April 2, 1929. H. F. ELLIOTT 1,707,948

TUNING SYSTEM

Original Filed Nov. 27, 1926 5 Sheets-Sheet 1

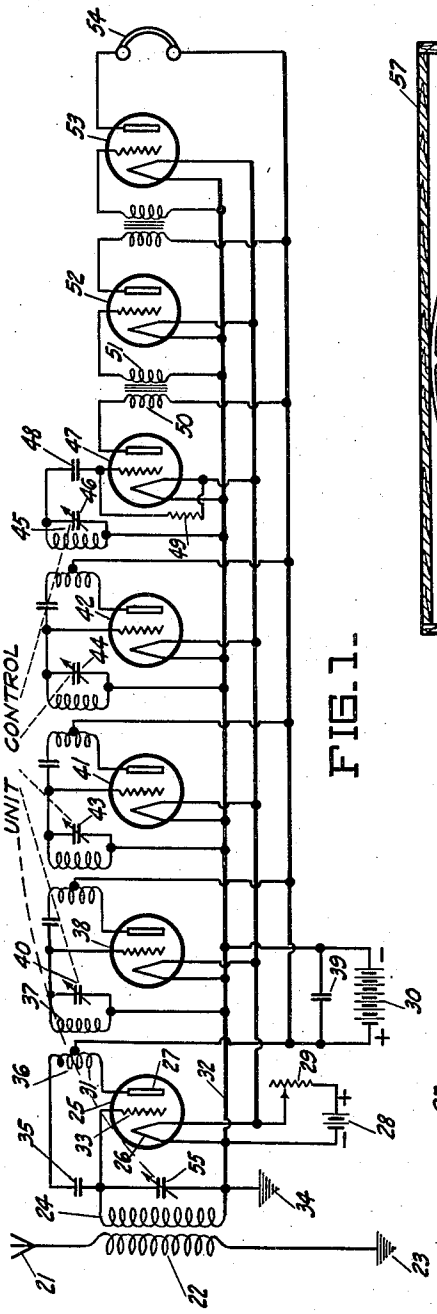


FIG. 1.

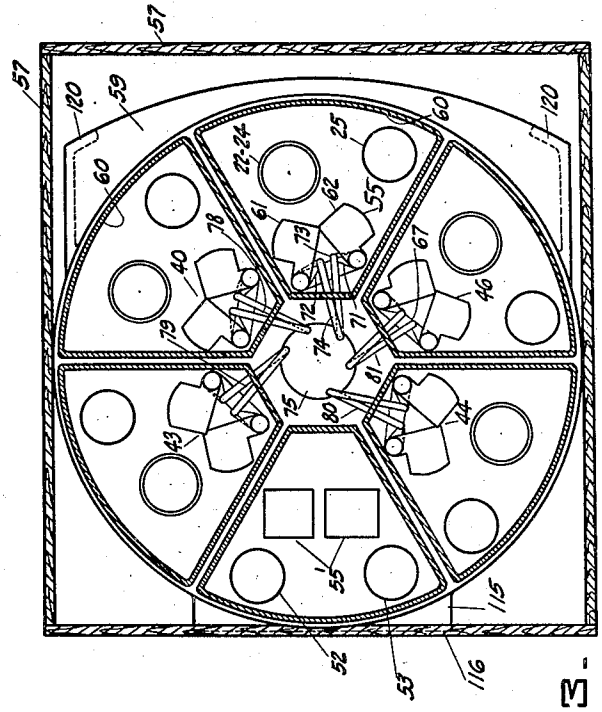


FIG. 3.

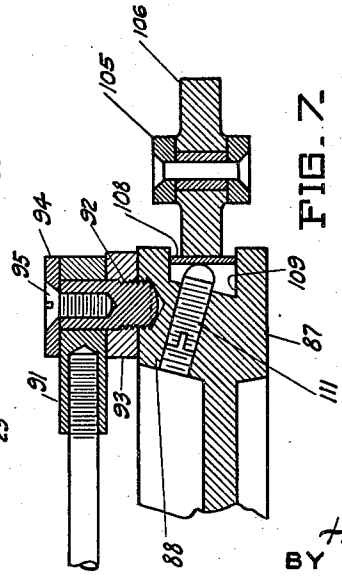


FIG. 7.

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TUNING SYSTEM

Original Filed Nov. 27, 1926 5 Sheets-Sheet 2

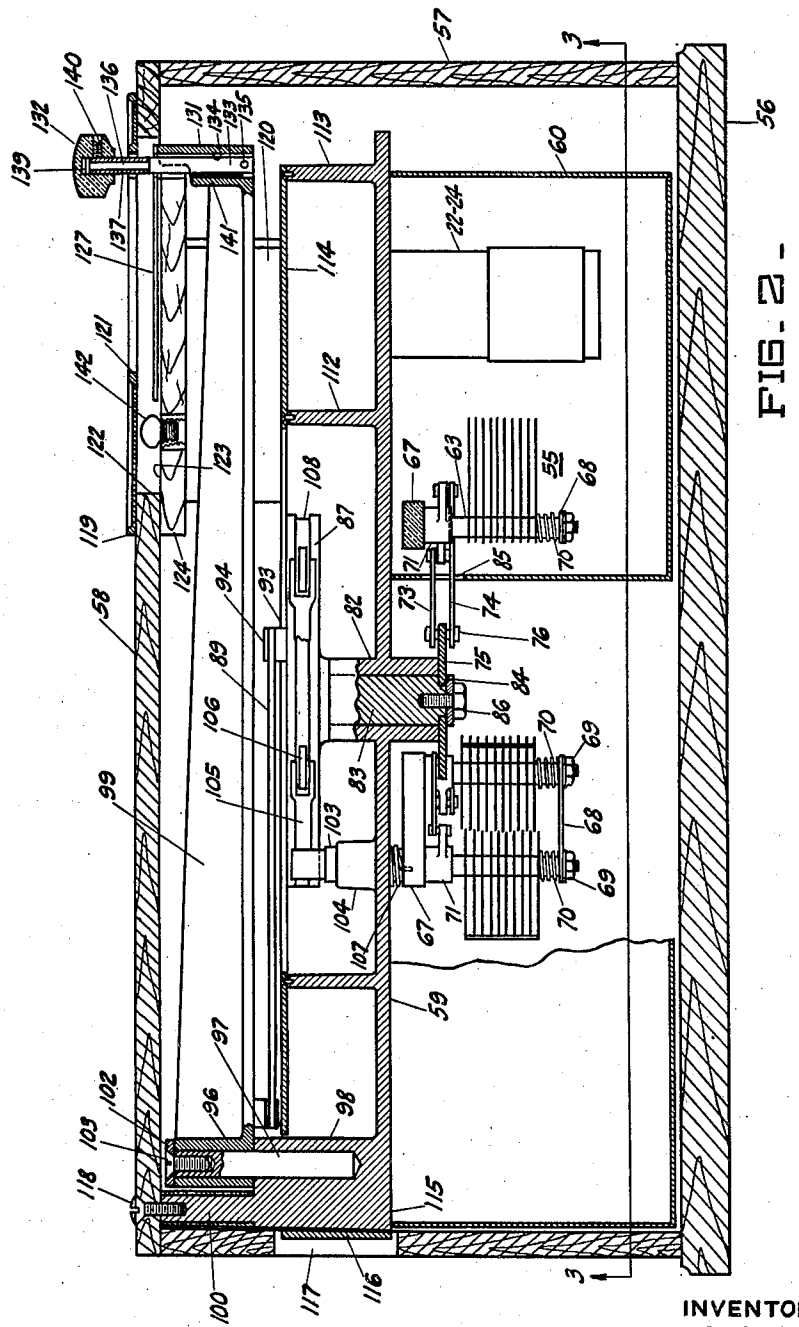


FIG. 2.

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Original Filed Nov. 27, 1926 5 Sheets-Sheet 3

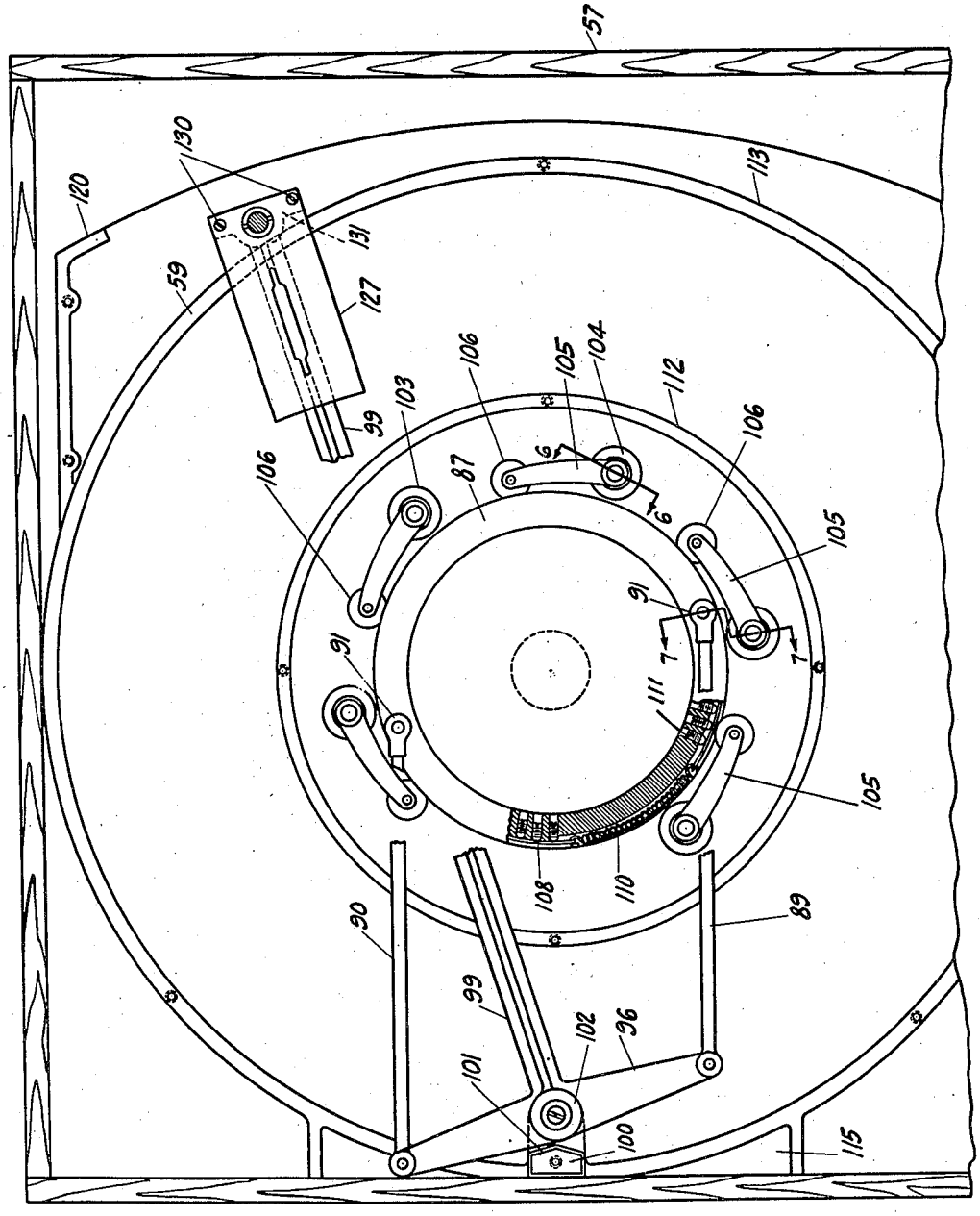


FIG. 4.

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TUNING SYSTEM

Original Filed Nov. 27, 1926 5 Sheets-Sheet 4

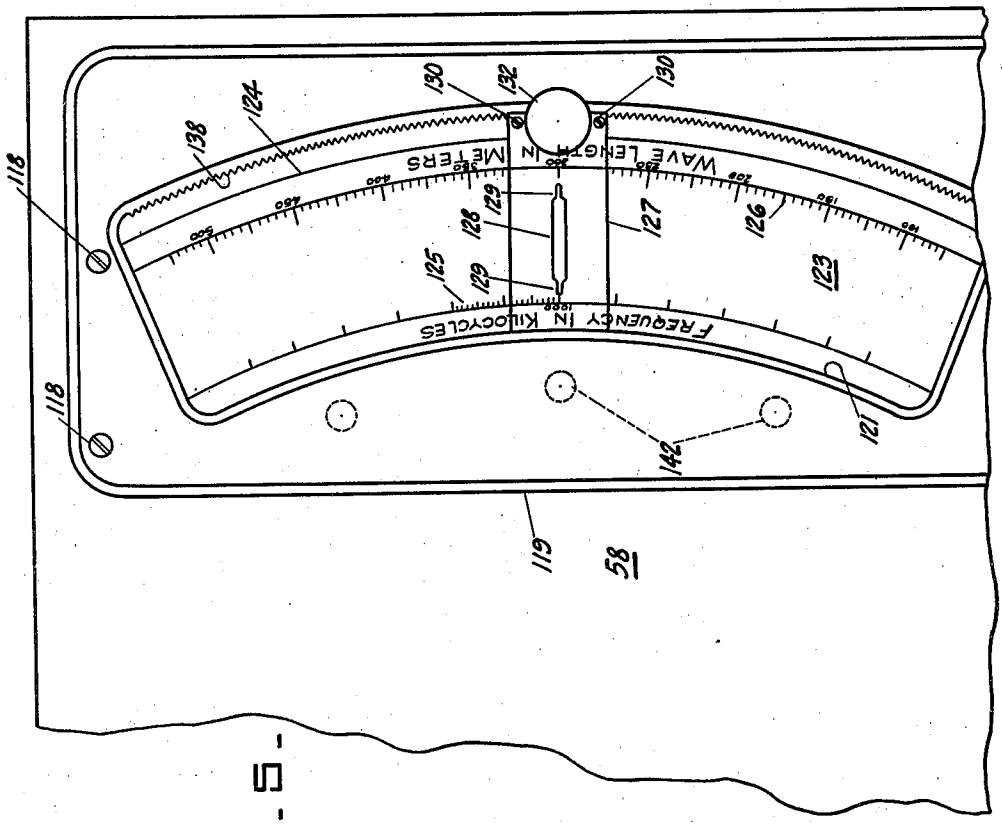
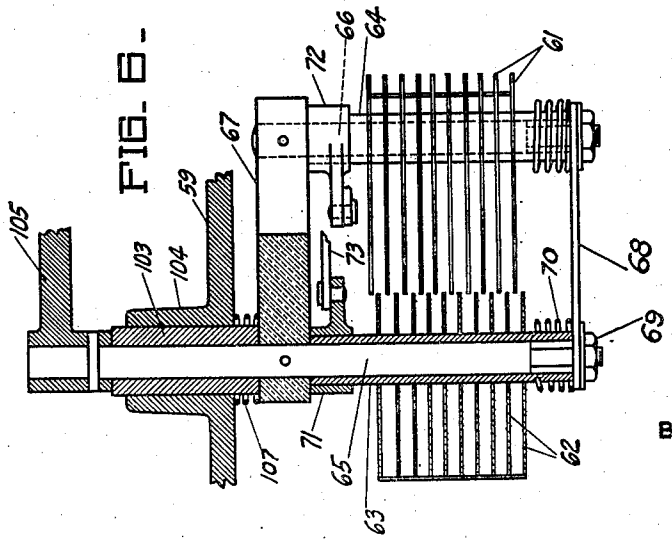


FIG. 5.

FIG. 6.



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TUNING SYSTEM

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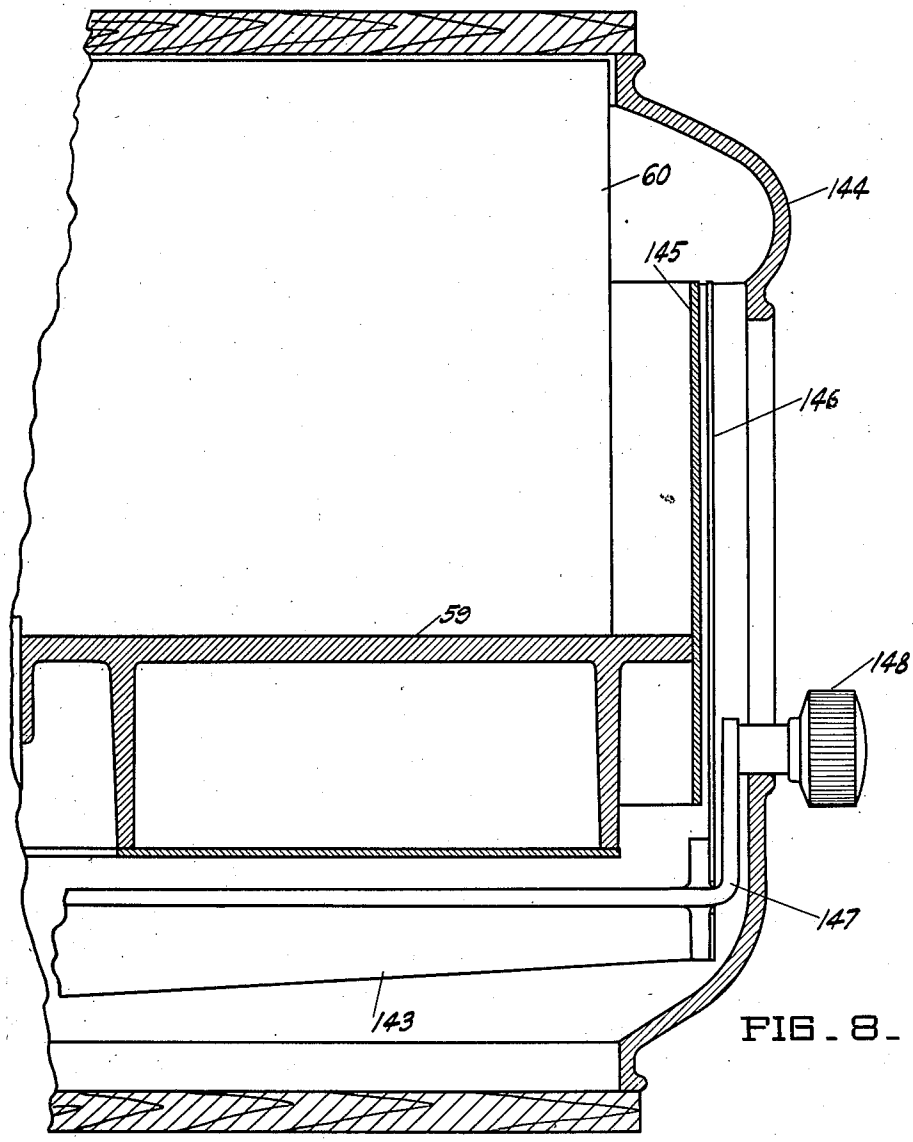


FIG. 8.

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Patented Apr. 2, 1929. 1,707,948

UNITED STATES PATENT OFFICE.

HAROLD F. ELLIOTT, OF PALO ALTO, CALIFORNIA, ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, TO VICTOR TALKING MACHINE COMPANY, OF CAMDEN, NEW JERSEY, A CORPORATION OF NEW JERSEY.

TUNING SYSTEM.

Application filed November 27, 1926, Serial No. 151,134. Renewed August 21, 1928.

This invention relates to radio, and more particularly to a system for receiving radio energy.

In my prior application, Serial No. 119,114, filed June 28, 1926, and entitled "High frequency tuning system," I describe several forms of mechanical tuners, such as variable condensers or inductances, whereby a plurality of tunable circuits can be simultaneously tuned and kept in proper tuned relation with each other over the entire range of tuning. This was accomplished by the aid of an element, such as a cam associated with each tuner, and having an adjustable surface so that the tuning characteristic of the associated tuner can be closely adjusted.

As clearly explained in my prior application many receiving systems include two or more tunable circuits connected in tandem relation in order to increase selectivity; and prior proposals, based upon mere simultaneous adjustment of the tuning elements, for securing simplicity of operation, have been impracticable. This results because it is practically impossible to compensate for stray or parasitic capacities and inductances. The net result is a definite loss in sharpness, the circuits not being accurately in alinement except possibly in one or two settings.

By the aid of a cam for operating each tuner, which can be accurately adjusted at the factory for compensating for these irregular variations, these disadvantages can be easily overcome. It is an object of the present invention to simplify the structure materially, over what is shown in my prior application.

This I am able to accomplish by providing only one adjustable cam, compensating the irregularities of all of the circuits, about which cam all of the tuners are arranged.

It is still another object of my invention to provide a novel and simple form of mechanism for operating the tuners.

Another object is to provide novel means for effecting the compensating adjustment of the tuners from the adjustable cams.

A further object is to provide novel means whereby the tuners may be operated normally and a supplemental adjustment of the tuners may be effected independently of the normal operation thereof to compensate for inequalities of the circuits in which the tuners are connected.

A further object is to provide a common actuator for a plurality of tuners and novel means whereby movement of the common actuator effects simultaneous normal operation of the tuners and individual supplemental compensating adjustment of the tuners independently of the normal operation thereof.

Another object is to provide a common actuating means for a plurality of tuners including a suitable indicating device and connections between said actuating means and tuners, the whole providing varying increments of movement of the tuners for equal increments of movement of the actuating means such that the relation of the values of the circuit in which the tuners are connected to the movement of the indicating device is substantially linear.

It is still another object of my invention to provide a compact, inexpensive receiving set.

It is still another object of my invention to provide a simple and novel tuning device that can be very quickly adjusted for coarse adjustment, and yet render it available at any time for fine adjustment.

My invention possesses many other advantages, and has other objects which may be made more easily apparent from a consideration of several embodiments of my invention. For this purpose I have shown a few forms in the drawings accompanying and forming part of the present specification. I shall now proceed to describe these forms in detail, which illustrate the general principles of my invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of my invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a schematic wiring diagram illustrating one form of receiving system in which my invention can be incorporated;

Fig. 2 is a vertical view, mainly in section, of a receiving set incorporating my invention;

Fig. 3 is a horizontal sectional view taken along plane 3—3 of Fig. 2;

Fig. 4 is a top plan view of the receiver with the cover and its associated parts removed, and some of the parts broken away, in order to disclose the structure clearly;

Fig. 5 is a fragmentary top plan view of the receiver, showing the form of the dial, and its associated parts;

Fig. 6 is an enlarged detail section, taken along plane 6—6 of Fig. 4;

Fig. 7 is an enlarged detail section, taken along plane 7—7 of Fig. 4; and

Fig. 8 is a fragmentary sectional view of a modified form of dial arrangement.

In Fig. 1, I illustrate a conventional form of radio receiving system that can be made to incorporate my invention. This system is used merely as an illustration of many other forms of systems that could as readily be used. It incorporates four stages of radio frequency amplification by the aid of thermionic amplifiers, as well as a thermionic detector and two thermionic amplifiers operating at audio frequencies. The number and arrangement of stages of amplification could obviously be varied. Furthermore, I indicate a neutralizing scheme for each radio frequency stage, in order to annul substantially the effect of the parasitic capacity between the electrodes of the amplifier tubes, and thus to ensure stable operation; but obviously this too, could be modified or omitted. The important point is that such systems, of which this is typical, include variable tuning devices in some or all of the stages of radio frequency amplification, whereby selectivity is improved.

More specifically, there is indicated a conventional form of absorbing circuit, including antenna 21, inductance 22, and a ground connection 23. Coupled to the inductance 22 is a coil 24, which serves to impress upon the first radio frequency stage, E. M. F.'s induced in it by the energy absorbed in the absorbing circuit. In order to amplify the signaling impulses thus received, the amplifier tube 25 is utilized, which is in the form of a sealed vessel evacuated to a high degree, and having therein several electrodes. One of the electrodes, such as 26, serves as a source of electrons, which flow across the tube to another electrode, such as a plate 27. In order to cause electrode 26 to emit electrons, it is made in filamentary form, and is heated by current passed through it from the source 28, such as a battery. The current can be regulated to vary the intensity of electron flow, as by rheostat 29. Futhermore, in order that plate 27 attract the electrons, it is kept at a potential positive with respect to the filament 26, by the aid of a source of uniform potential, such as battery 30. The space current (that is, the current supported by the electronic flow in the tube space) has a completed path, from the positive terminal of battery 30, through a coil 31, plate 27, filament 26, and connection 32 back to the negative terminal of battery 30.

It is a well-known phenomenon that the intensity of electron emission can be controlled by controlling the potential of a point in the path of the electrons, and this is usually done by the interposition of a third electrode 33 between the other two, serving as a control electrode. This control electrode is usually in the form of a grid. Minute variations in the potential difference between filament 26 and grid 33 cause correspondingly larger variations in the space current and it is due to this feature that the amplification is secured. The large fluctuations in space current, passing through coil 31, sets up large E. M. F. fluctuations utilized in succeeding stages. The E. M. F.'s existing across coil 24 are therefore impressed between the grid 33 and filament 26, whereby space current fluctuations in the output circuit of tube 27 are produced. As is customary, the filament 26 may be grounded, as indicated at 34.

In order to neutralize the effect of the capacity coupling between the plate 27 and grid 33, which coupling might otherwise cause the tube 25 to produce undesired oscillations, I indicate a circuit connecting these electrodes, and including a condenser 35 and a coil 36, coupled magnetically to coil 31 in the output circuit. It can readily be demonstrated that when such a circuit is properly designed, the E. M. F.'s in the coil 31 due to the parasitic coupling, are neutralized therein. All this is well understood, and is included here merely for the purpose of completing the disclosure.

The description of the first stage of amplification is now complete. In this instance, succeeding stages are inductively coupled; and for this purpose, coil 37 is coupled to coil 31, these coils forming an air core radio frequency transformer. This coil serves to impress an amplified E. M. F. upon the input electrodes of the succeeding amplifier tube 38, the scheme of connections being substantially identical as already described in connection with tube 25. The filament is heated from the source 28, and the plate voltage is secured from the battery 30, which is bridged by a radio frequency by-pass condenser 39. However, an arrangement is provided whereby the input circuit for this tube is tuned. This is accomplished by a variable condenser 40 bridging coil 37. It is well known that when the condenser 40 and coil 37 form a tuned circuit at the frequency of reception (which means that the capacity reactance is exactly equal to the inductance reactance), then the E. M. F. existing across either the coil 37 or condenser 40 is a maximum, and if the circuit is properly designed, this maximum is sharply defined, and is very rapidly reduced even for slight departures from resonance conditions. It is this feature which makes it possible, by a series of tuned circuits, to provide a high degree of selectivity. The first input stage is in this instance also shown as tuned, as by the aid of condenser 55 bridging coil 24.

The succeeding amplifier stages utilizing

tubes 41 and 42 may be coupled in succession in a manner entirely similar to that already disclosed. Each stage includes in its input circuit, a variable condenser 43 or 44. Any further number of radio frequency stages can if desired, be added; but since the principle is the same, only four radio frequency stages are shown.

The last stage of radio frequency amplification is coupled to a tunable circuit 45 including the variable condenser 46. The detector tube 47 has its input electrodes connected across this condenser. It is further so arranged that it "detects" the signals, by causing the audio frequency modulations of the radio frequency carrier waves to replace these radio frequency waves. This process is well understood, and can be secured by proper choice of tube 47, and usually by providing a small condenser 48 in the grid circuit. A high resistance 49 is also provided for assisting the detector action. The output circuit for the detector stage in this instance includes the primary 50 of an iron cored audio frequency transformer, the secondary 51 of which serves to impress the detected waves upon the audio frequency amplifier stage formed by the tube 52. Similarly, further audio frequency stages may be added, but only one additional one 53 is indicated. This last stage has in its output circuit a translating device, such as phone or loud speaker 54.

It is of course evident that the number of stages, as well as the arrangement of the coupling between stages, can be varied. It is sufficient for the present purpose to point out that the system includes a plurality of tunable circuits, in each of which there is incorporated a variable tuning device, exemplified in the present instance by condensers 55, 40, 43, 44 and 46. These are arranged to be controlled simultaneously, so as to bring all five tunable circuits into alinement by a common means. Due to the high frequencies employed, even slight variations from simultaneous resonance of these circuits, cause great loss in selectivity. With my arrangement it is possible to maintain all such circuits in uniform resonance for their range.

In the present instance, the receiving apparatus, including the tubes, coils, condensers, and connections, are shown as housed in a box having a bottom 56 (Fig. 2), sides 57, and a cover 58. The cover 58 serves as the main support for the parts. A main supporting member 59, made from sheet stamping or a casting, is fastened to the cover 58, in a manner to be hereinafter described, and provides a structure below the cover upon which the condensers, coils and tubes are supported. Fig. 3 illustrates in a somewhat diagrammatic manner, a possible arrangement of the elements on the bottom of support 59. Upon this support there are appropriately fastened, a series of sector-shaped metallic shielding cans 60, disposed in a circle. For the sake of simplicity, but one such can is shown in its entirety in Fig. 2. In the present instance, there are six cans, one for each of the five radio frequency tuning devices, and one for the two audio frequency amplifiers 52 and 53 and their transformers 55'. In each radio frequency can there is a complete radio frequency unit, such for example as tube 25, transformer 22—24, and condenser 55. Since the other cans contain entirely similar elements, it is not essential to describe them further; the can and its contents just referred to will be described in detail and will serve as an example of all of these cans. The elements 25, 22—24 are merely diagrammatically indicated, for their structure forms no part of my present invention.

Each of the variable condensers 40, 43, 44, 46, and 55 includes a pair of sets of substantially square plates, which are relatively movable so as to interleave to a greater or lesser extent. In Fig. 3, the sets 61 and 62 are shown as in the minimum setting, only the corners of the sets being adjacent. As shown most clearly in Fig. 6, each set is fastened to a tube 63 or 64, rotatable on relatively stationary rods 65 and 66, pinned to a bar 67 of insulation. This bar is supported on supporting elements 59 in a manner to be hereinafter described. The rods 65 and 66 are connected by insulation strap 68, passing over threaded ends of these rods, and held in place by nuts 69, which can conveniently form the terminals of the sets of plates 61, 62. Coiled springs 70 are disposed over rods 65 and 66 tending to open the plates.

It is of course understood that the capacity of the condenser is varied by varying the relative positions of the sets 61, 62. One manner in which this can be simply accomplished is indicated in Figs. 2, 3 and 6. An actuating arm 71 is fastened to tube 63, and a similar arm 72 is fastened to the other tube 64. Links 73 and 74 pivotally connect respectively to these arms, the other extremities of the links being fastened to an actuator 75. One of the links passes above, and the other below the actuator, as indicated in Fig. 2; thus readily permitting both links to be pivoted on a common pin 76.

The operation of each of the other condensers 40, 43, 44 and 46 is likewise secured by the aid of the same actuator 75, and sets of links 78, 79, 80 and 81. The actuator is in the form of a disc, rotatable about a vertical axis, the links being connected near the edge of the disc, as shown in Fig. 3. These links pass through apertures 85 in the cans. As viewed in Figure 3, a clockwise rotation of disc 75 will cause the condensers to close, and to increase the value of their capacities. A counterclockwise rotation will have the opposite effect, the sets of plates separating. Without

further description, it is evident that I have provided a novel form of unit control, permitting a circular arrangement of the variable tuners, the actuator for all of them being centrally located. This makes for compactness; and since no gears or the like are used, there is no appreciable lost motion. Furthermore, I find that the tuning characteristic can be made such as to give substantially a straight line characteristic for the curve connecting the extent of rotation of disc 75 and the frequency of resonance. This is due to the fact that equal increments of movement of disc 75 produce uneqal increments of movement of the condenser plates. By reason of this inequality of increments, the operation of the variable tuners can be made such that a substantially linear relation exists between the movement of the actuator and the frequency of resonance or the wave length, or between the movement of the actuator and both the frequency and wave length for respectively different portions of the range of movement of the actuator.

The manner in which the disc actuator 75 is moved will now be described. Support 59 has a large central vertical hub 82 in which is journaled a shaft 83. At the lower end of shaft 83 a boss 84 is provided, over which the disc 75 is passed. A screw 86 clamps the disc to the shaft. At the upper end of the shaft 83, there is carried integrally, a large wheel 87, the section of which is illustrated in Fig. 7. This wheel has an upper flange 88 that carries means for rotating the wheel, and thereby the shaft 83. Referring to Figs. 4 and 7, this means includes a pair of links 89 and 90 operating on opposite points of a diameter of wheel 87. Each link carries an ear 91 pivoted on a post 92 screwed into flange 88. A spacer washer 93 separates each of the links from the flange, and another washer 94 is disposed over each of the ears and is held in place by screw 95 threaded in the post 92. The links connect, at their other ends, to opposite extremities of a bar 96 pivoted on a pin 97, held for example as by driving, in a boss 98 on support 59. This arm is arranged to be moved by lever 99, shown as of ribbed construction, and integral with arm 96. This lever is arranged to be moved manually in a manner to be hereinafter described. It is sufficient for the present to notice that as the pivot of arm 96 is back of the axis of shaft 83, the links 89 and 90 stay parallel as this arm is moved about pin 97, but they move in opposite directions longitudinally, and thus serve to impress a torque couple on wheel 87.

In order to provide a stop for the movement of arm 96, a boss 100 is arranged on support 59, back of the arm 96, and having faces covered with resilient material 101 in the path of movement of arm 96. Furthermore, a washer 102 is disposed over the hub of arm 96 and is held in place by screw 103, whereby said arm is held against vertical displacement on pin 97.

The description of the mode of operation of the tuning elements is now complete. However, as explained in my prior application, it is impossible without some such arrangement as an adjustable cam, to aline the tuning elements so that they remain exactly in step for the entire range of variation. In order to provide the compensation, the insulation bar support of each condenser is arranged to be movable. Considering Figs. 3, 6 and 7, it is evident that if bar 67 is moved about either of the axes of rods 65 or 66, the relative positions of the condenser plates will be correspondingly varied, entirely independently of the movement of links 73 and 74. Only a slight compensating movement of this bar 67 is necessary to keep the elements alined, but such movement should be adjustable over the entire range of variation of condensers 40, 43, 44, 46, and 55. It is now to be noted that disc 75 moves only a small portion of a complete revolution to operate the condensers from minimum to maximum capacity. Thus it is possible to support an adjustable cam structure on wheel 87, which has separate cam portions serving to operate bars 67 independently of each other. In the first place, each bar 67 is supported on rod 65 which passes through a stationary bushing 103 forming a bearing, in boss 104. An arm 105 is fastened to shaft or rod 65, at the other end of which a cam follower roller 106 is pivoted. It is evident that a cam, acting on roller 106 will serve to move support 67 about the axis of rod 65. A spring 107 is fastened at one end to support 59, and at the other end, to bar 67, whereby the rod 65 and its associated parts are urged in a direction to cause roller 106 to engage a cam surface.

The cam surface itself is adjustable, and comprises a strip 108 of flexible material, such as sheet copper or bronze. It is accommodated in a groove 109 in the periphery of wheel 87 (Fig. 7) and it extends angularly a sufficient distance to affect all five of the followers 106 for the full angular movement of wheel 87. This strip 108 serves as a plurality of cams. The ends of the strip are connected by a tension spring 110 (Fig. 4). The radial position of each portion of the strip is adjustable by the aid of a plurality of adjusting set screws 111 set in the rim of wheel 87, preferably at an angle to permit ready insertion of a screw driver blade. Each of these screws has a round point contacting with the inner surface of the strip 108. In this way, relative movement between the screws and the strip 108 longitudinally of the strip is permitted, to form a smooth continuous surface.

It is evident that by proper adjustment of those screws 111 which are immediately under the cam rollers 106 at any point of the range of movement of wheel 87, the rods 65 can all be moved slightly so as to bring all the tuned

circuits into resonance. One cam structure, forming however a plurality of cam surfaces, is all that is needed; and this structure is substantially round, rendering it easy and inexpensive to manufacture. The screws 111 are set close enough together to ensure complete accuracy for the entire range of tuning. The method of adjustment is entirely similar to that disclosed in my prior application. It involves merely positioning the wheel 87 successively so that the followers 106 are immediately over certain screws 111; and at each of these positions, these certain screws are carefully adjusted to bring all the condensers into alinement.

The supporting member 59 is provided with an inner flange 112 and an outer flange 113, forming an annular space for accommodating the wiring, fixed condensers, and other elements needed in the system. A cover plate 114 is shown for this space in Fig. 2, but for the sake of clearness, is omitted in Fig. 4. Furthermore, adjacent the left hand portion of support 59, there is an extension 115 upon which is supported a terminal block 116, exposed through a window 117 for permitting connections to be made to the batteries, loud speaker, or other external elements.

The supporting member 59 is fastened to the cover 58 by several screws, such as 118. One of these passes into boss 100; and the others pass through a dial plate 119 (Figs. 2 and 5) and into bosses 120 which are formed on support 59 and extend upwardly to cover 58.

There remains to be described, the dial arrangement for indicating the setting of the apparatus. The dial plate 119 has an arcuate aperture, defined by the inner surface 121 of the rib on said plate. This plate covers a substantially coextensive aperture 122 in cover 58. Through aperture 121 can be sighted a scale 123 on a member 124 fastened on the bottom of cover 58. This scale can include a frequency scale 125, a wave length scale 126, and a clear space between these scales upon which station call letters can be written. A transparent pointer or indicator 127 is arranged to sweep over these scales as the tuner is operated. It has a main slot 128 and narrow end slots 129, the former for permitting call letters to be written on scale 123, and the latter for permitting a short mark to be drawn corresponding to these letters. To obtain any such setting marked as thus described, it is merely necessary to bring indicator 127 in such position that the narrow slot just exposes the mark.

The indicator 127 is of course carried by arm 99, so that as this arm is moved, the indicator moves also. This indicator is fastened, as by a pair of screws 130, to a boss 131 at the free extremity of lever 99. This boss 131 extends into aperture 122 and past the edge of member 124, so that its top surface is just slightly above the scale 123. In order to provide a manual control of lever 99, so as to make it possible to move it rapidly from one position to another, and also to provide for a fine adjustment, as by reduction gearing, a knob 132 is provided, carried by arm 99 in a manner now to be described. A shaft 133 passes through a large clearance aperture 134 in the end of arm 99, and is pivoted at its bottom by the aid of pin 135. This shaft carries an extension 136 on which is journaled a tube 137, having teeth meshing with teeth 138 on the larger arcuate edge of plate 119. This tube is held against vertical displacement by washer 139 riveted over the end of extension 136. Knob 132 passes over tube 137 and is tightened in place thereon by set screw 140. It is evident that by moving shaft 133 on its pivot 135 away from the teeth 138 by the aid of knob 132, tube 137 can be disengaged from the edge of aperture 121 and lever 99 can be quickly moved to any desired point. A flat spring 141 resiliently urges shaft 133 to engaging position. After this coarse adjustment is effected, the spring 141 can be allowed to return shaft 133 to the position indicated, and the knob can then be turned, to cause tube 137 to move along the stationary edge of aperture 121 in order to procure a fine adjustment. Of course if tube 137 be made from proper material, merely a frictional engagement, without teeth, could be relied on for the fine adjustment of lever 99. Furthermore, it is entirely feasible then to make shaft 133 rigid and without pivot 135 or spring 141. Under such circumstances, the coarse adjustment can be effected by grasping knob 132, and moving it without rotating it, in the arc prescribed by the axis of arm 99, the smooth outer surface of tube 137 slipping along the edge of the aperture. For fine adjustment, the knob can be turned, providing a friction gear movement.

One or more small incandescent lamps 142 can be provided on member 124 to illuminate the scale, and can be hidden by dial plate 119.

It will be noted in Fig. 5 that the wave length scale 126 is proportional; and by proper design either this scale or the frequency scale 125 can be made proportional. This is rendered possible by the particular mechanism used for setting the condensers 40, 43, 44, 46 and 55, that cause the condenser settings to be unequal for equal settings of actuator arm 99.

In the embodiment just described, the scale is located above the set. Such an arrangement is shown in the diagrammatic fragmentary section of Fig. 8. In this form, the support 59 and cans 60 are shown in a position that is just reversed, the actuating arm 143 (corresponding to arm 99) being below the support. However, the mechanical arrangement is identical except for the reversal. The right

hand portion of the cabinet has an apertured dial plate 144. This plate is circular about a vertical axis coinciding with that of arm 143. The stationary scale plate 145 is correspondingly curved, and is exposed to view through plate 144. The pointer 146 is fastened to the front portion of lever 143 and is closely spaced with respect to scale 145. The lever 143 has an extension 147 on which is supported a turning knob 148, arranged to coact with the bottom edge of the aperture in plate 144 to secure a fine adjustment. This knob can be supported in a manner analogous to that used in connection with knob 132, in order to permit disengagement of it with respect to the edge of the aperture and thus to secure coarse adjustment. The operation is analogous to that of the first form considered.

I claim:

1. In combination, a plurality of variable tuning devices angularly spaced from each other around an axis, an actuator rotatable about the axis, and pivotally joined link connections between each of the devices and the actuator for operating said devices.

2. In combination, a plurality of variable condensers, having relatively rotatable plates, said condensers being angularly spaced about an axis, an actuating disc rotatable about the said axis, and pivotally joined link connections between the condensers and the disc for causing movement of the condenser plates.

3. In combination, a pair of sets of plates, each movable about an axis that is spaced from the axis for the other set, a crank arm for each set, and pivotally joined links for operating said arms.

4. In combination, a plurality of tuning devices, a movable element for each device whereby the devices can be operated, all of said elements being angularly spaced about an axis, and a cam structure rotatable about the axis and operating all of said movable elements.

5. In combination, a plurality of tuning devices, a movable element for each device whereby the devices can be operated, all of said elements being angularly spaced about an axis, a wheel rotatable about said axis, a flexible strip extending around at least a portion of said wheel, and means for adjusting the radial positions of points on the strip, for providing an adjustable cam structure, said movable elements being operated by said cam.

6. In combination, a plurality of variable condensers angularly spaced about an axis, each of said condensers having a pair of electrodes pivoted for relative motion on spaced axes, a common support for both electrodes of each condenser, an actuator rotatable about the axis for causing relative motion of said electrodes, and an adjustable cam structure arranged to be rotated in unison with the actuator for supplementing the setting of the condensers.

7. In combination, a plurality of variable condensers angularly spaced about an axis, each of said condensers having a pair of electrodes pivoted for relative motion on spaced axes, a common support for both electrodes of each condenser, an actuator rotatable about the axis for causing relative motion of said electrodes, and an adjustable cam structure arranged to be rotated in unison with the actuator for compensating the condensers for inequalities, said cam operating to move the electrode supports relatively to the actuator for effecting this compensation.

8. In combination, a support, a shaft journaled in the support, a plurality of variable condensers supported on one side of the support, and angularly spaced around the shaft, a pivotally joined link connection between each condenser and the shaft, and means on the other side of the support for rotating the shaft.

9. In combination, a support, a shaft journaled in the support, a plurality of tuning elements angularly spaced around the shaft and supported on one side of the support, connections between the shaft and the elements for varying them, and an adjustable cam structure fastened to the shaft and located on the other side of the support, for imparting a supplementary adjustment to the elements.

10. In combination, a support, a shaft journaled in the support, a plurality of tuning elements, each having relatively movable parts, supported on one side of the support and angularly spaced around the shaft, a connection between the shaft and each element for causing rotation of the shaft to vary the elements, an adjustable cam structure rotatable with the shaft and on the other side of the support, and means operated by the cam to adjust the relative position of the elements and the shaft, whereby a supplemental adjustment is effected.

11. In combination, a support, a shaft journaled in the support, a plurality of variable condensers having relatively movable electrodes, a bar for each condenser upon which the electrodes are supported, a rotatable pin associated with each bar and fastened thereto, said pins passing through the support and being angularly spaced around the shaft, a connection between the shaft and each of the condensers whereby rotation of the shaft will operate all the condensers, a wheel fastened to the shaft and arranged on the other side of the support, said wheel having a groove in its periphery, a flexible strip in said groove, screws passing into the groove for adjusting the form of the strip and thereby providing an adjustable cam surface, and means whereby rotation of said cam surface moves the pins and causes the electrodes to be supplementarily adjusted.

12. In combination, a lever pivoted adja-

cent one end, a tuning device operated by said lever, a scale, an indicator carried by the lever and cooperating with the scale, a plate having an aperture through which the scale is visible, a rotatable knob carried by the lever adjacent the indicator, a wheel rotated by said knob and engaging the edge of the aperture for providing fine adjustment, and yielding means for maintaining the wheel in contact with said edge.

13. In combination, a pivoted lever, a tuning device operated by said lever, a pin pivoted adjacent one extremity of the lever, a rotatable sleeve carried by the pin, a plate having an aperture the edge of which is arranged to be engaged by the sleeve, and yielding means for urging the pin in a direction to engage the sleeve and the edge.

14. In combination, a pivoted lever, a tuning device operated by said lever, a scale arranged adjacent the free end of the lever, an indicator carried by the lever, a stationary plate over the scale, and means forming a disengageable rolling connection between the end of the lever and said plate, whereby coarse adjustment is effected when said connection is disengaged, and fine adjustment when said connection is engaged.

15. In combination, a pivoted lever, a tuning device operated by said lever, a scale arranged adjacent the free end of the lever, an indicator carried by the lever, a housing for the tuning device, lever, and scale, and means forming a disengageable rolling connection between the end of the lever and a portion of said housing, comprising a knob, a pin carried by the lever, a sleeve carried by the knob and rotatable on the pin, a portion of the periphery of said sleeve being arranged to contact with the housing, and means for resiliently urging the pin so as to move the sleeve into rolling engagement.

16. In combination, a lever pivoted adjacent one end, and a scale cooperating with the free end of the lever, a tuning device having a rotatable wheel pivoted on an axis spaced from but parallel to the lever axis, and a pair of links connecting the wheel and the lever, whereby movement of the lever causes corresponding movement of the wheel.

17. In combination, a plurality of variable tuning devices angularly spaced from each other around an axis, a common support for all of said devices, an actuator rotatable about the axis for operating all of said devices simultaneously, and metallic shields supported on said common support, enclosing and segregating each of said devices.

18. In combination, a plurality of variable tuning devices angularly spaced from each other around an axis, a common support for all of said devices, a metallic shield for each device, all of said shields being supported on the common support, and leaving an open space adjacent the axis, and an actuator rotatable about said axis and located in said space, said actuator serving to operate all of said devices.

19. In combination, a plurality of tuning devices, a movable element for each device whereby the devices can be operated, all of said elements being angularly spaced about an axis, a wheel rotatable about the axis, and a flexible strip carried by the wheel for operating said movable elements.

20. In combination, a series of tuning devices each having relatively movable elements, and means for simultaneously operating all of said devices, including a rotatable support, and a flexible strip resiliently held on the support but not rigidly attached thereto.

21. In combination, a lever pivoted adjacent one end, a tuning device operated by said lever, a scale, an indicator carried by the lever and cooperating with the scale, a plate having an aperture through which the scale in visible, a rotatable knob carried by the lever adjacent the indicator and a wheel rotated by said knob and engaging the edge of the aperture for providing fine adjustment.

22. In combination, a pivoted lever, a tuning device operated by said lever, a pin pivoted adjacent the free extremity of the lever, a rotatable sleeve carried by the pin, and a plate having an aperture the edge of which is arranged to be engaged by the sleeve.

23. In combination, a lever pivoted adjacent one end, a scale cooperating with the free end of the lever, a cross arm carried by the lever, a tuning device, and connections between the cross arm and the device.

24. In combination, a lever pivoted adjacent one end, a scale cooperating with the free end of the lever, a cross arm carried by the lever, a link pivoted at each end of the cross arm, and a rotatable tuning device actuated by the links.

25. In combination, a lever pivoted adjacent one end, a scale cooperating with the free end of the lever, a cross arm carried by the lever, a link pivoted at each end of the cross arm, a rotatable member to which the other ends of the links are connected, and one or more tuning devices operated by the rotatable member.

26. In combination, a tuning device, a rotatable actuator for said device, a lever for moving the actuator, a scale cooperating with the free end of the lever, and connections between the lever and the actuator, said connections being such that equal increments of movement of the lever cause unequal increments of movement of the actuator.

27. In combination, a tuning device, a rotatable actuator for said device, a lever for moving the actuator, a scale cooperating with the free end of the lever, and connections between the actuator and the tuning device, as well as between the actuator and said lever,

arranged to produce movements of the device out of proportion to the movements of the lever.

28. In combination, a tuning device, a rotatable actuator for said device, a lever for moving the actuator, a scale cooperating with the free end of the lever, and linkages between the lever and the actuator, and beween the actuator and the tuning device.

29. In combination, an actuator having an axis of rotation, means providing an axis of rotation parallel to but spaced from that of said actuator, a scale concentric with said latter axis, a member movable about the latter axis and cooperating with the scale, a link connection between said member and the actuator, and one or more tuning devices operated by said actuator.

30. In combination, an actuator having an axis of rotation, means providing an axis of rotation parallel to but spaced from that of said actuator, a scale concentric with said latter axis, a member movable about the latter axis and cooperating with the scale, a connection between said member and actuator such as to cause disproportionate movements thereof, and one or more tuning devices operated by said actuator.

31. In combination, an actuator having an axis of rotation, means providing an axis of rotation parallel to but spaced from that of said actuator, a scale concentric with said latter axis, a member movable about the latter axis and cooperating with the scale, a connection between said member and actuator such as to cause disproportionate movements thereof, one or more tuning devices, and connections between said actuator and the tuning devices such as to cause disproportionate movements thereof.

32. In combination, a variable tuning device having relatively movable members, an angularly adjustable support for the device, the angular adjustment thereof being on an axis transverse to the movement of the members, an actuator for moving the members relatively to each other, and means whereby the actuator causes angular movement of the support, so that the relative movement of the members is supplemented.

33. The combination as set forth in claim 32, in which means are provided for adjusting the extent of the angular motion upon a definite movement of the actuator.

34. In combination, a rotatable actuator, a plurality of variable condensers positioned radially about said actuator and each having a pair of sets of movable plates, a crank arm for each set of plates, and a plurailty of pivotally joined links each connecting one of said arms with said actuator.

35. In combination, a plurality of variable condensers each having a pair of sets of movable plates, a crank arm for each set of plates, a plurality of links each pivoted to one of said crank arms, and a rotatable actuator, the outer ends of each pair of links for each pair of sets of plates being pivoted to said actuator at a common point, whereby rotation of said actuator causes relative movement of each pair of sets of movable plates.

36. In combination, a plurality of variable tuning devices each having relatively movable members, an angularly adjustable support for each device, a rotatable actuator, an operating arm for each support operatively engaging said actuator, whereby rotation of said actuator causes angular movement of each support and its device, and means whereby said angular movement causes relative movement of said members.

37. In combination, a plurality of variable tuning devices each having relatively movable members, an angularly adjustable support for each device, a rotatable actuator, adjustable cam means on said actuator, an operating arm for each support operatively engaging said cam means, whereby rotation of said actuator causes cam-controlled angular movement of each support and its device, and means whereby said angular movement causes relative movement of said members.

38. In combination, a plurality of variable tuning devices each having relatively movable members, an angularly adjustable support for each device, a rotatable actuator, means whereby movement of said actuator causes relative movement of said members, and an operating arm for each support operatively engaging said actuator and causing angular adjustment of its support on movement of said actuator, whereby a supplemental relative movement of said members is produced.

39. In combination, a plurality of variable tuning devices each having relatively movable members, an angularly adjustable support for each device, a rotatable actuator, means operatively connecting said actuator with each device to cause relative movement of said members on movement of said actuator, adjustable cam means on said actuator, and an operating arm for each support operatively engaging said cam means to adjust said supports angularly on movement of said actuator.

40. In combination, a plurality of variable tuning devices each having relatively movable members, an angularly adjustable support for each device, a rotatable actuator, pivotally joined links connecting said actuator with said members, cam means on said actuator, and an operating arm for each support operatively engaging said cam means.

41. In combination, a plurality of variable tuning devices angularly spaced from each other around an axis, an actuator rotatable about the axis, pivotally joined link connections between each of the devices and the actuator for operating said devices, cam means

on said actuator, and means operatively connecting said cam means and said devices for supplementarily operating said devices.

42. In combination, a plurality of variable condensers having relatively rotatable plates, said condensers being angularly spaced about an axis, an actuating disk rotatable about the said axis, pivotally joined link connections between the condensers and the disk for causing movement of the condenser plates, adjustable cam means on the disk, and operating arms interposed between the condensers and the cam means for causing supplemental movement of the condenser plates.

43. In combination, a plurality of tuning devices, an actuator for said devices, means including an indicator arm for moving said actuator, and connections between said actuator and each tuning device causing unequal increments of movement of said tuning devices for equal increments of movement of said means, whereby the relation between the values of the circuits to be tuned and the movement of the indicator arm is substantially linear.

In testimony whereof I have hereunto set my hand.

HAROLD F. ELLIOTT.