April 1, 1952 H. T. LYMAN ET AL 2,591,081

RADIO-FREQUENCY TRANSFORMER

Filed Sept. 7, 1949 2 SHEETS—SHEET 1

Fig. 1

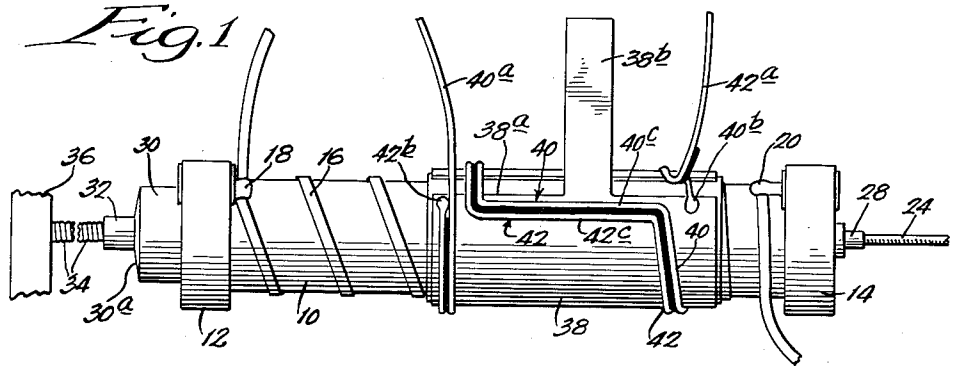


Fig. 2

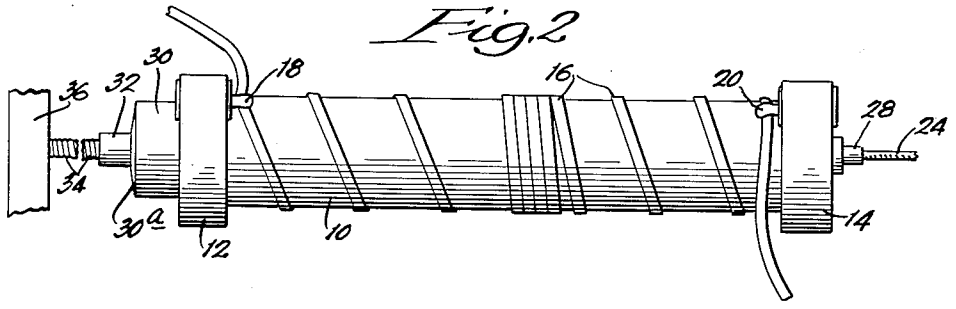


Fig. 3

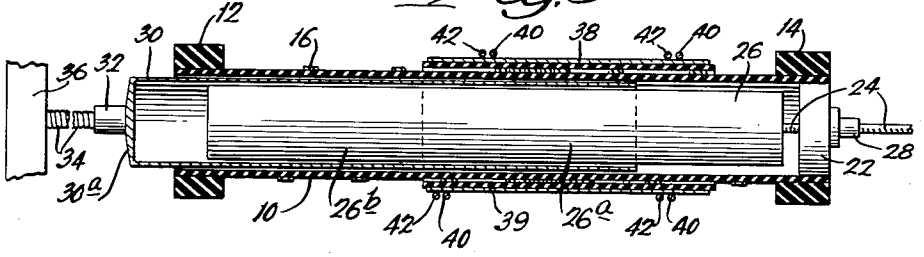
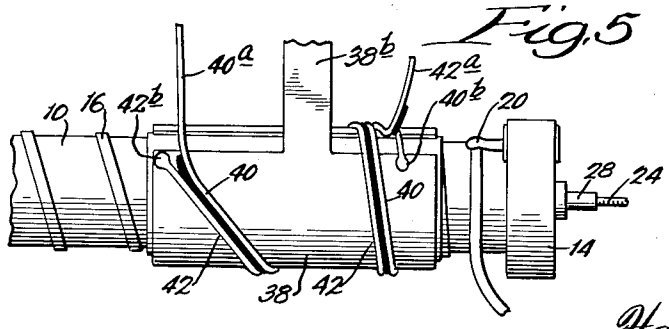


Fig. 5



INVENTORS:
Harold P. Lyman
and Donald R. De Par,
BY Dawson, Orrick, Booth and Haugenberg,
ATTORNEYS.

April 1, 1952 H. T. LYMAN ET AL 2,591,081

RADIO-FREQUENCY TRANSFORMER

Filed Sept. 7, 1949 2 SHEETS—SHEET 2

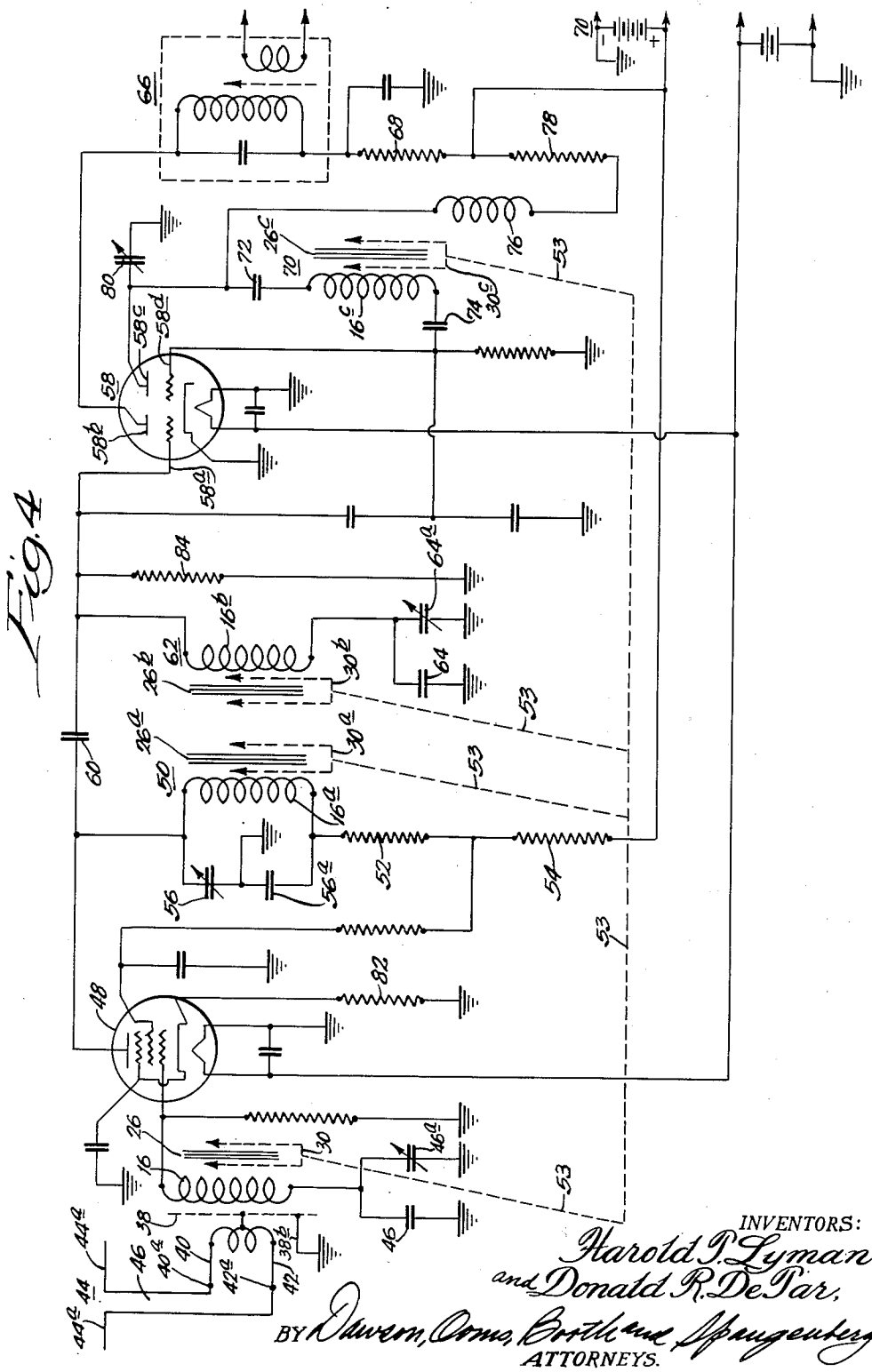


Fig. 4

INVENTORS:
Harold P. Lyman
and Donald R. DeTar,
BY Dawson, Orrin, Grotte and Spangenberg,
ATTORNEYS.

Patented Apr. 1, 1952

2,591,081

UNITED STATES PATENT OFFICE

2,591,081

RADIO-FREQUENCY TRANSFORMER

Harold T. Lyman, Milford, and Donald R. De Tar, Stratford, Conn., assignors to Aladdin Industries, Incorporated, Chicago, Ill., a corporation of Illinois

Application September 7, 1949, Serial No. 114,294

11 Claims. (Cl. 171—119)

1

Our invention relates to an improved tunable radio frequency transformers operable over a wide frequency range and reflecting a substantially constant impedance from the primary winding terminals.

In television service it is necessary to tune over two spaced radio frequency bands. One band (channels 2 to 6) extends from about 54 megacycles to about 88 megacycles and the other band (channels 7 to 13) extends from about 174 megacycles to 216 megacycles. In the case of the input transformer, it is further necessary to tune over this frequency range without substantially varying the impedance reflected to the antenna. This is of considerable importance because the wide band antenna structures necessary to secure response over the broad spaced bands are necessarily critical as to load impedance.

The present invention is particularly useful in connection with a tunable inductor of the type disclosed and claimed in the copending patent application entitled Wide Band Calibrated Tuner and Inductor for Use Therewith, Serial No. 110,176, filed August 13, 1949, now U. S. Patent No. 2,533,810. This inductor tunes over the two broad spaced television bands without switching and gives a substantially constant band width.

Moreover, it is desirable in radio frequency transformers to provide a structure that is substantially interference free insofar as pickup in the antenna input leads is concerned. In the structure of the present invention, this is provided by arranging the primary winding symmetrically relative to neutral or ground potential and by interposing an electrostatic shield between the primary and secondary windings.

It is therefore a general object of the present invention to provide an improved transformer tunable over a wide frequency range.

A further object of the present invention is to provide an improved wide-band tunable transformer reflecting a substantially constant impedance to the terminals of the primary winding.

Another object of the present invention is to provide an improved wide-band tunable transformer that is insensitive to interference induced in the antenna transmission line.

Yet another object of the present invention is to provide an improved tunable transformer having features of construction, combination, and arrangement rendering it particularly suitable for use in television service to cover the high

2

frequency band and the low frequency band without switching, with a substantially constant impedance to the antenna, and in a manner insensitive to interference induced in the antenna transmission line.

Still another object of the present invention is to provide a television system embodying the transformer of the present invention.

The novel features which we believe to be characteristic of my invention are set forth with particularity in the appended claims. Our invention itself, however, both as to its organization and method of operation will best be understood by reference to the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a side elevation view of a tunable transformer embodying the features of the present invention;

Figure 2 is a view like Figure 1 but with the primary winding and associated elements removed;

Figure 3 is an axial cross section view of the transformer of Figure 1;

Figure 4 is a schematic circuit diagram of a radio frequency system for television use utilizing the transformer of the present invention; and

Figure 5 is a fragmentary view of an alternative embodiment of the present invention.

Referring now to Figures 1, 2, and 3, there is shown at 10 a former sleeve of a phenol formaldehyde polymerization product or like insulating material. The sleeve terminates at its opposite ends in a pair of rings 12 and 14 of a similar material. The strip 16 of copper or other suitable conducting material is snugly wrapped about the sleeve 10 to define a helix or coil. Strip 16 is anchored at its opposite ends to the straps 18 and 20 which are received between the sleeve 10 and the rings 12 and 14 respectively. Preferably the strip 16 is affixed to the straps 18 and 20 by soldering.

A disk or slug 22 is snugly fitted within the former sleeve 10 as shown in Figure 3. This slug is made of insulating material and has a central opening which threadedly receives the spring 24. Spring 24 is molded in the magnetic core 26 to support that core from the slug 22.

The transformer is initially tuned or calibrated at one frequency by rotation of the spring 24 to shift core 26 of coil 16. When the desired calibration has been achieved, the spring 24 is secured to the anchoring sleeve 28 by a drop of solder or by crimping. Sleeve 28 is snugly held by slug 22 so that further movement of core 26

is prevented once the spring 24 is affixed to the anchoring sleeve.

If a core material having good performance over the entire frequency range is not available, the core 26 may be made in two sections; 26a and 26b. The former section is effective at the higher frequencies of about 174 to 216 mc. and is composed of material having low loss at these frequencies, even at the sacrifice of permeability. The latter section is effective only at the lower frequencies of about 54 to 88 mc. and may be of material having high permeability, since such permeability can be obtained at these frequencies without excessive loss.

The movable conducting sleeve 30 is interposed between the former sleeve 10 and the core 26. This sleeve is of aluminum or like low resistance conducting material and terminates at one end in the wall 30a. This wall is affixed to the anchoring sleeve 32 which is firmly secured to the coil spring 34.

The spring 34 is threadedly received in the carriage 36 which is shown fragmentarily in Figures 1, 2, and 3. This carriage is movably supported by suitable mechanical elements (not shown) and carries a number of similar springs for other tuning sleeves desired to be moved in unison with conducting sleeve 30. Simultaneous tuning of a plurality of inductors is thereby achieved.

The carriage 36 threadedly receives the spring support 34 so that the position of the sleeve 30 may be adjusted relative to the carriage 36 to tune coil 16 without changing the setting of other inductors carried by carriage 36.

A mechanism to move and support carriage 36 is described in detail in said U. S. Patent No. 2,533,810.

An electrostatic shield about a portion of the coil 16 is defined by the sheet 38 of low loss conducting material, such as copper. This sheet is received over the insulating sleeve 39, Figure 3, and substantially encircles the coil 16. That is, the adjacent ends of the sheet 38 are insulated from each other. Because of the gap 38a, the sheet 38 does not define a closed conducting path linking coil 16. The finger 38b is formed unitarily with the sheet 38 to provide a suitable connecting terminal for the shield formed by that sheet. This is connected to a point of neutral potential, such as the ground connection of the television receiver.

A primary winding for coil 16 is defined by the wires 40 and 42, Figure 1. At their ends, 40a and 42a, these wires form the insulated terminals for the transformer. As shown in Figure 1, the opposite ends of each of these wires, 40b and 42b, are soldered or otherwise attached to the opposite ends of sheet 38 at points adjacent one side of the gap 38a.

The wires 40 and 42 are wrapped about the shield 38 and are positioned adjacent each other as shown in Figure 1. As shown, the wires each define one turn about the left hand (low frequency) end of winding 16 and one turn about the right hand (high frequency) end of winding 16. The intermediate portions 40c and 42c are parallel with the axis of winding 16.

It will be observed that the end 40a of wire 40 leaves the sheet or shield 38 at a point adjacent end 42b of wire 42. Similarly, the wire 42a leaves the shield 38 at a point adjacent the point of attachment of end 40b of wire 40. Consequently, wires 40 and 42 define like loops about the shield 38.

The primary winding circuit may be traced

from end 40a of wire 40 around the shield 38, a total of two turns, to the end 40b where wire 40 is electrically connected to shield 38. The circuit continues through shield 38 from end 40b of wire 40 to the end 42b of wire 42. From end 42b of wire 42, the circuit may be traced through two full turns of wire 42 in the same direction as the turns of wire 40 to reach the end 42a of wire 42.

The wires 40 and 42 define a balanced primary winding when the finger 38b is connected with a point of neutral potential. Any interference inducing like potentials in wires 40a and 42a produces no induced electromotive force in coil 16. This will be evident from tracing the current flow from end 40a of wire 40 to finger 38b and from end 42a of wire 42 to finger 38b. The respective currents encircle the shield 38 in opposite directions at points closely adjacent each other so that equal and opposite magnetizing forces result.

The interference free operation of the transformer is further improved by the shield 38. This shield reduces the capacitive coupling between the wires 40 and 42 and coil 16 to a negligible value. Consequently, any electromotive forces tending to induce voltages in coil 16 by reason of capacitive couplings are ineffective in this respect and noise from this source is prevented.

Figure 4 is a schematic diagram showing a complete radio frequency amplifier for television use embodying the transformer of the present invention. As indicated, a symmetrical or balanced antenna 44 (which may, for example, include dipoles 44a) is connected to the transmission line 46, which is connected to the terminals 40a and 42a defined by the ends of wires 40 and 42. The primary winding formed by wires 40 and 42 is connected at its center point to shield 38 as indicated and the tab 38b is connected to ground. As shown in Figure 4, the coil 16 is in inductive relationship with the primary winding, and it is separated therefrom by the shield 38. The core 26 is fixedly positioned relative to winding 16 and is more or less shielded therefrom by the movable conducting sleeve 30.

The winding 16 is connected to ground through capacitors 46 and 46a and to the control electrode of electron tube 48. The anode of this tube is connected to a source of high voltage through the tunable inductor indicated generally at 50 and resistances 52 and 54. Inductor 50 includes a winding 16a similar to coil 16, a stationary core 26a similar to core 26 and a movable sleeve 30a similar to movable sleeve 30. As indicated by the dotted lines 53, the sleeve 30a is mounted for tuning movements in unison with the sleeve 30. Winding 16a is tuned by capacitors 56 and 56a.

Electron tube 58 defines an oscillator and mixer to receive the output voltage of the amplifier defined by tube 48. As indicated, the control electrode 58a of tube 58 is connected to inductor 50 by coupling capacitor 60. The inductor shown generally at 62 is connected by the control electrode 58a and ground through tuning capacitors 64 and 64a. Inductor 62 includes a winding 16b like winding 16a and similar to coil 16. A magnetic core 26b is placed adjacent the winding 16b and is encircled to a greater or lesser degree by the conducting sleeve 13b to tune the inductance 62. As indicated by the dotted lines 53, the sleeve 30b is mounted for movement in unison with sleeves 30a and 30.

The output circuit of the mixer portion of tube 58 may be traced from the anode 58b

through the I. F. transformer indicated generally at **66** and resistance **68** to the positive terminal of uni-directional voltage-source **70**. The intermediate frequency amplifiers (not shown) are energized from transformer **66**.

The oscillator portion of tube **58** is defined by the circuit which may be traced from anode **58***c* through the tunable inductor indicated generally at **70** and capacitors **72** and **74** to the control electrode **58***d*. Positive energizing voltage for the anode **58***c* is obtained through inductance **76** and resistor **78**. Capacitor **80** tunes inductor **70**.

The inductor **70** includes a winding **16***c* and a magnetic core **26***c* spaced from the winding. A low loss conducting sleeve **30***c* encircles more or less of the core **26** to tune the inductor **70**. As indicated by the dotted line **53**, the sleeve **30***c* is mounted for tuning movements in unison with sleeves **30**, **30***a*, and **30***b* to provide simultaneous tuning of all stages of the amplifier.

In a typical amplifier constructed in accordance with the circuit diagram of Figure 4 the following circuit components may be used:

Electron tube **48**	Type 6AG5
Electron tube **58**	Type 6J6
Capacitor **46**	10 $\mu\mu$f.
Capacitor **46***a*	0.8 to 3 $\mu\mu$f.
Resistor **82**	100 ohms
Capacitor **56**	0.8 to 3 $\mu\mu$f.
Capacitor **56***a*	13 $\mu\mu$f.
Capacitor **60**	1 $\mu\mu$f.
Capacitor **64**	7 $\mu\mu$f.
Capacitor **64***a*	0.8 to 3 $\mu\mu$f.
Resistance **52**	15,000 ohms
Resistance **54**	1,000 ohms
Resistance **84**	440,000 ohms
Capacitor **80**	0.8 to 3 $\mu\mu$f.
Capacitor **72**	33 $\mu\mu$f.
Capacitor **74**	100 $\mu\mu$f.
Resistor **78**	680 ohms
Resistor **68**	10,000 ohms
Source **70**	250 volts

It will be observed that the wires **40** and **42** each extend a substantial distance longitudinally of the coil **16** so that as the sleeve **30**, Figure 3, is shifted to encircle increased portions of the core **26**, it presents a low impedance circuit current path coupled with the winding defined by wires **40** and **42** as well as the winding **16**. Consequently, the winding formed by wires **40** and **42** is rendered less effective as the sleeve reduces the inductance of wire **16**. This automatic change causes the impedance reflected by the ends **40***a* and **42***a* of the wires **40** and **42**, respectively, to tend to be constant despite the fact that the inductance of coil **16** is being changed. This is a matter of great importance, since the transmission line **46**, Figure 4, can be terminated in its characteristic impedance and tuning does not cause loss of the impedance match. The pitch of the turns defined by wires **40** and **42** is varied if necessary to give uniform impedance as the sleeve **30** is shifted.

Moreover, since the portions of wires **40** and **42** rendered ineffective by the sleeve **30** are identical, the balanced condition of the winding defined by wires **40** and **42** is not altered and balanced noise-free operation is achieved at all positions of the sleeve **30**.

Figure 5 shows an alternative embodiment of the present invention wherein the wires **40** and **42** define one turn extending over a considerable axial distance along the axis of coil **16** in the left hand (low frequency) portion and a turn having little axial extent in the right hand (high frequency) portion.

While we have shown and described a specific embodiment of our invention, it will, of course, be understood that we do not wish to be limited thereto and that by the appended claims we intend to cover all variations and alternative embodiments falling within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States:

1. A pickup-free constant-impedance coupling coil for use with an inductor of the type having a conducting tuning sleeve, said coil including a sheet of conducting material substantially encircling said inductor with its adjacent ends insulated from each other and a pair of conducting elements insulatingly supported from said sheet and each extending a substantial distance longitudinally of said inductor, said elements being conductingly attached to spaced points on said sheet and each leaving the sheet substantially at the point of attachment of the other, said elements being closely adjacent each other in the regions intermediate said last points.

2. A pickup-free constant-impedance tunable radio-frequency transformer comprising in combination, an inductance coil, a conducting sleeve movably disposed in said coil to vary the effective inductance thereof, a sheet of conducting material substantially encircling said coil and insulated therefrom, the adjacent ends of said sheet being insulated from each other, and a pair adjacent conducting elements wrapped about said sheet and insulated therefrom, said elements being conductingly attached to said sheet at spaced points thereon and each leaving said sheet substantially at the point of attachment of the other.

3. The combination in a radio receiver of a balanced antenna system terminating in two terminals, an input inductor having a movable tuning sleeve, a sheet of conducting material insulated from and substantially surrounding said inductor with its adjacent ends insulated fom each other, a pair of conductors defining a primary winding to said inductor, said conductors being disposed adjacent each other and wrapped about said sheet, said conductors being conductively connected to spaced points on said sheet, and means connecting each of said conductors to one of said terminals at a point adjacent the point of connection of the other conductor to said sheet.

4. A radio-frequency transformer comprising in combination, a winding, a tube of conducting material movable relative to said winding to vary the inductance thereof, and a pair of conductors disposed adjacent each other and wrapped about said winding to form a primary therefor, said conductors terminating at spaced points lengthwise of said winding and being connected to a common point electrically, each of said conductors extending away from said inductor at a point adjacent the end of the other conductor.

5. A pickup-free constant-impedance coupling coil for use with an inductor of the type having a movable conducting tuning sleeve, said coil including a pair of conductors disposed adjacent each other and wound to define a primary winding, said conductors being connected at spaced points along the length of said inductor to a point of neutral electrical potential, each of said conductors extending away from said inductor at a point adjacent the point where the other con-

ductor connects to the point of neutral potential.

6. A wide-range constant-impedance tunable transformer to cover two radio frequency bands comprising an inductor having spaced portions, one corresponding to each band, an adjustable permeable core mounted within said inductor, a conducting member movably disposed relative to said inductor and operable to slide between said inductor and said core and thereby to tune said transformer, and a primary winding extending across portions of both of said portions.

7. A radio frequency transformer tunable over two spaced radio frequency bands comprising in combination, a helical coil having spaced portions of low turn density and an intermediate portion of high turn density, an adjustable permeable core mounted within said coil a conducting tuning member movably disposed within said coil and over said core to tune said transformer over two spaced frequency bands, and a primary winding having portions extending over each of said portions of said coil.

8. A pickup-free constant-impedance tunable radio-frequency transformer comprising in combination, an inductance coil, a magnetic core in said coil, a conducting sleeve movably disposed in said coil to telescope said core and vary the effective inductance of the coil, a sheet of conducting material substantially encircling said coil and insulated therefrom, the adjacent ends of said sheet being insulated from each other, and a pair adjacent conducting elements wrapped about said sheet and insulated therefrom, said elements being conductingly attached to said sheet at spaced points thereon and each leaving said sheet substantially at the point of attachment of the other.

9. A radio-frequency transformer tunable over two spaced radio frequency bands comprising in combination, a helical coil having spaced portions of low turn density and an intermediate portion of high turn density, a magnetic core in said coil, a conducting tuning sleeve movably disposed within said inductor and adjacent the turns thereof to telescope said core and tune the coil over said bands, and a primary winding snugly wrapped relative to said coil and having portions extending over each of said portions of said coil.

10. A pickup-free constant-impedance radio-frequency transformer tunable over two spaced radio frequency bands comprising in combination, a helical coil having spaced portions of low turn density and in intermediate portion of high turn density, a magnetic core in the coil, a conducting tuning sleeve movably disposed within said inductor and adjacent the turns thereof to telescope said core and tune the coil over said bands, and a primary coil defined by two adjacent conductors each defining a helical winding about each of said spaced portions of said helical coil, and means defining an electrical connection between said conductors and extending from one of said primary helical windings to the other.

11. A pickup-free constant-impedance radio frequency transformer tunable over two spaced radio frequency bands comprising, in combination, a helical coil having spaced portions, one corresponding to each band, a conducting tuning sleeve movably disposed within the inductor and adjacent the turns thereof to telescope the coil and tune the same over the bands, a primary winding defined by two adjacent conductors each defining one turn about each of the spaced portions of the winding and shield means interposed between the primary winding and the coil defining an electrical connection between the conductors and extending from one turn to the other, the shield means defining an incomplete path for current flow about the coil.

HAROLD T. LYMAN.
DONALD R. DE TAR.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,251,631	Mayer	Aug. 5, 1941
2,338,134	Sands et al.	Jan. 4, 1944
2,431,425	Sands	Nov. 25, 1947
2,448,642	Wilburn	Sept. 7, 1948
2,489,114	Vladimer	Nov. 22, 1949