March 11, 1958 F. G. MASON 2,826,698

TUNER

Filed Dec. 20, 1954 2 Sheets-Sheet 1

Fig. 1.

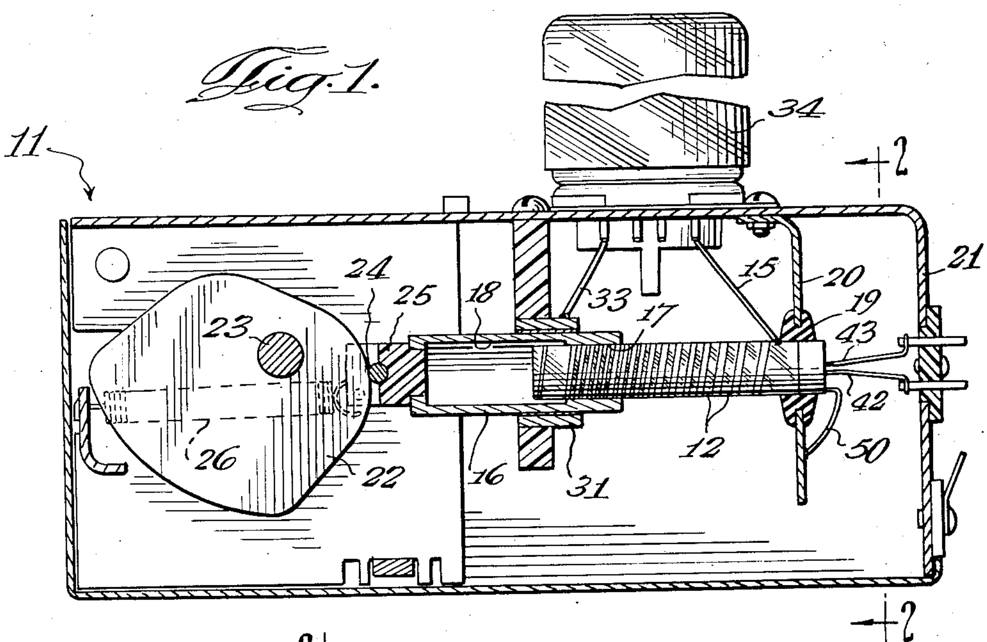
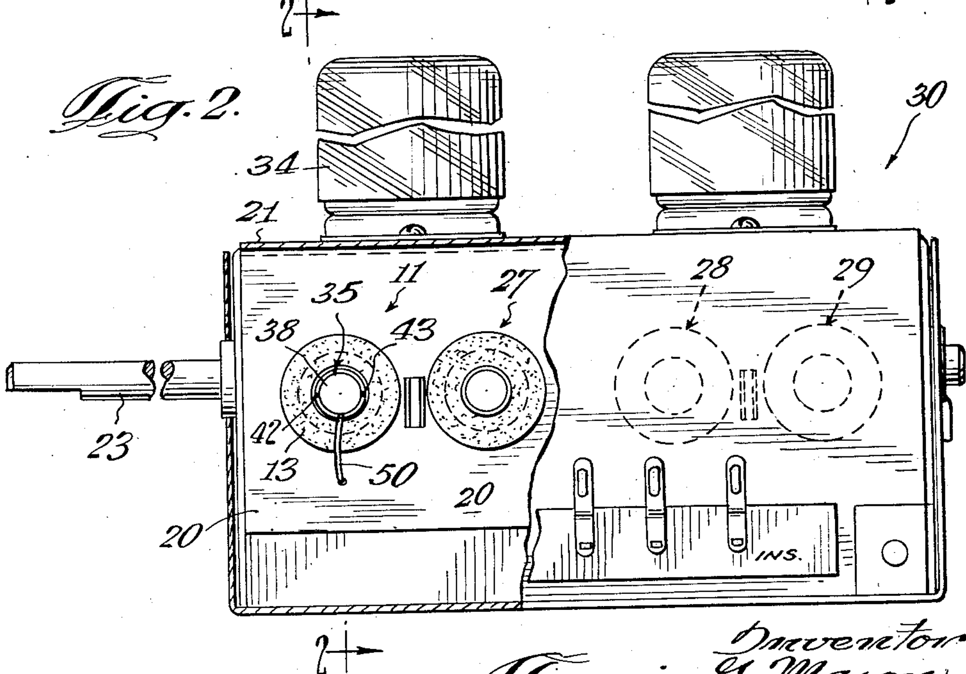


Fig. 2.



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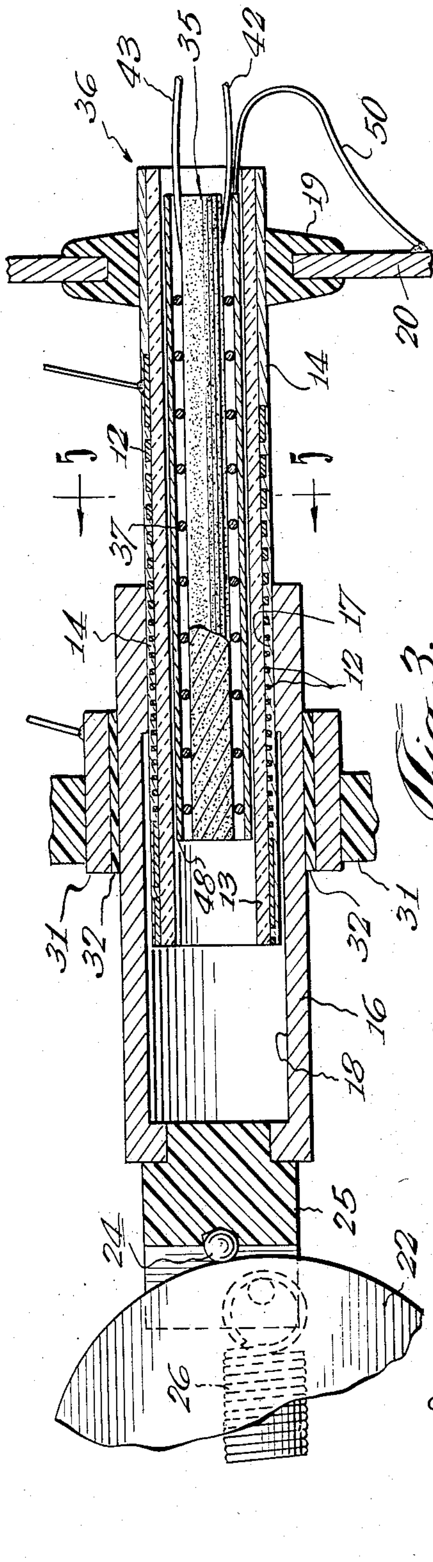

Fig. 3.

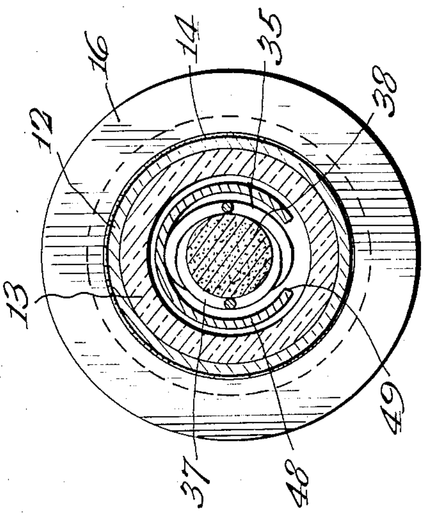

Fig. 5.

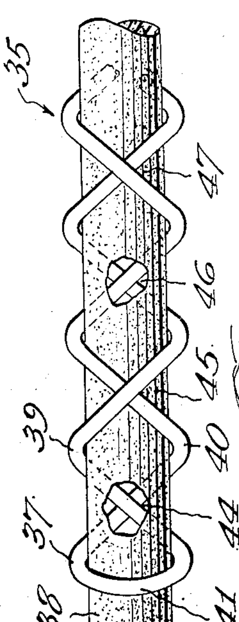

Fig. 4.

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TUNER

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Application December 20, 1954, Serial No. 476,199

5 Claims. (Cl. 250—40)

This invention relates to wide range, high radio frequency tuners, and particularly to an improved tuner having a balanced input.

One principal object of the invention is to provide an improved high frequency tuner adapted to couple a transmission line, leading from an antenna or the like, to the input of a radio or television receiver.

Another object is to provide an improved tuner having a tunable input balun or balanced input circuit.

A further object of the invention is to provide a tuner of the foregoing character which affords a balanced input adapted to be connected to a balanced antenna transmission line, while affording an unbalanced output for connection to the input of an electron discharge amplifier or the like.

It is another object of the invention to provide a tuner of the foregoing character adapted to match a low, balanced input impedance to a relatively unbalanced output impedance.

A further object is to provide a tuner capable of matching a relatively constant input impedance to a somewhat variable output impedance over an extremely wide frequency range.

Another object of the invention is to provide an improved tuned transformer in which both the primary and the secondary windings are tunable over a wide range at extremely high radio frequencies.

Further objects and advantages of the invention will appear from the following description, taken with the accompanying drawings, in which:

Figure 1 is an elevational sectional view of a television or radio tuner constituting an illustrative embodiment of the invention, the view being taken generally along a line 1—1 in Fig. 2;

Fig. 2 is a side elevational view of the tuner, partly in section along a line 2—2 in Fig. 1;

Fig. 3 is an enlarged fragmentary sectional view similar to Fig. 1;

Fig. 4 is an elevational view of a primary coil embodied in the tuner of Fig. 1; and

Fig. 5 is an enlarged fragmentary cross-sectional view taken generally along a line 5—5 in Fig. 3.

If the drawings are considered in greater detail, it will be seen that they illustrate a wide range radio frequency tuner **11** of the general type disclosed and claimed in the copending application of Harold T. Lyman, Serial No. 438,043, filed June 21, 1954. Accordingly, the tuner **11** comprises a tuning coil **12** which in this instance is carried on a tubular cylindrical form **13**, preferably made of glass or some other low-loss dielectric material. It will be observed that the coil **12** is in the form of a generally helical conductive metallic ribbon, which preferably is directly adherent to the coil form **13**. As shown, the width of the coiled metallic ribbon **12** varies from one end of the coil to the other. Likewise, there is a variation in the spacing between the turns of the coil. In this way, the change in inductance per unit length is adjusted so as to provide a predetermined tun-

ing curve. It is preferable to protect and insulate the coil **12** with a film or coating **14** of a low-loss dielectric material such as a styrene resin, for example.

While the coil **12** may be made in various ways, it is produced to best advantage as disclosed in the copending applications of Harold T. Lyman, Serial No. 450,750, filed August 18, 1954, and the copending application of Harold J. Yanosik, Serial No. 450,751, filed August 18, 1954. These applications disclose methods and apparatus for forming the coil **12** by photographic circuit printing techniques.

A circuit connection may be made to one end of the coil **12** by means of a lead **15** soldered or otherwise connected to the coil. In this instance, the lead **15** is soldered directly to the right hand end of the coil.

Provision is made for tuning the coil **12** while at the same time effecting energy exchange with the opposite or left hand end of the coil. Accordingly, a sleeve **16** or other energy exchange element is movable along the coil **12**. In this instance, the sleeve **16** is adapted to be telescoped over the left hand end of the coil **12** so as to effect a progressive envelopment of the coil. At its right hand end, the sleeve **16** is formed with an internally necked-down or reduced cylindrical surface **17** which fits closely around the coil **12**. Accordingly, there is close capacitive coupling between the surface **17** and the underlying turns of the coil **12**. The remainder of the sleeve **16** has an internal cylindrical surface **18** of somewhat greater diameter to avoid impairment of the figure of merit or "Q" of the coil **12** by the sleeve **16**. It will be understood that the dielectric coating **14** over the coil **12** insulates the coil from the sleeve **16** so that the mode of energy transfer between the sleeve **16** and the coil **12** will be purely capacitive. By thus avoiding conductive coupling between the sleeve **16** and the coil **12**, the generation of electrical noise is prevented.

Provision is made for effecting relative axial movement between the coil **12** and the sleeve **16** so as to vary the effective inductance between the sleeve and the end lead **15** of the coil. In this instance, the coil **12** is cemented into or frictionally held in an insulating grommet **19** supported by a metal wall **20** which is mounted on a chassis **21** serving to support the component parts of the tuner **11**. Accordingly, the coil **12** is stationary. On the other hand, the sleeve **16** is adapted to be moved longitudinally along the coil by means of a cam **22** mounted on a rotatable control shaft **23**. The cam **22** is engaged by a ball or roller **24** carried by an insulating plug or member **25** mounted on the left hand end of the sleeve **16**. A spring **26** biases the sleeve **16** toward the cam **22** and thus maintains engagement between the cam and the roller **24**.

It will be understood that a plurality of additional cams (not shown) may be mounted on the shaft **23** to operate additional tuner units or sections **27**, **28**, and **29** (Fig. 2) which may be of the type disclosed in the above mentioned application of Harold T. Lymans, Serial No. 438,043.

The tuners **11**, **27**, **28**, and **29** constitute component parts of a superheterodyne converter **30** adapted to be employed in television or very high frequency radio receivers.

In order to effect a circuit connection to the movable sleeve **16**, an element **31** is disposed in energy exchange relation to the sleeve **16**. In this instance, the element **31** is in the form of a ring coaxially disposed around the sleeve **16**. An insulating bushing **32** may be provided between the sleeve **16** and the ring **31** so that the mode of energy exchange between these elements will be purely capacitive. A circuit lead **33** may be soldered directly to the ring **31**. In the exemplary tuner **11**, the leads **15** and **33** are connected to the input circuit of an electron discharge device or tube 34 employed in the input stage of the superheterodyne converter 30.

It will be understood by those skilled in the art that the portion of the coil 12 between the sleeve 16 and the end lead 15 is resonated by the distributed capacitances provided by the circuit and the discharge tube 34. The resonant frequency of the coil 12 is varied by rotating the cam 22 so as to slide the sleeve 16 along the coil. In this way the effective inductance of the coil is varied. The sleeve 16 tends to suppress any spurious self-resonances in the portion of the coil 12 enveloped by the sleeve. While the exemplary tuner 11 may be arranged to cover various frequency ranges, it may be considered, by way of example, to cover the very high frequency (V. H. F.) television channels between 54 and 216 megacycles.

In accordance with the invention, provision is made for coupling energy to and from the coil 12. In the exemplary tuner 11, a primary coil 35 is provided to couple energy to the coil 12 from a transmission line (not shown) leading from an antenna or the like. Thus, the coils 12 and 35 constitute a transformer, designated 36, with the coil 12 functioning as the secondary of the transformer. The illustrated primary coil 35 is in the form of a winding 37 of wire carried on a nonconductive form or core 38. In order to extend the tuning range and improve the Q of the tuner 11, the form 38 preferably is made of powdered finely divided magnetic material which is suitably bonded as by partial sintering. The coil 35 is coaxially received within the tubular form 13 which supports the secondary coil 12.

To maintain electrostatic balance in the primary coil 35 and thereby provide a balanced input, the winding 37 is formed with two portions or legs 39 and 40 connected together at one end, as at 41, and wound in opposite directions around the core 38 toward the opposite end of the core. The portions 39 and 40 terminate in leads 42 and 43 which constitute the ends of the winding 37 and are adapted to be connected to a low impedance, balanced transmission line (not shown) leading from an antenna or the like.

It will be observed that the portions 39 and 40 of the winding 37 cross over at a plurality of longitudinally spaced points designated 44, 45, 46, and 47 in Fig. 4. The crossovers 44 and 46 are on one side of the core 38, while the crossovers 45 and 47 are on the opposite side. Electrostatic balance is maintained in the coil 35 by arranging the winding 37 with the portions 39 and 40 alternately uppermost at the crossover points 44—47. Preferably, this alternation of uppermost portions of the winding 37 is maintained on both sides of the core 38. Thus, in the construction illustrated in Fig. 4, the portion 39 is uppermost at the crossover 45, while the portion 40 is uppermost at the crossover 47. On the other side of the core 38, the portion 40 is outside of the portion 39 at the crossover 44, but is inside the portion 39 at the crossover 46. By thus arranging the winding 37, capacitive balance is maintained between the portions 39 and 40 of the winding, with respect to ground and the secondary coil 12.

It will be appreciated that the primary coil may be wound by laying the midpoint of a length of wire at the point 41 and then winding the two half portions 39 and 40 of the wire simultaneously but in opposite angular directions toward the opposite end of the core 38. In this way, the half portions 39 and 40 can be arranged so as to be alternately uppermost at the crossover points.

To minimize capacitive coupling between the primary and secondary coils 35 and 12 and to assist in maintaining capacitive balance to ground between the input leads 42 and 43 of the primary winding, the tuner 11 is provided with an electrostatic shield 48 disposed between the primary and secondary coils. As illustrated, the shield 48 is in the form of a thin conductive metallic sleeve received within the tubular form 13 and surrounding the primary coil 35. For the purpose of minimizing eddy currents, a longitudinal slot 49 is formed in the sleeve 48. The slot 49 extends for the full length of the sleeve 48 so that the latter is circumferentially discontinuous. It will be seen that the wall of the sleeve 48 extends through about 300 degrees, while the slot 49 occupies the remaining 60 degrees. A lead 50 or other conductor is provided to connect the shielding sleeve 48 to the grounded metallic wall 20.

In operation, the primary input leads 42 and 43 are connected to an antenna by means of a transmission line having a low characteristic impedance, such as 300 ohms, for example. The output leads 15 and 33 extend to the grid-to-cathode or other input circuit of the discharge tube 34. The resonant frequency of the tuner 11 is varied between the low and high frequency ends of the tuning range by progressively telescoping the sleeve 16 over the coil 12, from the left hand or free end of the coil toward the right hand end, which is connected to the lead 15. With the sleeve overlying only the extreme left hand end of the coil 12 so as to utilize the full inductance of the coil, the tuner 11 is tuned to the low frequency end of the range. For this setting of the sleeve 16, the entire primary coil 35 is inductively coupled to the secondary coil 12. The magnetic flux components generated by all of the turns of the primary 35 are effective to transfer energy to the secondary 12.

Movement of the tuning sleeve 16 to the right envelops a portion of the secondary coil 12 and thereby renders that portion ineffective to deliver energy to the resonant circuit or to the electron discharge device 34. The sleeve 16 is in close capacitive coupling with that portion of the coil 12 underlying the necked-down portion 17 of the sleeve 16, with the result that only that portion of the coil between the sleeve 16 and the end lead 15 is effective in the resonant circuit. The remaining portion of the coil 12, enveloped by the sleeve 16, is substantially short circuited by the sleeve.

It has been found that the portion of the primary winding 35 underlying the portion of the coil 12 received within the sleeve 16 is rendered largely ineffective to transfer energy to the coil 12 and hence is effectively removed from the primary circuit between the input leads 42 and 43. This result is thought to be due to the shielding and short circuiting effect of the sleeve 16. As the sleeve 16 is moved over the coil 12, the primary coil 35 is progressively cut out of the input circuit. In this way the primary 35 is effectively tuned by the sleeve 16. This has the advantage of maintaining the turns ratio of the primary 35 to the secondary 12 at a value such as to match the constant input impedance of the antenna transmission line to the variable output impedance provided by the input circuit of the electron discharge tube 34. This matching of input and output impedances is satisfactorily maintained throughout the entire frequency range of the tuner 11. Due to the arrangement of the winding 37 and the provision of the electrostatic shield 48, the primary coil 35 is maintained in a balanced condition relative to ground throughout the tuning range.

It will be realized that the input balun or balanced input circuit provided by the primary coil 35 eliminates any need for complicated input balancing networks. The input circuit or balun is effectively tunable over the entire frequency range of the tuner, with the result that any need for antenna switching or complicated crossover networks is eliminated. The matching of impedances between the balanced, low impedance input and the unbalanced, high impedance output is substantially maintained throughout the tuning range.

Various modifications, alternative constructions and equivalents may be employed without departing from the true spirit and scope of the invention as exemplified in the foregoing description and defined in the following claims.

I claim:

1. In a tuner for high radio frequencies, the combination comprising a generally cylindrical tubular form, a coil carried on said form, means for making a circuit connection to one end of said coil, a tuning sleeve adjustably received over the opposite end of said coil and in capacitive energy exchange relation thereto, a coupling element in capacitive energy exchange relation to said sleeve, means for making a second circuit connection to said element, a core of powdered magnetic material received within said tubular form, a tunable primary winding carried on said core, said winding comprising a coil of wire having a first portion progressing from one end to the opposite end of said core and a second portion returning from said opposite end to said one end of said core, said portions crossing each other at a plurality of points with said portions alternately uppermost to provide capacitive balance between said portions, and a longitudinally slotted circumferentially discontinuous grounded electrostatic shielding sleeve disposed between said primary winding and said tubular form, said winding affording a balanced input and being tunable by said tuning sleeve.

2. In a tuner for high radio frequencies, the combination comprising a generally cylindrical tubular form, a coil carried on said form, means for making a circuit connection to one end of said coil, a tuning sleeve adjustably received over the opposite end of said coil and in capacitive energy exchange relation thereto, a coupling element in capacitive energy exchange relation to said sleeve, means for making a second circuit connection to said element, a second form received within said tubular form, a tunable primary winding carried on said second form, said winding comprising a coil of wire having a first portion progressing from one end to the opposite end of said winding and a second portion returning from said opposite end to said one end thereof, said portions crossing each other at a plurality of points with said portions alternately uppermost to provide capacitive balance between said portions, and an electrostatic shielding sleeve disposed between said primary winding and said tubular form, said winding affording a balanced input and being tunable by said tuning sleeve.

3. In a radio frequency tuner, a primary coil having a pair of winding portions interconnected at one end of said coil and wound in oposite angular directions toward the opposite end thereof, said winding portions crossing over at a plurality of points with said windings alternately uppermost to afford electrostatic balance, and a secondary coil disposed around said primary coil.

4. A radio frequency tuner, comprising a primary coil having a pair of winding elements interconnected at one end of said coil and wound in opposite angular directions toward the opposite end thereof, said windings crossing over at a plurality of points with said windings alternately uppermost to afford electrostatic balance, a secondary coil disposed generally coaxially around said primary coil, and a tuning sleeve movable over said secondary coil from one end thereof and in energy exchange relation thereto for tuning both said coils.

5. A radio frequency tuner, comprising a primary coil having a pair of winding elements interconnected at one end of said coil and wound in opposite angular directions toward the opposite end thereof, said windings crossing over at a plurality of points with said winding elements alternately uppermost to afford electrostatic balance, an electrostatic shield around said primary coil, a secondary coil disposed generally coaxially around said primary coil and shield, and a tuning sleeve movable over said secondary coil from one end thereof and in energy exchange relation thereto for tuning both said coils.

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