Nov. 30, 1954 | E. P. THIAS | 2,695,963

FINE TUNER

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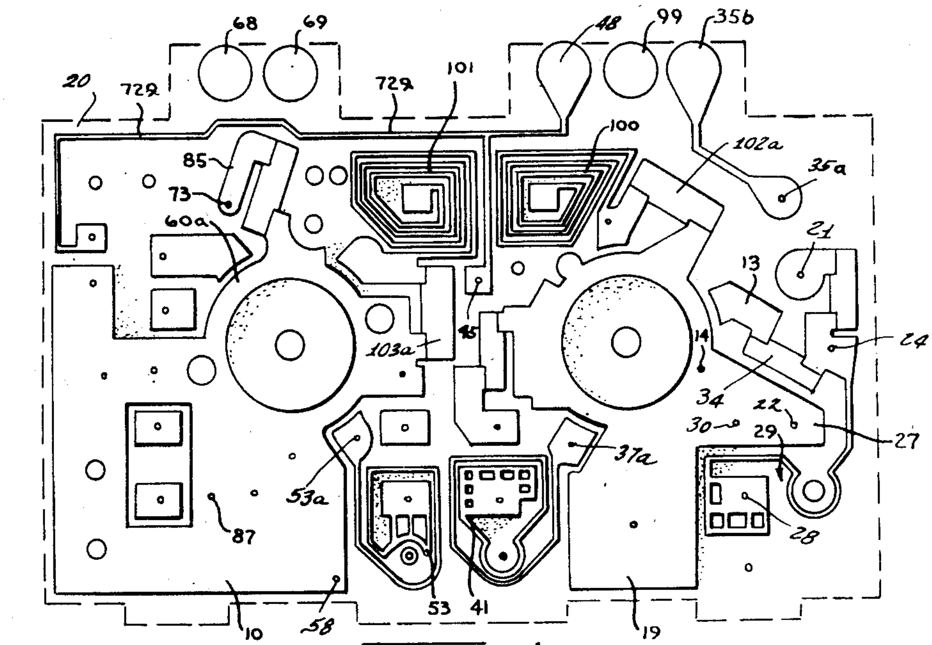

FIG. 1

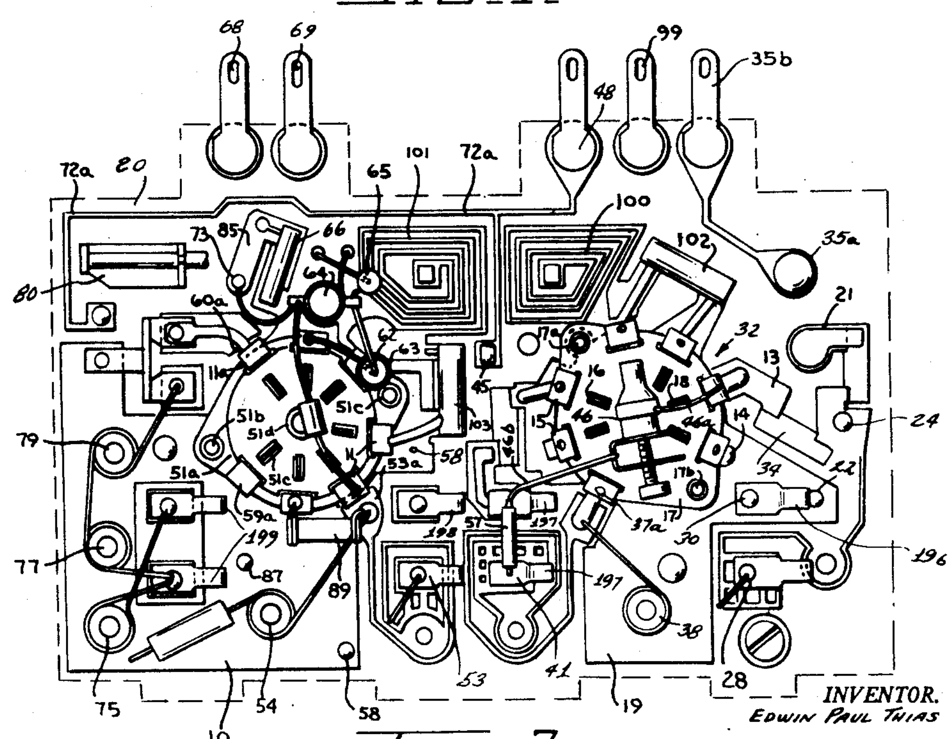

FIG. 2

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FIG. 3

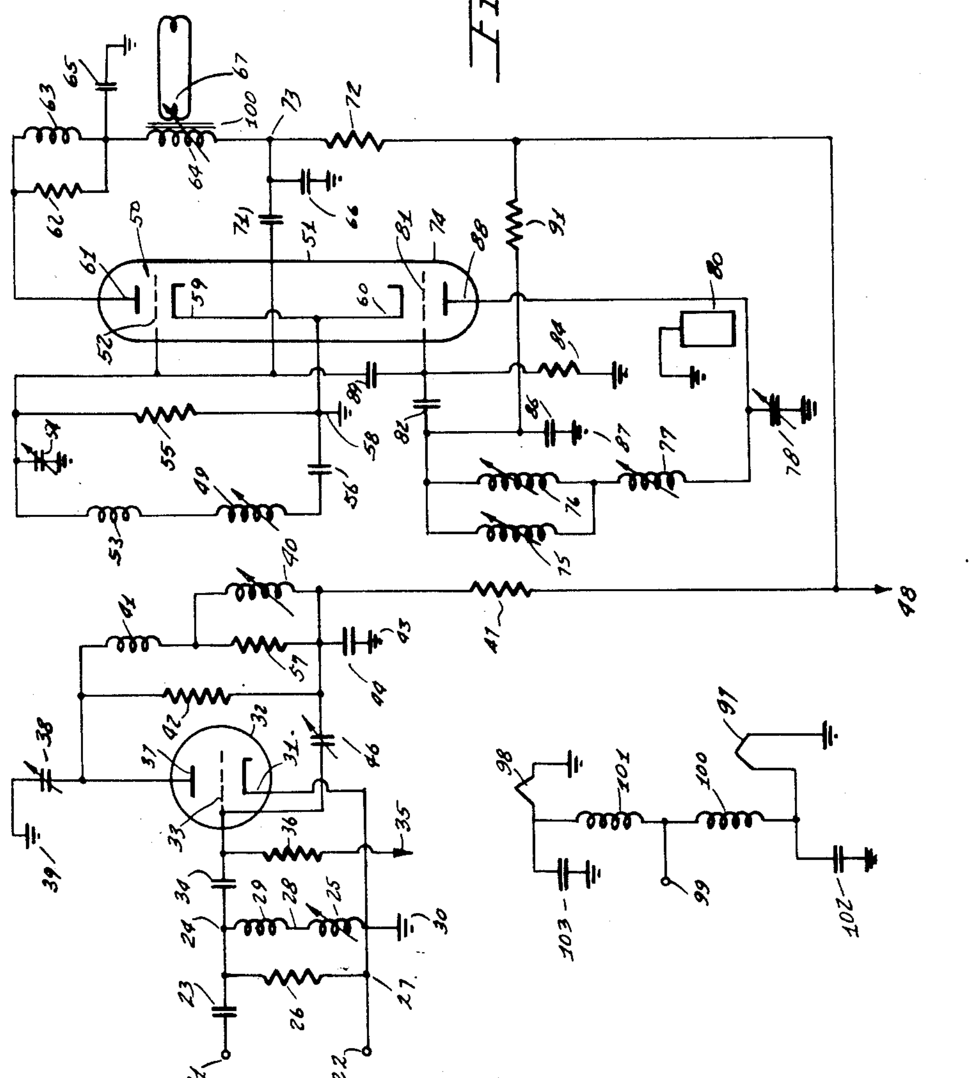

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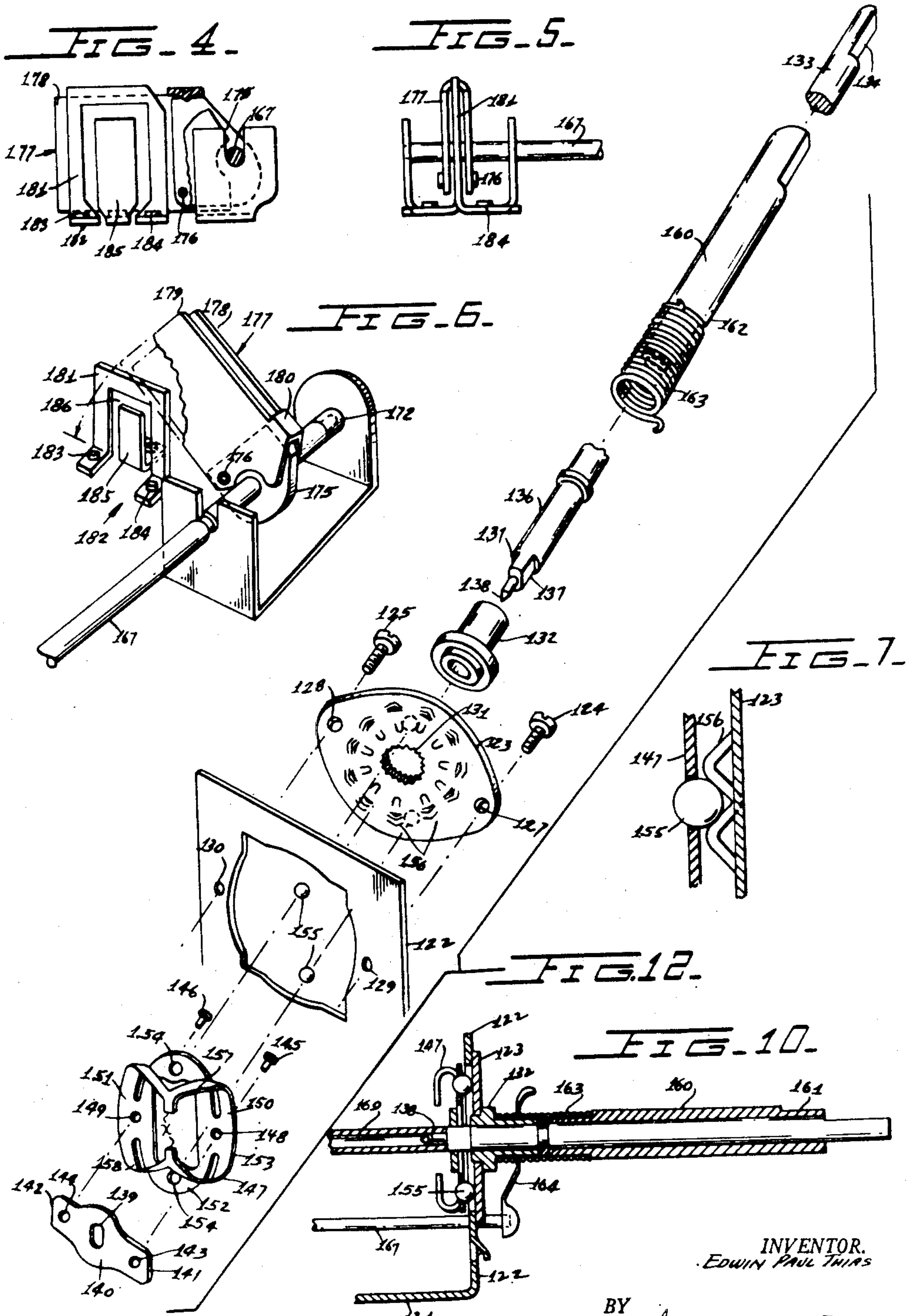
FIG. 4 FIG. 5 FIG. 6 FIG. 7 FIG. 12 FIG. 10



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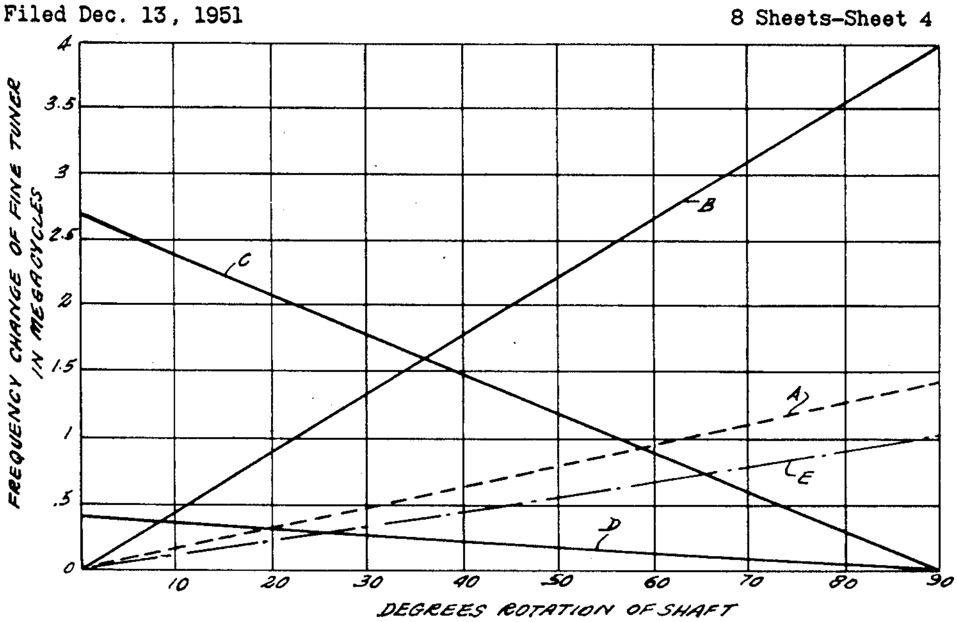

FIG. 8

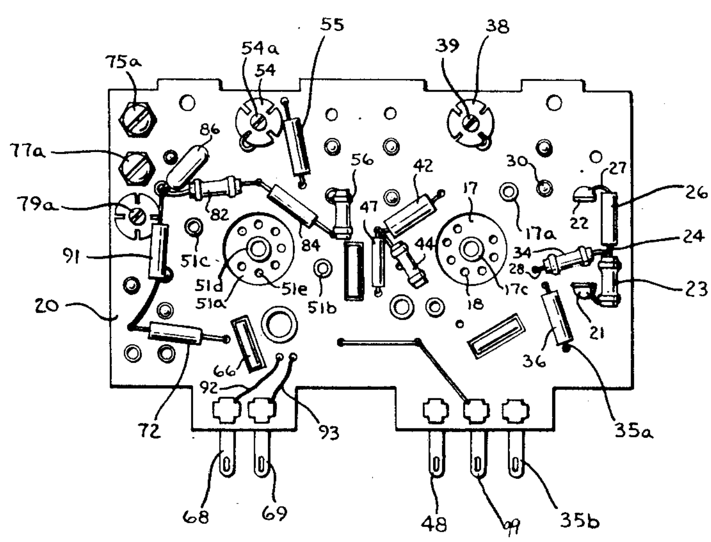

FIG. 17

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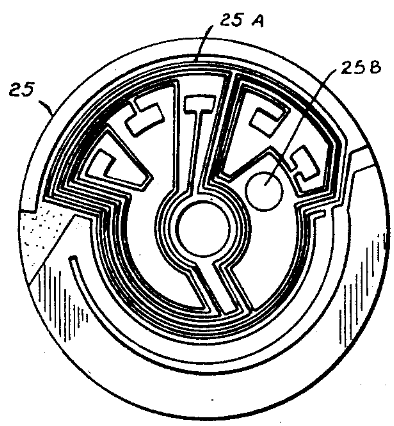

FIG. 14.

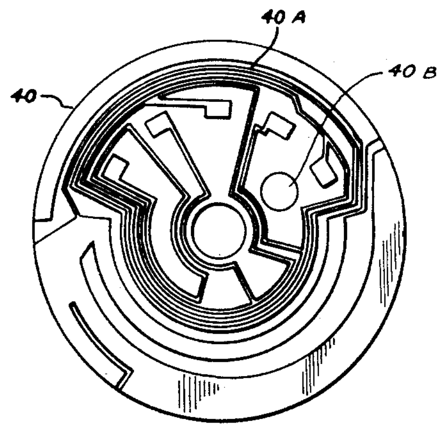

FIG. 15.

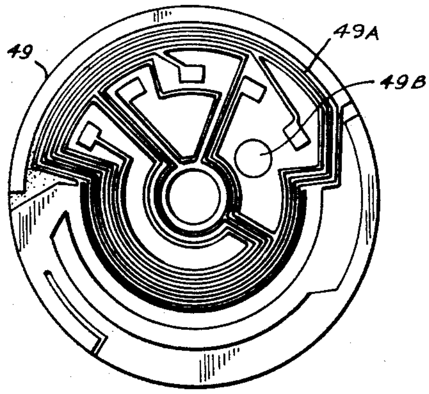

FIG. 16.

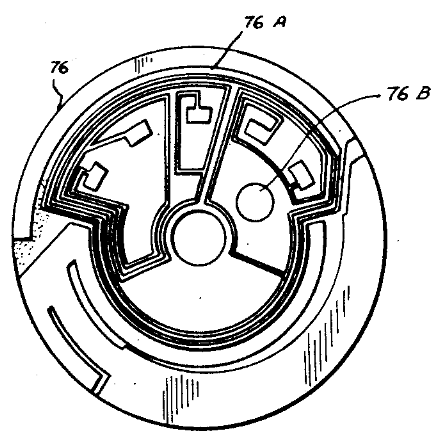

FIG. 9.

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FIG. 11

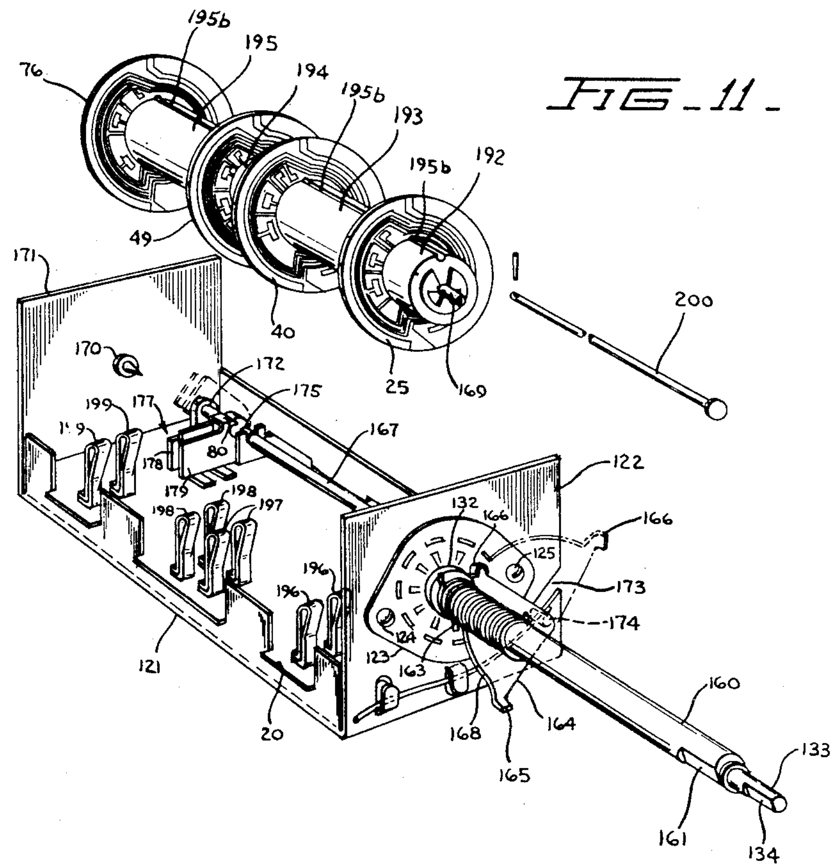
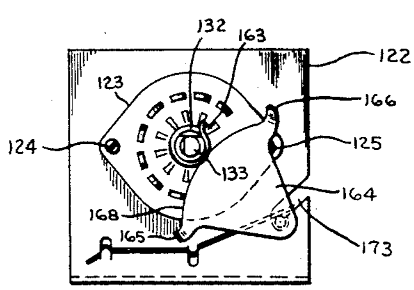


FIG. 13



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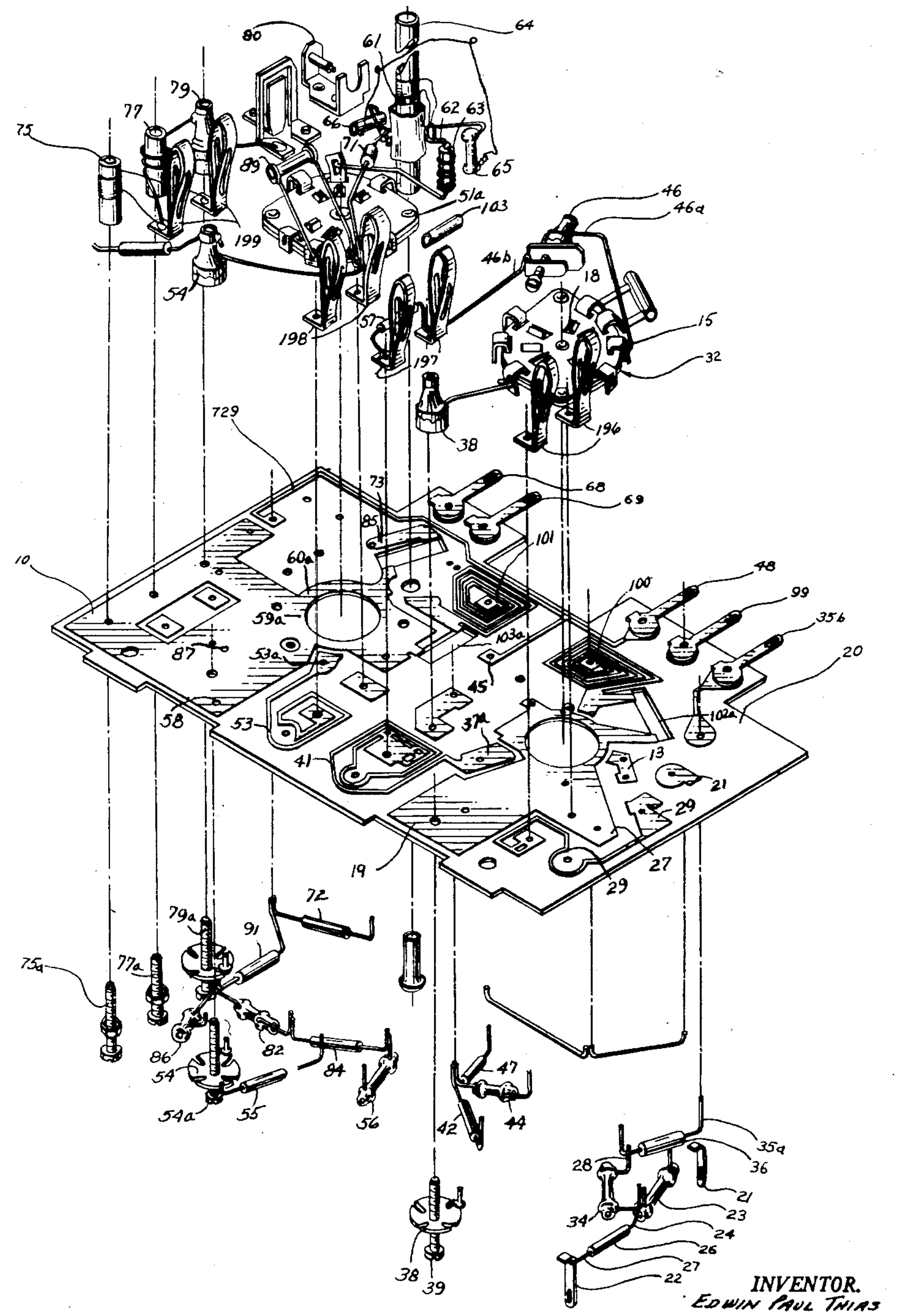

FIG. 18

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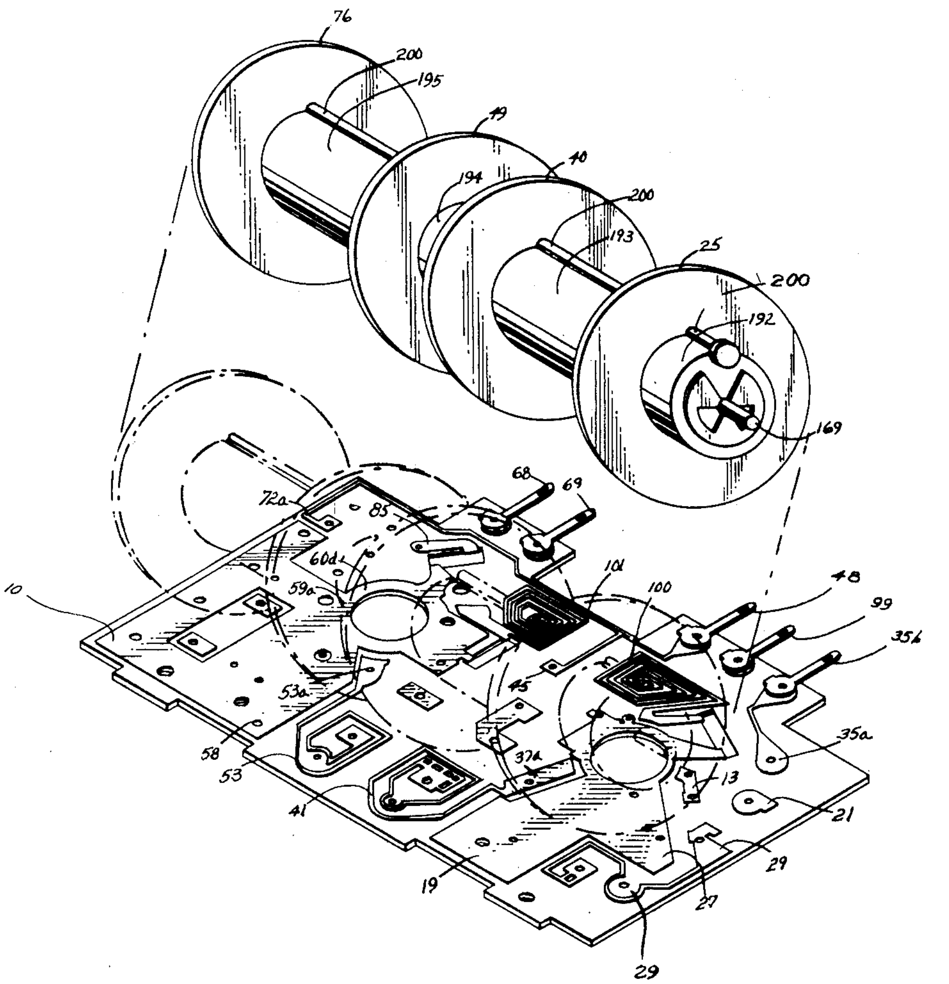

FIG. 19

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United States Patent Office

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Patented Nov. 30, 1954

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2,695,963

FINE TUNER

Edwin Paul Thias, Los Angeles, Calif., assignor to Standard Coil Products Co. Inc., Los Angeles, Calif., a corporation of Illinois

Application December 13, 1951, Serial No. 261,426

5 Claims. (Cl. 250—40)

This invention relates to television selectors of the type now known generally as television tuners and is directed more particularly to the arrangement of the fine or vernier tuning elements of the local oscillator structure.

In frequency selectors of the television tuner type, a step by step tuning arrangement is provided which is operated by a rotatable shaft to move successively a plurality of inductors into engagement with contact elements in order to tune the unit to the different television channels. As disclosed in prior applications' 218,162, Patent No. 2,650,298, dated August 25, 1953, and 226,718, Patent No. 2,658,394, dated November 10, 1953, a fine or vernier tuning arrangement is also provided.

Various problems arise in fine tuners for television receivers due to the fact that the high channels from 7 through 13 operate at essentially three times the frequency of the low frequency channels 2 through 6.

Heretofore, in the prior art, the fine tuners of the conventional capacity type had a tuning range approximately three times as great on the high channels as on the low channels, due to the fact that as the frequency increases, the percentage change of frequency remains essentially constant so that the same angular rotation of the fine tuning shaft produces a greater absolute change in frequency. The fine tuning assemblies then tend towards rougher tuning on the high channels, covering a greater range of frequencies.

These difficulties are overcome by the provision of a fine tuning element having novel compact tuning assembly utilized cascade circuitry, having a simple driving mechanism, a printed base, printed coils, and inductive bucking effect which in combination with the capacitive variation provides substantially equal tuning ranges for the high and low channels.

It is then an important object of the present invention to provide a fine tuning assembly which has approximately the same tuning range on the high channels as it does on the low channels.

Another object of the present invention is the provision of a finer tuner having an inductive bucking effect so that two-thirds of the capacitive effect on the high channels is neutralized.

Still another important object of the present invention is to provide a novel fine tuning mechanism for television where the fine tuning may be initiated on a shaft concentric with the shaft for the rough tuning.

Still another object of the present invention is the provision of a fine tuning mechanism that permissibly slips when rotated beyond fixed limits.

The novel features that are considered characteristic of this invention are set forth in the appended claims. The invention, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in conjunction with the drawings, in which:

Figure 1 is a top view of the printed base of a tuner embodying my present invention.

Figure 2 is a top view of the assembled circuit components of my novel tuner.

Figure 3 is a schematic drawing of the circuitry of the tuner of my invention.

Figure 4 is a side view of the fine tuning element of the present invention.

Figure 5 is a side view of the unit of Figure 4.

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Figure 6 is a perspective view of the fine tuning element of the present invention.

Figure 7 is a sectional view of a portion of the stepping mechanism of my present invention.

Figure 8 is a series of reactance vs. shaft rotation curves.

Figure 9 is a top view of a printed tuning inductor of the present invention.

Figure 10 is a sectional view of the driving elements of my invention.

Figure 11 is a partially exploded view of the chassis and driving elements.

Figure 12 is an exploded view of the driving element.

Figure 13 is a front view of the chassis.

Figure 14 is a top view of a printed tuning inductor of the present invention.

Figure 15 is a top view of a printed tuning inductor of the present invention.

Figure 16 is a top view of a printed tuning inductor of the present invention.

Figure 17 is a bottom view of the printed base.

Figure 18 is an exploded view of the printed base and the components mounted thereon.

Figure 19 is an exploded view of the printed base and printed coils of the present invention.

Referring to Figure 11, a chassis **121** has a front panel **122** and supports a base **20**, hereinafter described. The front panel **122** supports the notched member **123** by means of two screws **124** and **125** over the opening **126**. The screws **124** and **125** fit through the holes **127** and **128** in the notched member **123** and thread the holes **129** and **130** in the front panel **122**. The notched member **123** has a centrally located multi-toothed opening **131**, which opening **131** seats a brass bushing **132**, shown also in Figure 12.

The bushing **132** rotatably supports a shaft **133**, which is the rough tuning or channel selector shaft. The shaft **133** has a milled portion **134** which supports a knob, not shown, and a hollow fine tuning shaft **160**, hereinafter described.

The end **136** of the shaft **133** has two diametrically opposed milled faces **137** and a pin **138** as an integral part thereof. The end **136** protrudes from the bushing **132** and fits into the opening **139** of crank member **140**. The crank member **140** has diametrically opposed arms **141** and **142** having the holes **143** and **144**, respectively.

The openings **148** and **149** are located in the sections **150** and **151** which join the two units **152** and **153** of the resilient member **147**. The unit **152** is elliptically shaped and has two diametrically opposed openings **154**. The openings **154** seat ball bearings **155** against the notched member **123**. The diameter of the opening **154** is slightly smaller than the diameter of the bearings **155**. The bearings **155** are seated between the rounded notches **156**, shown more particularly in Figure 7.

The rotation of shaft **133** causes the crank **140** bearing resilient member **147** to rotate. The rotation of the resilient member **147** causes the bearings **155** to ride over the notches **156** to a subsequent position between two other notches **156**.

The other unit **153** of resilient member **147** is also elliptically shaped and is bent at **157** and **158** to resiliently supported a disk **159**, hereinafter described, shown in Figure 11.

The spring member **147** provides a symmetrically balanced detent mechanism in which the required spring force or tension is evenly divided and so eliminates any side thrust or distortion of the main driving shaft.

The spring member **147** also provides the thrust force which force is required to hold the tunable element of coil boards **25**, **40**, **49** and **76** against the pivot point **170**, hereinafter described. The member **147** has a third function by providing the tuning force or torque required to turn the movable tuning elements. This action is accomplished through the two fingers or protrusions X (Figure 12). The fingers X provide spring tension in the direction of the main drive shaft **169** being supported by the two bent supporting portions **157** and **158** of the spring member **147**.

The advantages of this type of construction is that one unit or stamping for the part **147** essentially serves as two or three more separate springs, levers or members necessary to accomplish the functions of positioning the tuning element in the chassis, of providing the turning moment for the tuning element, and of providing for adequately detenting or stopping the tuning element in accurately controlled position or positions.

The main tuning element or drum consisting of the printed coils is supported between pivots 170 and 138 and the driving moment is provided by the two points X of the spring **147**.

Any slight misalignment of the sometimes long tuning shaft **161** will not throw any distortion or strain on the main tuning assembly. The distortion or strain is taken up by the spring action of member **147** which the fingers X then move in the corresponding slots **159***a* and **195***a* in member **192**, hereinafter described.

The shaft **133** described above supports a hollow shaft **160**. The hollow shaft **160** is milled at one end **161** to support a knob, not shown.

At the other end **162** of the hollow shaft **160** is rigidly attached a coil spring **163**. The spring **163** may be fixed to the shaft **160** by brazing or by tight threading or by any other means known in the art. The spring **163** is in frictional relationship with a resilient member **164**. The resilient member **164** is shaped as the sector of a circle and has two extensions **165** and **166**. The member **164** is rigidly supported on a shaft **167** either by a welded connection or otherwise.

The rotation of the hollow shaft **160** causes the rotation of the resilient shaped member **164** and thus the shaft **167**.

The contact between the spring **163** and the resilient member **164** is a high frictional one. The resilient member **164** is deformed against the spring **163**. The contacting arcuate edge **168** of the member **164** bears tangentially against two surfaces of the spring **163** as it fits into the space between the coils of the spring **163**. The construction results in a substantially positive drive with no slippage.

The extensions **165** and **166** come into contact with the spring **163** and prevent further rotation of the resilient member **164**. Further rotation of the hollow shaft **160** causes slippage between the resilient member **164** and the coil spring **163**.

The shaft **167** performs the fine tuning in a manner hereinafter described.

The pin **138** helps support a partially hollow shaft **169**. The shaft **169** is suspended between one support, the pin **138** on the front panel **128** and upon a bearing pin **170**, as shown in Figure 11, on a back panel **171**. The shaft **169** has firmly attached to the front thereof, as is hereinafter described, a cylindrical member **192**. The member **192** is removably attached to the resilient member **147** at points X, described above, so that upon rotation of the shaft **133**, the crank **140**, the resilient member **147**, the member **192** and the shaft **169** all rotate together. The shaft **169** also carries four tuning inductors or printed coils **25**, **40**, **49** and **76**, hereinafter described, and shown in Figures 14, 15, 16 and 9, respectively. The tuning inductors **25**, **40**, **49** and **76** bear against spring contacts **196**, **197**, **198** and **199**, as shown in Figures 2, 11 and 18, and have conductive paths *25a*, *40a*, *49a* and *76a*, respectively.

The printed coils **25**, **40**, **49** and **76** are each essentially a number of individual coils in series or one complete series coil in which taps are taken off at the exact inductive position necessary for each of the 12 television channels or frequencies.

The success of these coils lies entirely in the geometric configuration which is so arranged that the normal position of each tap is taken off having the inductance at the proper value for the consecutive television station or frequency. Any change in the configuration of the coil or overall size of the coil will therefore throw the conductance out of range of the particular television frequency.

A further advantage of this type of construction in which the coil rotates and in which all coils in this configuration are in series is that this construction eliminates all necessity of further soldered connections or joints or the necessity of adding any external inductance. In other words, after the coil is etched, fabricated and punched out there are no further soldering operations or any further electrical connections to be made to the coil. The inductance is complete as etched and only requires for operation that contact be made to it by the spring clips **196**—**199**, described above.

The rotation of shaft **133** as described above by means of a knob, not shown, causes the tuning inductors **25**, **40**, **49** and **76** to rotate, changing the tuned frequency to which the set is tuned.

The coil board **25**, **40**, **49** and **76** is rigidly fixed in position by the plastic bushings **192**–**195**, and **195***a*, which slide on the shaft **169**; **195***a* being behind the disc **76** and thus not shown. The bushings **192**–**195** and **195***a* each have a longitudinal groove **195***b* through which a plastic rod **200** fits. The rod **200** passes through the holes **25***b*, **40***b*, **49***b* and **76***b* of the inductors **25**, **40**, **49** and **76**, maintaining them rigidly in position.

The shaft **167**, as shown in Figure 11, and more particularly in Figures 4, 5 and 6, carries a variable condenser unit, hereinafter described. The shaft **167** is positioned on the back panel by means of a hole **172** and on the front panel **126** by means of a slot **173**, having a groove **174** which fits into the slot **173**. The shaft **167** has rigidly attached thereto a partially circular dielectric member **175**. The partially circular dielectric member **175** has rigidly attached thereto by means of a rivet **176** a plate assembly **177**. The plate assembly **177** is thus insulated from the shaft **167**. This insulation is provided to eliminate sliding contacts wherever possible since sliding metallic contacts contribute appreciably to the noise during the operation of a fine tuner.

Another reason for insulating the plate assembly **177** is to reduce the amount of coupling of oscillator energy to the shaft **167**.

The plate assembly **177** comprises two metallic plates **178** and **179** which are connected by means of a connection **180**, all of which are integral parts of the plate assembly **177**.

The rotation of shaft **167** by means described above in reference to Figures 11, 12 and 13 causes the dielectric member **175** and the plate assembly **177** to rotate. The rotation of the plate assembly **177** causes the plate assembly **177** to rotate over a U-shaped conductor **181** which is rigidly attached to the base **182** by means of two rivets **183** and **184**. The plate assembly **177** also rotates over a substantially rectangular member **185** which is seated centrally in the opening of the U-shaped member **181**.

The rectangular plate **185** lies substantially in the same plane as the space **186** which is between the two plates **178** and **179** and also in the same plane as the U-shaped member **181**. The U-shaped member **181** and the rectangular plate **185** are essentially of the same thickness and preferably of the same conducting material having approximately a 1/16 of an inch rectangular gap between the rectangular member **185** and the U-shaped member **181**. The central rectangular plate **185** is connected to the base **182** of the tuner. The rotation, then, of the plate assembly **177** increases the capacity between the U-shaped member **181** and the rectangular member **185**. The increasing capacity is due to two series capacitors, one from the U-shaped member **181** to the plates **178** and **179** and the other from the movable plates **178** and **179** to the rectangular plate **185**.

The reason for the above construction is to provide an approximately equal fine tuning range on high frequency channels as well as the low frequency channels. Since the high frequency band is approximately two to three times the frequency of the low frequency band, the percentage change of frequency when capacitance change alone is used for fine tuning is substantially constant. Thus an equal rotation of the fine tuning knob will now cause a greater variation in frequency at the upper band channel frequencies than at the lower band channel frequencies.

When operating on the high frequency band, the fine tuning tends to become rougher, giving greater variations and making it harder to tune accurately. The construction as shown in Figures 4, 5 and 6 alleviates this condition by introducing a variation in inductive reactance in the U-shaped member **181** due to eddy currents. The variation in inductive reactance on the low channels as illustrated in Figure 8 on the curve marked D is practically negligible as the shaft is rotated. The variation in inductive effect, however, on the high channels as illustrated by the curve marked C is substantial and the frequency change produced by this variation is correspondingly large. This frequency change produced by variation in inductive reactance is in opposition to the frequency change produced by the simultaneous change in capacitance.

The tuning range on the low channels is shown by the dashed curve A. Curve A is the approximate curve which is the desirable tuning range on the high channels. The tuning range of the capacitor alone on the high channels is illustrated by the curve B. Combining the effects of curve B, the tuning range of the capacitor alone on the high channels, together with the inductive effect on the high channels, curve C produces a resultant tuning range on the high channels as illustrated by curve E. Thus if the high frequency was, say three times as great as the low frequency, an equivalent inductive reactance, which would be approximately two-thirds the capacitive reactance, would be introduced at this high frequency, leaving an equivalent capacity of one-third the capacitor resulting in a tuning range which is substantially the same as on the low frequency. The result of this construction is a fine tuning means which gives substantially the same tuning frequency range on the high band channels as on the low band channels.

The base **20** described above is a printed base and is hereinafter described in reference to Figures 1, 2, 3, 17 and 18.

Referring now to Figures 1, 2, 3, 17 and 18, the terminals **21** and **22** are the input terminals to the printed base **20**. Figure 17, which is the bottom view of the printed base **20**, and Figure 18, show the physical point of connection to the terminals **21** and **22** whereas Figures 3, 1 and 2 show the electrical equivalent in the circuit and as a printed portion on the top of the printed base **20**. The input terminal **21** is connected through an impedance transformation capacitor **23** (Figures 3, 17 and 18) to the terminal **24**. One of the electrodes of the capacitor **23** is connected to the terminal **21** and the other to the terminal **24**. The capacitor **23** essentially transforms the input impedance of 300 ohms to an approximate impedance of 1000 ohms. This higher input impedance allows the antenna tuning inductor **25** (Figures 3, 11, 14 and 19), described above, to operate with proper loading.

The terminal **24** is connected through a loading resistor **26** (Figures 3, 17 and 18) to the terminal **27** which is electrically the same as terminal **22**.

The loading resistor **26** has comparatively large resistance and so effectively maintains the impedance of the circuitry associated with the inductor **25** fairly constant over the complete television band width. The terminal **24** is also connected to terminal **28** through an inductor **29** which is a lumped printed inductance on the printed base **20**, shown specifically in Figure 1.

The inductor **29** allows tuning to the frequency of channel **13** with a minimum of inductance on the coil board inductor or antenna tuning inductor **25**. The inductor **29** may be a variable inductor to compensate for variations in the manufacture of the inductor coil board **25**. The inductor **25** is connected between the terminals **28** and **30**, described above; the terminal **30** being at ground potential as indicated at Figure 3.

The terminals **30**, **27** and **22**, as shown specifically in Figure 1, are all points on the large metallic surface **19**, hereinafter described, which is at ground potential. The inductor **25** is positioned as is also hereinafter described in a plane that is perpendicular to the base **20** and makes contact with two leaf springs **196** which are riveted to the base **20** at terminals **28** and **30** described above and shown in Figures 2, 11 and 19.

The surface **19** containing the terminals **22**, **27** and **30** is connected to the cathode **31** of the triode tube **32**. The triode tube **32** is shown only in Figure 3 and may be a 6AB4 tube, acting as a radio frequency amplifier. The triode **32** has its prongs (not shown) which fit into the openings **18** in the tube base **17**. The tube base **17** is riveted at **17*a***, **17*b*** and **17*c*** (Figures 2, 17 and 18) to the base **20** and is so rigidly fixed thereto. The openings **18** enclose two resilient arms **16** (Figure 2) which seat the prongs of the tube **32** and thus seat the tube **32** rigidly in the base **17**. The base **17** also contains a plurality of lugs **15** (Figure 2) which make contact with prongs of tube **32** and with the surrounding circuitry. The lug **15** connected to the prong leading to the cathode **31** is connected to the surface **19** at point **14**.

The terminal **24** described above is connected through an impedance transformation capacitor **34** (Figures 3, 17 and 18) to the grid **33** of the triode **32**. The capacitor **34** connects through the base **20** to the printed portion **13** (Figures 1, 2 and 18) which is soldered to the lug **15** connected to the prong leading to the grid **33**. The impedance transformation capacitor **34** allows the tuning of the antenna inductor **25** with reduced grid capacity loading.

The grid **33** is connected to an automatic gain control unit **35** (not shown) through an isolation resistor **36** (Figures 3, 17 and 18). The circuitry of automatic gain control units is well known in the art and is therefore only indicated by an arrow in Figure 3. The resistor **36** is connected through the board **20** at point **35*a*** to the external terminal **35*b*** which subsequently connects to the automatic gain control unit **35**.

The triode tube **32** is neutralized by means of a split capacitor arrangement in the plate circuit, as is hereinafter described. The plate **37** is connected at **37*a*** (Figures 1, 2 and 18) to the board **20** and through a trimmer capacitor **38** (Figures 2, 3 and 18) to ground at surface **19**. The capacitor **38** compensates for the differences in capacity of different tubes **32** that may be used and allows tuning of the variable inductor or coil board **40**, hereinafter described in reference to Figures 15 and 19, being the tuned plate inductance. The trimmer capacitor is adjusted by a screw **39** shown in Figures 17 and 18.

The plate **37** is connected to the variable inductor **40** through an inductor **41** which is essentially a lumped inductance. Inductor **41** can also be made variable to help compensate for variations in the manufacture of the coil board **40** or for variations in the tube capacities.

The inductor **41** has mounted thereon a leaf spring **197** which makes contact, as is hereinafter described, with the coil board **40**. The plate **37**, described above, is loaded by means of a load resistor **42** (Figures 3, 17 and 18) connected across coils **40** and **41** and a resistor **57** (Figures 2, 3 and 18) which is connected across the leaf springs **197**. The load resistor **42** loads the total plate tuning and has the greater effect on the high channels.

The low channels are tuned by the coil **40** which is composed essentially of low channel coils. This loading procedure tends to give a fairly uniform tuning range on all the channels.

The inductor **40** is connected through the second spring leaf **197** to the neutralizing capacitors **44** and **46**. Capacitor **46** returns to the grid **33** of the triode **32**, and the capacitor **44** returns to ground **43** as shown in Figures 2, 3, 17 and 18.

The trimmer capacitor **46** is mounted above the base **17** and is supported by means of the wire leads **46*b*** and **46*a***, which are attached to the grounded spring leaf **197** and the cathode lug **15**, respectively.

At this point in the plate circuitry the neutralization is constant or practically constant on all channels. The resistor **47** (Figures 3, 17 and 18) connected to point **45** (Figures 1, 2 and 3) is the plate driving resistor and also acts to isolate the circuit from the B+ at the external terminal **48**. The external terminals are terminals on the printed circuit board **20** protruding from the chassis and are connected thereto from the outside.

The circuitry associated with the tube **32** as described above is designed to be very compact and of high economy as a great portion of the circuitry printed is on the base **20**. The tube **32** is a radio frequency amplifier tube which feeds into a converter section simultaneously with the output of an oscillator, as is hereinafter described, to get a fixed intermediate frequency output from the converter.

The output from the tube **32** is coupled through the inductor **40** as is hereinafter described in reference to Figure 19 to an inductor **49** (Figures 3, 11, 16 and 19). The inductor **49** is a printed coil board somewhat similar in construction as the inductors **40** and **25** and is connected through a printed inductor **53** (Figures 1, 2, 3, 18 and 19) to the grid **52** of a triode **50**.

The inductor **53** is essentially a lumped inductance which may be variable and has essentially the same effect as the lump inductance **41** in the plate circuit of the triode **32**. The triode **50** in the present modification is part of the double triode **51** (Figure 3).

The double triode **51** is mounted on a base **51*a*** which is similar in construction to the base **17** described above. The tube base **51*a*** is rigidly attached to the base **20** by rivets **51**_b_, **51**_c_ and **51**_d_ (Figure 2) and has opening **51**_e_ (Figures 2 and 17) to seat the prongs, not shown, of the double triode **51**. The prongs are connected through the connecting lugs **11** (Figure 2) to the surrounding circuitry.

The inductor **53**, described above, is connected to a lug **11** of the triode **50** at **53**_a_ (Figures 1, 2, 18 and 19) on the printed board **20**. The lug **11** at point **53**_a_ connects to the grid **52** (Figure 3) of the triode **50**.

The triode **50** acts as a converter tube as in hereinafter described.

The grid **52** is connected to ground through the converter grid trimmer capacitor **54** (Figures 2, 3 and 18) which has a range from ½ a micromicrofared to 3 micromicrofarads. Capacitor **54** is adjusted by means of the adjusting screw **54**_a_ (Figures 17 and 18). The grid **52** is also connected to a 220,000 ohm grid resistor **55** (Figures 3, 17 and 18) and thence to ground at **58** (Figures 2, 3, 18 and 19) on the surface **10**, and to the grid coupling capacitor **56** (Figures 3, 17 and 18). The grid coupling capacitor **56** has only 20 micromicrofarads capacitance in order to permit tuning with the printed coils, hereinafter described. The grid **52** of the triode **50** returns then to point **58** on the printed surface **10** through inductors **53**, **49** and capacitor **56**.

The cathodes **59** and **60** of the double triode **51** are grounded to point **59**_a_ and **60**_a_ which is also on the sheet of copper **10** on the printed board **20**. The plate **61** of the converter **50** of the double triode **51** is connected to the parallel combination of a resistor **62** and inductor **63**, (Figures 2, 3 and 18). The inductor **63** is physically a long lead which is wound on the resistor **62** so as to conserve space. The resistor **62** and inductor **63** combination has been found to give optimum results with regard to the grid loading at grid **52** on the high channels. The Q of the inductor **63** is thus lowered by the resistor **62** and results in a flattened frequency response. The inductor **63** and resistor **62** are connected to the output intermediate frequency coil **64** (Figures 2, 3 and 18) which is grounded at both ends through the capacitors **65** and **66** respectively (Figures 2, 3 and 18). The capacitor **65** in conjunction with the capacitor **66** tunes the coil **64** to approximately 20 megacycles. To increase the tuning range inductor **64** is provided with an iron core indicated at **100**_a_ in Figure 3.

The coil **64** is coupled to a coupling loop **67** (Figures 3 and 18) which enables the output of the tuner to be coupled to the rest of the television set. The coupling loop **67** is connected to two external terminals **68** and **69** as seen in Figures 2, 17, 18 and 19, which protrude from the outside of the printed board **20** and are connected through the lines **92** and **93** (Figure 17). The coupling loop **67** couples to the first intermediate frequency tube, not shown. Enough coupling has been provided from inductor **64** by coil **67** to provide adequate coupling to the first intermediate frequency stage of the television set. The coil **67** has five turns wound on the coil **64**, which is constructed of twenty-five turns of #40 wire. Link type coupling is provided to reduce oscillator radiation.

The converter tube **50** is neutralized to reduce the amount of reflection of the intermediate frequency in the radio frequency pattern by providing a neutralizing capacitor **71**. The neutralizing capacitor **71** has 2½ micromicrofarads capacity and is coupled to the grid **52** of the converter tube **50**. The output coil **64** is connected to the converter plate load resistor **72** (Figures 3, 17 and 18) which is a 4700 ohm resistor. The resistor **72** is connected to the resistor **47** described above by the printed lead **72**_a_ (Figures 1, 2, 18 and 19) and does not load the neutralizing arrangement as described above, since the neutralizing voltage is taken from point **73** (Figures 1, 2 and 18) where the 20 micromicrofarad tubular capacitor **66** connects to ground. This construction is another split capacitory type of neutralization as described above and is not critical due to the single frequency operation at 20 megacycles, which is the frequency of the output.

The oscillator section is associated with the triode **74** of the double triode **51** and contains a parallel combination of inductors **75** (Figures 2, 3 and 18) and **76** (Figures 3, 9 and 11) which is connected to the grid **81** of the triode section **74** through a capacitor **82** (Figures 3, 17 and 18). This parallel combination of the inductance **75** and **76** is essentially the tuning inductance which determines the frequency at which the oscillator operates. The inductance **76** is the tunable inductance or the coil board inductor which is connected to a shaft and turned with the other coil board inductors, as described above. By varying the inductance **75** by means of the screw **75**_a_ (Figures 17 and 18) it is possible to vary the oscillator frequency without moving the variable inductor **76**. This provision is necessary as the printed coil **76** is fixed on the shaft with the other printed coil boards **25**, **40** and **49**, described above.

Two other adjustments have been provided which can be made at the factory. The two adjustments consist of the variable inductor **11** (Figures 2, 3 and 18) and the variable capacitor **79** (Figures 2, 3 and 18). The variable capacitor **77** is a small lump inductance which is connected in series to the parallel combination of the inductances **75** and **76** and is adjusted by means of the screw **77**_a_ (Figures 17 and 18). The other end of the inductor **77** is connected to the trimmer capacitor **78** which is adjusted by means of the screw **79**_a_ (Figures 17 and 18) and thence to ground on base **10**. The trimmer capacitor **78** compensates for variations in the rated capacity and the inductor **77** compensates for inductance variation on the high channels. These three means of adjusting the oscillator frequency are provided to give proper tracking of the oscillator on all channels. The inductance **77** effects only the high channel tuning and has no effect on the low channels due to its relatively small value.

The fine tuning is accomplished by fine tuning element **80** (Figures 2 antd 18) which is hereinafter described in detail with reference to Figures 5, 6 and 7, connected from the plate **88** of the tube **74** to the trimmer capacitor **78**. The lug **11** from the plate **88** is shown in Figure 2 as **11**_a_.

The grid **81** is connected through a conventional grid leak resistor **84** (Figures 2, 3 and 18) to ground at **85** (Figures 1, 2, 18 and 19) and through capacitor **82**, described above, and capacitor **86** (Figures 3, 17 and 18) to ground **87** (Figures 1 and 2). The injection to the converter **50** from the oscillator **74** is accomplished by means of the capacitor **89** (Figures 2, 3 and 18) which connects the grids **52** and **81**. The capacitor **89** has two microfarads capacity and in conjunction with the circuitry arrangement of the oscillator provides a constant injection voltage to the converter section **50**.

B+ from terminal **48**, described above, is supplied to the oscillator through the resistor **91** (Figure 3, 17 and 18).

The filaments **97** and **98** (Figure 3) of the tubes **32** and **51**, respectively, receive a 6.3 volt supply through terminal **99** (Figures 1, 2, 3, 18 and 19). Terminal **99** is connected through printer inductor **100** (Figures 1, 2, 18 and 19) to filament **97** and through an inductor **101** to filament **98** and simultaneously through tubular capacitors **102** and **103**, respectively, to ground.

The tubular condensers **102** and **103** are fitted into slots **102A** and **103A** (Figures 1 and 18) in the base **20**, to form a compact and strong structure.

As described above and as shown specifically in Figures 11 and 19, the low channel coupling between the radio frequency tube **32** and the converter triode **50** is accomplished by means of the relative positions of the inductors **40** and **49**. The field of the inductor **40** crosses the inductor **49** and thus accomplishes inductive coupling on the low channels. The coupling remains approximately constant on each of the low channels at a value in the neighborhood of 4½ megacycles. The mutual inductance of the inductors **40** and **49** is not effective on the high channels due to the coil construction.

The coupling on the high channels is accomplished by the relative positioning and direction of current flow in the printed circuit of the lump inductances **41** and **53** so as to be essentially inductive coupled. The inductors **41** and **53** are positioned parallel to each other on printed board circuit **20**, and as shown more specifically in Figure 19, are formed in position so as to be predominantly inductive coupled, i. e., with a minimum of capacitive coupling. The coupling on the high channels is nearly constant having a flat response over approximately 4½ megacycles for each channel.

One of the important features of the printed circuit tuner described above is that the oscillator converter tube **51** and associated circuitry of the tuner has a ground plate **10** on the printed board **20** to which all of the circuit grounds are made. This in turn is grounded to the metal chassis **121** hereinafter described at one point only. Similarly, the ground plate **19** printed on the printed board **20** has connected to it all of the circuit grounds for the radio frequency or amplifier section of the tuner which in turn is grounded to the metal chassis **121**, described above, at another point near the antenna input. These features reduce oscillator radiation since there is less chance for a circulating current in ground plate **19** or chassis **121** to cause energy from the oscillator to be inducted into the radio frequency section of the tuner. There is no physical connection on the printed plate **20** itself between the two ground plates **10** and **19**, the one in the oscillator converter and the other in the amplifier.

If such a current would flow in the chassis between various grounds of the radio frequency section and the oscillator section it would very likely lead to excessive oscillator energy being transmitted through the radio frequency section and into the antenna.

While certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

I claim:

1. In a tuning device having a plurality of individually selectable pre-tuned elements; a rotatable shaft for effecting the selection of said pre-tuned elements; an additional infinitely variable tunable element rotatively operable between predetermined limits on a shaft having an independent axis displaced from said first mentioned rotatable shaft; co-axial operating member for said rotatable shaft and said variable tunable element comprising an operating shaft for said variable tunable element; means for rotating said first mentioned rotatable shaft; a sleeve rotatably mounted on said first mentioned rotatable shaft; means for rotating said sleeve; and a connection between said sleeve and said second-mentioned shaft, said variable tunable element being a variable capacitor unit; said unit comprising two parallel movable plates of conductive material, a U-shaped conductive member and a rectangular plate of conductive material, said rectangular plate lying in the same plane as the U-shaped member, said plane being a plane between said two parallel movable plates, said U-shaped member being essentially a variable inductor presenting negligible impedance on said lower frequency band and presenting an impedance approximately two-thirds the impedance of said capacitor on said upper frequency band.

2. A tuning device comprising variable capacitive and inductive means, said capacitive means consisting of a plurality of plates, one of said plates being U-shaped to form said inductive means, another of said plates extending into the open side thereof, said two plates being positioned in one plane, and additional plates electrically interconnected on each side of the said plane for simultaneously decreasing the capacitance between the plates of the said plurality of plates and increasing the inductance of the said U-shaped plate at motion in one direction of said last mentioned plates with respect to the other mentioned plates.

3. A tuning device comprising variable capacitive and inductive means, said capacitive means consisting of a plurality of plates, one of said plates being U-shaped to form said inductive means, another of said plates extending into the open side thereof, said two plates being positioned in one plane, and additional plates electrically interconnected on each side of the said plane for simultaneously decreasing the capacitance between the plates of the said plurality of plates and increasing the inductance of the said U-shaped plate at motion in one direction of said last mentioned plates with respect to the other mentioned plates, operating means mechanically connected to and electrically isolated from the said additional plates.

4. In a television tuner having an upper and lower frequency band, fine tuning device having equal frequency variation on said upper and said lower frequency band, said fine tuning device comprising variable capacitive and inductive means, said capacitive means consisting of a plurality of plates, one of said plates being U-shaped to form said inductive means, another of said plates extending into the open side thereof, said two plates being positioned in the plane, and additional plates electrically interconnected on each side of the said plane for simultaneously decreasing the capacitance between the plates of the said plurality of plates and increasing the inductance of the said U-shaped plate at motion in one direction of said last mentioned plates with respect to the other mentioned plates.

5. In a television tuner having an upper and lower frequency band, fine tuning device having equal frequency variation on said upper and said lower frequency band, said fine tuning device comprising variable capacitive and inductive means, said capacitive means consisting of a plurality of plates, one of said plates being U-shaped to form said inductive means, another of said plates extending into the open side thereof, said two plates being positioned in one plane, and additional plates electrically interconnected on each side of the said plane for simultaneously decreasing the capacitance between the plates of the said plurality of plates and increasing the inductance of the said U-shaped plate at motion in one direction of said last mentioned plates with respect to the other mentioned plates, the inductance of said U-shaped plate being of a magnitude such that it is essentially ineffective as an inductance in said lower frequency band and presenting a change in impedance of approximately two-thirds the change in impedance of the said capacitance means on said upper frequency band at movement of the said additional plates with respect to the other mentioned plates.

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