June 28, 1960 F. G. MASON 2,942,333

METHOD OF MAKING A SLUG TUNER

Filed April 26, 1955

FIG. 1

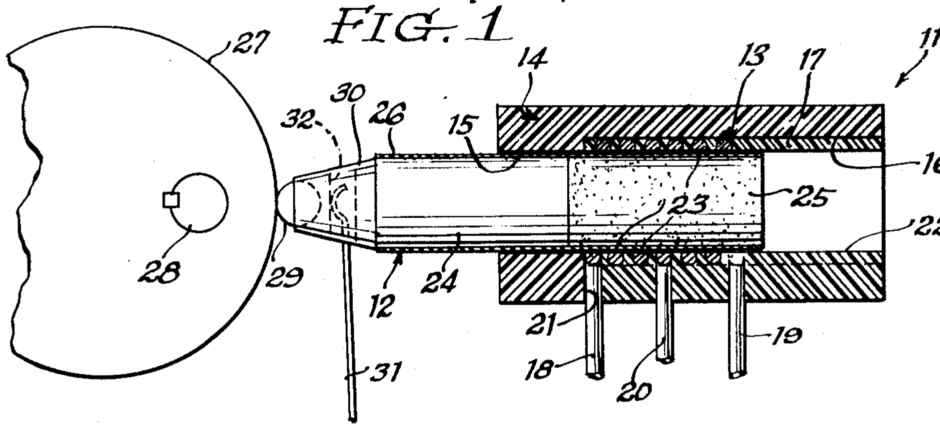



FIG. 2

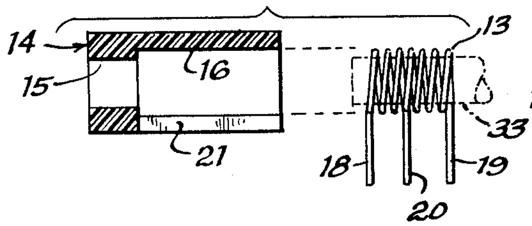



FIG. 3

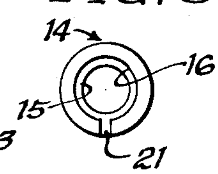



FIG. 4

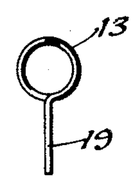



FIG. 5

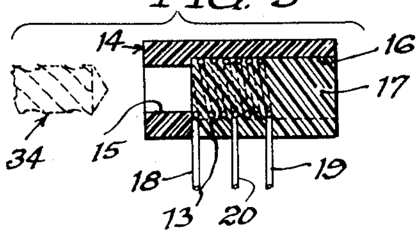



FIG. 6

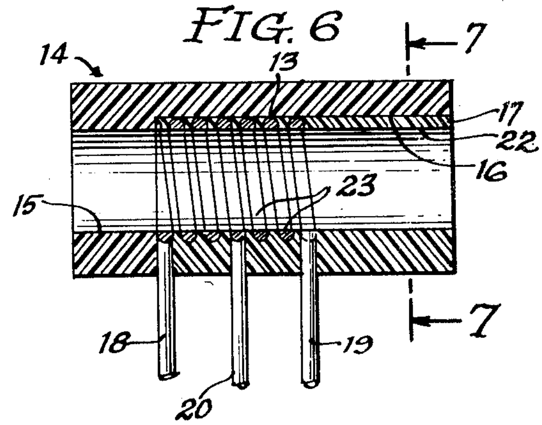
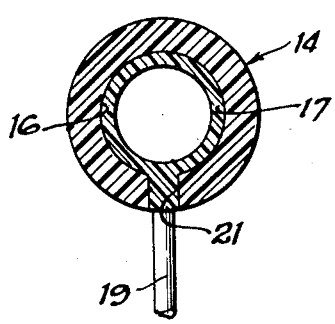



FIG. 7

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# METHOD OF MAKING A SLUG TUNER

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This invention relates to tuners of the type having a tuning slug or core movable within a coil to vary the inductance thereof.

One principal object of the invention is to provide a method of making a new and improved slug tuner having an extremely wide range of frequency variation, so that, for example, the tuner may be able to cover the present very high frequency (VHF) television band extending from 50 to 216 megacycles.

Another object is to provide a method of making a new and improved tuner having a coil which is supported internally within a form so that the tuning slug will move within the coil in extremely closely spaced relation thereto.

It is a further object of the invention to provide a method of making a tuner of the foregoing character in which the movable tuning slug is received in a bore which cuts into the turns of the tuning coil so that the slug will have a maximum effect on the inductance of the coil.

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

Figure 1 is a somewhat diagrammatic longitudinal cross section view of an exemplary slug-type tuner constituting an illustrative embodiment of the invention.

Fig. 2 is an exploded sectional view of a holder and a coil employed in making the tuner of Fig. 1.

Fig. 3 is an end view of the holder of Fig. 2.

Fig. 4 is an end view of the coil of Fig. 2.

Fig. 5 is a longitudinal sectional view showing the holder and the coil after the coil has been imbedded in a plastic material received within the holder, the view also illustrating the manner of drilling out the plastic material.

Fig. 6 is a longitudinal sectional view of the finished coil imbedded in plastic within the holder, the view being similar to Fig. 1 but with the core or tuning slug removed from the coil.

Fig. 7 is a cross-sectional view taken generally along a line 7—7 in Fig. 6.

If the drawings are considered in greater detail, it will be seen that Fig. 1 illustrates a slug-type tuner **11**, comprising a tuning slug **12** which is movable within a coil **13**. It will be seen that the coil **13** is supported internally within a tubular holder **14** made of any suitable insulating material, such as a hard, substantially rigid, synthetic resinous plastic material. Formed within the holder **14** are first and second coaxially aligned bores or cylindrical openings **15** and **16**, the bore **15** being smaller in diameter than the bore **16**. In other words, the bore **15** may be considered to be a reduced end portion of the bore **16**.

The coil **13** is helical in form and is made with a plurality of turns, composed of any suitable conductive metal strand, such as the illustrated wire, which is of generally circular cross section. The coil is imbedded in a bushing-like or sleeve-like element **17** of electrically insulating, resinous plastic material. It will be seen that the plastic imbedding material **17** is received within the bore **16** so as to secure the coil **13** in place within the holder **14**.



The coil **13** is formed with a pair of end leads **18** and **19** and an intermediate tap or lead **20** connected to an intermediate point along the length of the coil. A slot **21** is formed longitudinally in the holder **14** so that the leads **18—20** may be brought radially outwardly from the bore **16**. As shown, the slot **21** extends along the entire length of the large bore **16**, but not along the smaller bore **15**. The plastic imbedding material **17** fills all portions of the slot **21** not occupied by the coil **13**.

Within the plastic imbedding material **17**, a bore or cylindrical opening **22** is formed, so as to constitute a smooth continuation of the bore **15**. In other words, the bores **15** and **22** are coaxially aligned and are of the same diameter. It will be seen that the bore **22** cuts into the turns of the coil **13**. In other words, the inside of the coil is formed with an internal cylindrical surface element **23** which extends helically along the turns of the coil. As shown to best advantage in Fig. 6, the cylindrical surface element **23** is flush with the imbedding plastic material **17** along with bore **22**.

It will be seen that the tuning core **12** is received with a close sliding fit within the bores **15** and **22**. In this way, the core **12** is movable within the bore **22** in closely spaced relation to the cylindrical surface element **23** of the coil **13**. Accordingly, the core has a maximum effect upon the inductance of the coil **13**.

It will be seen that the illustrated core or slug **12** is formed in two coaxially aligned cylindrical portions **24** and **25** arranged end to end. The lefthand portion **24** may be made of any suitable conductive metal, such as silver, copper, aluminum or brass, for example. On the other hand, the righthand portion **25** of the tuning slug **12** is preferably made of a low-loss, electrically insulating magnetic material, such as sintered iron ferrite. Such ferrite and other low-loss magnetic materials are well known in the art. Slugs of such materials are usually made by molding the material in finely-powdered form, with a suitable binder, into the desired shape, and then sintering the material.

In order to insulate the core **12** from the coil **13**, the core **12** is provided with a thin insulating coating **26** made of a suitable low-loss insulating material, such as various synthetic plastic lacquer-like materials. The material of the coating **26** should also be hard and smooth so as to resist mechanical wear. A number of such coating materials are available commercially. The insulating layer **26** need be only about .001″ in thickness. A minimum thickness is desirable to obtain the widest possible tuning range.

It will be seen that the core **12** is received within the bores **15** and **22** with a close sliding fit. The fit is made as close as possible so that the core **12** will be spaced a minimum distance from the coil **13** as it moves through the bore **22**. It is preferable that the spacing between the outer surface of the core and the inner cylindrical surface element **23** of the coil **13** be no more than .003″.

Any suitable mechanism may be provided for moving the core **12** within the coil **13**. In this case, such movement is effected by means of a cam **27** mounted on a rotatable shaft **28**. The cam is engaged by a ball-type roller **29** mounted in a member **30** which is fixed to the lefthand end of the core **12**. A wire spring **31** is received in a slot **32** to bias the core **12** to the left and thereby maintain the roller **29** in engagement with the cam **27**.

In making the tuner **11**, the coil **13** is wound on a cylindrical form or mandrel 33, shown in dotted lines in Fig. 2. The coil 13 is then removed from the mandrel and inserted into the large bore 16 in the holder 14. The leads 18, 19 and 20 are oriented so that they will extend outwardly through the slot 21.

With the coil 13 in position in the holder 14, the plastic material 17 is added so as to fill the bore 16, as indicated in Fig. 5. In this way, the coil 13 is imbedded in the plastic material. It is preferred to add the plastic material in a liquid, unpolymerized or partially polymerized state. The plastic material 17 is then allowed to harden by a spontaneous polymerization process, with or without the application of heat. A number of such liquid, hardenable plastic materials are available commercially. One suitable material is a polyester synthetic resin, in a liquid, unpolymerized or partially polymerized state. Such a polyester resin may be hardened quickly with the application of moderate heat.

The next step in the method of making the tuner 11 is to employ a suitable boring tool, such as a drill 34, as shown in dotted lines in Fig. 5, to bore out a portion of the plastic material 17 and thereby form the cylindrical opening or bore 22. In drilling out the plastic material, the drill also cuts into the turns of the coil 13 so as to produce the cylindrical surface element 23 within the coil. The bore 15 in the holder 14 is made of the same size as, or slightly smaller than the drill 34 so that the bore 15 will function as a guide for the drill in performing the drilling operation. After the drilling operation, the tuner 11 is completed by forming the core 12 and inserting it into the aligned bores 15 and 22.

Because of the internal mounting of the coil 13 within the holder 14, the tuner 11 will cover an extremely wide frequency range. The provision of the composite slug 12 also increases the frequency range of the tuner. It will be understood that the coil 13 will provide maximum inductance when the magnetic portion 25 of the slug 12 is fully received within the coil, as shown in Fig. 1. Moving the slug 12 to the right shifts the magnetic portion 25 out of the coil 13 and thereby tends to reduce the inductance of the coil. At the same time, the conductive metal portion 24 of the slug 12 is moved into the coil 13. This tends to effect a further reduction in the inductance of the coil, because of the demagnetizing action of the currents induced in the conductive portion 24. Thus the minimum inductance of the coil is obtained when the conductive element 24 is fully received within the coil.

Because of the internal mounting of the coil 13 within the holder 14, the slug 12 is disposed in closely spaced relation to the coil. Accordingly, the slug affects the inductance of the coil to the maximum possible extent. Because of the extremely close spacing between the coil and the slug, a maximum portion of the magnetic flux generated by the coil passes through the slug 12. It will be understood that the formation of the cylindrical surface element 23 along the inside of the coil contributes to the extremely close spacing which is obtainable between the coil and the slug. In other words, the formation of this cylindrical surface element 23 permits a closer sliding fit between the slug and the coil. Any minor variations in the diameter of the individual coil turns is eliminated by cutting into the coil turns in performing the drilling operation. Thus, the internal diameter of the coil is finally determined by the size of the drill, rather than by the original wound diameter.

The holder 14 provides external support for the coil 13, as well as serving as a protective outer housing for the coil. The plastic imbedding material 17 supports the coil immovably within the holder 14 and is strongly adherent to both the holder and the coil. In the finished tuner, the bore 22 in the plastic material guides the slug 12 in its movement through the coil 13.

It has been found in actual practice that the illustrated tuner, when suitably proportioned, is capable of covering the VHF television band from 50 megacycles to 216 megacycles, when the tuner is employed in the radio frequency resonating circuits of a television receiver. The tuner will also cover the range from about 101 megacycles to 257 megacycles, when the tuner is employed in the oscillator circuit of a television receiver. It will be understood that the coil 13 is resonated by the usual circuit and interelectrode capacitances normally present in receiver circuits.

For use in a television receiver, the coil 13 may be wound with six or seven turns of wire and may have an initial internal diameter of 3/16", although the diameter may be varied from 1/8" to 1/4". The coil holder may be as small as 5/8" long and 1/4" in outside diameter. The VHF television band may be covered with a slug movement of as little as 3/8". Thus, very little space need be provided for the tuner in a television receiver.

Because of the small size of the coil and the efficiency of the tuning slug in affecting the inductance of the coil, it has been found that the tuner has an extremely high self-resonant frequency. For this reason, the tuner, when used in an oscillator circuit, will provide jump-free operation over an extremely wide turning range, extending from 85 to 280 megacycles, for example. Moreover, when the tuner is employed in radio frequency resonating circuits, a remarkable freedom from dead spots or "suckouts" has been noted. Because of the insulation on the tuning slug, the coil may be connected to a high voltage plate supply and hence may be employed in a plate circuit without using a radio frequency choke or a blocking capacitor.

It will be evident that the tuner may be readily manufactured at low cost. Moreover, the tuner lends itself to mass production.

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 method of making a tuner, the steps comprising winding a conductive metal strand into a helical coil having a plurality of spaced convolutions, imbedding said coil in an electrically insulating plastic material to rigidify said coil and maintain said convolutions in spaced relation, and cutting a bore through said material within substantially the entire length of said coil, said bore being formed of a diameter to cut into the convolutions of said coil and thereby form cylindrical inner surface elements on said convolutions, said bore being cut substantially cylindrical and with said bore comprising said cylindrical inner surface elements of said spaced convolutions, said plastic material rigidly supporting said coil during said cutting operation, and slideably disposing an electrically insulated tuning core in said bore.

2. In a method of making a tuner, the steps comprising winding an elongated conductor to form a generally helical coil with spaced convolutions, forming an electrically insulating holder with an opening therein of a size to receive said coil, inserting said coil into said opening in said holder, filling said opening with an electrically insulating liquid hardenable resinous plastic material and thereby imbedding said coil in said material, said plastic material being capable of bonding with said coil and said holder, hardening said material to bond said material to said coil and said holder while maintaining said convolutions in spaced relation, and cutting a bore through said material and said coil of a diameter to cut into said convolutions of said coil and thereby form cylindrical surface elements therein, said bore being cut substantially cylindrical and with said bore comprising said cylindrical inner surface elements of said spaced convolutions, said plastic material rigidly supporting said coil during said cutting operation.

3. In a method of making a tuner, the steps comprising winding wire to form a helical coil with spaced convolu-

tions, forming an electrically insulating holder with an opening therein of a size to receive said coil, forming laterally extending terminal leads on said coil, forming said holder with a longitudinal slot extending radially from said opening for receiving said leads, inserting said coil into said opening in said holder with said leads extending outwardly therefrom through said slot, filling said opening with an electrically insulating liquid hardenable resinous plastic material and thereby imbedding said coil in said material, said plastic material being capable of bonding with said coil and said holder, hardening said material to bond said material to said coil and said holder while maintaining said convolutions in spaced relation, cutting a bore through said material and said coil of a diameter to cut into said convolutions of said coil and thereby form cylindrical surface elements therein, said bore being cut substantially cylindrical and with said bore comprising said cylindrical inner surface elements of said spaced convolutions, said plastic material rigidly supporting said coil during said cutting operation, and forming an electrically insulating tuning core of a diameter to be slideably received in said last-mentioned bore, said core being formed with an insulating coating thereon to insulate said core from said wire.

4. In a method of making a tuner, the steps comprising forming an electrically insulating tubular holder with first and second coaxially aligned interconnected bores therein, said first bore being substantially smaller in diameter than said second bore, winding conductive metal wire on a cylindrical form and thereby forming a generally helical coil having a plurality of spaced convolutions, removing said coil from said form, positioning said coil in said second bore, said second bore corresponding in diameter to the outer diameter of said coil, filling said second bore with an electrically insulating liquid hardenable plastic material and thereby imbedding said coil therein, said plastic material being capable of bonding with said coil and said holder, hardening said material to bond said material to said coil and said holder while maintaining said convolutions in spaced relation, and drilling out said plastic material from the inside of said coil along the entire length thereof to form a cylindrical opening extending through said plastic material as a smooth continuation of said first bore, said drilling being done to a greater diameter than the inner diameter of said coil so that said drilling will cut into said convolutions of said coil and will form cylindrical inner surface elements on said convolutions flush with said plastic material in said drilling opening, said plastic material supporting said coil in rigid relation to said holder during said drilling operation, said drilling operation producing a substantially uniform internal cylindrical surface within and along the entire length of said coil, with said cylindrical surface comprising said inner surface elements on said spaced convolutions.

5. In a method of making a tuner, the steps comprising forming an electrically insulating tubular holder with first and second coaxially aligned interconnected bores therein, said first bore being substantially smaller in diameter than said second bore, forming a longitudinal slot in said holder and extending outwardly from said second bore, winding conductive metal wire on a cylindrical form and thereby forming a generally helical coil having a plurality of spaced convolutions, removing said coil from said form, forming radial terminal leads on said coil, positioning said coil in said second bore with said radial leads extending outwardly through said slot, said bore corresponding in diameter to the outer diameter of said coil, filling said second bore and said slot with an electrically insulating liquid hardenable plastic material and thereby imbedding said coil therein, said plastic material being capable of bonding with said coil and said holder, hardening said material to bond said material to said coil and said holder while maintaining said convolutions in spaced relation, drilling out said plastic material from the inside of said coil along the entire length thereof to form a cylindrical opening extending through said plastic material as a smooth continuation of said first bore, said drilling being done to a greater diameter than the inner diameter of said coil so that said drilling will cut into said convolutions of said coil and will form cylindrical inner surface elements on said convolutions flush with said plastic material in said drilled opening, said plastic material supporting said coil in rigid relation to said holder during said drilling operation, said drilling operation producing a substantially uniform internal cylindrical surface within and along the entire length of said coil, with said cylindrical surface comprising said inner surface elements on said spaced convolutions, forming a tuning core with one end portion of electrically insulating magnetic material and an opposite end portion of electrically conductive material, applying an insulating coating to said core to insulate said core from said coil, and slideably disposing said core in said first bore and said drilled opening, said core being formed of a diameter to make a close sliding fit with said drilled opening.

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