

Oct. 4, 1932.

H. F. ELLIOTT

1,880,933

HIGH FREQUENCY TUNING SYSTEM

Filed June 28, 1926

4 Sheets-Sheet 1

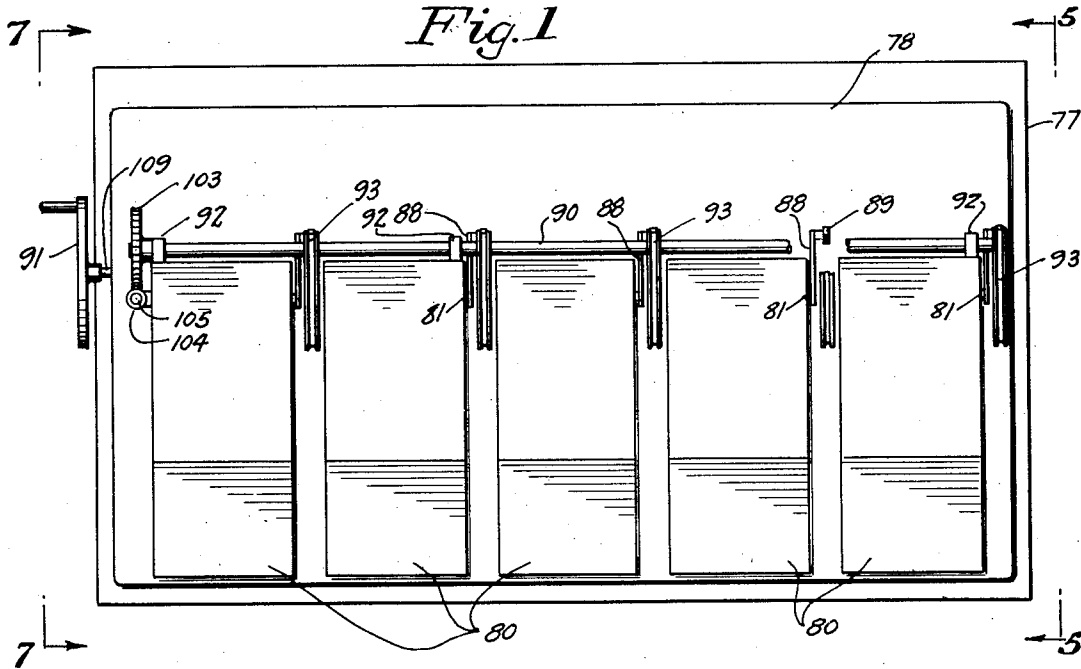


Fig. 2

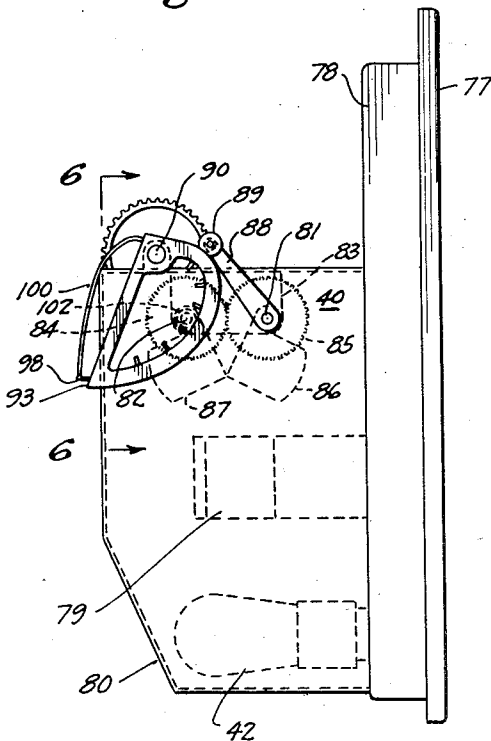
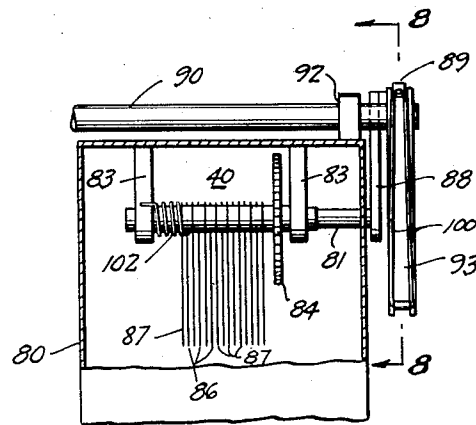


Fig. 3



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4 Sheets-Sheet 2

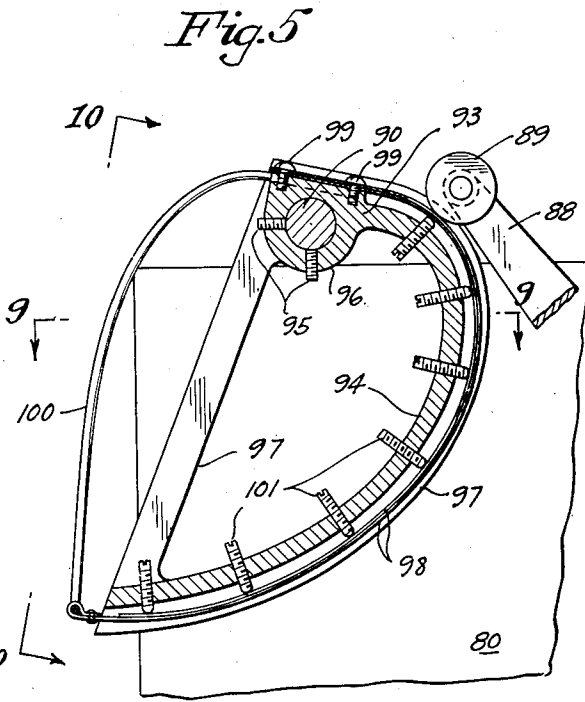
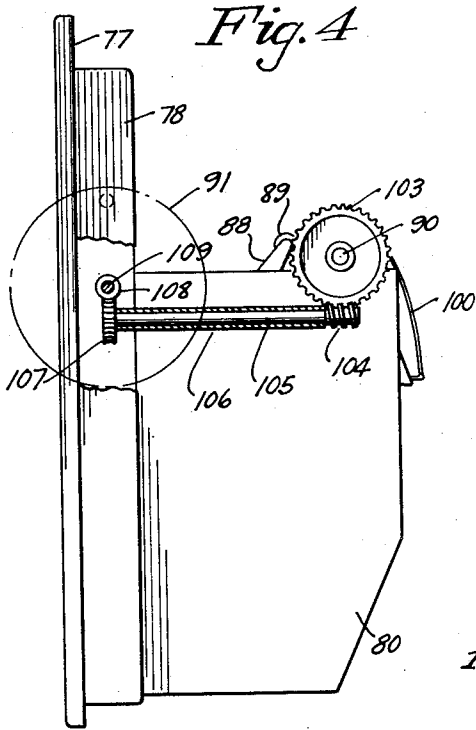


Fig. 7

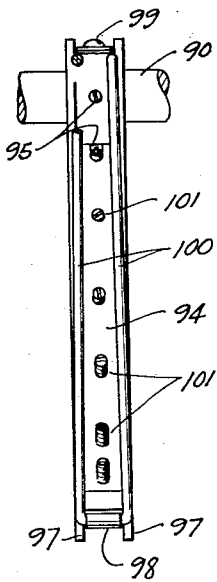
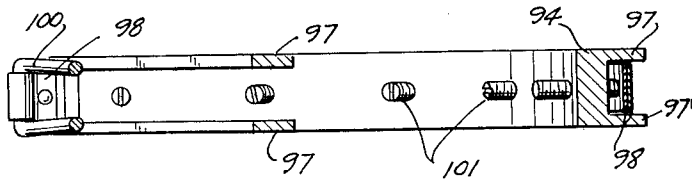


Fig. 6



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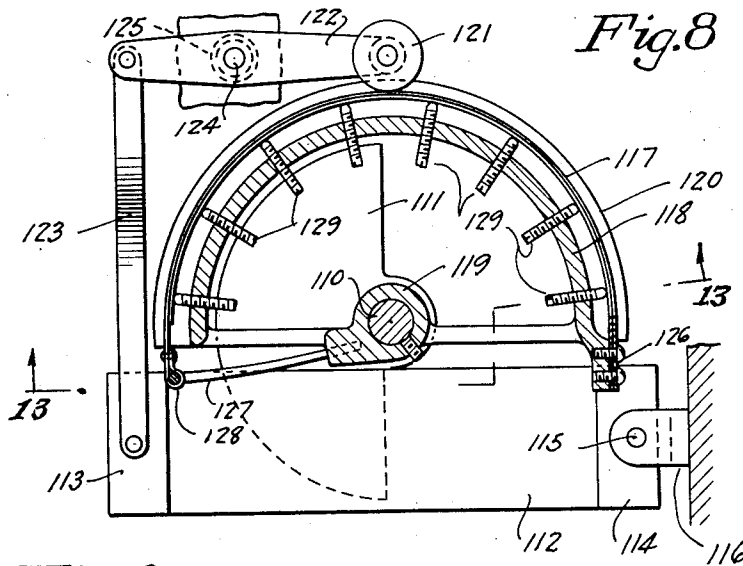


Fig. 9

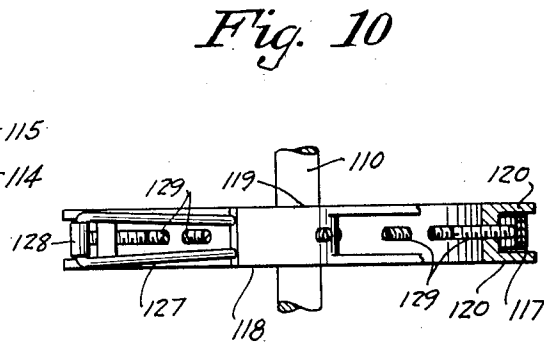
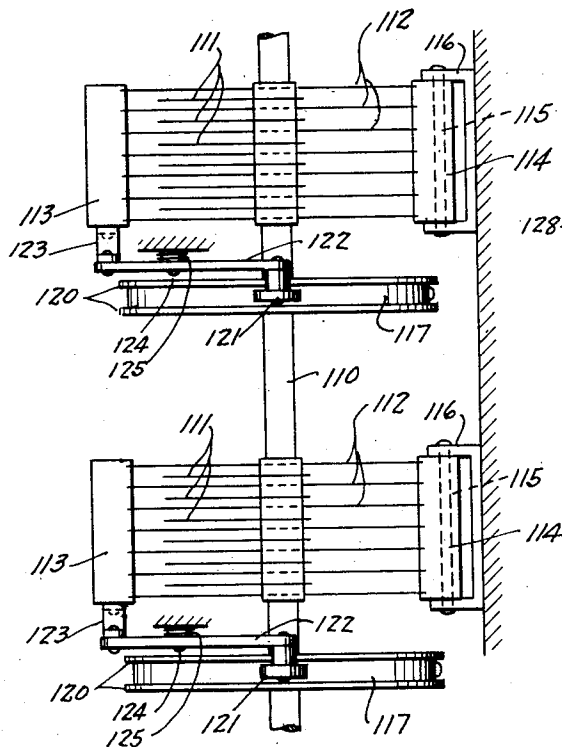


Fig. 10

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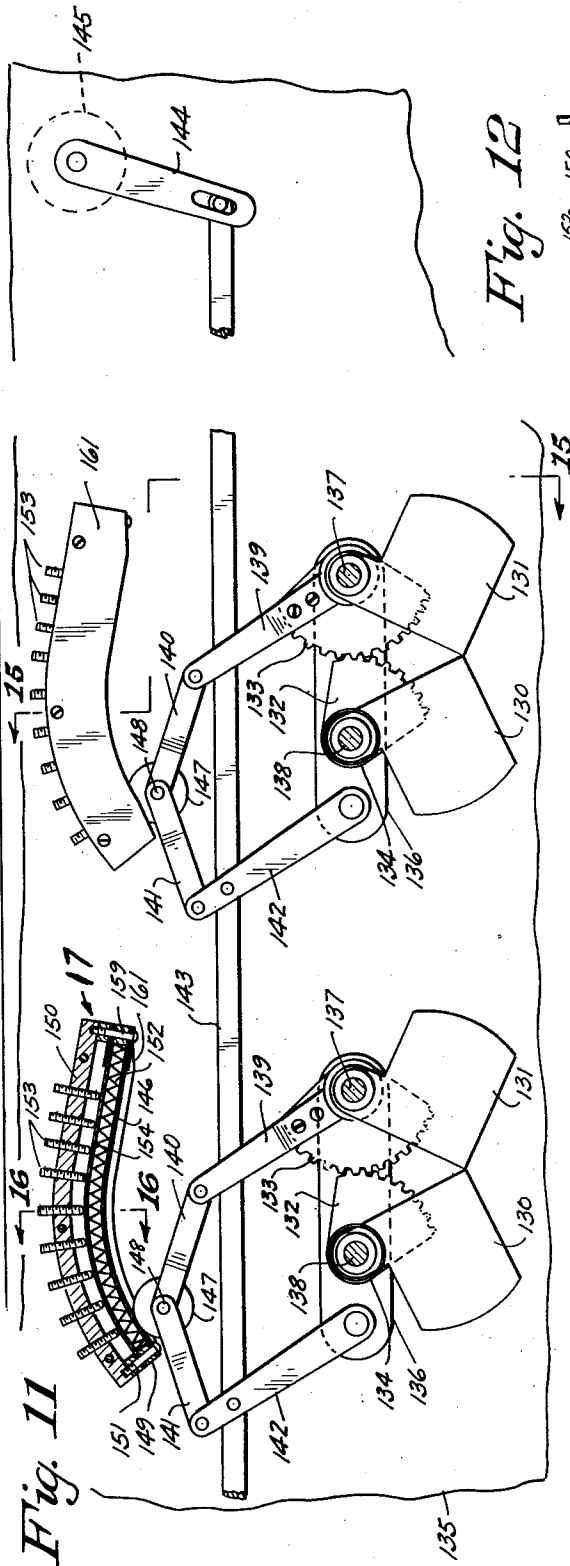


Fig. 12

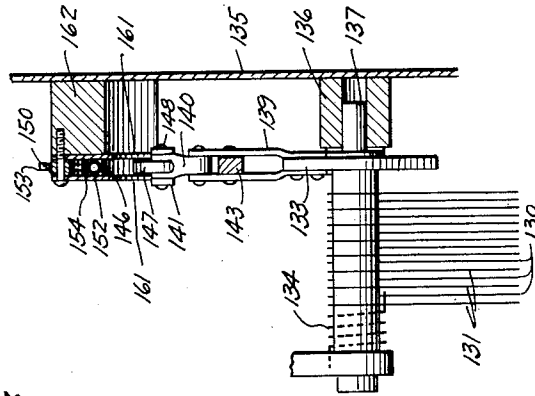


Fig. 13

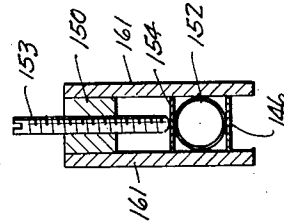


Fig. 14

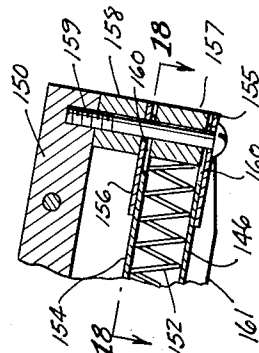
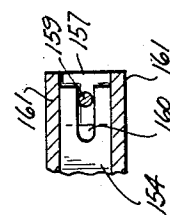


Fig. 15



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UNITED STATES PATENT OFFICE

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TO RADIO CORPORATION OF AMERICA, OF NEW YORK, N. Y., A CORPORATION OF
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HIGH FREQUENCY TUNING SYSTEM

Application filed June 28, 1926. Serial No. 119,114.

This invention relates to the tuning of electrical circuits arranged to carry high frequency currents, such for example, as is encountered in radio apparatus, either for transmitting or for receiving.

It is now well-known that when dealing with high frequency electrical energy, the degree of response to such energy by a circuit can be very materially enhanced by tuning the circuit so that it will be resonant to the frequency at which the energy is transmitted. In this way, it is not only possible to increase the response, but also to render the system selective as regards frequency. All this is well understood, and is utilized most often in connection with radio receivers, so that the signals from a plurality of stations can be segregated by this tuning process.

In many instances, the mere provision of one or two tuned circuits is insufficient to provide the desired degree of selectivity, and to overcome this effect, the advent of several stages of radio frequency amplifiers in cascade has taken place in the past few years. Each amplifier stage, besides increasing the amplitudes of the e. m. f.'s received, provides in addition, a tunable circuit; and all of the tuned circuits contribute to render the receiver a great deal more selective than when only a few tunable circuits are used.

The tuning of the circuits can be accomplished in any one of several ways. For example, a variable condenser or a variable inductance can be incorporated in each of the circuits, and one or both of such elements can be operated until the desired resonance is obtained. It has also been common to attempt simultaneous tuning of all of the associated tunable circuits, by providing a unit control for all of the tuning elements. For instance, the rotors of all of the variable elements have been mounted on a common shaft, or else arranged to be moved in unison by a common motion transmitting device.

At first blush, it appears entirely feasible to secure simultaneous and accurate tuning of all of the circuits in this manner. When it is considered however, that very high frequencies are dealt with, it becomes evident

that apparently minute effects, incapable of being compensated in this manner, can have serious deleterious results upon the selectivity of the system. For example, slight variations from absolute uniformity of the parts making up the tuning element cause sufficient variations in distributed capacity or stray inductance to cause a large variation in the resonance settings.

Another disturbing feature is that the stray electrostatic and electromagnetic fields have necessarily no uniform variation for all of the tuning elements, as they are simultaneously moved. Thus it happens that even if exact resonance be secured simultaneously for one setting, there is no assurance that such exactitude persists for any other setting.

Some systems in the past have attempted to overcome these disadvantages of single unit control by providing supplementary controls for all but one of the units; but it is evident that in many respects this arrangement would be as bad as a series of independently controlled tuning devices. Another proposal was to design the tunable circuits so that their resonance curves are broad. This is highly objectionable, for it largely nullifies the selectivity which it is aimed to secure by a succession of tuned circuits; and besides, the efficiency of the set is very materially reduced.

It is one of the objects of my invention to make it possible to obviate all these disadvantages of a unit control system.

It is still another object of my invention to provide a unit control system that can be accurately and permanently adjusted over the entire range of operation of the system so that all of the circuits remain accurately in step for that range.

It is another object of my invention to compensate for the inherent inaccuracies in the parts making up the tuning elements, whereby less care need be exercised to build and assemble such parts.

My invention can be applied readily to all forms of variable tuning devices. For example, in connection with measurement of wave lengths or frequencies, it is necessary to calibrate the wave meter readings careful-

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ly for each instrument, due to the unavoidable small variations in the parts making up the wave meter. With the aid of my invention, the dial or other form of scale can be printed in large quantities, and the variable tuning element can be readily adjusted so as to make the resonance conditions coincide with the scale readings. Therefore it is another object of my invention to make it possible to provide control apparatus for receivers, wave meters, or the like, which may be adjusted to correspond with the indications of the scales upon which the frequencies are permanently marked in advance of the assembly of the parts; thus these scales can be produced in quantities, in well-known ways without the necessity of hand calibration for each individual dial or scale.

It is still another object of my invention to make it possible to fix the characteristic tuning curve of the tuning device so as to give any desired form of curve; thus it may be desirable to have the frequency of resonance, or the wave length of resonance, vary as a straight line when plotted against the amount of movement of the controlling member; and with my device, such characteristic curves or curves of other forms also, can be produced in a simple and inexpensive manner.

It is still another object of my invention to make it possible to alter existing receiving sets so that they may have the advantages hereinbefore discussed, yet with little expense.

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:

Fig. 1 is a back view of an adjustable tuning device mounted on a receiver panel and embodying my invention;

Fig. 2 is an end view of the panel and device of Fig. 1, as seen from plane 5—5 of Fig. 1;

Fig. 3 is a back view of one of the tuning elements, with a few of the associated parts, taken along plane 6—6 of Fig. 2, and having a few parts broken away;

Fig. 4 is a view of the panel shown in Fig. 1, from plane 7—7, some of the parts being broken away;

Fig. 5 is an enlarged sectional view of one of the operating devices for a tuning element, taken along plane 8—8 of Fig. 3;

Fig. 6 is a sectional view taken along plane 9—9 of Fig. 5;

Fig. 7 is a view taken from plane 10—10 of Fig. 5;

Fig. 8 is a front elevation, partly diagrammatic, and partly in section, of a modified form of my invention;

Fig. 9 is a top plan view of the form shown in Fig. 8;

Fig. 10 is a sectional view, taken along plane 13—13 of Fig. 8;

Fig. 11 is a view, partly in section, of still another form of my invention;

Fig. 12 is a sectional view, taken along plane 15—15 of Fig. 11;

Fig. 13 is a detail sectional view taken along plane 16—16 of Fig. 11;

Fig. 14 is an enlarged detail of a portion of the apparatus, indicated by arrow 14 on Fig. 11; and

Fig. 15 is a sectional detail taken along plane 18—18 of Fig. 14.

One form of my invention is illustrated in Figs. 1 to 7, and will now be described.

In the present instance, all of the parts are shown as mounted on the back of a panel 77. A metallic sub-base 78 is used to conceal the wiring on the rear surface of the panel. On the sub-base can be mounted the radio frequency elements, such as tubes 42, as well as the radio frequency transformers, such as 79, and variable condensers, such as 40. In order to ensure against variations in stray capacity, such as due to body capacity or the like, and also to serve as shields for the radio frequency parts, metal screens 80 are provided. Each of these screens is associated with one radio frequency unit, including the tube, the radio frequency transformer, and the variable condenser associated with the transformer. These screens form, with sub-base 78, completely enclosed spaces for these elements. Five such screens are indicated in Fig. 4, but of course the number can be varied, and depends upon the number of radio frequency circuits utilized.

Each of the variable condensers, such as 40, is provided with an operating member, such as shaft 81 which in this instance extends slightly out of the side of its screen 80, and has an axis parallel with the horizontal edge of panel 77. Although any particular kind of tuning element is not essential to the invention, nevertheless I shall now briefly describe the form which is indicated in the drawings.

In the present instance, the condenser 40 includes a pair of parallel shafts, one of which is 81, and the other 82. These are supported on insulation standards 83, supported on the top of the corresponding screen 80. They are geared together to rotate in unison, by gears 84 and 85. Each shaft carries a set of metallic plates 86 and 87. All of the plates on each shaft are electrically connected, but

are insulated from their shafts. As shaft 81 rotates, the plates 86 and 87 interleave, and the extent of the interleaving determines the effective capacity between the sets. The overlapping of the plates begins at the corners, as indicated in Fig. 5, whereby a straight line wave length characteristic is obtained.

Each of the projecting shafts 81 carries an operating arm 88, the free end of which has a cam roller 89. These arms are arranged to be moved by the aid of a common motion transmitting mechanism, but not necessarily in unison. To secure this effect, a shaft 90 is provided, in this instance parallel to shafts 81, and journaled in bearings 92 on base 78. The shaft carries a series of cams 93 arranged to rock the arms 88 by acting on roller 89. Each cam is adjustable so that the corresponding condenser movement can be compensated to give accurate adjustments for all positions of shaft 90.

The cam structure is disclosed most clearly in Figs. 8, 9 and 10, and is merely representative of the class of adjustable cams. It includes a body portion 94 (in the present instance in the form of a half-heart), fastened as by screws 95 to shaft 90, said screws passing through a hub 96 on body 94. The body has flanges 97, which extend completely around the cam 93, although the body portion 94 terminates at the tip of the heart.

The roller 89 is guided between these flanges, and rests on the cam surface proper, formed by one or more flexible non-rigid strips 98 extending around the heart shaped body 94, and anchored as by screws 99 to hub 96. In the present instance, two strips are shown, of flexible metal such as phosphor bronze, the outer one projecting beyond the inner one and looped over the end of a spring wire 100. This spring serves to tension the outer cam strip 98; it is of U shape, the ends of the legs being anchored at hub 96, and the connecting portion being looped as clearly indicated, by the outer strip 98.

It is evident that as thus far described, the strips 98 are confined over body 94 and held in place by spring tension. The shape of the cam surface can be varied at will however, by a series of set screws 101 that project through body 94 and engage the inner strip 98. By individual adjustment of these screws, the non-rigid cam face can be made to compensate for irregularities in the tuning characteristics. These screws can readily be reached by a screw driver extending between the legs of the spring 100.

By properly fashioning body 94, it is evident that subsequent fine adjustment of screws 101 can be readily made to give any desired characteristic to each of the condensers, such as straight line wave length, or straight line frequency. Adjustment of screws 101 can be resorted to for making scale

readings accurate, even when such scales are produced cheaply in quantity. It is also evident that due to the non-rigid character of the active cam surface, it is possible independently to adjust relatively small increments of that surface, and without disturbing its continuous character.

In connection with radio receiving sets, the adjustment of the condensers during the process of assembly, is a simple matter. The shaft 90 is set in succession, at several distinct points, and for each setting, the cam screw 101 nearest the rollers 89 for that setting are adjusted to bring all of the condensers into proper position for resonance condition of their associated circuits. Preferably the settings are such that the rollers 89 come directly over one of the screws 101 for each setting. Then shaft 90 is set to a new setting, and the process repeated. After adjustment of all of the screws 101, the non-rigid cam surface is of the proper shape to ensure uniform variation of the associated circuits.

In order to keep roller 89 on the cam track, a resilient force is used, as for instance that exerted by a helical spring 102 (Fig. 3) acting on shaft 82 to urge gears 84 and 85 in a direction to decrease the capacity; this resilient force being overcome by the action of cam 93, urging roller 89 in a position to rotate wheels 84 and 85 to increase the capacity.

The shaft 90 can be rotated in any convenient manner. For example, it may carry a worm wheel 103 at one end, engaged by a worm 104. The worm is fastened to a transverse shaft 105 suitably journaled in a stationary guide 106 (Fig. 4), and carrying a worm or spiral gear 107 at its other end. This in turn can be rotated by the aid of a gear 108 fastened on shaft 109 on which handle 91 is fixed for manual operation.

It is not essential to utilize any particular kind of tuning element. Thus in Figs. 8, 9, and 10, a pair of a modified form of tuning device is shown, operated by a common shaft 110. This shaft carries the usual form of rotary plates 111 of a variable condenser. The cooperating plates 112 are in this instance rectangular, and are mounted in spaced relation in a pair of insulation blocks 113 and 114. These plates, instead of being stationary, are movable about the pivot 115 passing through the support 114 and supported in clip 116. The arrangement is such that as shaft 110 rotates, adjusting the position of plates 111, plates 112 may also be slightly shifted about pivot 115 to provide a compensation effect, in accordance with the position of shaft 110.

To effect this result, an adjustable cam 117 is provided for each condenser. Each cam structure includes a spider or body 118, in this instance of substantially circular form,

mounted as by the aid of hub 119, on shaft 110. Flanges are provided for forming a groove for the follower roller 121, which is mechanically connected to the plates 112, as through the arm 122 and link 123. Arm 122 is pivoted on stationary pivot 124, and is urged to cause roller 121 to engage cam 117, by the spring 125.

The flexible strips 117 forming the adjustable cam surface are anchored as at 126 to one end of body 118. The free end of the outer strip is held to the end of bow spring 127 by loop 128, this spring pulling the strips against the adjustable set screws 129. The legs of spring 127 are driven into hub 119 and are thus held in place.

The manner of adjusting the condensers is substantially the same as that described in connection with the first form. The main difference in the mode of operation is that the compensation is secured by small angular variations of the plates 112 about pivot 115.

A still further modification of the compensating arrangement is illustrated in Figs. 11 to 15 inclusive. In this form, condensers such as illustrated in Figs. 2 and 3 are again used, each having two sets of movable plates 130, and 131, with intermeshing gear segments 132 and 133. As before, a helical spring 134 (Fig. 12) tends to separate the plates, the separation being limited by the cam arrangement to be now described.

A supporting panel 135 has fastened thereon bearings 136 for the shafts 137 and 138 of the condensers, which may be held in proper position by any appropriate means. Each shaft 137 carries a forked arm 139 for moving the shaft. Movement is imparted to the arm by a series of links 140 and 141, from an actuator arm 142; all of the actuator arms are moved in unison by a rod 143, moved in turn manually by a lever 144 having a hand knob 145. Rod 143 passes through the fork of arm 139. The links 140 and 141 determine the extent of movement of arm 139, and thus the extent of the corresponding condenser, by the aid of an adjustable cam strip 146. This strip coacts with roller 147 carried by pivot 148 joining the links 140 and 141. It is evident that due to the resilient force exerted by spring 134 on shaft 138, the roller 147 will be resiliently urged against this cam face, the face serving to limit the relative movement of links 140 and 141. The cam strip 146 is supported at its left hand end on top of block 149, which is fastened to a cam body 150. Another block 151 below block 149 serves with that block to confine another strip 154. Between the strips 149 and 151 there is a flexible resilient element such as a coiled spring 152. Set screws 153 in body 150 operate on strip 154 to vary its configuration, and through the spring 152, that of cam strip 146. The spring 152 serves efficiently to eliminate unevenness in the cam surface, as is apparent.

The free ends of strips 146 and 154 are slidable on short strips 155 and 156 held in proper spaced relation by the aid of blocks 157 and 158 fastened to body 150 by screw 159. The ends of strips 146 and 154 are slotted, as indicated at 160, Fig. 18, to encompass this screw and further to guide the movement of this free end during the process of adjustment of cam screws 153. Flanges 161 are located on each side of body 150, and these flanges as well as the body are supported on block 162, Fig. 12, fastened to panel 135.

The mode of operation of this embodiment is probably entirely clear from what has been said with regard to the other forms. The main difference resides in the fact that the condensers are mounted side by side instead of in tandem arrangement; and that a concave cam is used instead of a convex one. It is evident that since spring 134 tends to rotate gear segment 132 in clock-wise direction, and that since the position of arm 142 is fixed by bar 143, arm 139 can move in a counter clock-wise position only far enough to cause engagement of roller 147 with the cam surface. By adjusting the cam surface, the relative movement of arm 139 and that of arm 142 is accurately controlled, thereby providing an accurate and simple compensation for all positions of the bar 143.

Although several modifications of the invention have been outlined, yet they all rest upon the common conception that the law of variation of a series of tuning elements can be independently adjusted, even when a common actuating means is provided for all of them. It is this feature that makes the invention so well adapted to maintain a series of circuits in exact resonance for all positions of adjustment, and thereby to maintain a high degree of selectivity without the inherent disadvantages common in other forms of tuning devices.

I claim:

1. In a tuning device having a plurality of separate variable tuners and a common means for directly actuating the movable elements of said tuners, the improvement which comprises an additional adjustable operating means, for precise adjustment, operated by said common means, said additional means including a cam comprising a body having an arched surface, adjusting screws projecting through said surface and a flexible strip resiliently held against the projecting ends of said screws and forming an adjustable cam surface.

2. In combination, a plurality of separate variable tuners for high frequency circuits, a common means for actuating said tuners, and in addition, adjustable cams for precise adjustment of said tuners, actuated by said common actuating means, said cams each comprising a body, and a separate strip forming an adjustable cam surface, resiliently

held toward said body, and adjusting screws for determining the configuration of said cam surface whereby the movable elements of said tuners may be brought into precise
5 adjustment throughout their operating range.

3. In combination, a plurality of separate variable tuners, having relatively movable elements, an actuator for each tuner positively connected thereto, a common operating means for said actuators, and adjustable cam means actuated by said common means for effecting relative movement of said elements independently of that caused by said
10 actuators, said cam means comprising a body having convex surface, a series of adjusting screws projecting through said surface and a strip forming an adjustable cam surface resiliently held in contact with the projecting
15 ends of said screws.

4. In combination, a plurality of separate variable tuners for high frequency circuits, each tuner comprising elements relatively movable, actuating means for each tuner
20 positively connected thereto, a common rotary operating means for said actuating means, one element of each said tuner being mounted for movement independent of that due to its said actuating means, a separate
25 actuator for each said one element, adjustable cam means connected to said common operating means for operating said separate actuators, said cam means comprising a body
30 carrying a flexible strip forming an adjustable convex cam surface, the configuration of said surface being determined by screws projecting through said body and against said strip.

5. In combination, a plurality of variable
40 tuners for high frequency circuits, each tuner comprising elements movable with respect to each other, actuating means for each tuner to cause relative movement between the respective elements thereof, a common operator to operate said actuating means in unison,
45 one element of each tuner being mounted for movement independent of that caused by the said actuating means, a separate actuator for each of said one elements, cam means actuated by said common operator for actuating
50 said separate actuators, said cam means comprising a rigid cam body having an arched surface, a series of set screws projecting through said surface, and a flexible laminated strip resiliently stretched over the projecting
55 ends of said set screws to form a continuous adjustable cam surface.

6. In combination, a plurality of separate variable tuners for high frequency circuits,
60 each tuner comprising a stator and a rotor, actuating means for each tuner to cause relative movement between the stator and rotor thereof, a common operator for operating said actuating means in unison, the stator of
65 each tuner being mounted for relative move-

ment independent of that caused in the rotor by its said actuating means, a separate actuator for each of said stators, adjustable cams actuated by said common operator for operating said separate actuators, each of said
70 cams comprising a rigid grooved cam body, a flexible strip lying in said groove forming an adjustable cam surface, means resiliently urging said strip toward the bottom of said
75 groove, and a series of set screws projecting through the bottom of said groove, and adjustable in said body for varying the contour of said adjustable cam surface.

7. In combination a plurality of separate variable radio frequency tuners, each having
80 a rotor and a stator, actuating means positively connected to each rotor, common operating means for said actuating means, said stators mounted for movement with respect to said rotors independent of that due to said
85 actuating means, separate actuators for said stators, separate adjustable cams moved by said common means to effect movement of said actuators, said cams each comprising a
90 rigid body having an arched surface, and a flexible strip forming a cam surface, the configuration of said surface being determined by a series of set screws projecting from within said body into contact with said strip
95 and resilient means holding said strip in contact with the projecting ends of said set screws.

8. In an electrical system having a plurality of continuously variable reactors for
100 regulating the reactance characteristics of the system over a range of frequencies, a primary control actuating the reactors in unison and adjusting each to approximately the required reactance for each setting of said
105 primary control, and a secondary control for each reactor connected to operate in unison with the primary control, said secondary controls providing adjustable means for slightly increasing or decreasing the reactance of each reactor independently of the
110 others and independently of the adjustment imparted to it by the primary control, said secondary controls each comprising a cam body having a convex surface, a series of adjusting screws projecting through said surface and a flexible strip, forming an adjustable cam surface, resiliently held in contact
115 with the projecting ends of said screws.

9. A tuner, an actuator therefor, and
120 means for precisely controlling the motion of the tuner relative to the actuator including an adjustable cam, said cam characterized by the following constructional features, a rigid body, a flexible strip overlying said
125 body and forming an adjustable cam surface, adjusting means, over which the strip may slide freely longitudinally, for adjusting the contour of said strip relative to said
130 body, and means longitudinally stressing

said strip whereby the strip is resiliently held against the said adjusting means.

10. In combination, a plurality of separate variable tuners and means for precisely adjusting each tuner including an adjustable cam having the following elements in combination, a rigid body having a substantially circular portion, a series of set screws radially arranged in and projecting through said portion, said screws being accessible from the concave side of said portion for adjustment in said body, a flexible strip overlying the projecting outer ends of said screws and means stressing said strip longitudinally and resiliently holding the strip against the projecting ends of said screws thereby forming an adjustable cam surface.

11. In a receiving system having continuously variable tuners and a control for actuating said tuners in unison, the improvement which includes an adjustable cam and follower means actuated by said control for precise adjustment of each of said tuners independently, each cam comprising a rigid body and screws projecting through said body and adjustable therein, a flexible strip freely overlying the projecting ends of said screws and forming a cam surface, the contour of the cam surface being determined by said screws and limited to curvature in one direction but not limited as to radius of curvature, and spring means resiliently urging said strip into contact with the projecting ends of said screws.

12. In combination, a plurality of variable tuners for high frequency circuits, an actuator for each tuner, a cam for each actuator for determining its law of motion, said cam having a cam body, as well as a flexible strip forming a cam surface, said cam also having means for resiliently stretching said strip over the body, as well as means for adjusting the configuration of said strip and adjustable in said body, and a common means for causing relative motion between each cam and its actuator.

13. In combination, a shaft, a series of cams on said shaft, and a variable tuner for high frequency circuits controlled by each cam and arranged to be varied thereby, each of said cams comprising a cam body, a flexible strip forming a cam surface, set screws in said body for adjusting the configuration of the strip, and means longitudinally stressing said strip whereby the strip is resiliently held against said set screws.

14. In combination, a variable tuner having relatively movable members, means forming a continuous cam surface fixed at one point for causing relative movement between the members, and means for adjusting said surface at a plurality of points other than said fixed point, said adjusting means and the cam surface being arranged to permit free longitudinal movement of the cam surface

relative to the fixed point and the adjusting means during the process of adjustment.

15. In combination, a plurality of variable tuners, and a common means for adjusting the tuners, comprising means forming a continuous cam surface, fixed at one point for operating each tuner, and means for adjusting said surface at a plurality of points other than said fixed point, said adjusting means and the cam surface being arranged to permit free longitudinal movement of the cam surface relative to the fixed point and the adjusting means during the process of adjustment.

16. In combination, a variable tuner having relatively movable members, means forming a conformable cam surface for causing relative movement between the members, said surface being movable longitudinally with respect to a fixed point at which it is secured and a plurality of means forming adjustable points over which the cam surface conforms, said means being closely spaced and permitting the cam forming means to move thereover with respect to the fixed point, whereby said conformable surface is caused to present a continuous smooth curve throughout its active length.

17. In a radio apparatus, the combination of a variable tuner, a cam having an adjustable surface for controlling said tuner, and means for adjusting the surface of said cam at a plurality of points, said cam surface being fixed at one point against movement and being free to move longitudinally therefrom to assume a substantially smooth and continuous curvature through and between the adjusting points.

In testimony whereof I have hereunto set my hand.

HAROLD F. ELLIOTT.