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TUNER WITH PRIMARY COIL ON MOVING SLEEVE

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Fig. 1

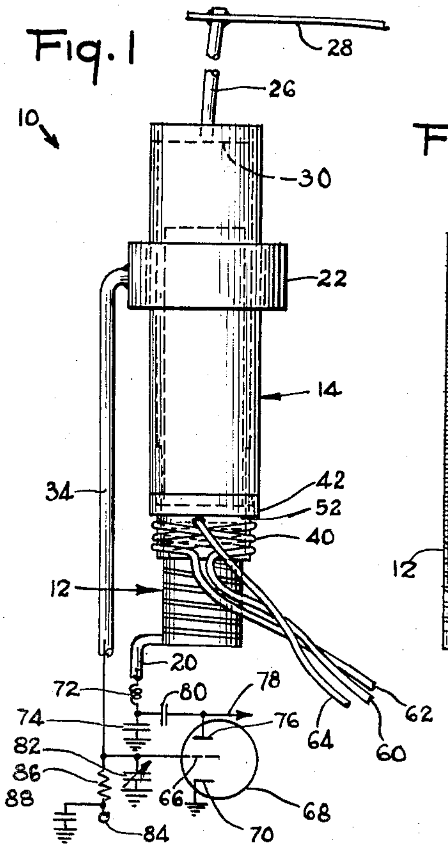


Fig. 2

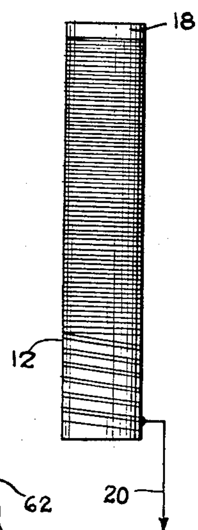


Fig. 3

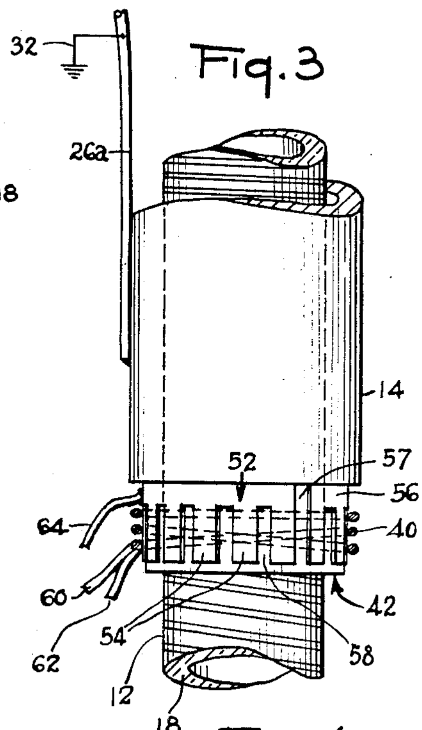
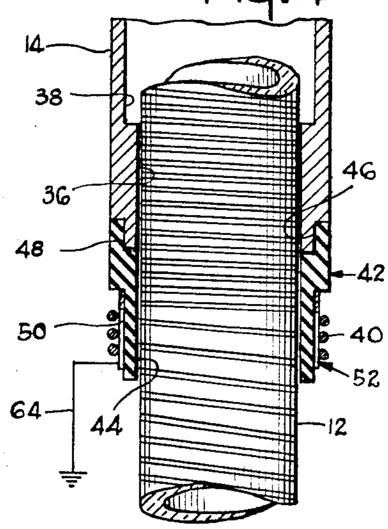


Fig. 4



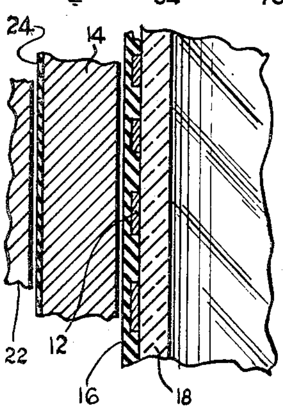


Fig. 5

INVENTORS
Francis G. Mason
Harold T. Lyman
BY
Ooms, McDougall, Williams & Hersh
Attorneys

United States Patent Office

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TUNER WITH PRIMARY COIL ON MOVING SLEEVE

Francis G. Mason, Weston, and Harold T. Lyman, Milford, Conn., assignors to Aladdin Industries, Incorporated, Nashville, Tenn., a corporation of Illinois

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5 Claims. (Cl. 250—40)

This invention relates to tuners, particularly those adapted to cover a wide frequency range at high radio frequencies such as those employed for television broadcasting and the like.

One object of the present invention is to provide a new and improved tuner in which the effective inductance of a coil is varied by moving a conductive sleeve therealong, and in which the sleeve is arranged to carry an additional coil so that the coupling and transformation ratio between said coils will be varied by the movement of the sleeve.

A further object is to provide a tuner of the foregoing character in which the coil carried by the sleeve is adapted to be employed as a primary coil, while the other coil is employed as a secondary coil in a tuned circuit, and in which the coupling and transformation ratio between the coils is progressively increased as the inductance of the secondary coil is decreased by the movement of the sleeve.

Thus, it is an object of the present invention to provide a new and improved tuner in which the coupling and transformation ratio between primary and secondary coils is progressively varied with changing frequency of operation, so that the band width afforded by the tuner may be maintained substantially constant.

A further object is to provide a new and improved tuner of the foregoing character which is durable, inexpensive and easy to manufacture.

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

Fig. 1 is an elevational view of a tuner to be described as an illustrative embodiment of the present invention.

Fig. 2 is an elevational view of the coil employed in the tuner of Fig, 1.

Fig. 3 is a fragmentary enlarged elevational view of the tuner, showing a slight modification.

Fig. 4 is a fragmentary central longitudinal sectional view of the tuner.

Fig. 5 is a fragmentary greatly enlarged longitudinal sectional view to show details of the tuner.

It will be seen that the drawings illustrate a wide-range tuner **10** which is especially arranged and particularly well adapted for tuning the antenna stage of a television receiver for covering the very high frequency (VHF) television bands. It will be understood, however, that the tuner **10** may be utilized in many other situations, either in the particular form shown or any suitably modified form. In a certain aspect, the tuner **10** may be regarded as an improvement upon the tuner covered in the copending application of Harold T. Lyman, Serial No. 438,043, filed June 21, 1954, now Patent No. 2,832,891 granted April 29, 1958. Thus, the tuner **10** comprises a coil **12** which is tuned by means of a conductive sleeve **14** movable along the coil. In this case, both the coil **12** and the sleeve **14** are substantially cylindrical in form, although other forms might be employed. The sleeve **14** is closely received around the coil **12** but is freely slidable therealong. A suitable dielectric or insulating material is preferably provided between the coil **12** and the sleeve **14** so that the coupling therebetween will be substantially capacitive, rather than conductive. This arrangement eliminates the electrical noise which would be caused by conductive coupling. In this case, the dielectric takes the form of an insulating coating or sheath **16** over the coil **12**, as shown to best advantage in Fig. 5. However, it will be understood that the dielectric might be provided in some other manner, as by merely providing an air space between the sleeve and the coil, or by providing a thin layer of insulation inside the sleeve. The dielectric coating **16** of the illustrated arrangement may be made of a synthetic epoxy plastic, or any other material having good electrical and mechanical characteristics. The coating **16** should be hard, smooth and wear-resistant, and should afford low frictional resistance to movement of the sleeve.

In the illustrated construction, the coil **12** is advantageously formed as a thin conductive ribbon carried on an insulating cylindrical support or form **18**. It is preferred to form the coil **12** on the support **18** by suitable circuit-printing techniques, which are known to those skilled in the art and need not be described. The support **18** may be of a ceramic or other suitable insulating material.

It will be seen from Fig. 2 that the pitch of the coil **12** increases progressively between its upper and lower ends. Thus, the inductance per unit length of the illustrated coil decreases between its upper and lower ends. While this arrangement is quite advantageous, it is not strictly necessary to the present invention, as will be apparent shortly.

Means are provided for making a circuit connection to at least one end of the coil **12**. In this case, a lead **20** is simply soldered or otherwise connected to the lower end of the coil **12**. Thus, the circuit connection is of a conductive character, but it will be understood that it might be of some other character, such as capacitive. A circuit connection might also be made to the opposite end of the coil, chiefly for the purpose of utilizing the coil as a direct current path to supply a direct current potential to the lower end of the coil.

Means are also provided for establishing a circuit connection to the movable tuning sleeve **14**. In the arrangement shown to best advantage in Figs. 1 and 5, the circuit connection is of a capacitive character. Thus, a capacitive coupling electrode, in the form of a ring **22**, is mounted in closely spaced relation to the sleeve **14**. Thus, the ring **22** is closely received around the sleeve. A dielectric or insulating material is preferably provided between the sleeve **14** and the coupling ring **22** so that the coupling will be capacitive rather than conductive. This arrangement again avoids the electrical noise that would be caused by a sliding conductive connection. In the arrangement illustrated in Fig. 5, the dielectric takes the form of a thin insulating coating **24** on the outside of the sleeve **14**, although it will be understood that the insulation might be on the inside of the ring, or might simply be an air gap therebetween.

Generally, the coil **12** and the coupling ring **22** are stationary, while the sleeve **14** is movable. However, this situation might be reversed, the important thing being that the sleeve on one hand, and the ring and the coil on the other hand, are relatively movable. Various means may be provided for effecting such relative movement. In the arrangement illustrated in Fig. 1, the sleeve **14** is adapted to be moved by a flexible rod **26** which is suitably connected to the upper end of the sleeve. The rod **26** is connected between the sleeve **14** and a swingable operating arm **28** or the like. The rod **26** may be secured to a disc **30** mounted in the upper end of the sleeve **14**, as shown in Fig. 1, or may be connected directly to the wall of the sleeve, as shown in the modified arrangement of Fig. 3. In the arrangement of Fig. 1, it is preferred to form the rod **26** of metal, while forming the disc **30** of insulating material. However, the rod **26** may be made of suitable insulating material, such as nylon or the like. The specific arrangement of Fig. 3 utilizes a metal operating rod **26*a*** which is soldered or otherwise secured to the outside of the sleeve **14**, the ring **22** being dispensed with. The circuit connection to the sleeve **14** is then made through the flexible operating rod **26*a***. It is often convenient to connect the rod **26*a*** to ground, as indicated by a grounded lead **32** in Fig. 3. However, the rod **26*a*** may be insulated and connected to some point in the circuit other than ground.

It will be understood that the sleeve **14** is capacitively coupled to the portion of the coil **12** within the sleeve. Thus, the effective inductance of the coil is provided by the uncovered portion between the sleeve **14** and the end lead **20**. As the sleeve **14** is moved along the coil, the effective inductance is varied over a wide range. When the sleeve **14** is withdrawn to the upper end of the coil **12**, the inductance is high. As the sleeve is moved to the lower end of the coil, the effective inductance is progressively decreased. The inductance may be resonated by the distributed capacitance of the coil and the various stray and circuit capacitances between the terminals of the tuner.

Thus, the tuner provides a two-terminal tuned circuit, with the end lead **20** and the sleeve **14** as the opposite terminals. In the arrangement of Fig. 1, a circuit lead **34** is connected to the coupling ring **22** to complete the connection to the sleeve **14**.

In the arrangement illustrated to best advantage in Fig. 4, the inside of the tuning sleeve **14** is stepped to reduce the losses in the tuned circuit. At its outer end, the sleeve **14** has a reduced inner surface or bore **36** which is closely received around the coil **12**. This surface **36** is in close capacitive coupling with the coil. The remainder of the sleeve **14** is stepped outwardly on the inside to provide an enlarged inner surface or bore **38** which is spaced outwardly some distance from the coil and thus is not in close capacitive coupling thereto. Accordingly, the capacitive coupling between the sleeve **14** and the coil **12** is largely restricted to the reduced inner surface **36**, so that the capacitive current transfer is localized at this point. This avoids any need for the current to flow any distance along the unused portion of the coil within the sleeve **14**, and has the effect of greatly reducing the losses in the tuned circuit.

The sleeve **14** eliminates or greatly reduces spurious resonances in the coil **12** by largely or completely enveloping the unused portion of the coil, which might otherwise cause spurious resonances of a serious character. By being closely coupled to the unused portion of the coil in an inductive sense, the sleeve virtually short-circuits the unused portion of the coil, or at least greatly detunes the unused portion so as to displace any resonances to a frequency far away from the frequency range covered by the tuner. The sleeve retains its value in suppressing spurious resonances, even when the enlarged portion **38** is spaced outwardly some distance from the unused portion of the coil.

The tuner of the present invention is provided with a primary coil **40** which is carried by the movable sleeve **14** so that the turns ratio and the percentage coupling between the coils **40** and **12** may be varied as the sleeve is moved along the coil. In this case, the primary coil **40** is formed by a few turns of wire wound around an insulating extension **42** secured to the lower end of the sleeve **14**. It will be seen that the extension **42** projects from the lower end of the sleeve **14** toward the lower end of the coil **12**. The extension **42** may be generally cylindrical in form and may be made of nylon or other suitable insulating material.

In the construction illustrated to best advantage in Fig. 4, the extension **42** has a main or lower bore **44** which fits closely around the coil **12** and is freely slidable therealong. At its upper end, the extension has an enlarged bore **46** which is fitted over a reduced lower end portion **48** on the sleeve **14** and is cemented or otherwise suitably secured thereto. The illustrated extension **42** has a lower portion **50**, of reduced outside diameter, on which the primary coil **40** is supported.

Within the primary coil **40**, it is preferred to provide an electrostatic shield **52** of the Faraday type, to minimize capacitive coupling between the primary coil **40** and the secondary coil **12**. With such a shield, the primary coil **40** may be arranged to be substantially balanced with respect to ground, so that an efficient connection may be made between the coil and an antenna lead-in which is balanced to ground. It will be seen that the electrostatic shield **52** comprises a plurality of spaced longitudinal conductors **54** which are connected together at the upper ends by a split metallic ring **56**, the split being parallel to the coil axis as indicated at **57**. In the illustrated construction, the conductors **54** and the ring **56** are formed as portions of a thin split metal cylinder, which is formed with longitudinal slots **58**, opening from its lower end, to define the conductors **54**. Thus, the longitudinal conductors **54** resemble fingers or bars on the lower end of the shield **52**. It will be seen that the shield **52** is closely received over the reduced portion **50** of the extension **42**, while the primary coil **40** is directly wound over the shield. The coil **40** may be made of insulated wire so as to be insulated from the shield. Of course, the insulating extension **42** insulates the shield and the coil **40** from the moving sleeve **14**.

Circuit connections may be made to the ends of the primary coil **40** by various means, such as the illustrated flexible leads **60** and **62**, which may simply constitute the ends of the wire employed in winding the coil. A third flexible lead **64** may be soldered or otherwise connected to the shield **56**. This lead **64** is usually connected to ground, as indicated in Fig. 4. The flexible leads **60** and **62** may be connected to an antenna lead-in, often through a suitable network. The leads **60**, **62** and **64** should be of a highly flexible character, highly resistant to breakage and affording little resistance to the movement of the sleeve **14**. Wire for such leads, giving extremely long life, is available commercially. The leads must be of adequate length to avoid any interference with the movement of the sleeve. With the provision of the shield **52**, the primary leads **60** and **62** are substantially balanced to ground.

The secondary coil **12** may be connected to various circuits, such as the input circuit of an amplifier of a television tuner, for example. Various other connections are feasible, as to a crystal or other mixture, or the like, for example. With respect to the embodiment of Fig. 1, it has already been noted that the effective terminals of the secondary coil **12** are the lead **20**, connected to one end of the coil, and the lead **34**, connected to the coupling ring **22**. Merely by way of example, the lead **34** is shown connected to an input electrode **66** of an amplifier **68**. While amplifier **68** might assume various forms, it is shown as a neutralized triode tube, which may constitute the first stage of a cascode amplifier. In this instance, the input electrode **66** comprises the grid of the triode **68**.

Other suitable connections may be made to the amplifier triode **68**. In this case, the triode **68** has a cathode **70** which is connected to ground. The end lead **20** of the coil is connected to ground through a small trimming inductance **72** and a capacitor **74**, connected in series.

The illustrated triode **68** has a plate or anode **76** from which the output of the triode is taken by way of an output lead **78**. A small neutralizing capacitor **80** is connected between the plate **76** and the junction of the inductance **72** and the capacitor **74**.

A small variable trimming capacitor **82** may be connected between the grid **66** and ground. Automatic gain control voltage may be supplied to the grid **66** from a suitable source, indicated merely as a terminal **84**. In this case, a high value resistor **86** is connected between the grid **66** and the terminal **84**. A bypass capacitor **88** may be connected between the terminal **84** and ground.

It will be understood that various other amplifier arrangements may be employed within the scope of the present invention.

It will be understood that the primary coil **40** is inductively coupled to the main or secondary coil **12**. As the tuning sleeve **14** is moved downwardly along the coil **12**, the inductance of the coil **12** is decreased. This raises the resonant frequency of the tuner. As already noted, the inductance of the coil **12** is resonated by the distributed or stray capacitance of the coil itself and the circuit connected thereto, plus the inductance of the trimmer **82** (Fig. 1) and the input capacitance of the amplifier **68**.

In this case, the primary coil **40** is essentially untuned. However, the primary coil is inductively coupled to the active portion of the secondary coil **12**, below the sleeve **14** (Fig. 1) so that energy is transferred from the primary coil to the secondary coil **12**. As the tuning sleeve **14** is moved downwardly along the coil **12**, the coupling between the primary and secondary coils is changed in two respects: (*a*) the effective primary-to-secondary turns ratio is changed; and (*b*) the percentage coupling or linkage between the primary and secondary coils is changed.

The change in the percentage coupling is employed to maintain the proper band width in the secondary tuned circuit. The change in the primary-to-secondary turns ratio is utilized to present the proper matched impedance to the primary circuit. When the primary coil is connected to an antenna, it is desirable to provide a primary impedance to match the characteristic impedance of the antenna. With the type of amplifier shown in Fig. 1, the input impedance of the amplifier changes substantially over the very high frequency (VHF) television band. For example, the input impedance to the triode **68** might be of the order of 3,000 to 5,000 ohms at television channel 2, while dropping to about 300 to 500 ohms at channel 13. Throughout this tuning range, the number of turns in the primary coil **40** remains constant, while the number of active turns in the secondary coil **12** decreases substantially. Thus, the primary-to-secondary turns ratio increases with increasing frequency. This increase tends to maintain the primary impedance at the desired substantially constant value, despite the sharp decrease in the secondary impedance.

With the arrangement of Fig. 1, the percentage coupling between the primary coil **40** and the secondary coil **12** increases substantially with increasing frequency, as the sleeve **14** is moved downwardly toward the high frequency end of the coil **12**. This effect is highly desirable in this case, because the decreasing input impedance of the tube **68** decreases the factor of merit or "Q" of the secondary circuit. Thus, the increase in the percentage coupling may advantageously be utilized to maintain the desired band width. In some cases, the secondary coil **12** may be connected to a device of more nearly constant input impedance, such as a crystal mixer, in which case the increase in the percentage coupling may be controlled and minimized by spreading the turns of the coil **12** at the high frequency end.

It will be apparent that the mounting of the primary coil on the movable tuning sleeve is a great advantage in the design of a practical television tuner, or the like. This great advantage is obtained in a construction which is highly serviceable, yet is remarkably simple, inexpensive and easy to manufacture.

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

We claim:

1. In a tuner, the combination comprising a generally cylindrical inductance coil having first and second ends, a lead connected to said first end of said coil for establishing a circuit connection thereto, a generally cylindrical conductive sleeve slidable along and around the outside of said coil between said first and second ends thereof for varying the effective inductance of said coil between said sleeve and said first end, an insulating coating on the outside of said coil to insulate said sleeve therefrom so that said sleeve will be capacitively coupled to said coil, a conductive electrode adjacent said sleeve, means insulating said electrode from said sleeve to establish capacitive coupling therebetween, a lead connected to said electrode for establishing a circuit connection thereto, a generally cylindrical insulating extension mounted on the end of said sleeve directed toward said first end of said coil, a thin conductive generally cylindrical shield mounted around said extension, said shield having a plurality of longitudinal slots therein opening from the outer end thereof and defining shielding fingers on said shield between said slots, a first flexible lead connected to said shield for establishing a circuit connection thereto, a primary coil wound around said shield and movable with said sleeve, said primary coil being received around said inductance coil and being movable therealong, said shield being disposed between said primary coil and said inductance coil, and second and third flexible leads connected to the ends of said primary coil for establishing circuit connections thereto.

2. In a tuner, the combination comprising an inductance coil having first and second ends, means for establishing a circuit connection to said first end, a sleeve closely received around the outside of said coil and slidable therealong to vary the effective inductance between said sleeve and said first end, dielectric means between said sleeve and said coil to provide for capacitive coupling therebetween, means for establishing a circuit connection to said sleeve, a primary coil carried on said sleeve at the end thereof adjacent said first end of said coil, means mounting said primary coil on said sleeve to provide for inductive coupling between said primary coil and said inductance coil while insulating said primary coil from said sleeve, said primary coil being disposed around the outside of said inductance coil and being movable with said sleeve along said inductance coil, and means for establishing circuit connections to the opposite ends of said primary coil, the movement of said sleeve along said inductance coil toward said first end thereof being effective to decrease the inductance of said inductance coil while changing the coupling between said primary coil and said inductance coil.

3. In a tuner, the combination comprising an inductance coil having first and second ends, means for establishing a circuit connection to said first end, a conductive sleeve closely received around the outside of said coil and movable therealong between said ends for varying the effective inductance between said sleeve and said first end, dielectric means between said sleeve and said coil to provide for capacitive coupling therebetween, means for establishing a circuit connection to said sleeve, an insulating extension mounted on the outer end of said sleeve and extending toward said first end of said coil, a conductive electrostatic shield mounted around said extension, said shield comprising a plurality of spaced longitudinal conductors, means for establishing a circuit connection to said shield, a primary coil mounted around said shield and insulated from said shield and said sleeve, and means for establishing circuit connections to the opposite ends of said primary coil, said primary coil being

disposed around the outside of said coil and being movable with said sleeve to vary the turns ratio between said primary coil and said inductance coil, said turns ratio being increased as the inductance of said inductance coil is decreased by the movement of said sleeve toward said first end of said inductance coil.

4. In a tuner, the combination comprising an inductance coil, means for establishing a circuit connection to one end of said coil, a sleeve closely received around the outside of said coil and slidable therealong to vary the effective inductance between said sleeve and said one end, means for establishing a circuit connection to said sleeve, a primary coil carried on said sleeve at the end thereof adjacent said one end of said coil, means mounting said primary coil on said sleeve to provide for inductive coupling between said primary coil and said inductance coil, and means for establishing circuit connections to the opposite ends of said primary coil, said primary coil being disposed around the outside of said inductance coil and being movable with said sleeve along said inductance coil, the movement of said sleeve along said inductance coil toward said one end thereof being effective to decrease the inductance of said inductance coil while changing the coupling between said primary coil and said inductance coil.

5. In a tuner, the combination comprising a generally cylindrical inductance coil having first and second ends, a

lead connected to said first end of said coil for establishing a circuit connection thereto, a generally cylindrical conductive sleeve slidable along the outside of said coil between said first and second ends thereof for varying the effective conductances of said coil between said sleeve and said first end, an insulating coating on the outside of said coil to insulate said sleeve therefrom so that said sleeve will be capacitively coupled to said coil, a conductive electrode adjacent said sleeve, means insulating said electrode from said sleeve to establish capacitive coupling therebetween, a lead connected to said electrode for establishing a circuit connection thereto, a generally cylindrical extension mounted on the end of said sleeve directed toward said first end of said coil, a primary coil disposed around said extension and movable with said sleeve, said primary coil being disposed around the outside of said inductance coil, and flexible leads connected to said primary coil for establishing circuit connections thereto.

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