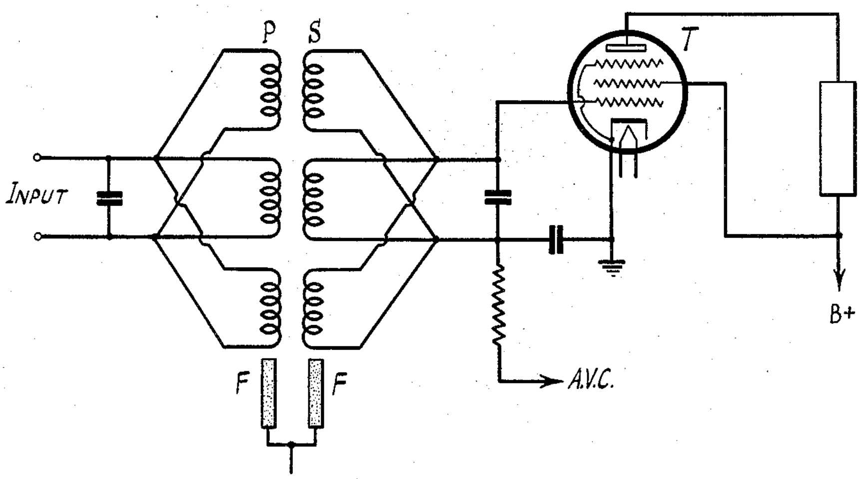


Fig. 1.

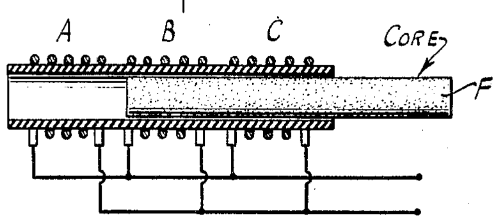
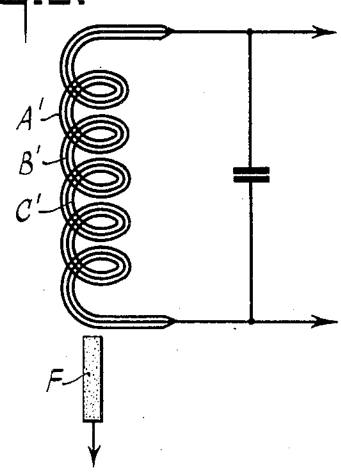


Fig. 2.



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2,322,722

PERMEABILITY TUNING SYSTEM

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Application May 29, 1942, Serial No. 444,974

9 Claims. (Cl. 171—242)

The present invention relates to permeability tuning systems and more particularly to adjustable magnetically tuned resonant circuits which are capable of operating more efficiently and over a wider range of frequencies than known similarly-tuned circuits.

One of the objects of the invention is to so construct and arrange the coil that it will tune the circuit of which it is a part over an extended range of frequencies.

Another object is to provide a low loss (high Q) tuned circuit for obtaining higher gain and greater selectivity per amplifier stage than hitherto obtained with conventional circuits.

Another object is to provide a coil system particularly adaptable for high frequency uses.

A still further object of the invention is to increase the tuning range obtainable at high frequencies with a given ferro-magnetic core.

The novel features characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and mode of operation together with further objects and advantages thereof will best be understood by reference to the following description taken in connection with the accompanying drawing wherein Fig. 1 shows a preferred form of coil arrangement in accordance with the invention; Fig. 2 shows a modified form of the invention; and Fig. 3 shows the coil system of the invention serving as the input coupling means to an amplifier stage.

The tuning range of a given core at any frequency depends upon the core and coil geometry and the current distribution over the surface of the coil. With a given core the tuning range increases (1) as the coil length increases up to the length of the core; (2) as the coupling between the core and coil is increased; (3) as the winding density is increased; and (4) as the current distribution approaches a theoretically uniform current sheet over the surface of the coil.

The winding-density increase in tuning range is really due to an improvement in current distribution, because to effect the increase in tuning range the winding density must be increased by reducing the wire size and spacing between turns and not by adding a second layer to the coil, hence providing a more uniform current distribution.

At high frequencies the inductances involved are small; this means short coils with wide spacing between turns. Both of these conditions tend to decrease the tuning range. Some improvement can be obtained by increasing the length of coil at the expense of winding density, but under these conditions the current distribution over the coil surface is very poor—the current is concentrated in narrow channels widely spaced, whereas it should be uniformly distributed over the entire surface.

If a coil is wound having twice as many turns as is desired its inductance will be four times too high. If four of the coils are wound and connected in parallel the resulting inductance will be the desired inductance. If all four of these coils are placed end to end and connected in parallel such that their mutual inductances are all aiding, the result is, in effect, a long coil with the desired inductance and a fairly good current distribution. A further improvement in current distribution can be made by making a quadrifilar winding. Of course, a winding consisting of as many strands as desired could be made—the more strands the better the current distribution. The strands, of course, must be uniformly and closely spaced in a single layer over the surface of the coil form for best results.

With conventional coils it is practically impossible to provide iron core tuning at high and ultra-high frequencies with any reasonable range. As indicated above, at such high frequencies the coils are required to be very short or the spacing between turns becomes unreasonably large and only very limited range is possible. I have found that by using a plurality of coils which are short with respect to their diameter and by connecting them in parallel, the tuning range even at ultra-high frequencies may be extended as much as approximately 15%.

In Fig. 1 I have shown a plurality of short coils A, B and C, three having been shown by way of example, placed end to end on a coil form and electrically connected in parallel with their magnetic flux mutually aiding. The adjustable tuning core F may be of the type which consists of finely divided or comminuted magnetic material, such as iron dust, held together with a suitable insulating binder.

In order to show the effect of connecting coils in parallel the following measurements were made with different coil combinations. Each coil was 1⅝ inches long, of No. 20 single enamel copper wire wound on styrol tubing having ½ inch outside diameter and ⅜ inch internal diameter:

	Tuning capacity	No core		With core all the way in—	
		Freq.	Q	Freq.	Q
	μμfds.	Mc.		Mc.	
Conventional coil—7 turns	79	30	175	19.9	109
2 coils in parallel—9 turns/coil	69.2	30	228	17.5	117
3 coils in parallel—10 turns/coil	65.6	30	240	16.9	117
Conventional coil—5 turns	32.9	65	189	43.2	62
5 coils in parallel—6 turns/coil	34.6	65	245	37.2	60
Conventional coil—3 turns ($\frac{5}{16}$″ long)	33.9	65	197	46.9	72

The capacity was held constant for the no-core and the core-all-way-in conditions. The core was inserted in the coil and the frequency was changed to bring the coil to resonance again.

From the above data it can be seen that a tuning range approximately 15% greater can be obtained by using coils in parallel to make effectively a longer coil. In some cases the Q is improved.

Another form of coil that may be used is shown in Fig. 2, wherein the several coils A′, B′ and C′ are wound together and in parallel on a common form, which for the sake of clarity is not shown. Except for the point of connection at their ends the several coils are insulated from one another.

In Fig. 3 a pair of coil systems P and S, each of which may be of the form shown in Fig. 1 or in Fig. 2, serves as the coupling means between a source of signals and the input of an amplifier T. The source of signals may be an antenna circuit or the output of a preceding amplifier.

While I have shown and described certain preferred embodiments of my invention, it will be understood that modifications and changes may be made without departing from the spirit and scope of the invention, as will be understood by those skilled in the art.

What I claim is:

1. An inductance device comprising a plurality of coils disposed end to end and electrically connected in parallel, and a magnetic core arranged for axial movement with respect to said coils.

2. An inductance device comprising a plurality of coils disposed end to end and electrically connected in parallel with their magnetic flux mutually aiding, and a comminuted magnetic core arranged for axial movement with respect to said coils.

3. An inductance device comprising a plurality of coils wound on a form and disposed end to end, said coils being electrically connected in parallel with their magnetic flux mutually aiding, and a comminuted magnetic core adapted to be moved axially within the coil form.

4. An inductance device comprising a plurality of short coils disposed end to end and electrically connected in parallel, a coil form on which the several coils are wound, and a magnetic core adapted to be moved axially within the coil form.

5. An inductance device comprising a plurality of short coils disposed end to end and electrically connected in parallel with their magnetic flux mutually aiding, a coil form on which the several coils are wound, and a comminuted magnetic core adapted to be moved axially within the coil form.

6. An inductance device comprising a coil having a plurality of windings which are wound together on a form, the turns of said windings being spaced and only the terminals of the windings being electrically connected to effect a parallel connection of the windings with their magnetic flux mutually aiding, and a comminuted magnetic core arranged for movement within the coil form.

7. An adjustable magnetically tuned resonant circuit, comprising a plurality of coils electrically connected in parallel and with their magnetic flux mutually aiding, and an adjustable magnetic core cooperating with said coils, the arrangement being such that the operating range of said circuit is extended beyond that obtainable with a single coil having substantially the same inductance as the plurality of parallel coils.

8. An adjustable magnetically tuned resonant circuit, comprising a plurality of coils co-axially disposed end to end, electrically connected in parallel and with their magnetic flux mutually aiding, and an adjustable magnetic core cooperating with said coils, the arrangement being such that the operating range of said circuit is extended beyond that obtainable with a single coil having substantially the same inductance as the plurality of parallel coils.

9. An adjustable magnetically tuned resonant circuit, comprising a coil having a plurality of windings only the terminals of which are electrically connected to connect the several windings in parallel with their magnetic flux mutually aiding, and an adjustable magnetic core cooperating with said windings, the arrangement being such that the operating range of said circuit is extended beyond that obtainable with a single coil winding having substantially the same inductance as the plurality of parallel coil windings.

CHANDLER WENTWORTH.

DISCLAIMER

2,322,722.—*Chandler Wentworth*, Haddon Heights, N. J. PERMEABILITY TUNING SYSTEM. Patent dated June 22, 1943. Disclaimer filed Dec. 13, 1945, by assignee, *Radio Corporation of America*.

Hereby enters this disclaimer to claims 1 to 9 inclusive of said Letters Patent.

[*Official Gazette January 29, 1946.*]

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