June 3, 1958 W. PEARLMAN ET AL 2,837,726

RELUCTANCE TUNED RADIO FREQUENCY COIL

Filed July 1, 1953 2 Sheets-Sheet 1

FIG.1.

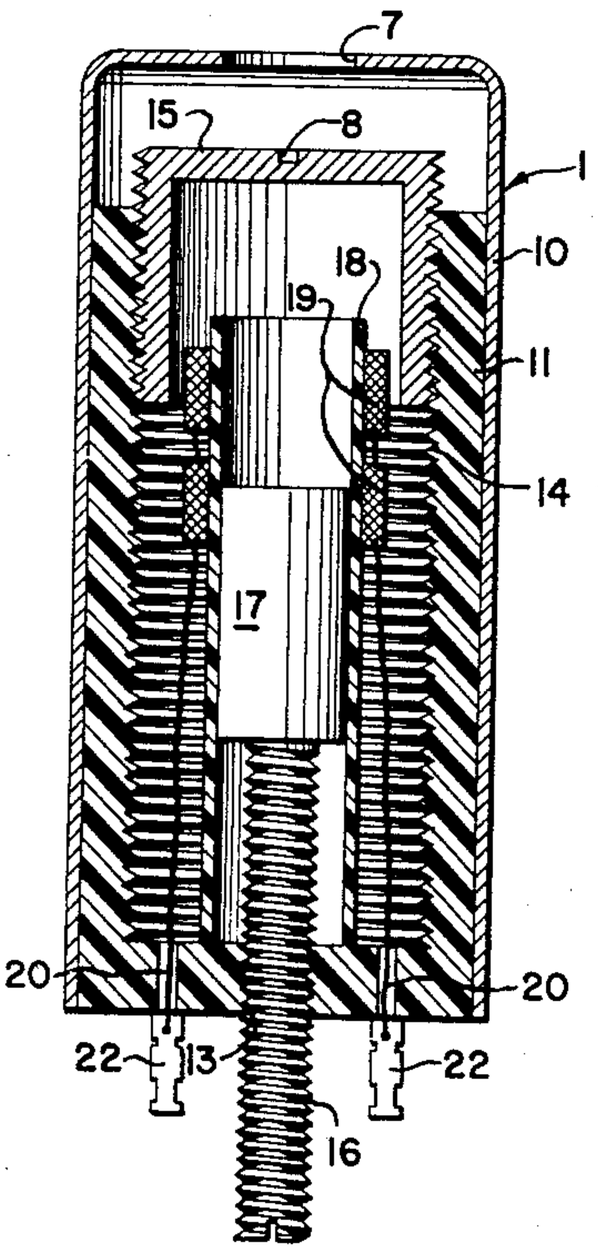


FIG.2.

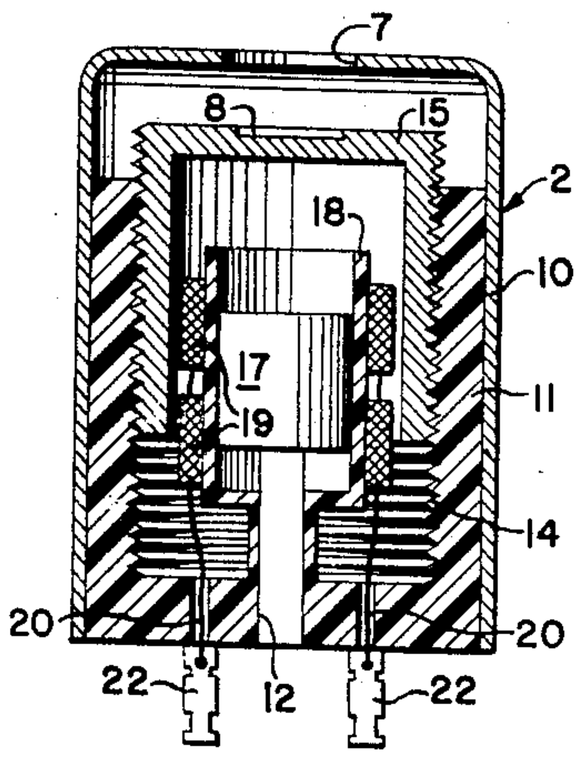


FIG.3.

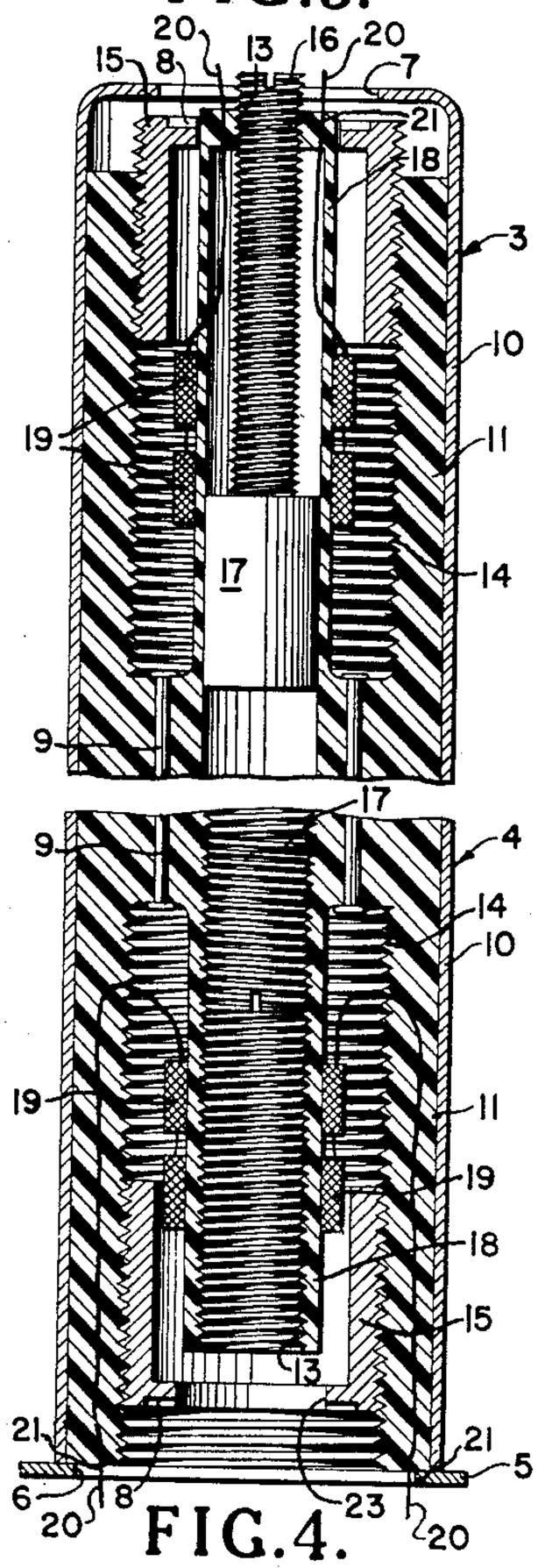


FIG.4.

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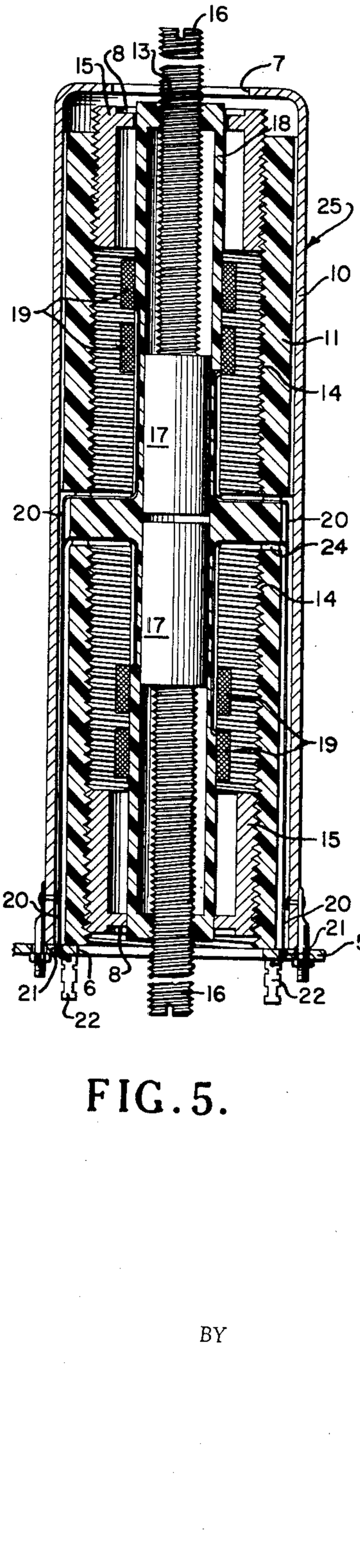


FIG. 5.

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RELUCTANCE TUNED RADIO FREQUENCY COIL

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Application July 1, 1953, Serial No. 365,569

1 Claim. (Cl. 336—131)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to a high frequency coupling device comprising a tunable coil and core assembly and more particularly to a miniaturized tuned radio frequency coil having suitable properties for use as a tuned tube plate load in miniature R. F. amplifiers. More specifically the instant invention provides an improved tunable coil structure which advantageously is equally well adapted for tuned intermediate frequency coupling transformers in superheterodyne circuits.

In addition to R. F. circuits the invention lends itself to a wide variety of variable reluctance tuned inductance circuits, including usage in transformer coupling circuits which is accomplished with a plurality of coils along a comon axis with each coil being provided with two separate tunable components. The structural arrangement is generally the same whether the device is to be used with a single R. F. coil wound on a cylindrical form or with transformers utilizing a plurality of coils.

The device in its most general form comprises, a coil, a first cup shaped high frequency powdered iron type magnetic component which provides a movable shell about the coil, and a second adjustable powdered iron component possessing the same magnetic characteristics and which is independently adjustable with respect thereto. This second element comprises a cylindrical core which is coaxial with the coil and coil form and can be moved in an axial direction with respect to the cup shaped shell element and along substantially all of the coil axis, thereby to provide means for varying the reluctance of the magnetic circuit by variation of the gap between the two magnetic elements. The reluctance between the two magnetic components is varied by altering the air gap adjustment through changes of the penetration of the core inside the coil form while maintaining full magnetic coupling of the iron shell with the coil. This system additionally provides for variation of coupling of the flux through the coil assembly by the withdrawal of the shell to provide the desired minute reluctance variations for fine tuning or the like. This in effect is accomplished by varying the air gap rather than by the more conventional pereambility arrangements.

The device is also well adapted for applications requiring variable mutual inductance of two or more coil systems for coupling along the common axis thereof, and of the character shown in Patent No. 2,558,573 to A. G. Manke, dated June 26, 1951.

While certain prior devices have utilized an adjustable unitary shell and core for permeability tuning of the coils of I. F. transformer components, and have embodied adjustable slugs in variable reluctance or variable permeability tuning arrangement in similar R. F. coil or tank circuit applications, those providing a cup shaped iron portion and a core affixed thereto to provide a W-shaped iron cross section which is movable into the coil have provided certain limitations as to the frequency range

and fine tuning which can be accomplished thereby. The devices of the type incorporating a slug fixed to the cup thereof provide tuning of a permeability character by advancing the core and shell simultaneously over and into the coil form. Other prior devices have provided a fixed iron shell about the coil with means for adjustably moving a high frequency iron core to vary the penetration thereof with respect to a second fixed cylindrical core to provide a reluctance tuning arrangement. In the aforementioned permeability type of assembly wherein the core and shell are in a fixed relationship the air gap is maintained substantialy constant as the high frequency iron magnetic circuit elements are moved axially with respect to the coil, while the latter maintains a substantially constant flux field with tuning being accomplished by distortion of the field pattern. A device of the latter character is shown in the patent to Gusdorf et al. No. 2,544,152, dated March 6, 1951. This device provides a substantially fixed magnetic field and fixed air gap relationship with tuning by movement of the iron slug means in the inner magnetic core provided to vary the flux field distortion and thereby alter the tuning of the coil.

The instant system provides an adjustable cup shaped shell which may substantially enclose the coil, or in the event a pair of tandem coils are used in the assembly, may substantially enclose both coils and provide the broad tuning characteristics therefore with a second variable element of iron core material for the fine tuning adjustment. The device of the preferred embodiment additionally provides the advantageous arrangement whereby both coarse and fine tuning may be accomplished from the same end of the coil assembly. It is also within the scope of a second embodiment to provide a coil with adjustable means for movement of the shell about the coil from one end thereof for initial tuning and thereafter position the movable core from the opposite axial end of the coil to change the air gap between the core and shell and effectively tune the coil in a manner to provide greater sensitivity of tuning or to permit the final tuning from the shell end if desired. The advantage of such provisions will be apparent when it is desired to retune a circuit by a serviceman who can accomplish the same from either the top or bottom of the chassis. In the case of the transformer construction the complete primary may be tuned from the top and the secondary from the bottom, in a conventional manner but gaining the advantage in each case of an additional element to provide a higher degree of fine tuning.

One object of the instant invention resides in the provision of a new and improved high frequency coil device utilizing variable reluctance tuning.

Another object is to provide a variable reluctance tuned R. F. coil assembly, the tuning of which may be accomplished from the top or bottom of the coil.

It is also an object of this invention to provide a coil assembly incorporating provisions for both coarse and fine tuning.

Another object of the invention lies in the provision of an improved coil assembly incorporating dual element variable reluctance tuning which is well adapted for utilization in both tuned transformer and tuned impedance type coupling circuitry.

It is a further object to provide a variable reluctance tuned coil of small dimensions which is well adapted for miniaturized electronic apparatus applications.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a sectional view in elevation of an R. F. coil

of the instant invention with provisions for air gap adjustments at opposite ends of the coil;

Fig. 2 is a sectional elevation view of an R. F. coil incorporating a fixed slug and an adjustable shell;

Fig. 3 is a sectional view of an R. F. coil similar to Fig. 1 with provision for adjustment of both of the magnetic tuning elements from the top end thereof;

Fig. 4 is a view similar to Fig. 3 and showing a modified manner of adjusting the magnetic elements thereof from the bottom or under chassis end; and

Fig. 5 is a sectional view in elevation of a variable reluctance tuned dual transformer or multiple coil mutual inductance tuned transformer incorporating a plurality of tuning shells and slugs, of an additional embodiment of the invention.

Referring now to Fig. 1 of the drawings for the showing of a coil assembly of the instant invention which is generally designated by the reference character **1** having a shielding shell **10** of aluminum for example, of an enclosing nature to provide shielding of the coil system from stray radio frequency energy of other electronic components in the vicinity thereof or from coupling with circuit elements used in adjacency thereto. This casing **10** encloses the plastic body **11** which is provided with an aperture **12**, Fig. 2, or a threaded portion **13**, Figs. 1, 3 and 4, and a threaded bore **14** therein. The bore **14** is for reception of a powdered metal cap or shell **15** which is adapted for longitudinal movement therethrough. The tapped portion **13** provides for adjustment of the non-magnetic slug screw **16** for axial movement of the powdered iron slug **17** with respect to the shell **15**.

The plastic body additionally includes a cylindrical coil form portion **18** which is shown as integral therewith but, which may be a separate element and cemented thereto if desired. The coil windings **19** are of a machine wound type which are positioned on the form **18** and cemented in place by coil dope or the like to maintain the positioned adjustment thereof. The showing of the drawings is directed to tandem or divided winding of the pair of elements which are connected in series with the leads **20** thereof brought out through the plastic body at **21** in any desired manner or they may be connected to terminals **22** which may be moulded into the plastic body in a conventional manner.

Suitable shunt capacitance may be connected across these terminals **22**. The coil assembly **2** of the embodiment of Fig. 2 is generally similar in function to that of Fig. 1, but differs therefrom mechanically in that the slug element **17** is fixed at a predetermined location within the coil form **18**. The only adjustable element for varying the air gap for reluctance tuning is the iron cup **15** which is adjusted from the upper end thereof by means of the screw driver slot **8** therein for movement in the threaded bore **14**. Access to this slot is provided by the aperture **7** in the shield **10**.

The coil assembly embodiment **3** of Fig. 3 differs generally from the assembly **1** in that all adjustments, i. e., movement of the slug and shell, may be accomplished from the top of the shield **10** and through the aperture **7** therein. The threaded portion **13** of the plastic body unit **11** and including the coil form **18**, is incorporated at the upper or outer extremity of the coil form cylinder. If desired, a lock nut, not shown, or other locking arrangements may be used as required to set the final adjustment thereof. In this arrangement a spanner type screw driver or the equivalent is required to adjust the movable shell or cup **15**.

It will be apparent from the relative positions of Figs. 3 and 4 that a dual ended unit **25**, of Fig. 5, comprising a combination of the units of these two R. F. coil assemblies may advantageously be incorporated into an I. F. transformer assembly or the like, preferably utilizing identical adjusting arrangements of either of Figs. 3 and 4 in a unitary plastic body or one fastened together as by rivets **9**.

The leads from R. F. coils units of Figs. 3 and 4 may be brought out of the shell through apertures located substantially in the regions of the rivets or to terminals as shown at **22** of Figs. 1 and 5. However, in the event it is desired to minimize coupling between the leads and the magnetic elements it is preferably to have the leads brought out at the top of the primary of Fig. 3 and out of the bottom of the secondary of Fig. 4. In practice these leads would preferably lie in grooves or channels as shown at **24**, Fig. 5, and provided in the plastic body **11** in a manner known in the art.

The embodiment **4** of Fig. 4 is similar in function to the assembly **3** as to the arrangement for providing for all air gap adjustments from one end. The adjustments of **4** may be made from an under chassis position through the aperture **6** in the chassis **5**. It will be obvious, however, that the adjustment of the slug **17** having a threaded outer surface for movement in the internally threaded portion **13** of the body **11** and coil form **18**, as accomplished through the aperture **23** in the cup **15** may equally well be made through the aperture **7** in the top of the shield if top adjustment be desired. This arrangement as hereinbefore stated is well adapted for transformer constructions or usage in coupling circuits wherein the slugs **17** are positioned sufficiently close together to provide for adjustment of the mutual inductance therebetween thereby providing inductive coupling of the coil or coils of the lower form **18** with that of the coil or coils of the upper coil unit. The reluctance variation for tuning such an arrangement is accomplished with movement of the cups **15**.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claim the invention may be practiced otherwise than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

A high frequency tunable transformer comprising a pair of coarse tuning separately movable susbtantially cup-shaped elements of magnetic material, a pair of coil supporting elements, each of said supporting elements being of non-magnetic material and coaxially positioned within said cup-shaped elements respectively and spaced therefrom, a pair of coil elements, each of said coil elements being disposed on said coil supporting elements and within each of said cup-shaped elements respectively, one of said coil elements constituting a transformer primary winding and the other of said coil elements constituting a transformer secondary winding, a pair of fine tuning axially movable core elements of magnetic material, each of said core elements being disposed within said coil supporting elements respectively, an elongated electrical shield surrounding all of said elements, said shield having an aperture formed on each end wall thereof, a first pair of adjusting means individually accessible by one of said apertures for effecting independent axial movement of the cup-shaped element and the core element associated with the primary winding, and a second pair of adjusting means individually accessible by the other of said apertures for effecting independent axial movement of the cup-shaped element and the core element associated with the secondary winding.

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