

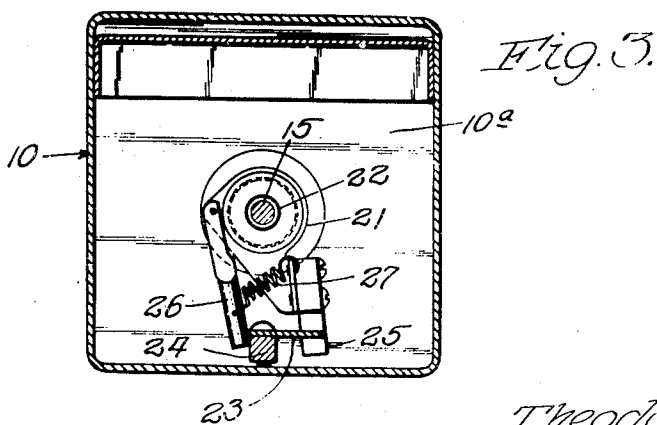
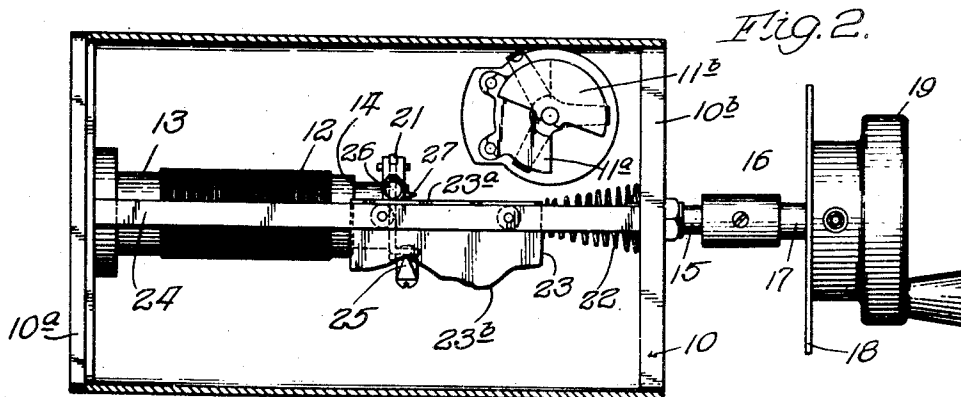
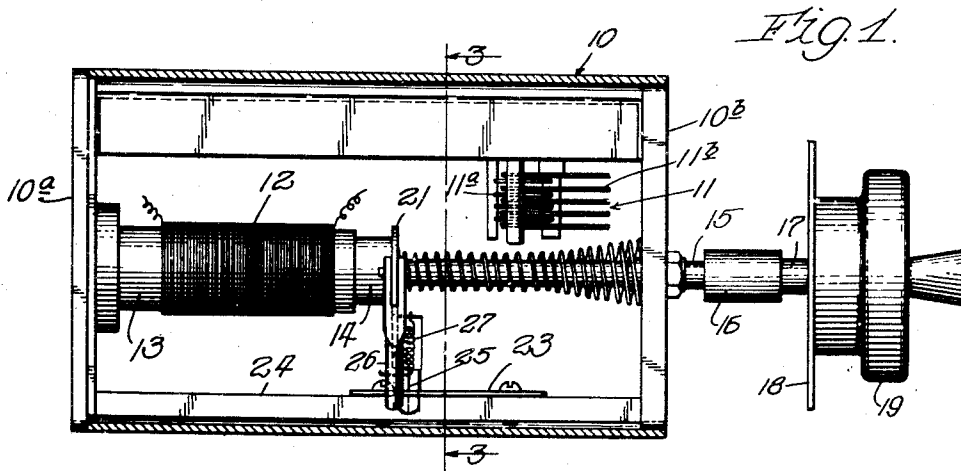
April 26, 1949.

T. A. HUNTER
TUNING APPARATUS WITH STRAIGHT LINE
CHARACTERISTIC CURVE

2,468,071

Filed March 30, 1946

3 Sheets-Sheet 1



Inventor:
Theodore A. Hunter,
By Clinton Schrader, Herman H. Hagen,
Attorneys.

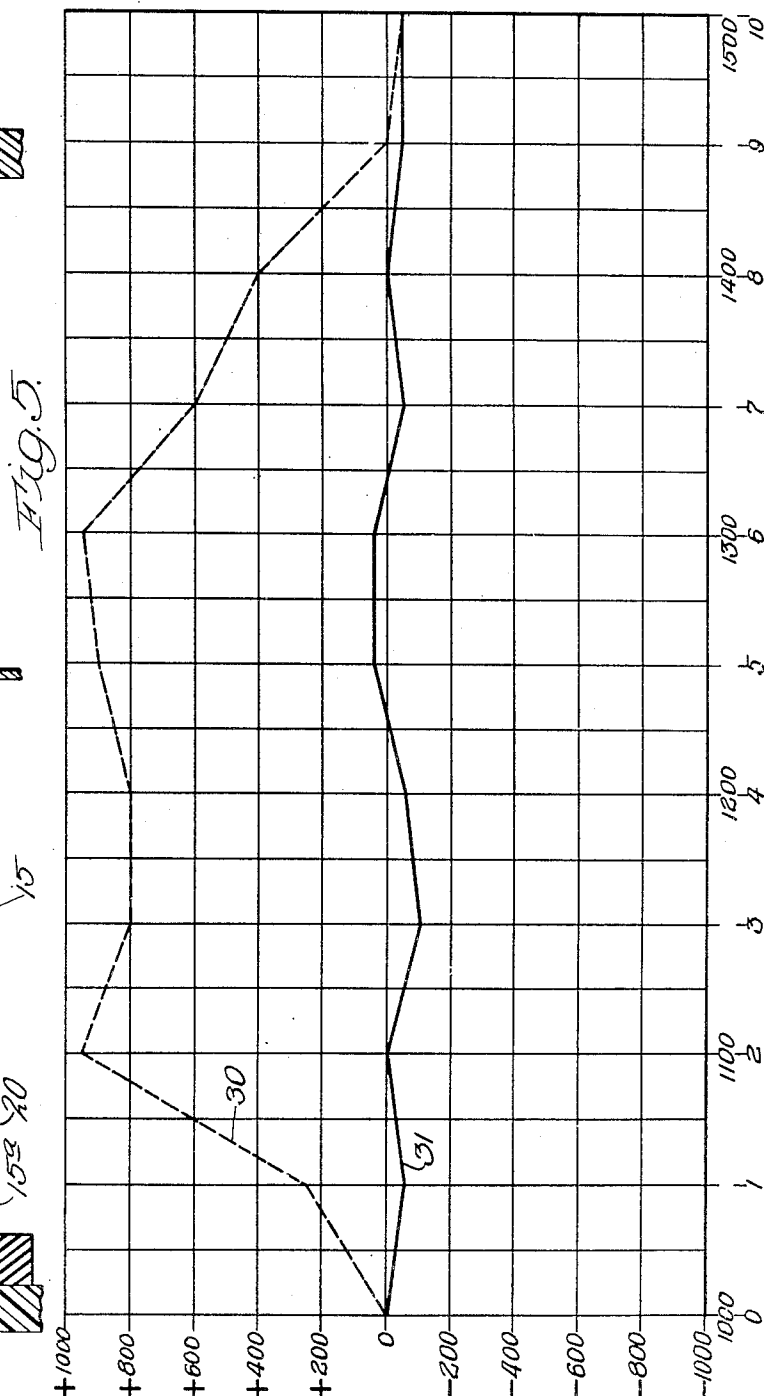
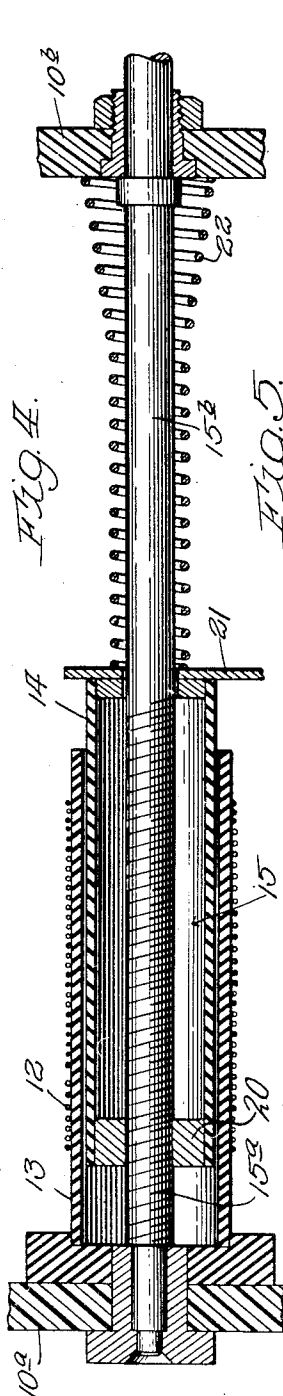
April 26, 1949.

T. A. HUNTER
TUNING APPARATUS WITH STRAIGHT LINE
CHARACTERISTIC CURVE

2,468,071

Filed March 30, 1946

3 Sheets-Sheet 2



Inventor:
Theodore A. Hunter,
By E. A. Hunter, Attorney, New York, N.Y.

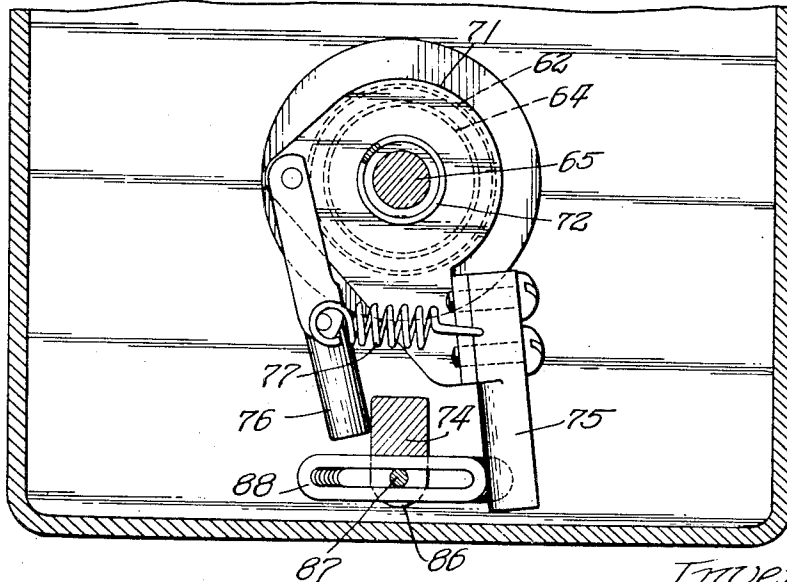
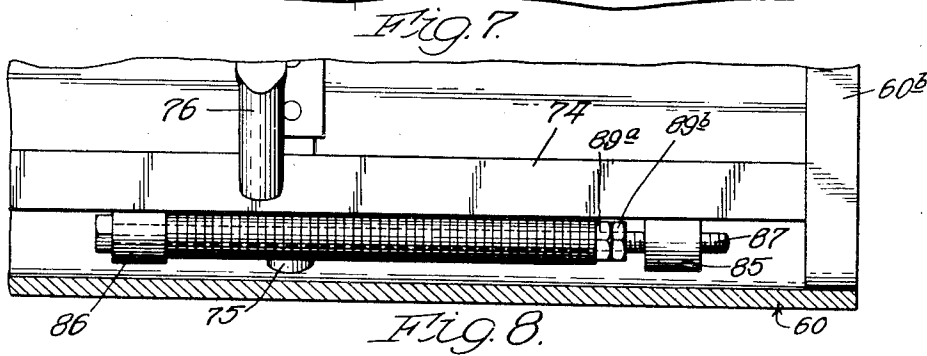
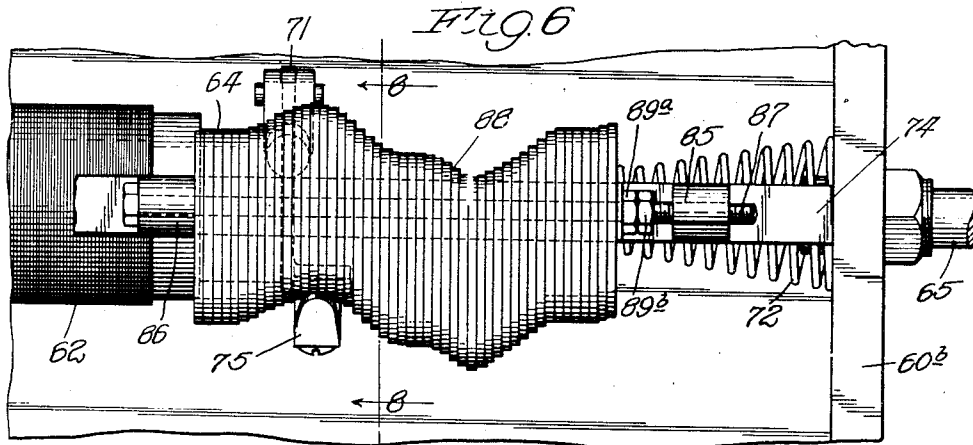
April 26, 1949.

T. A. HUNTER
TUNING APPARATUS WITH STRAIGHT LINE
CHARACTERISTIC CURVE

2,468,071

Filed March 30, 1946

3 Sheets-Sheet 3



Inventor:
Theodore A. Hunter.
By *Charles Schröder, Merriam Hopper,*
Attys.

UNITED STATES PATENT OFFICE

2,468,071

TUNING APPARATUS WITH STRAIGHT-LINE
CHARACTERISTIC CURVETheodore A. Hunter, Iowa City, Iowa, assignor to
Collins Radio Company, a corporation of Iowa

Application March 30, 1946, Serial No. 658,419

16 Claims. (Cl. 171-242)

1

This invention relates to tuning apparatus, and more particularly to means for minimizing deviations from a straight line tuning characteristic curve in a reactance element varied by rotation of a threaded shaft.

Tuning of a tank circuit of radio apparatus, and more particularly of a high frequency oscillator, is frequently effected by movement of a core of permeable material, as powdered iron, into and out of a coil by means of a rotatable shaft in threaded relation with the core. Such a movable core has been customarily so mounted as to be axially but non-rotatably movable, so that rotation of the threaded tuning shaft effects axial movement of the core with respect to the cooperating coil. This has always resulted in certain irregularities in the tuning characteristic curve of an oscillator or other tank circuit so tuned, and I have devised and am here disclosing means for minimizing such deviations.

In my invention the movable core member is so mounted as to be both axially and rotatably movable, at least through a limited rotational range; and I provide means for preventing unrestricted rotation of the core member and for at the same time effecting slight rotational movements of the core member during its axial movement. I preferably accomplish this by having a follower mounted on the core member engage an irregular side or edge of cam means, the cam edge being formed, after testing of the device, in such manner as to compensate substantially entirely for deviations from straight line tuning characteristics which would otherwise occur.

Various features and advantages of my invention will be apparent from the following specification and the drawings, in which:

Figure 1 is a vertical sectional view of an oscillator tuning unit embodying my invention; Figure 2 is a bottom plan view of the device shown in Figure 1, with the bottom portion of the casing removed; Figure 3 is a transverse sectional view along the line 3-3 of Figure 1; Figure 4 is an enlarged fragmentary sectional view of the coil shown in Figures 1-3 and its associated core and threaded shaft; Figure 5 is a diagram indicating tuning characteristics of a tank circuit with and without my invention; Figure 6 is an enlarged fragmentary bottom plan view of another embodiment of my invention; Figure 7 is a side elevational view of the apparatus shown in Figure 6; and Figure 8 is a transverse sectional view along the line 8-8 of Figure 6.

In the particular embodiment of my invention

2

illustrated in Figures 1-4, a housing 10 having end plates 10a and 10b encloses at least the capacitive and inductive reactance elements of the tank circuit of radio apparatus, as an oscillator designed for use in aircraft and adapted to work at relatively high frequencies of 1 megacycle or above; and this housing may also contain other parts of the oscillator, for example, although the same are not shown here since they do not form a necessary part of the present invention. The capacitive element in this case is shown as a condenser 11 having stator plates 11a and rotor plates 11b. While the condenser is of a variable type, it will be understood that it is varied only for initial adjustment, and that, in operation of the equipment, it acts only as a fixed reactive element. This condenser is in parallel with an inductive reactance element which has its reactance varied to effect tuning of the tank circuit.

The inductive reactance element is here shown as comprising a coil 12 wound on a suitable form 13 rigidly mounted on the end plate 10a of the housing. A cylindrical core member 14 of suitable permeable material, as powdered iron in an appropriate plastic binder, is mounted so as to be axially and rotatably movable with respect to the coil 12. Within the core 14 and co-axial with it and the coil 12 is a shaft 15 having a threaded portion 15a within the coil and a smooth portion 15b. This shaft is rotatably journaled in suitable bearings in end plates 10a and 10b of the housing, and is adapted to be connected, as by a coupling 16, to a stub shaft 17 projecting through the panel 18 of radio apparatus, for example, and adapted to be rotated by a tuning knob 19 rigidly mounted thereon. The permeable core member 14 is supported on the shaft 15 by being mounted at one end on a nut 20 internally threaded and in threaded engagement with the portion 15a of the shaft and being mounted at the other end on an end member 21 slidable on the smooth portion 15b of the shaft. A spring 22 serves to urge the core member into the coil 12 at all times and to take up any slack or lost motion during tuning by rotation of the shaft 15.

Spaced from, but parallel with, the shaft 15 is a cam member 23 of sheet material, as sheet brass, this member having one side or edge 23a which is regular (i. e., straight) and parallel to the shaft 15 and an opposite side or edge 23b which is irregular, but still generally parallel to the shaft. While this cam member or plate 23 may be mounted in any suitable manner, it is

here shown as carried by a bar 24 extending between the end plates of the housing. Rigidly mounted on the end member 21 of the core member is a follower member or follower means here identified as 25, this follower means being adapted to engage the irregular edge of the cam member 23. On the other side of the cam member is a member 26 pivotally mounted on the end member 21 (as may be best seen in Figure 3), and adapted to bear against the regular side or edge of the cam 23. The two members 25 and 26 are pulled toward each other by the tension of a spring 27, this spring tending to rotate the core member in a direction tending to bring the follower member 25 toward the bar 24, such rotation being prevented by engagement of the follower member with the irregular edge 23b of the cam.

As may be best seen in Figure 2, the cam edge 23b may have any appropriate conformation, having portions of its edge both closer to the mounting bar 24 than what might be termed a straight line edge, and other portions further from the mounting bar. In manufacturing an oscillator incorporating my invention, I prefer to complete the oscillator and test it accurately to determine its frequency-characteristic curve, and then to cut or grind the irregular edge of the cam 23 in such manner as to compensate for deviations from the desirable straight line tuning characteristic enabling accurate calibration of the tuning dial 19. When the cam surface is tending to move the follower 25 further away from the bar 24, the core tends to move slightly more or less axially (depending upon the direction of threading and rotation of the tuning shaft 15) than would be the case if no rotation of the core member took place; and the opposite is true if the irregular edge of the cam is such that at any given point in its axial movement the follower 25 is moving toward the bar 24. The result is that the irregular edge of the cam may be so shaped as to compensate not only for what may be termed general or expected deviations from a straight line tuning characteristic curve, but also to compensate for any special deviations which are peculiar to the particular tank circuit in which the cam member is installed. As a matter of manufacturing procedure, deviations in frequency from the desired straight line can be worked up into a table of positive or negative deviations from a straight line or base line, and the cam 23 cut or ground directly to the proper shape.

Referring more particularly to Figure 5, I illustrate the deviation of a frequency characteristic curve in the case of a given tank circuit of the kind illustrated both with and without my compensating arrangement. The particular tank circuit tested was part of an oscillator designed to be tuned over a range from 1 megacycle to 1.5 megacycles by rotation of the tuning shaft through ten turns. Deviation of the oscillator frequency from a desired straight line tuning characteristic is shown on the chart as deviation from a "O" base line by the dotted line curve identified as 30. It will be noted that at certain portions of the frequency range (namely at about 1.1 and 1.3 megacycles) the deviation was nearly a thousand cycles from the desired straight line. The same oscillator, with a suitable corrector cam cut and mounted in the manner shown in Figures 1 to 4, provided a curve of the kind shown in a solid line and identified as 31, at no time deviating more than 100 cycles from the base line. This resulted in a maximum deviation of less than ten

per cent of the maximum deviation previously present in the uncompensated oscillator; and in an oscillator which differed so slightly from an absolute straight line tuning curve that for all practical purposes it might be calibrated and used as having an absolutely straight line tuning characteristic.

Another embodiment of my invention which is very satisfactory commercially is shown in Figures 6, 7 and 8, to which reference will now be made. Inasmuch as the primary difference between this and the modification heretofore described resides in the arrangement of the guide means for the follower, and since the major construction and operation of the oscillator is otherwise similar, reference numerals 50 higher will be applied to analogous parts so that reference back to the preceding portions of the specification may be made if desired to supplement this portion of the specification.

In the embodiment illustrated in Figures 6-8, a housing 60 is adapted to contain at least the tuned tank circuit of an oscillator, the coil 62 comprising the inductive element of such a tank circuit. This coil again has a movable permeability tuning core 64 therein, this being mounted on the threaded portion of a shaft 65 adapted to be rotated to effect axial movement of the tuned core. A spring 72 again urges the core in one direction, bearing against the end plate 60b in which the shaft is journaled. The end member 71 of the core arrangement again has a follower 75 rigidly mounted thereon and another member 76 pivotally mounted thereon, these two members being pulled together by the spring 77.

In this case the member 76 bears directly against one side of the mounting bar 74, which in this case forms the leg or straight side of the guide means. Depending from the bar 74 at suitable spaced points are lugs 85 and 86, these serving to carry a long mounting stud or threaded shaft 87.

The cam providing the irregular surface adapted to be contacted by the follower 75, and corresponding to the cam 23 of the form of my invention heretofore described, in this case comprises a plurality of segments of sheet material so mounted that they may be moved and then locked in a desired position to provide a cam profile of adjustable configuration. The individually movable segments of the cam are here shown as about 50 in number, although it will be understood that any suitable number may be used, and since they are all identical only one segment will be described in more detail, referring more particularly to Figure 8. The segment 88 is representative, and will be seen to be in the form of an elongated washer or straight-sided oval with a slot in the center, the long dimension being preferably several times the width. Then central slot or opening is adapted to receive the threaded shaft 87, and one side of the segment (the upper side as viewed in Figure 8) is adapted closely but slidably to abut the lower surface of the square mounting bar 74. This arrangement enables the individual segments, here shown as metal washers, to be individually moved in a plane parallel to that of the shaft 65 and substantially transverse to the follower 75, so that the side of the cam surface adapted to be contacted by the follower (the lower side as the parts are viewed in Figure 6) can be provided with an adjustable profile by individual movement of the segments as desired.

In use of this form of the invention, the fre-

quency of the oscillator embodying a tuned tank circuit incorporating my invention would be determined throughout the full tuning range with the side of the adjustable cam engaged by the follower 75 initially straight, and deviations from a straight line tuning characteristic curve would be determined. The nuts 89a and 89b would then be loosened slightly and the segments individually moved, as by tapping them with a small mallet or the like, until the desired compensating cam profile is attained, whereupon the nut 89a would be drawn up tight to clamp the segments in the desired position and the nut 89b tightened to provide a locking arrangement. Thereafter the operation of the device would be similar to that of the form illustrated in Figures 1-4 and described earlier.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. Tuning apparatus of the character described, including: a reactance element including a first member and a second movable member rotatable with respect to said first member; a rotatable shaft in threaded relation with said movable member and adapted to effect movement of said member axially of said shaft; and apparatus operable to slightly vary the rotational position of said movable member with respect to said first member during said axial movement while preventing unlimited rotational movement of said movable member.

2. Tuning apparatus of the character described, including: a reactance element including a movable member; a rotatable shaft in threaded relation with said member and adapted to effect movement of said member axially of said shaft; and guide means engaged by a portion of said member, this guide means being irregular for slightly varying the rotational position of said member during axial movement thereof.

3. Tuning apparatus of the character described, including: a reactance element including a movable member; a rotatable shaft in threaded relation with said member and adapted to effect movement of said member axially of said shaft; means tending to rotate said member in a certain direction; and guide means having a side engaged by a portion of said member, this side being irregular for slightly varying the rotational position of said member during axial movement thereof.

4. Tuning apparatus of the character described, including: an inductance element including a fixed member and a member mounted for rotational and axial movement; a rotatable shaft in threaded relation with said movable member and adapted to effect movement of said movable member axially of said shaft; spring means tending to rotate said movable member in a certain direction; follower means rigidly mounted on said movable member; and guide means having a side generally parallel to the axis of said shaft and engaged by said follower means, this side being irregular for slightly varying the rotational position of said movable member during axial movement thereof.

5. In a radio tank circuit, tuning apparatus including: a reactance element including a movable member; a rotatable shaft in threaded rela-

tion with said member and adapted to effect movement of said member axially of said shaft; and guide means engaged by a portion of said member, this guide means being irregular for slightly varying the rotational position of said member during axial movement thereof.

6. In a radio tank circuit, tuning apparatus including: an inductance element including a fixed coil member and a core member mounted for rotational and axial movement; a rotatable shaft in threaded relation with said movable member, and adapted to effect movement of said movable member axially of said shaft; spring means tending to rotate said movable member in a certain direction; follower means rigidly mounted on said movable member; and guide means having a side generally parallel to the axis of said shaft and engaged by said follower means, this side being irregular for slightly varying the rotational position of said movable member during axial movement thereof.

7. In a radio tank circuit, tuning apparatus including: an inductance element including a fixed coil member and a core member mounted for rotational and axial movement; a rotatable shaft in threaded relation with said movable member, and adapted to effect movement of said movable member axially of said shaft; spring means tending to rotate said movable member in a certain direction; follower means rigidly mounted on said movable member; and guide means comprising a member of sheet material arranged generally parallel to the axis of said shaft and having an edge engaged by said follower means, this edge being irregular for slightly varying the rotational position of said movable member during axial movement thereof.

8. In a radio tank circuit, tuning apparatus including: an inductance element including a fixed coil member and a core member mounted for rotational and axial movement; a rotatable shaft in threaded relation with said movable member and adapted to effect movement of said movable member axially of said shaft; spring means tending to rotate said movable member in a certain direction; follower means rigidly mounted on said movable member; and guide means comprising a member of sheet material arranged generally parallel to the axis of said shaft and having an edge engaged by said follower means, this edge being irregular for slightly varying the rotational position of said movable member during axial movement thereof, the spring means being connected between said follower means and means engaging the opposite edge of said guide means.

9. Tuning apparatus of the character described, including: a reactance element including a movable member; a rotatable shaft in threaded relation with said member and adapted to effect movement of said member axially of said shaft; and guide means engaged by a portion of said member, this guide means having an adjustable irregular side adapted to be engaged by said portion for slightly varying the rotational position of said member during axial movement thereof.

10. Tuning apparatus of the character described, including: a reactance element including a movable member; a rotatable shaft in threaded relation with said member and adapted to effect movement of said member axially of said shaft; means tending to rotate said member in a certain direction; and guide means having a side engaged by a portion of said member, this side having an adjustable profile for slightly

varying the rotational position of said member during axial movement thereof.

11. In a radio tank circuit, tuning apparatus including: an inductance element including a fixed coil member and a core member mounted for rotational and axial movement; a rotatable shaft in threaded relation with said movable member and adapted to effect movement of said movable member axially of said shaft; spring means tending to rotate said movable member in a certain direction; follower means rigidly mounted on said movable member; and guide means providing an adjustably irregular side adapted to be engaged by said follower means for slightly varying the rotational position of said movable member during axial movement thereof.

12. In a radio tank circuit, tuning apparatus including: an inductance element including a fixed coil member and a core member mounted for rotational and axial movement; a rotatable shaft in threaded relation with said movable member and adapted to effect movement of said movable member axially of said shaft; spring means tending to rotate said movable member in a certain direction; follower means rigidly mounted on said movable member; and guide means comprising a plurality of relatively movable segments of sheet material and clamping means therefor, this guide means providing an adjustably irregular side adapted to be engaged by said follower means for slightly varying the rotational position of said movable member during axial movement thereof.

13. A device for adjusting reactance characteristics of an electrical network of the type having an adjustable reactance element, comprising a threaded control shaft having said element threadably mounted thereon for moving said element rectilinearly between two points to change the reactance correspondingly therebetween, a fixed cam member, and a cam follower which cooperates with said cam member and rotates said element relative to said shaft to produce a reactance variation between said points in accordance with a predetermined desired law while maintaining said rectilinear motion of said element.

14. Apparatus of the character claimed in claim 13 in which the cam has an adjustable contour causing reactance variation corresponding to the said desired law.

15. A device for adjusting reactance characteristics of an electrical network of the type having an adjustable reactance element, comprising a threaded control shaft mounted for rotation, but restrained against rectilinear motion, a lead-screw follower threadably mounted on said shaft, said follower carrying said element, and rotation of said shaft moving said element rectilinearly between two points to change the reactance correspondingly therebetween, a fixed cam member, and a cam follower connected to said element and movable rectilinearly as a unit therewith and adapted to cooperate with said cam member to rotate said element relative to said shaft to produce a reactance variation between said points in accordance with a predetermined desired law while maintaining said rectilinear motion of said element, said cam having a predetermined configuration causing a reactance variation corresponding to said desired law.

16. A device for adjusting reactance characteristics of an electrical network of the type having an adjustable reactance element, comprising a rotatable control shaft carrying a lead screw; a lead-screw follower threadably mounted on said lead screw and attached to said reactance element, rotation of said shaft moving said element rectilinearly between two points to change the reactance correspondingly therebetween, a fixed cam member extending along said shaft substantially parallel thereto, and a cam follower which engages the edge of said cam member and rotates said element relative to said shaft to produce a reactance variation between said points in accordance with a predetermined desired law while maintaining said rectilinear motion of said element, said cam edge having a configuration causing reactance variation corresponding to said desired law.

THEODORE A. HUNTER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,131,953	Pilkington	Mar. 16, 1915
2,144,353	Weis	Jan. 17, 1939
2,175,554	Bliss	Oct. 10, 1939
2,398,112	O'Brien	Apr. 9, 1946
2,407,359	White	Sept. 10, 1946