Dec. 15, 1931.

H. F. ELLIOTT

1,836,583

VARIABLE CONDENSER

Filed Aug. 25, 1925

2 Sheets--Sheet 1

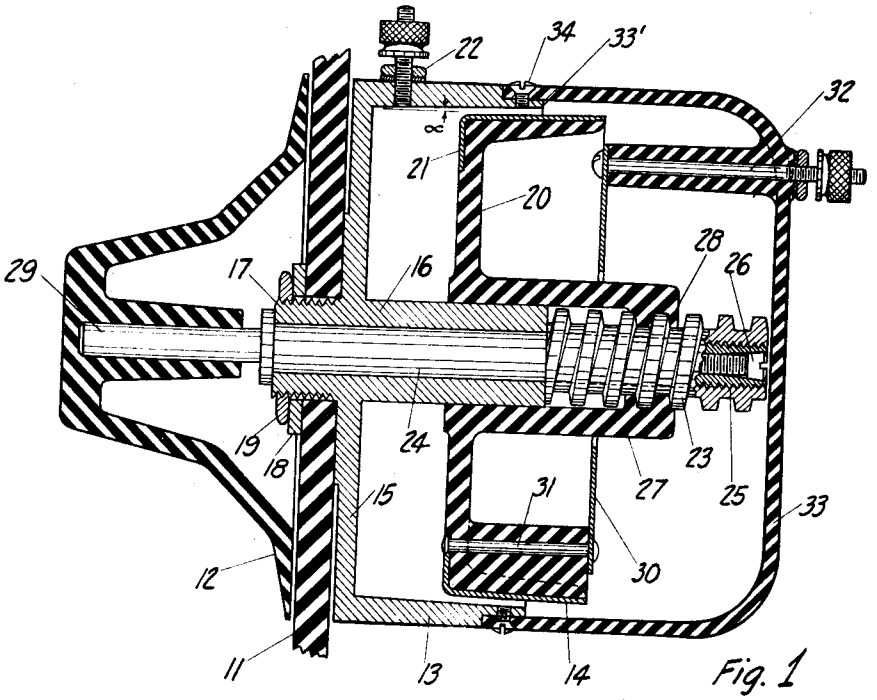


Fig. 1

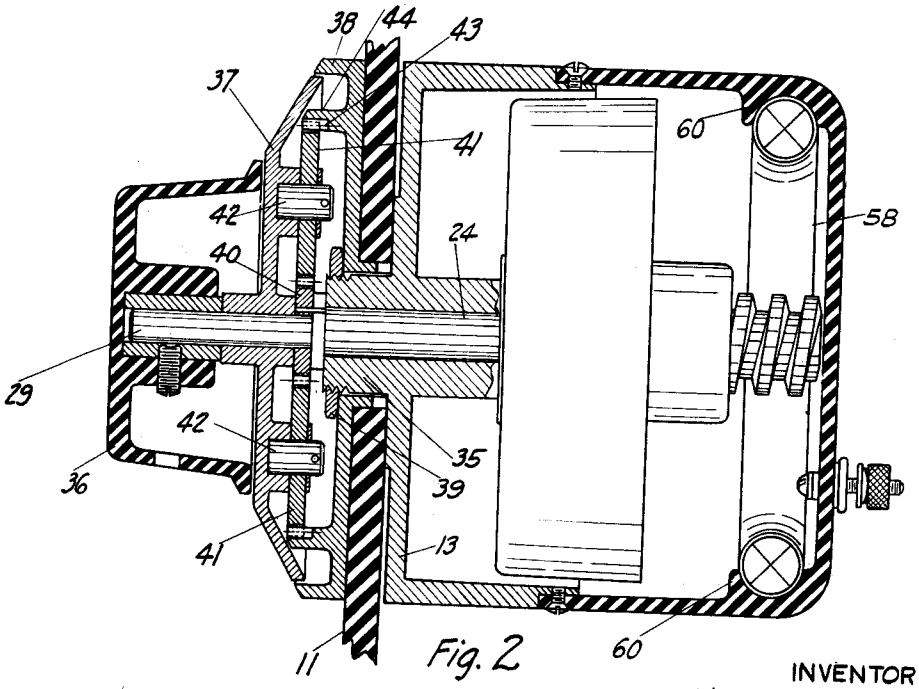


Fig. 2

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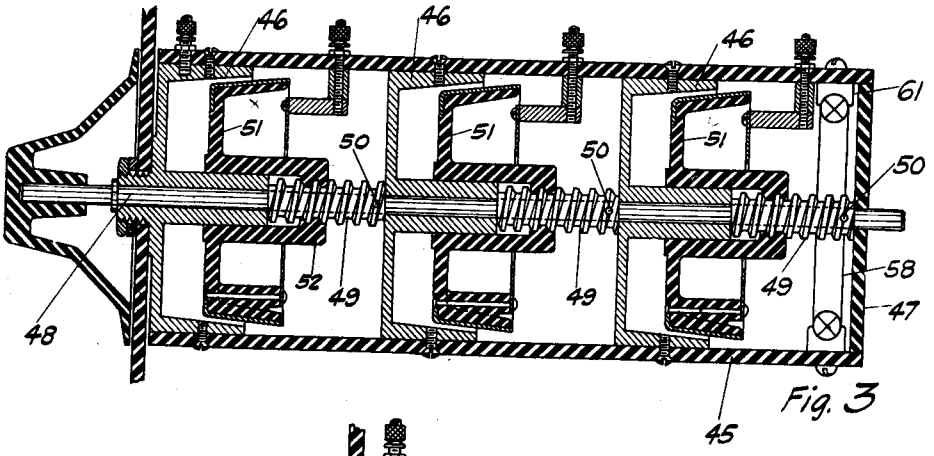


Fig. 3

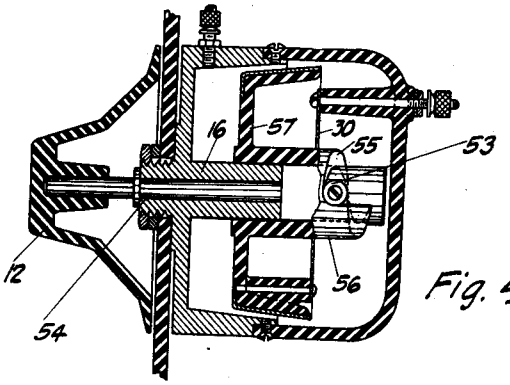


Fig. 4

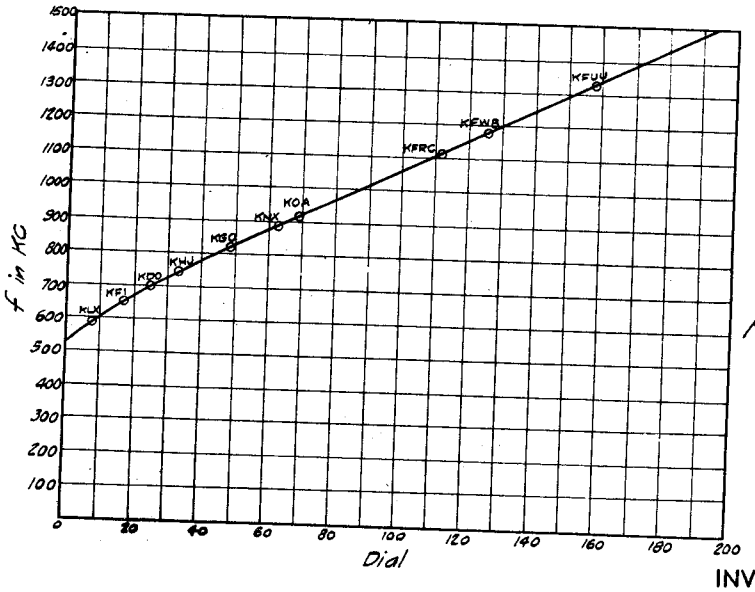


Fig. 5

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Patented Dec. 15, 1931 1,836,583

UNITED STATES PATENT OFFICE

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VARIABLE CONDENSER

Application filed August 25, 1925. Serial No. 52,384.

This invention relates to an apparatus for varying the capacity of an electric circuit, and especially to a condenser having relatively movable electrodes.

Such devices are now in common use in connection with systems for radio transmission and reception. The recent extensive development in broadcasting has especially created a large demand for simple and inexpensive instruments for tuning high frequency circuits, so essential to secure selectivity in a receiver set. The most common form of such a condenser includes a plurality of interleaving flat plates of conducting material, formed into two sets. The extent of the interleaving can be varied in order to vary the capacity between the sets of plates. The flat plates in such condensers must be carefully assembled, and adjusted after assembly in order to assure proper interleaving without short circuits; and such adjustment of the plates is usually required from time to time after the condenser is in use. Furthermore, the contact between the individual plates and the common support for each set, is apt to become loose, with attendant loss in efficiency and sharpness.

Other forms of variable condensers also have structuural disadvantages. It is one of the objects of my invention to obviate substantially all such disadvantages, and to make it possible to construct a simple and reliable variable condenser that can not only be manufactured at a low cost, but assembled easily and kept in good working order indefinitely.

It is another object of my invention to obviate the necessity for accurate adjustments of any of the moving parts during assembly.

In and near substantially all of the large cities, there are now a number of broadcasting stations from which radio signals can easily be received. In order to impart selectively, it is desirable that the variable condenser be adjusted by a substantial amount in varying the frequency of resonance of its associated radio circuit, from the frequency of one station to that of the station broadcasting at the nearest frequency to that of the first. In other words, it is desirable to have a variable condenser for tuning a circuit, by which the stations are separated by an appreciable condenser adjustment. Since broadcasting stations are numerous and operate within a limited range of frequencies (approximately from 500,000 cycles to 1,500,000 cycles), the separation of the stations in this manner is sometimes difficult. It is thus another object of my invention to make is possible to tune a receiver circuit in such a way that the frequencies of operation are separated to a substantial extent in the variation of the condenser.

In order to secure the foregoing advantage, I arrange the relative movement of electrodes in such a way that the amount of the movement is directly proportional to the difference in the resonant frequency of the circuit being tuned. In this way, the characteristic curve of the condenser, connecting the setting of the condenser with the frequency at which the particular setting provides a tuned circuit, is a straight line, when plotted in rectangular coordinates.

It is still another object of my invention to make it possible to vary the capacity of the condenser by minute increments in a convenient manner. Ordinarily, variable condensers are adjustable by the aid of a rotatable shaft, and in accordance with my invention, the extent of angular movement of the shaft can be made as large as desired, to secure accurate adjustment of the condenser.

It is another object of my invention to provide a reduction mechanism for this large angular movement, whereby it is possible to indicate the variation of the condenser by the aid of a single dial of the ordinary form.

It is another object of my invention to make it possible to operate a plurality of variable condensers by a common means, in an expeditious and simple manner.

It is still another object of my invention to make it possible to manufacture the various parts of condensers in a commercial way and on a large scale, and yet insure that all of the parts can be readily fitted and assembled together to form a simple and rugged structure.

My invention possesses many other advan-

tages, 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 sectional view of a variable condenser constructed in accordance with my invention;

Fig. 2 is a fragmentary view of a modified form of the condenser, illustrating especially the manner in which the large angular movement of the condenser shaft may be reduced, for securing proper indications;

Fig. 3 illustrates a further embodiment of my invention, and discloses how several variable condenser elements can be arranged to be operated in unison;

Fig. 4 is a sectional view of a further modification; and

Fig. 5 is a curve showing the relation between the dial setting and the frequency of resonance of the circuit with which the variable condenser constructed in accordance with my invention is associated.

In Fig. 1, I illustrate a variable condenser adapted to be mounted on a vertically arranged panel 11. As is common, a rotary dial 12 is arranged on one side of the panel for manual control, and the condenser parts are arranged on the other side of the panel to be hidden from view. The active portions of the condenser include a pair of electrodes which may be moved relatively to each other by manual rotation of the dial 12. One of the important features of my invention resides in the form of these electrodes. They are arranged in such manner that upon relative movement, there is a variation in the active surfaces of the electrodes, as well as of the thickness of the dielectric between them.

This I can accomplish by arranging the electrode surfaces obliquely to the direction of their relative movement. A convenient manner in which this may be accomplished is by forming one metal electrode, such as 13 as a portion of an internal cone surface, and by forming the other electrode 14 with a cooperating external cone surface, there being a movement of one electrode with respect to the other along the common axis of the cone surfaces, which are thus concentrically formed. In order to facilitate the mounting of the electrodes and to provide for proper axial movement, the electrode 13 has a disc-like portion 15 with a central hub 16 projecting toward the other electrode. A left hand hub 17 is threaded, and is arranged to project thru an aperture in the panel 11. A washer 18 and a nut 19 are passed respectively over the free end of this hub 17 in order to clamp the electrode 13 securely on the panel 11.

The right hand hub 16 forms a convenient guide upon which the other electrode structure can slide. In order to accomplish this result, the electrode 14 is supported on the outer face of a cone shaped disc 20 made from appropriate insulation material such as bakelite. The electrode 14 forms a covering for the periphery of this disc 20; and it also has a depending portion 21 inset in its left hand face.

It is evident that telescopic or axial movement of disc 20 on hub 16 will serve to vary the spacing of the active surfaces of the two electrodes. The rate of the variation can be very accurately determined by proper choice of the cone angle α. It is further evident that the axial movement being oblique with respect to the active surfaces, the thickness of the dielectric between the surfaces is varied by such movement as well as the area of the active surfaces.

Due to the concentric arrangement, it is possible to manufacture the electrode structures 13 and 14 on a commercial scale with sufficient accuracy to insure proper centering of one with respect to the other. There is no necessity of further adjustment after assembling, for the mere act of assembling is sufficient to space the electrodes properly with respect to each other.

The electrode 13 can be provided with a binding post structure 22 fastened in this instance, near the upper portion of the concentric active surface of this electrode.

In order to slide the disc 20 on the hub structure 16, any appropriate mechanical movement may be used. In the embodiment of Fig. 1 I illustrate a worm 23 mounted on a shaft 24 that is rotatable within the hubs 16 and 17. This worm is fastened to the right hand end of shaft 24 by the aid of the screw threads 25. In order to provide for relative axial adjustment of the worm with respect to the shaft 24, the end of this shaft where it is threaded is split, and a wedge in the shape of a screw 26 is provided in the end of the shaft to spread this end of the shaft and to clamp it tight to the worm 23. By the aid of this structure, it is possible to adjust the relative axial positions of the worm 23 and the shaft 24. The disc 20 has a hub 27 provided with a nut portion 28 in which the worm 23 engages. It is evident that on rotation of shaft 24 the hub 27 will be moved axially, provided this hub is restrained from rotation. The rotation of shaft 24 is accomplished by the aid of the dial 12, which is fastened to the extension

29 of the shaft 24. Restraint against rotation of disc 20 is accomplished by the aid of a member 30 in the form of a flat spring, apertured to permit passage of hub 27. One end of the spring is fastened as by a rivet 31 to the disc 20, and the other end is fastened by the aid of a binding post structure 32 to a casing 33 of insulating material. The flat spring 30 may thus serve as the lead-in connection for the electrode 14 by the aid of the rivet 31, which extends thru the disc structure 20 and electrically connects the spring 30 with the depending portion 21 of the electrode 14. The spring also serves conveniently to hold the nut 27 frictionally against the worm 23, whereby said worm is maintained against inadvertent movement. The cover 33 is arranged to telescope over the projection 33′ of the electrode 13 and may be fastened thereto by the aid of a series of screws 34. Thus a dust proof casing is provided for all of the moving parts of the condenser.

The binding post structure 32 extends thru the cover whereby connection may be made to it externally of the enclosed structure.

The mode of operation of the device is evident from the foregoing description. When assembling the parts, the movable electrode structure 14—20 is properly alined without the necessity of frequent or further adjustments. Furthermore, it should be noted that as the disc 20 moves to the left axially on the hub 16, the extent of the surfaces which are active on the two electrodes becomes greater and greater, while at the same time, the dielectric thickness between them is reduced. The walls of the enclosing casing may conveniently form stops, limiting the movement of the electrode structure 20. By the aid of the wedge screw 26, it is possible to adjust the axial position of the worm 23 with respect to the hub 16, to avoid end play. The axial position of the electrode 20 may then be adjusted and the dial 12 set to give the desired reading. In this way, it is possible to adjust the dial reading to compensate for minor electrical effects.

It is also to be noted that since both electrodes are rigidly supported on parts capable of being finished accurately in large quantities, the process of assembly is rendered extremely simple. Since the amount of dielectric between the electrodes is small, there is a minimum dielectric loss. Furthermore, the worm and nut construction can be so designed that the dial 12 can be made to vary the electrode spacing at a slow rate, whereby accurate adjustment is afforded.

A further very important advantage is that, by calculation and on actual trial, it has been found that a condenser constructed in accordance with this disclosure varies the frequency of resonance substantially as a straight line function with respect to the dial setting. Thus, in Fig. 5, there is reproduced a curve in which the abscissae are dial settings, reading from 0 to 200 and corresponding to complete movement of the disc 20, and the ordinates represent frequencies in kilocycles corresponding to the frequency of resonance for the particular dial settings represented by the abscissae. This curve represents an actual test taken with the apparatus, and has marked thereon the various broadcasting stations which were tuned in by the aid of the condenser. It is seen that they fall substantially on a straight line. This is a highly desirable feature, for the stations can be kept separated and the arrangement is selective.

It is evident that in the construction of Fig. 1, the dial 12 must rotate thru several revolutions in order to produce a full movement of the disc 20. Under such circumstances, it is not practicable to keep track of the angle of movement of the shaft 24. In order to obviate this difficulty, I illustrate a modification in Fig. 2 in which this dial movement is reduced by the aid of a reduction mechanism such as planetary gears arranged in a compact train. In this figure, the shaft 24 is mounted for rotation as before in a hub 35 of the stationary electrode 13. The knob 36 is securely fastened to the shaft at its free extremity, and is arranged to impart a reduced motion to the dial 37, coacting with a stationary index plate 38. This dial is free to rotate on shaft extension 29. This index plate is fastened by the lock nut 39 to the panel 11, which lock nut serves also to hold the stationary electrode 13 in place.

In order to provide a reduced motion to the dial 37, a small gear 40 is fastened on the shaft 24 and is arranged to mesh with and drive one or more planetary gears 41. These planetary gears are rotatably mounted on short stub shafts 42 fastened on the inner side of the dial 37, and mesh with a stationary gear 43 formed on an internal surface of the flange 44, integral with the index plate 38. It can readily be proven that by making pinion 40 small enough, and the diameter of the internal gear 43 large enough, any desired reduction in the movement of the dial 37 can be obtained. Thus, movement of gear 40, due to movement of knob 36, results partly in a rotary movement of planetary gears 41 about their own axes, and partly in a planetary movement; the planetary movement being that which causes dial 37 to rotate about its own axis, it is thus seen that a reduced movement thereof is secured.

The arrangement of Fig. 2 is of course applicable to other types of condenser, in which a large shaft movement is necessary to produce a full movement of the variable condenser.

In this figure I also show a toroidal "astatic" inductance coil 58, which can be used in

conjunction with the condenser, to form a complete tuning unit. There is ample space for this coil in the cover member 33, and it can be arranged to be coaxial with the condenser electrodes. In order to permit the carrying out of this compact arrangement, merely a binding post 59 is provided in lieu of the spring 30; and furthermore, several projections 60 can be provided in cover member 33 between which the coil can be readily sprung to retain it in place.

In many sets now on the market, it is possible to tune accurately several stages of radio frequency by the movement of a common shaft. My condenser structure is especially adapted for this type of set. I illustrate in Fig. 3 one embodiment of a multiple condenser constructed in accordance with my invention. In this figure a hollow tube 45 of insulating material carries within it, a series of stationary electrode structures 46, the extreme left hand structure serving as a closure for that end of the tube. A cover 47 may be provided in the other end which also serves to support the long shaft 48, extending thru the entire structure. This shaft is journaled in the stationary electrodes 46 and adjustably carries a plurality of worms 49. The adjustment of these worms may be performed by the aid of set screws 50, which serve to hold the worms 49 to the shaft 48. The movable electrodes 51 are provided with threaded portions 52 engaged by the worms 49, whereby upon rotation of shaft 48 all of the movable electrode structures 51 are axially moved.

The connection for each of the condenser elements may be provided as indicated and in general are substantially identical to that illustrated in Fig. 1.

Since each of the worms 49 may be independently adjusted along the axis by the aid of their set screws 50, it is possible to compensate for lack of uniformity in the radio frequency circuits which are to be tuned simultaneously by this structure. In other respects, the operation of the condensers is substantially identical with that already disclosed. I also indicate a toroidal inductance coil 58 in this embodiment, to form a tuning unit with at least one of the condensers. In this instance, the coil is shown as supported by the aid of several saddles 61 fastened to the inside of tube 45.

It is possible to cause relative movement of the electrode structure by mechanism other than the worm and nut arrangement thus far disclosed. As an additional example of such plurality of other forms, I show in Fig. 4 an arrangement whereby a roller 53 is fastened to the operating shaft 54 of the condenser and is arranged to co-act with a cam surface 55 at the right hand surface of the hub 56, formed on the movable electrode structure 57. This cam surface 44 may conveniently be in the form of helicoid of steep pitch. In this way, a complete rotation of the dial 12 can cause a complete movement of the movable electrode 57 on the hub extension 16. The spring 30 serves to cause a proper engagement at all times between the cam roller 53 and the cam surface 55. The electrode 57 is of course limited in its movement by the walls of the enclosing casing.

I claim:

1. In a variable condenser, a pair of electrodes, one of said electrodes having a ring-like body forming said electrode, on which there is an annular inner active surface, said body having one end closed, an insulating closure for the other end, and means for supporting the other electrode in the space enclosed by the body and the closure, in such manner as to permit relative movement of the electrodes.

2. In a variable condenser, a stationary electrode, a movable electrode, a rotatable shaft, a screw on the shaft for moving said movable electrode, and means for axially adjusting said screw with respect to the shaft.

3. In a variable condenser, a stationary, hollow electrode having an inner active surface extending around an axis of symmetry of said electrode, said electrode also having a hub at the axis, a shaft journaled in said hub for rotation about said axis, an electrode structure movable axially of the shaft, and slidable along said hub, said electrode structure having an outer surface cooperating with the said inner surface of the stationary electrode, a worm on said shaft engaging threads in the said movable electrode structure to move it axially, an insulating cover fastened to the stationary electrode and enclosing the movable electrode, a binding post extending through said cover, and a metallic spring member fastened at one end to the inner end of the binding post, and fastened at the other end to the movable electrode structure and serving to provide a connection therefor.

4. In combination, a tubular insulation member, a series of spaced, annular stationary electrodes fastened within the hollow tubular member, a shaft extending through the tubular member and through the stationary electrodes, and a series of movable electrodes carried by the shaft and cooperating with the stationary electrodes.

In testimony whereof I have hereunto set my hand.

HAROLD F. ELLIOTT.