

May 7, 1946.

S. Y. WHITE

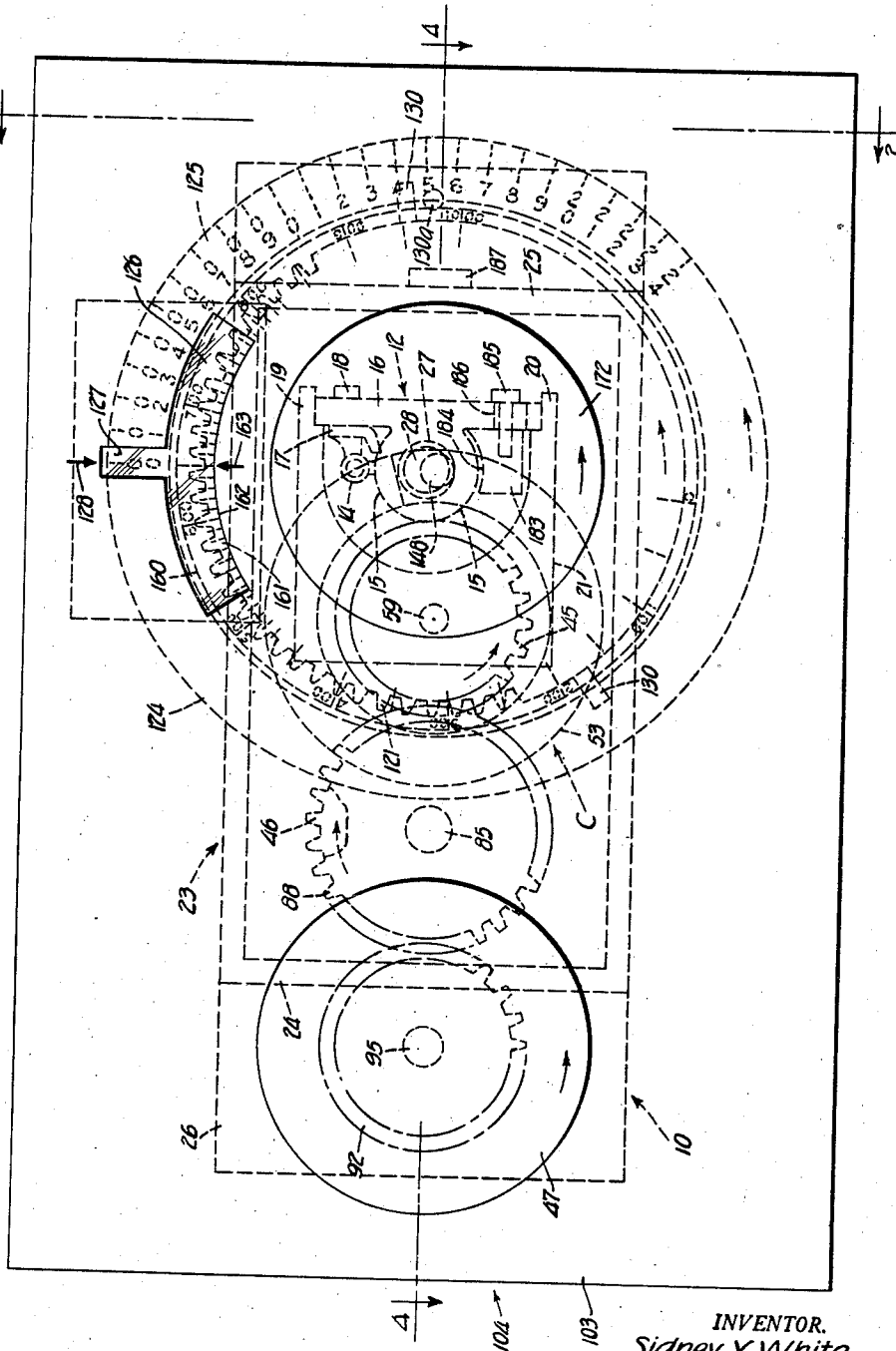
2,399,704

RADIO TUNING MEANS

Original Filed Nov. 6, 1942

7 Sheets-Sheet 1

Fig. 1.



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7 Sheets-Sheet 2

Fig. 2.

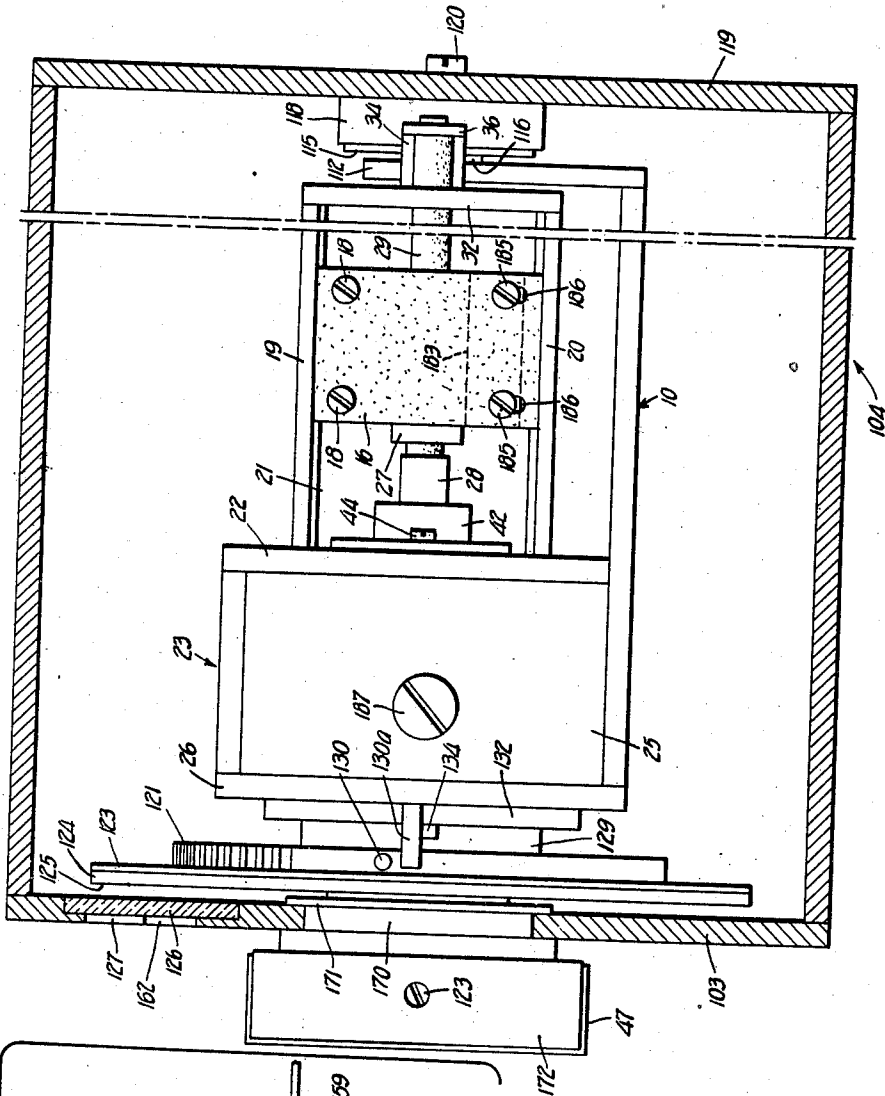
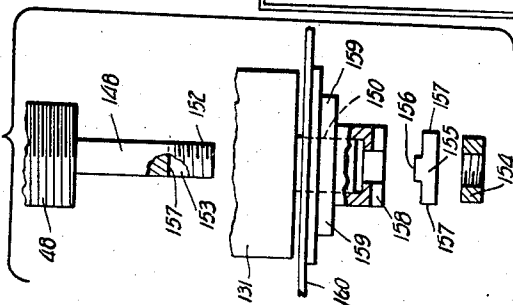


Fig. 3.



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7 Sheets-Sheet 3

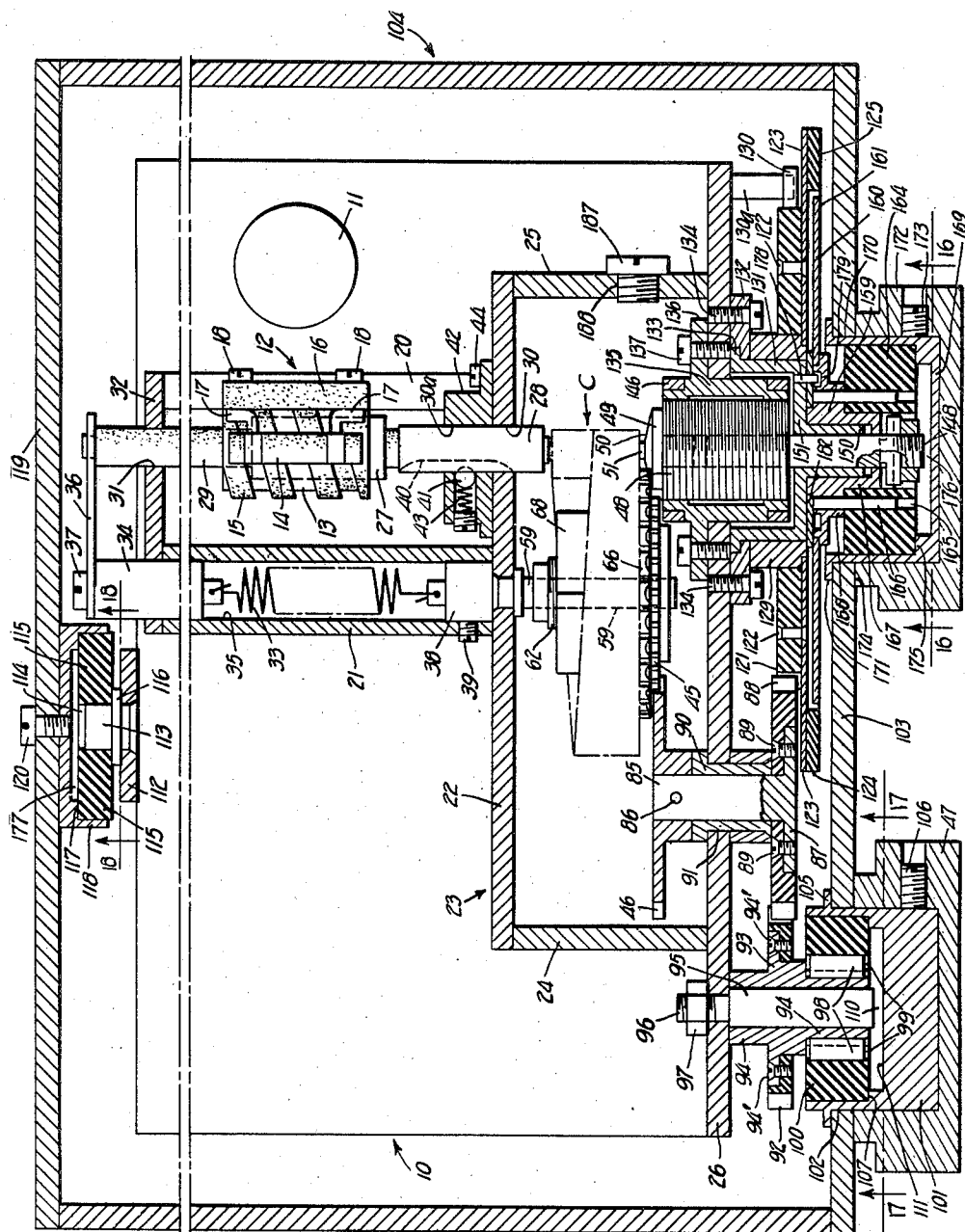


Fig. 4.

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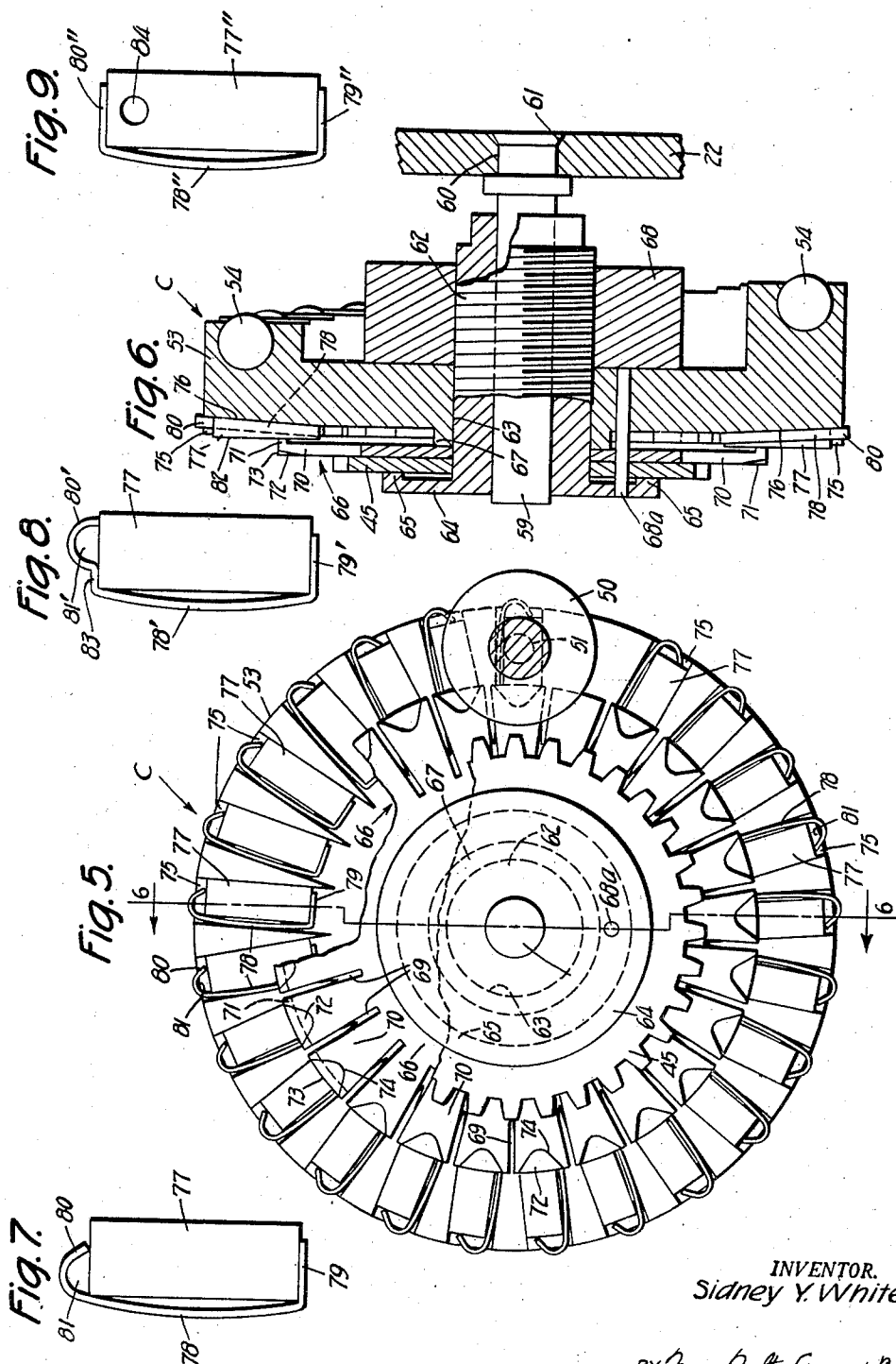
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RADIO TUNING MEANS

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7 Sheets-Sheet 4



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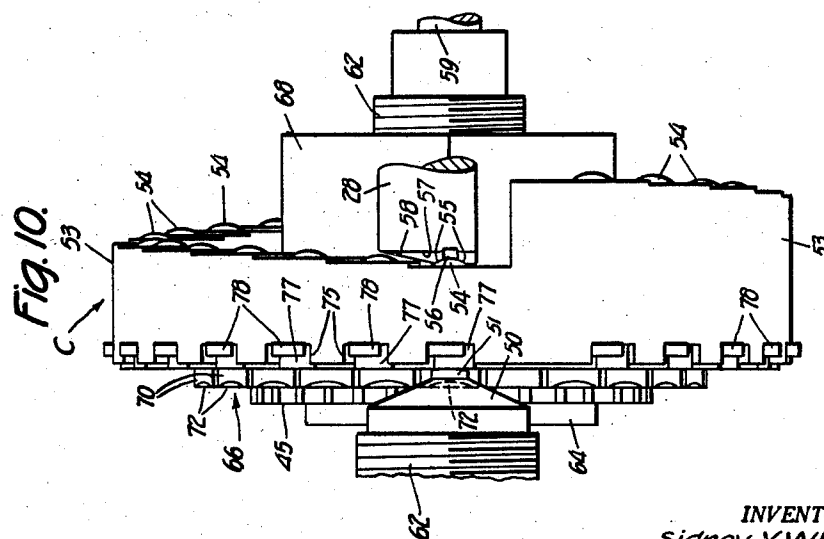
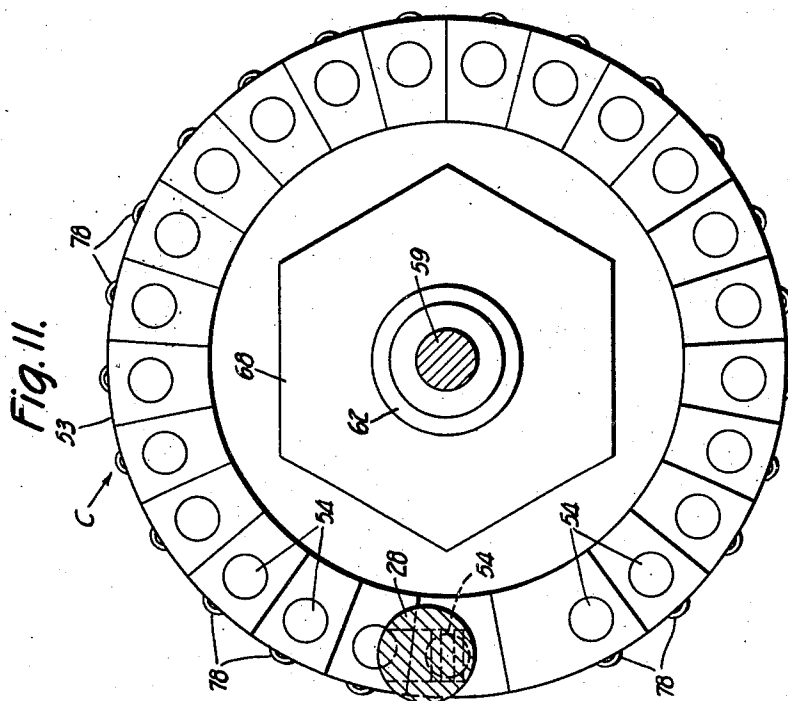
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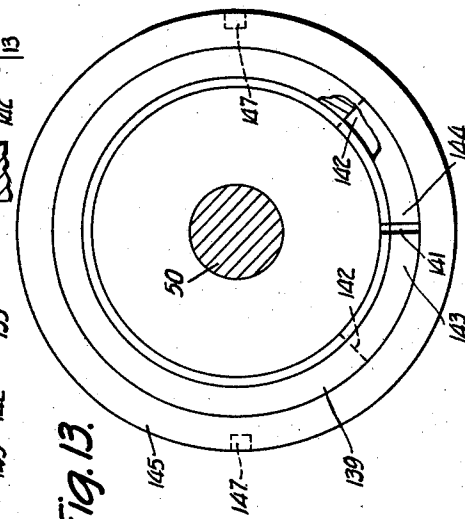
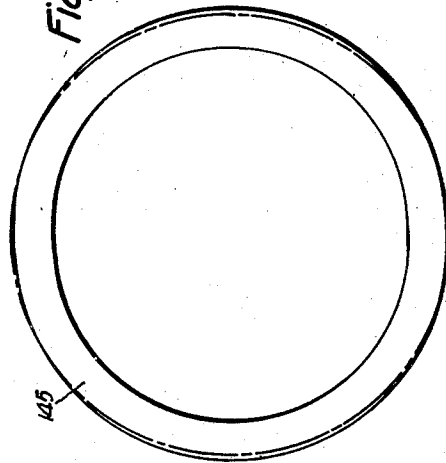
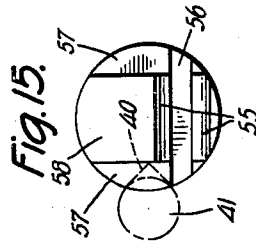
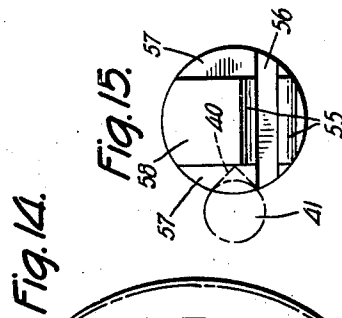
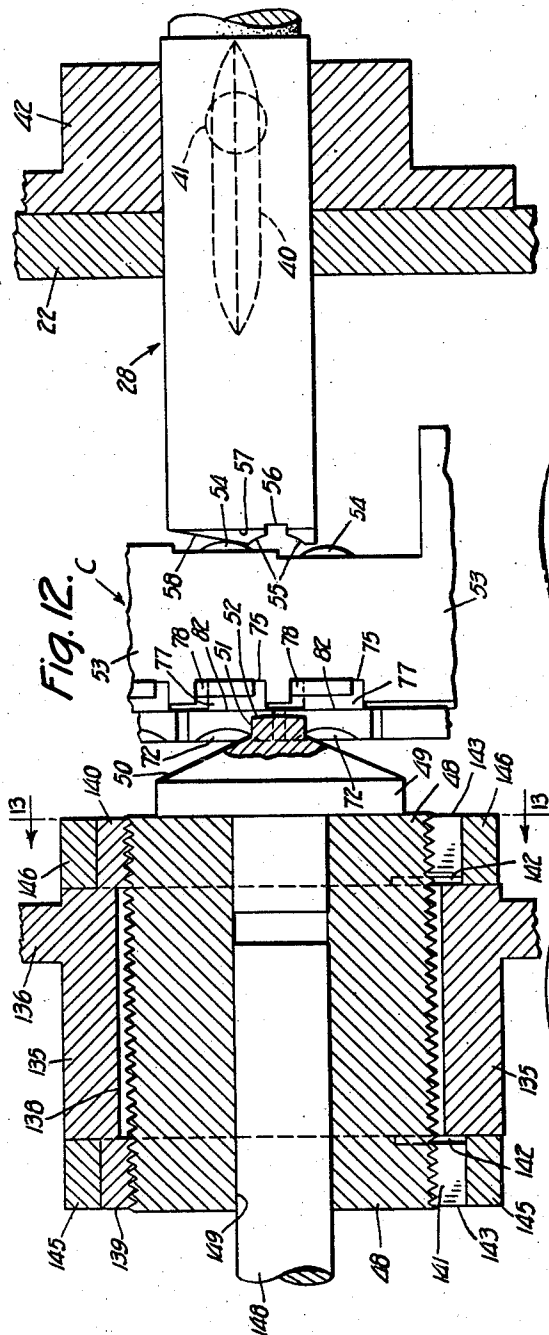
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RADIO TUNING MEANS

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7 Sheets-Sheet 7

Fig. 16.

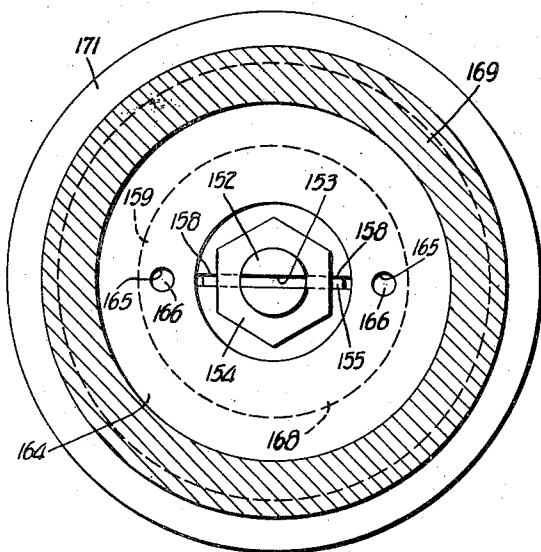


Fig. 18.

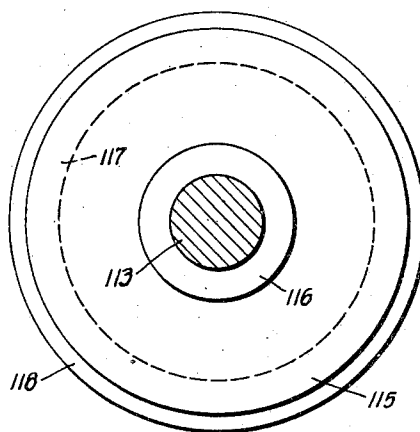


Fig. 17.

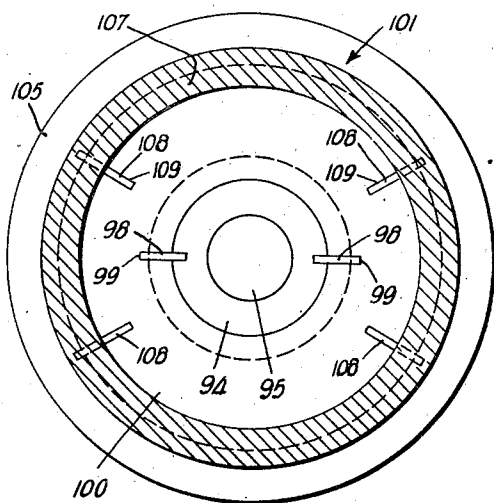
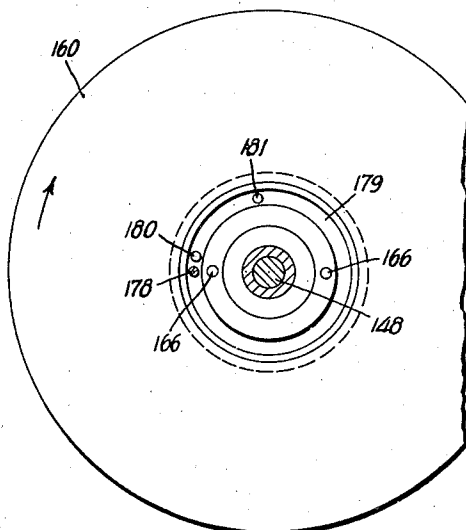


Fig. 19.



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UNITED STATES PATENT OFFICE

2,399,704

RADIO TUNING MEANS

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Original application November 6, 1942, Serial No. 464,812. Divided and this application June 2, 1944, Serial No. 538,347

7 Claims. (Cl. 250—16)

This invention relates to radio tuning means including a tuning or control member, a drive member, and intermediate movement transmitting means.

It is an important object of the invention to provide in radio apparatus a tuning inductor having relatively movable elements comprising a coil and a cooperating inductance changing core, a panel, supporting means at the rear of the panel to support one of the inductor elements at a distance behind the panel, drive means extending rearwardly from the panel connecting to the other inductor element to adjust its position with reference to the first, the material or materials composing said supporting means and drive means being such that changes in position of any substantial amount of one inductor element with reference to the other element due to changes in temperature of the apparatus are prevented.

A further object of the invention is to provide a radio tuning means for tuning a radio circuit over an extended range of frequencies which includes, in combination, frequency determining elements, a control member acting on one of said elements to tune the circuit, a cam provided with a plurality of steps arranged to advance the control member to a plurality of different positions within its range of adjustment in response to the movement of the cam, and a fine pitch adjusting screw in engagement with the cam and arranged to move the control member by small amounts from any position determined by the cam, within the range of adjustment of the adjusting screw.

It is a further object of the invention to provide, in combination, a radio chassis having a movable control member, resilient means arranged to support the chassis with limited freedom of movement in all directions including a rotatable member, a drive connection between the rotatable member and said movable control member, and a control knob connected to rotate the rotatable member.

Other objects and advantages will hereinafter appear.

The present application is a division of my pending application Serial No. 464,812, filed November 6, 1942, for Device for adjusting or tuning to close limits.

No claim is made herein to the details of structure of the cam per se, nor to its combination broadly with a member operated by it. Claims of this character are included in my parent application, referred to above.

For a better understanding of the invention, reference is made to the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a front view of a radio tuner embodying the invention;

Fig. 2 is a vertical sectional view of the tuner of Fig. 1 taken on the line 2—2 thereof;

Fig. 3 is a view partly in section showing the driving connections to the adjusting screw of the tuner disassembled;

Fig. 4 is a horizontal sectional view of the tuner of Fig. 1 taken on the line 4—4 thereof;

Fig. 5 is a front view with portions cut away showing the drive cam of the tuner;

Fig. 6 is a vertical sectional view of the cam shown in Fig. 5 taken on the line 6—6 thereof;

Fig. 7 is a front view, showing on an enlarged scale, one of the cam adjusting blocks and its retaining spring;

Figs. 8 and 9 show modified forms of cam adjusting blocks with their retaining springs;

Fig. 10 is a side view of the drive cam of the tuner showing also the ends of the adjusting screw and the tuner push rod;

Fig. 11 is a rear view of the cam shown in Fig. 10 also showing the end of the tuner push rod operated by the cam;

Fig. 12 is an enlarged fragmentary view partly in section showing the adjusting screw, a portion of the cam and the cooperating end of the push rod with the cam at an intermediate position between two tuner setting positions thereof;

Fig. 13 is a vertical section of the adjusting screw of Fig. 12 taken on the line 13—13 thereof;

Fig. 14 is a view of a clamping ring for a nut of the adjusting screw showing its elliptical shape before being placed in position;

Fig. 15 is a front view showing the front end of the tuner push rod;

Fig. 16 is a vertical section on an enlarged scale taken on the line 16—16 of Fig. 4 showing portions of the driving connections to the tuner adjusting screw;

Fig. 17 is a vertical section on an enlarged scale taken on the line 17—17 of Fig. 4 showing portions of the driving connections to the cam;

Fig. 18 is a vertical section on an enlarged scale taken on the line 18—18 of Fig. 4 showing the resilient supporting means for the rear end of the tuner chassis; and

Fig. 19 is a rear view of the continuous dial of the tuner and its associated parts, with the dial adjusted to its zero position.

Referring to Figs. 1, 2 and 4, the invention is

shown in connection with a radio tuner adapted to be tuned to ultra-high frequencies of the order of 100 to 125 megacycles. The tuner is especially adapted for mobile use where it may be subjected to shocks and jars caused by rough handling and to extreme changes in temperature and humidity, the tuner being constructed so that such changes have no effect on its tuning. The chassis 10 of the tuner comprises an oscillator tube 11 (see Fig. 4) provided with a tunable tank circuit 12 comprising a coil 13 formed of silver ribbon and a condenser 14 of fixed capacity whose ends are connected across the ends of coil 13. Coil 13 is wound in a helical groove formed in a cylindrical tube 15 of ceramic material which is fused to and supported by a rectangular block 16 also of ceramic material. The ends of coil 13 are soldered to a pair of silver blocks 17 which are secured to the supporting block 16 by the screws 18 which also serve as the terminals of the resonant circuit. The block 16 is clamped between the upper and lower walls 19—20 of a generally U shaped die casting 21 which extends from the rear wall 22 of a closed casing 23. The side walls 24—25 (Fig. 4) of casing 23 are secured by any suitable means (not shown) to the front wall 26 of chassis 10. The circuit 12 is tuned by means of a cylindrical powdered iron core 27 which is mounted on a push rod 28, the portion 29 of rod 28 on which the core 27 is mounted being of insulation material, as shown. Push rod 28 is guided in openings 30 and 31 provided, respectively, in the wall 22 and the rear wall 32 of the die casting 21. Push rod 28 is biased forwardly with a force preferably of a pound or more, by means of a spring 33 (Fig. 4) whose rear end is connected to a plunger 34 slidable in a cylindrical bore 35 formed in the casting 21, the plunger 34 having readily separable connection with the rear end of the rod 28 by a bar 36 which is secured to the end of plunger 34 by a screw 37. The tension of spring 33 may be regulated by means of a rod 38 to which the front end of the spring is connected, and which is clamped in position in the bore 35 by a screw 39. To prevent rotation of push rod 28 during its longitudinal adjustment, it is provided along one side thereof near its front end with a groove 40 (see Figs. 4 and 12) in which a ball 41 is seated, the ball being carried by a bushing 42 and biased inwardly by a spring 43. The bushing 42 is secured to the rear wall 22 of casing 23 by the screws 44 and is provided with a bore 30a which assists bore 30 in supporting and guiding the push rod 28 during its longitudinal adjustment.

Referring to Figs. 1, 4 and 10, the front end of push rod 28 engages a floating cam C which is mounted for both rotation and longitudinal movement, the cam being rotated by a gear 45 which is driven by a meshing gear 46 the latter gear being driven by a tuning knob 47 through connections to be later described. Rotation of the cam C by the knob 47 and gear 45 serves to rapidly tune the resonant circuit 12 in steps through a large range of frequencies in a manner to be later described. The cam C is also adapted to be moved bodily in a rearward direction to tune circuit 12 through a smaller range of frequencies by means of an adjusting screw 48 of fine pitch as, for example, 75 threads per inch. Screw 48 may be suitably made of Monel metal, and at its rear end rigidly has secured thereto a button 49 of tough steel such as Ohio Airidy (see Fig. 12). Button 49 has a conical shaped intermediate portion 50 and terminates in a tip 51 of reduced

diameter, the rear end of tip 51 being ground to have a smooth spherical curvature as indicated at 52, a suitable radius of such curvature being about 5 inches.

For a more detailed description of step cam C reference is made to Figs. 5, 6 and 7 wherein it is shown as comprising a disc shaped cam member 53 which is preferably formed as a die casting of aluminum alloy having a composition of approximately 4% copper, 6% silicon and 90% aluminum. The rear face of cam disc 53 is provided with 24 steps of increasing thickness, a hardened steel ball 54 being secured in each step in a manner described in the above noted application. The balls are of the same diameter and are all disposed at the same radius from the center of cam disc 53, the bearing face of each ball being elevated exactly .010 inch above that of the next adjacent ball. As the cam is rotated, the balls are arranged to come successively into engagement with spaced apart surfaces 55 formed on the end of push rod 28 (see Figs. 10 and 12), a deeper horizontal slot 56 being formed between the surfaces 55 so that the high point of the ball is clear of the push rod. Vertical cuts 57 are made in the end of the push rod at each side of the surfaces 55, so that both of these surfaces are of the same length to permit of their being conveniently lap finished simultaneously to a smooth finish, the radius of curvature of which is the same as that of the balls 54. From the upper surface 55 the top of the push rod tapers gradually rearwardly as indicated at 58, Figs. 10, 12 and 15. By this construction the position of the push rod at each setting of the cam is not determined by the high point of the ball, which tends to wear away more rapidly than other portions thereof, but by lower zones on the ball which have line engagement with the curved surfaces 55. The construction also operates substantially the same in either direction so that the amount of torque required to be applied to the tuning knob 47 (Fig. 4) is substantially the same whether the push rod 28 is to be stepped forwardly or rearwardly by the cam.

Cam disc 53 is mounted for rotation and longitudinal movement on a horizontal spindle 59 whose rear end is secured in a bore 60 provided in the vertical wall 22 (Fig. 6), the spindle being secured by having its end riveted over, as indicated at 61. A threaded screw 62 passes through an opening 63 provided at the center of cam disc 53, the front end of screw 62 having an enlarged cylindrical head 64 which is provided with a short shoulder 65 which engages the front face of gear 45. A member 66 formed of resilient material as, for example, Phosphor bronze is disposed between gear 45 and a forwardly extending shoulder 67 provided at the center of cam disc 53. The several parts comprising the cam are secured together by a pin 68a and a nut 68 which is threaded on the rear end of screw 62. A plurality of radial slits 69 are formed in member 66 which define a series of radially extending spring fingers 70, the outer end of each finger being provided with a short lug 71. The front face of each spring finger near the outer end thereof is cut away to form a tapered surface 72 which is deepest at the outer end of the finger, as indicated at 73, and merges with the front surface of the finger in the curve 74 (Fig. 5).

Means is provided for adjusting the thickness of cam C at the region of each ball 54. For this purpose the front surface of cam disc 53 is provided with a plurality of radially extending

grooves 75 whose bottom walls 76 are inclined at a small angle as, for example, 2 degrees with reference to a vertical plane through the front face of the cam disc, this angle being exaggerated in the drawings for the purpose of clarity. Disposed in each of the grooves 75 is a thin compensating block 77 whose front surface is vertical and whose rear surface is tapered at an inclination of the order of 2° and is seated against the bottom wall 76 of the groove 75. The rear surface of each block 77 is biased against the bottom wall 76 of its groove by means of one of the spring fingers 70, the lug 71 on which bears against the front surface of the compensating block, as shown in Figs. 5 and 6. Each block 77 is also held firmly in engagement with one side wall of its groove 75 by means of a spring 78 which is disposed between the side of the compensating block and the other side wall of the groove 75. The ends of spring 78 engage the ends of the compensating block 77 and in the form of the invention shown in Figs. 5 and 7 the inner end 79 of the spring lies flat against the inner end of the compensating block while the outer end 80 of the spring is in the shape of a hook, thereby providing an opening 81 between the outer end of the block and the end of the spring for a purpose to be later described. Since a compensating block 77 is provided opposite each ball 54 it will be readily understood that as a block is moved radially inward within its groove 75, due to the gradual slope of the bottom wall 76 of the groove, the distance between the ball 54 and the front vertical surface 82 of the block will be gradually increased, the compensating blocks thus affording a means for readily regulating the thickness of the cam within close limits at the region of each ball. The spring fingers 70, together with the springs 78, provide means for retaining the compensating blocks in their adjusted positions, so that they do not move within their grooves during operation of the radio device.

Modified forms of springs are shown in Figs. 8 and 9. In the form shown in Fig. 8 the outer end 80' of the spring terminates in a short flat portion 83 which rests against the outer end of the compensating block 77 so that if the block is pushed inwardly along its groove by means of a tool applied to the outer end 80' of the spring, all the applied force will be transmitted to the outer end of the block 77 and none of it transmitted to the bowed portion of the spring. Such force applied to the bowed portion might set up a strain therein which would remain after the adjustment of the block and possibly cause the block to creep slightly along its groove 75 for a short distance upon the operation of the device. Such creeping of the compensating block would change the thickness of the cam slightly at this region and introduce a slight error in the setting of the push rod 28.

In the form of the invention shown in Fig. 9 the outer end 80'' of spring 78'' is straight and bears against the outer end of compensating block 77'' so that any radial pressure applied to the end 80'' of the spring is entirely taken up by the compensating block, and none of it is transmitted to the bowed portion of the spring. Thus no strain is stored up in the bowed portion which might tend to cause the compensating block to creep along its groove 75 slightly during the operation of the device. An opening 84 is provided in the outer end of the block 77'' wherein the end of a tool may be inserted to pull the block out-

wardly along its groove in the cam disc 53 for a purpose to be later described.

For transmitting the rotation of knob 47 (see Figs. 4 and 17) to gear wheel 46 and cam C, the gear 46 is secured to a shaft 85 as by a pin 86, the front end of shaft 85 being enlarged to form a disc 87 to the rear surface of which a Bakelite gear wheel 88 is secured by screws 89. The shaft 85 is journaled for rotation in a tubular bearing 90 which is secured to the front wall 26 and extends through an opening 91 provided in this wall. Gear wheel 88 is in turn driven by a Bakelite gear wheel 92 which is secured to an enlarged central portion 93 of a hollow supporting hub 94 as by screws 94'. The hub 94 is journaled for rotation on a short spindle 95 whose rear end extends through an opening provided in the wall 26 and is threaded as at 96, to receive a lock nut 97 which secures the spindle 95 in position. At its front end the hub 94 is provided with a pair of outwardly extending, radially disposed thin fins 98 whose outer ends are seated in a pair of shallow grooves 99 formed in a rubber supporting collar 100. The collar 100 is in turn supported in a rotatable metallic supporting cup 101 which is disposed in a circular opening 102 in the front panel 103 of a closed casing 104 in which the radio chassis 10 is resiliently supported for a limited degree of movement in all directions. The cup 101 is provided with an outwardly extending flange 105 which bears against the rear surface of the wall 103 and tuning knob 47 is provided with a threaded screw 106 for securing it to the cup 101, the rear face of knob 47 bearing against the front surface of panel 103, as shown in Fig. 4. Cup 101 near its front end is provided with a reduced shoulder portion 107 which bears against the front surface of rubber collar 100 to take up the end thrust of such collar in a forward direction. Cup 101 is shown as provided with four fins 103 (see Fig. 17) which extend radially inwards into corresponding grooves 109 provided in the rubber collar 100 so that rotation of the cup 101 is transmitted to the rubber supporting collar 100 and by the latter through the fins 98 to the hub 94 and gear wheel 92. It will be observed in Fig. 4 that there is a clearance space 110 provided between the end of spindle 95 and the interior end wall 111 of the cup 101.

From the above description it will be readily understood that the rubber collar 100 not only serves as a portion of the means used to transmit the rotation of tuning knob 47 to cam C, but also serves as a means for resiliently supporting a portion of the chassis 10 at its front end with limited freedom of movement in all directions within the casing 104.

The means for resiliently supporting the rear end of the chassis for limited movement in all directions comprises a vertically disposed narrow plate 112 (see Figs. 2 and 4) to the upper end of which is secured a short cylindrical stud 113 which is disposed in a central opening 114 formed in a rubber supporting collar 115. The stud 113 has an enlarged flange portion 116 whose rear surface bears against the front surface of rubber collar 115 and transmits any rearward thrust of the chassis 10 to the center portion of the rubber collar. Such end thrust is taken up by a shoulder 117 provided on a hollow supporting cup 118 in which the collar 115 is seated and which is secured in a fixed position on the rear vertical wall 119 of casing 104 by a threaded screw 120.

For indicating the tuning of circuit 12 and the setting of core 27 as determined by the rotation of knob 47, gear 88 drives a Bakelite gear wheel 121 (see Figs. 1 and 4) to whose front face is secured by pins 122 a thin metallic disc 123. Disc 123 carries near its outer periphery a Bakelite ring 124 whose front face constitutes a graduated dial 125, the graduations being discontinuous and shown as extending from 100 to 124 megacycles, see Fig. 1. These graduations appear behind a glass 126 set in a window opening 127 provided in front panel 103, a suitable index mark 128 being provided on panel 103. At their centers gear wheel 121 and disc 123 are secured to a hub 129 which is mounted for free rotation on the peripheral surface of the rear end portion of a hollow outboard bearing member 131. Bearing member 131 is secured in fixed position on the chassis wall 26 by a retaining collar 132 which extends inwardly and overlies an outwardly projecting flange 133 formed at the rear end of member 131. Collar 132 is secured in position on wall 26 by any suitable means, as by the screws 134. The rotation of the cam C and the dial 125 are limited to less than one revolution by two stops 130 on the gear 121 which engage with a pin 130a fixed on the plate 26.

Referring to Figs. 4, 12 and 13, adjusting screw 48 is supported for rotation in a hollow supporting nut 135 which is provided with an outwardly extending flange 136 through which pass securing screws 137 which secure the nut to the vertical wall 26. Throughout its center portion nut 135 is cut away as indicated at 138, to provide a clearance space between the center portion of adjusting screw 48 and the center portion of the nut. The front and rear end portions 139 and 140 of the nut are interiorly threaded to receive the screw 48 and at the bottom each of the end portions 139—140 is cut vertically as indicated at 141, Fig. 13, and is also cut vertically in a direction normal to the axis of screw 48 at a distance from the end of the nut as indicated at 142. Two threaded loading fingers 143 and 144 are thus formed which may be forced slightly inwardly to load the screw 48 and eliminate the major portion of the backlash between the screw and nut. Each end portion 139 and 140 of the nut has its outer surface cut away to receive a pair of clamping collars 145—146 which are slightly elliptical in shape before being placed in position on the nut portions 139 and 140, the eccentricity of the members 145—146 being shown on an exaggerated scale in Fig. 14 in which the dot and dash line represents a circle. Each clamp member 145 and 146 is provided with a pair of shallow bores 147 adapted to receive the end of a spanner wrench used for rotating the clamp to bias its loading finger 143—144 into firm engagement with the threads of screw 48. It will also be understood that any wear of the threads of screw 48 resulting from the continued use of the device may be taken up by slightly rotating the clamping collars 145 and 146 on the nut. The illustrated means for supporting the adjusting screw by nut portions which engage the threads of the screw at spaced apart regions thereof provides against any sidewise, vertical or endwise undesired motion of the screw in the nut so that only the desired longitudinal movement of the screw due to its rotation is secured.

Screw 48 is rotated by means of a short shaft 148 whose rear end extends into a bore 149 provided in the screw and is a drive fit in the bore (see Figs. 4 and 12). Shaft 148 is firmly sup-

ported for rotation in a forwardly projecting hub 150 formed on the outboard bearing member 131 and which is connected thereto by a radial flange 151. The front end of shaft 148 (see Figs. 3 and 4) is threaded as at 152, and is provided with a thin longitudinally extending slot 153, a nut 154 being screwed on to the threaded end portion thereof. Nut 154 engages the front end of a thin flat key 155 whose inner end 156 becomes seated against the rear wall 157 of the slot 153. The outer ends 157 of the key are disposed in a narrow slot 158 formed in the front end of a rotatable hollow cup member 159 which is supported for rotation on the supporting hub 150. Cup 159 has secured to its outer periphery a thin circular disc 160 whose front surface constitutes a graduated dial 161 whose graduations are continuous and disposed closely adjacent to those of the dial 125 and appear through a circumferentially extending portion 162 of the window opening 127 (see Fig. 1). An index mark 163 is formed on the panel 103 adjacent to the graduations of dial 161. The hollow cup 159 is rotated by means of a rubber supporting collar 164 which is provided with a pair of holes 165 into which extend a pair of forwardly projecting pins 166 which are carried by the cup 159. The front end 167 of cup 159 is reduced in diameter to provide a shoulder 168 which engages the rear face of rubber collar 164, as shown in Fig. 4. Rubber collar 164 is seated in a hollow retaining cup 169 which is rotatable in a bore 170 provided in the front panel 103, the cup 169 having at its end an outwardly turned flange 171 which engages the rear face of the panel. The cup 169 is in turn rotated by a tuning knob 172 which is secured to the cup by a set screw 173, the rear face 174 of the knob 172 being disposed against the front surface of the vertical panel 103, as shown in Fig. 4.

The front face of rubber collar 164 near its periphery bears against a shoulder 175 provided on the retaining cup 169. The rubber supporting collars 100 and 164 thus provide means for resiliently supporting the front portion of the radio chassis 10 at spaced apart regions thereof with limited freedom of movement in all directions within the casing 104 while the rubber collar 115 similarly supports the rear portion of the chassis. Any forward movement of the chassis which might result from shocks or vibrations imparted thereto is limited by the rubber collars 100 and 164 which absorb the shock and transmit it to the panel 103, the portion of collar 164 within the shoulder 175 on cup 169 bulging forward slightly, a suitable clearance space 176 being provided beyond the front end of adjusting screw shaft 148 for this purpose. The portion of rubber collar 100 disposed inwardly of the shoulder 107 on cup 101 similarly bulges forward a slight amount. Any rearward movement of the chassis resulting from shock or vibration is limited and absorbed by the rubber collar 115, the portion thereof which is disposed inwardly of the shoulder 117 on supporting cup 118 bulging rearwardly a slight amount, a suitable clearance space 177 being provided at the rear of collar 115 for this purpose. Any vertical or sidewise movement of the chassis 10 resulting from shock or vibration is transmitted to and absorbed by all three of the rubber collars 100, 115 and 164.

The rotation of adjusting screw 48 and continuous dial 161 is limited to substantially three-fourths of a revolution by means of a pin 178 (Figs. 4 and 19) which is set in the flange 151 and projects forwardly into a shallow circular groove

179 provided in the rear face of cup 159. A pair of spaced apart pins 180, 181 (Fig. 19) are set in the rear face of cup 159 and extend rearwardly into the groove 179 where one or the other of them comes into engagement with the pin 178 as the tuning knob 172 is rotated to its extreme position in one direction or the other. A thin washer 182 (Fig. 4) is interposed between the dial disc 160 and the flange 151 to separate the dial disc 160 slightly from dial disc 123 so that the two dials do not rub together.

Referring to Figs. 1 and 2, the ceramic block 16 is shown as also supporting a compressed powdered iron block 183 shown as having an arcuate upper face 184. The block 183 is adjustably secured in position on supporting block 16 by a pair of screws 185 which pass through narrow vertical slots 186 formed in the block 16.

A suitable material for the compensating blocks 77 is #440 stainless steel which has been hardened to a degree of 62 Brinell. The steel balls 54 are preferably nitrided to harden their surfaces while the push rod 28 may be made of Ohio Airdy steel. The nut 135 may be made of Tobin bronze, and the springs 78 and 33 of Phosphor bronze. The device is designed to prevent any change in position of substantial amount of the iron core 27 with reference to its coil 13 due to changes in temperature of the apparatus. This compensation is secured not by making the apparatus of relatively non-expanding material such as Invar, but by assuring that the parts which determine the distance between core 27 and coil 13 and the front wall 26 expand and contract together by equal amounts so that the relative position of the core and coil remains unchanged.

In using the radio tuner the dial 125 is set at 124 and the dial 161 is set at 1000. The coil 13 is now adjusted lengthwise of push rod 28 by slightly spreading apart the upper and lower walls 19 and 20 of the die casting 21, see Figs. 1, 2 and 4, a special expanding tool (not shown) being provided for this purpose, whereupon the coil supporting block 16 is slid along the walls 19 and 20 until the oscillator circuit 12 is tuned to exactly 125 megacycles, as indicated by the sum of the readings on the dials 125 and 161. The expanding tool is then removed, whereupon the supporting block 16 becomes firmly clamped in position by the walls of casting 21, it being found that this clamping action is adequate to prevent the supporting block from moving thereafter even when the radio tuner is subjected to sudden shocks or considerable vibration. The core 27 is now in its extreme forward position with reference to coil 13, cam disc 53 is in the position shown in Figs. 5, 6, 10 and 11, and the bearing surfaces 55 on the end of push rod 28 are in engagement with the lowest ball 54, as shown in Fig. 10. Knobs 47 and 172 are now rotated in a clockwise direction until dial 125 reads 100 and dial 161 reads zero, which adjustment moves the push rod 28 and core 27 to their extreme rearward position. The iron block 183, see Figs. 1 and 2, is then raised or lowered until the oscillator circuit 12 is tuned to 100 megacycles, whereupon the block is secured in fixed position by tightening the screws 185. The adjustment of this block has the effect of changing the slope of the tuning curve of resonant circuit 12. After such adjustment of the circuit to the indicated frequencies, rotation of knob 172 and adjusting screws 48 counterclockwise, as indicated by the arrow in Fig. 1, for a distance of one division on continuous dial 161 permits the cam C and push rod 28 to be moved forwardly

a distance .0001 inch, thereby tuning the circuit 12 to a frequency of 100,010 kc. as determined by taking the sum of the readings on dials 125 and 161. The knob 172 is now rotated another dial division of dial 161 which causes push rod 28 and core 27 to be moved forwardly another .0001 inch under the bias of spring 33 and oscillator circuit 12 to be tuned to the frequency of 100,020 kc., as determined by adding together the two dial readings. When the knob 172 has thus been rotated through 100 dial divisions of dial 161, the circuit 12 will be tuned to 101 megacycles and the iron core 27 will have been adjusted .010 inch forwardly of its initial position. By now rotating the knob 172 and dial 161 to their initial or zero positions, push rod 28 and core 27 will be moved rearwardly by screw 48 to their initial position, and the frequency of oscillator circuit 12 will again be 100 megacycles. By now rotating knob 47 counterclockwise, as indicated by the arrow in Fig. 1, until the outer dial 125 reads 101 megacycles, the cam disc 53 is rotated until the next lower ball 54 thereon comes into engagement with the bearing surfaces 55 of push rod 28. Under the bias of spring 33, the push rod is moved forwardly a distance of .010 inch and causes the circuit 12 to be tuned to the indicated dial reading of 101 megacycles. Any slight inaccuracy of the tuning to this frequency may be compensated for by the operator withdrawing a screw 187 from a threaded opening 188 provided in the cam casing 23, see Figs. 2 and 4. A special micrometer head (not shown) provided for this purpose is now inserted in the opening 188, the end of the micrometer screw engaging the end 80 of spring 78, Fig. 7, and by rotating the micrometer screw the compensating block 77 which is in engagement with curved end 52, Fig. 12, of adjusting screw 48 is moved inwardly within its groove 75 to move cam disc 53 and push rod 28 rearwardly a suitable amount until circuit 12 is tuned to the desired frequency. Should the compensating block be adjusted inwardly in its groove slightly too far, the micrometer head is withdrawn from the opening 188 and a tool inserted therethrough which has a projecting end portion which may be inserted within the opening 81, Fig. 7, of spring 78, then by pulling on the tool the compensating block may be pulled outwardly in its groove a substantial amount. After removing such tool, the micrometer head is again inserted in the opening 188 and the compensating block 77 moved inwardly in its groove by the micrometer screw until the correct resonant frequency of circuit 12 is secured.

The radio tuner may now be tuned consecutively through the next one hundred settings by rotating the knob 172 and dial 161 consecutively through one hundred divisions of this dial one by one until the dial reads 1000, when the circuit 12 will be tuned to 102 megacycles and push rod 28 will be .020 inch forwardly of its initial position. By now rotating knob 172 clockwise until continuous dial 161 reads zero and then rotating the knob 47 and dial 125 counterclockwise until a reading of 102 megacycles appears on this dial, the third ball 54 on cam disc 53 will have been brought into engagement with the bearing surfaces 55 on push rod 28 and the circuit 12 will be again tuned to 102 megacycles. Any slight inaccuracy of the tuning for this dial position may be corrected in the manner above described by adjusting the compensating block 77 which is now in engagement with the end 52 of button 49 in its groove by the micrometer device in the

manner above described. By continuing this operation repeatedly the circuit 12 may be tuned through all the frequencies corresponding to the 2500 dial settings and the tuning of the circuit adjusted to the desired value for each of the divisions on the outer dial 125 by adjusting the compensating blocks 77 in their grooves in the manner above described. It will be understood that, after all the compensating blocks have been appropriately adjusted, the screw 187 will again be screwed into the threaded opening 188, Figs. 2 and 4, thereby sealing the cam C, adjusting screw 48 and their associated parts in the casing 23 against the entrance of dust or dirt particles which might otherwise collect on different parts of the mechanism and destroy its accuracy by interfering with its proper operation. The radio tuner is then ready for operation, and it is found that within the short interval of four seconds the oscillator circuit 12 may be readily tuned from any frequency to any of the other frequencies corresponding to the 2500 different dial readings.

If it is desired to advance the push rod 28 rearwardly step by step by rotating the knob 47 and cam C clockwise, when the rotation of the cam is commenced the tapered surface 72 on the front of spring finger 70 (Figs. 5, 10 and 12) immediately comes into engagement with the conical surface 50 of button 49 and exerts a component of force on the spring finger and its underlying compensating block 77 which pushes the cam C rearwardly along its supporting spindle 59 into the position shown in Fig. 12, so that the end 51 of button 49 clears the edge of the next adjacent compensating block as this block is brought into position by the rotation of the cam. When the front face 82 of the next compensating block has been brought opposite the curved surface 52 on the end of button 49, the tapered surface 72 on its spring finger 70 rides down the conical surface 50 as the rotation of cam C continues and the cam moves forwardly under the bias of spring 33 (Fig. 4) until the spring finger is entirely clear of button 49 and the front face 82 of the block is in engagement with the curved surface 52 defining the end of button 49.

Referring to Fig. 9, the compensating block 77 is adjusted inwardly along its groove 75 in the cam by placing the end of the aforescribed micrometer screw in engagement with the flat end 80 of its spring, and then rotating the micrometer screw a suitable amount. Should the compensating block accidentally be moved too far inwardly, it may be withdrawn by placing the end of the aforementioned tool in the hole 84 in the block and pulling the block outwardly in its groove, after which the block may be again moved inwardly by the micrometer screw to the correct position.

While the invention has been illustrated in connection with the tuning of an oscillator circuit, it will be understood that additional iron cores may be mounted on push rod 28 to tune the radio frequency circuits of a radio receiver or other radio device, in the manner illustrated and described in my aforementioned application. Furthermore, the push rod 28 may be used to operate an adjustable gage used for measuring the size of articles as illustrated in my aforementioned application or for operating the controlled element of any other device which is required to be adjusted within close limits.

While I have illustrated my invention as including a step cam as a spacing means for effecting different positions for the operated rod

or member 28, each of which cam steps as described differs uniformly in thickness from the preceding one of said cam steps, it will be understood that for some purposes these cam portions may have any desired different thicknesses to meet the requirements of different purposes of use, whether the limited amount of movement of the screw or continuously operated drive member 48 is equal to the difference between successive thicknesses of the cam or not. It will further be understood that my invention is adapted for use where lesser degrees of accuracy of movement are permissible than for the uses described. For example, for the purpose of the relatively general grading or grouping of objects as to size, or the resonant selection of radio stations from a relatively small group of such stations such as the broadcast band, the high degree of accuracy described may not be required. In such cases the spacing means or cam C need not be provided with the balls 54, but may be an integral structure made from a single metal block with a degree of accuracy, in any case, that is commensurate with the intended purposes of the structure. I have described what I believe to be the best embodiments of my invention. I do not wish, however, to be confined to the embodiments shown, but what I desire to cover by Letters Patent is set forth in the appended claims.

I claim:

1. Radio apparatus comprising, in combination, a tuning inductor having relatively movable elements comprising a coil and a cooperating inductance-changing core, a panel, supporting means at the rear of the panel arranged to support one of said inductor elements at a distance behind the panel, drive means extending rearwardly from the panel connected to the other inductor element to adjust its position with reference to said one inductor element, the materials composing said supporting means and drive means having coefficients of expansion such that changes in position of any substantial amount of one inductor element with reference to the other element due to changes in temperature of the apparatus are prevented, and a control knob disposed in front of the panel for actuating said drive means.

2. In combination, a supporting structure having an opening therein, a radio chassis having a movable control member, means arranged to support the chassis with limited freedom of movement in all directions including a resilient rotatable member mounted in said opening and carried by said supporting structure, a drive connection between the rotatable member and the said movable control member, and a control knob connected to rotate said rotatable member, said drive connection including a shaft supported on the chassis and interfitted with the resilient member.

3. In combination, a supporting structure having a plurality of openings therein, a radio chassis having a movable control member, means arranged to support the chassis with limited freedom of movement in all directions including a resilient rotatable member mounted in each of said openings and carried by said supporting structure, a drive connection from one of said rotatable members to said control member arranged to adjust the control member to any one of a plurality of positions, and a drive connection from another of said rotatable members to said control member arranged to adjust the con-

trol member through a limited range of continuous movement from the position to which it has been adjusted by said one rotatable member, said drive connections including a shaft supported on the chassis and interfitting with the resilient member.

4. In combination, a vertical panel having an opening therein, a radio chassis disposed behind the panel and having a movable control member; means arranged to support the chassis with limited freedom of movement in all directions, said supporting means comprising a drive member formed of flexible material and disposed in the panel opening; a drive connection between said drive member and said movable control member, and a control knob disposed in front of the panel and connected to actuate said drive member through a desired range of movement, said drive connection including a shaft supported on the chassis and interfitting with the resilient member.

5. In combination, a vertical panel having at least two openings therein, a radio chassis disposed behind the panel and having a movable control member; resilient means arranged to support the chassis with limited freedom of movement in all directions, said supporting means comprising drive members formed of flexible material and disposed in said panel openings, a drive connection between one of said drive

members and the movable control member arranged to advance the control member to any one of a plurality of positions, a drive connection between the other of said drive members and the movable control member arranged to continuously advance the control member through a limited range of movement from the position to which it has been previously advanced, and control knobs disposed in front of the panel and connected to actuate said drive members.

6. A radio device as claimed in claim 5 in which the movable control member is supported on the chassis for longitudinal movement and the drive members are supported for rotation in the panel openings.

7. In combination, a radio chassis having a movable control member, a rotatable supporting member formed of resilient material and arranged to support at least a portion of the weight of the chassis, a drive shaft connected to the said control member and arranged coaxially with the supporting member, means connecting the supporting member and drive shaft arranged not only to transmit torque to the drive shaft but to permit limited endwise movement of the drive shaft in the supporting member, and a control knob adapted to rotate the said supporting member.

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