Aug. 31, 1937. E. R. STOEKLE 2,091,616

ELECTRICAL CONDENSER AND THE LIKE

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Fig. 1.

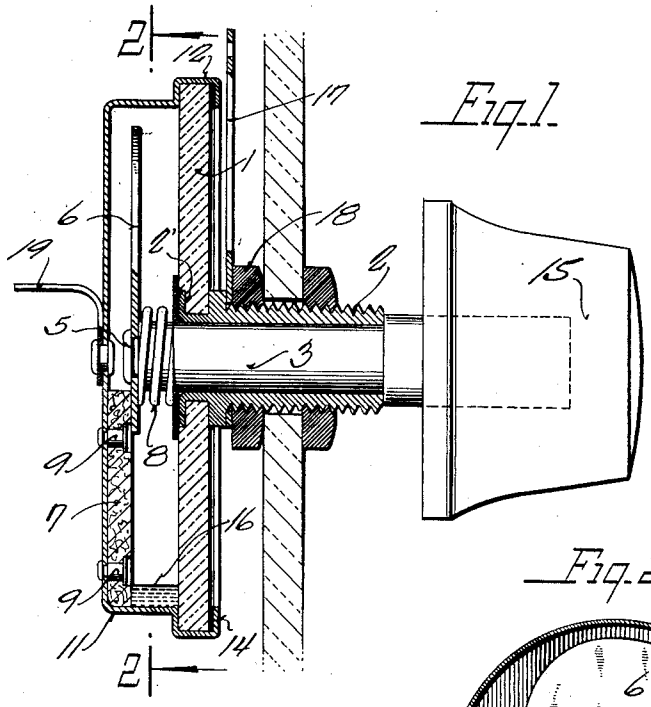


Fig. 2.

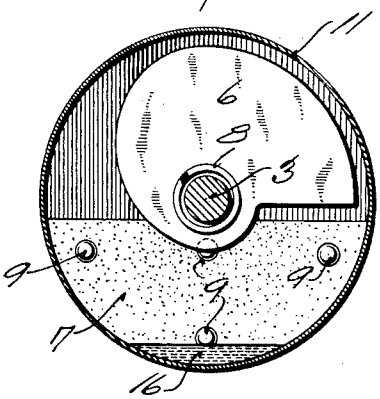


Fig. 3.

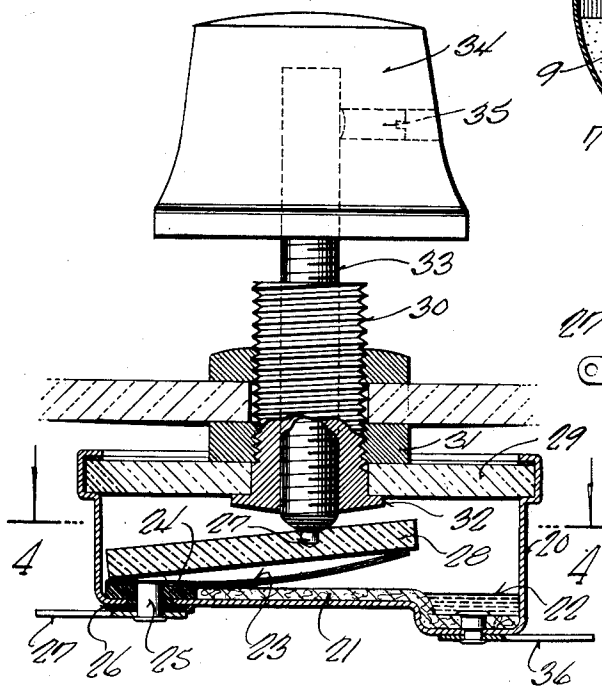
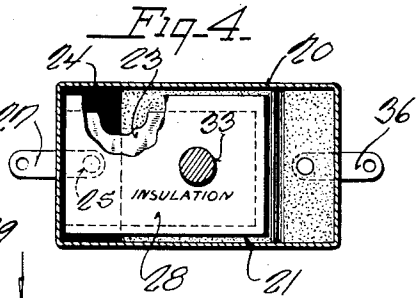


Fig. 4.



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Fig. 5.

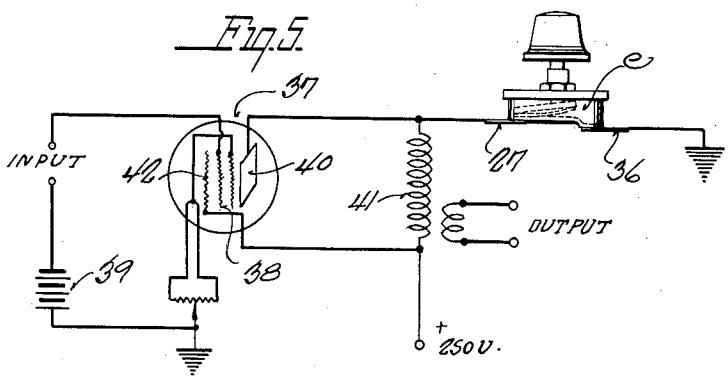


Fig. 6.

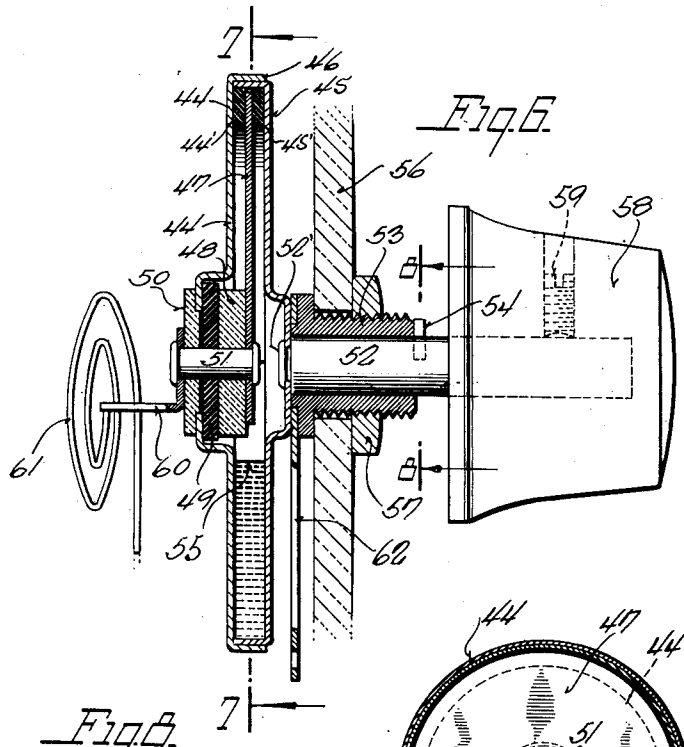


Fig. 8.

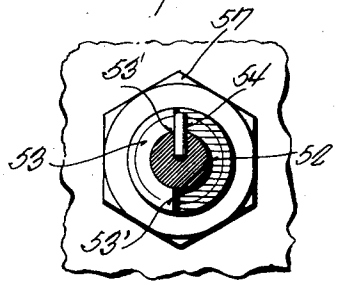
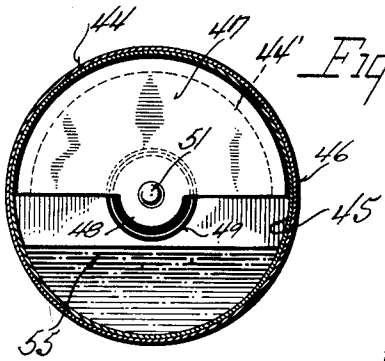


Fig. 7.



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ELECTRICAL CONDENSER AND THE LIKE

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Application October 8, 1931, Serial No. 567,569

11 Claims. (Cl. 175—315)

This invention relates to improvements in electrical condensers, particularly of a continuously adjustable type. Condensers with continuously adjustable capacity now used in the art almost uniformly use air as a dielectric. This produces a very great limitation in the amount of capacity that can be obtained in such condensers without unduly increasing the number of plates.

One object of the present invention is, therefore, to provide an electrical condenser, whose capacity shall be continuously adjustable in infinitesimal steps over a wide range, from very low values of capacity to values much higher than have been previously obtainable with the air dielectric condensers. Another object of this invention is to obtain a condenser continuously adjustable over a wide range of capacity which shall employ a minimum number of plates and occupy a minimum of space.

The new condenser to be described while capable of a wide variety of uses and applications is particularly applicable to the construction of variable filter circuits to be used at audio frequency. Such application is characterized by the so-called tone control, now commonly used in the audio amplifiers of radio receivers for the purpose of by-passing a variable amount of the high frequencies in the original tone, so as to accentuate the lower frequencies and produce a deeper tone quality. In this application, capacities of the order of hundredths of micro-farads are frequently employed. Since compact and inexpensive variable condensers of such high capacity have not been available in the past, it has been customary to use a high capacity fixed condenser in series with a variable resistance, whereby the effectiveness of the capacity in by-passing the high frequencies is varied by varying the resistance in series with the condenser. This method of tone control, however, produces a very undesirable change in the volume of the tone, as well as changing the tone quality. This advantage of the present methods of tone control is overcome in my present invention, wherein a continuously variable capacity alone is used without a series resistance.

Other objects and advantages reside in certain novel features of the construction, arrangement and combination of parts which will be hereinafter more fully described and particularly pointed out in the appended claims, reference being had to the accompanying drawings forming a part of this specification and in which:

Figure 1 is a view partly in elevation and partly in central vertical longitudinal section showing one form of condenser embodying the present invention;

Figure 2 is a view in section taken on line 2—2 of Figure 1;

Figure 3 is a view similar to Figure 1 but showing a different form of the invention;

Figure 4 is a sectional view on a somewhat smaller scale and taken in the plane of line 4—4 of Figure 3;

Figure 5 is a diagrammatic view showing the last stage of the audio amplifier in a modern radio receiver with a condenser embodying the present invention organized therewith in such manner as to be capable of exerting a tone control;

Figure 6 is a view similar to Figure 1 but showing still another form of the invention; and

Figures 7 and 8 are sectional views taken on lines 7—7 and 8—8, respectively, of Figure 6.

Referring now to the Figure 1, an insulating base 1 has riveted to it a threaded bushing 2. A shaft 3 extends rotatably through the hole in the bushing 2. The end of the shaft 3 extending to the inside of the unit is turned down in diameter at 5 and has fastened to it a vane 6. This vane 6 is made of a metal capable of forming a highly capacitative film when immersed in or in contact with a suitable electrolyte and charged to a positive potential with respect to that electrolyte. One metal that may be employed for this purpose is aluminum. A suitable electrolyte may be a solution of ammonium phosphate, of sodium bicarbonate, or of borax. The surface of the aluminum plate 6 is made to bear firmly against a fabric 7 which is saturated with one of the electrolytes above mentioned. A spring 8 serves to urge the vane 6 into intimate contact with the fabric 7 and also will take up any wear or abrasion of this fabric 7 due to the rubbing of the vane 6 upon the surface of the fabric. Aluminum rivets 9 whose heads are sunk below the inside surface of the fabric serve to hold the latter to the aluminum case 11. The case 11 has a shoulder against which the insulating base 1 fits and the outer edges of the case are spun over this inner insulating base as at 12 to form a tight seal. A gasket 14 may be placed between the insulating base 1 and the turned over edge of the case 12 to further insure tightness.

An area of aluminum of about one square inch has a capacity of the order of several hundredths of a micro-farad when a potential difference of the order of 200 volts is applied across it and the electrolyte. An operating knob 15 is fastened to the outer end of the shaft 3 and serves to rotate

the vane 6 into variable contact with the saturated fabric 7. In Figures 1 and 2 the vane 6 is shown with its minimum area in contact with the fabric 7, corresponding to a condition of minimum capacity of the condenser. The vane 6 is shown in Figure 2 shaped in such a manner as to give a gradual increase of capacity as it is rotated. It is, of course, to be understood that any desired shape of vane may be used in order to get any desired variation of capacity with rotation of the knob. The simplest form of vane would be semi-circular, in which case the change in capacity would be directly proportional to the movement of the knob. In order to insure that the fabric 7 will always be saturated with the electrolyte, a small quantity of the latter is shown at the bottom of the case at 16. A terminal 17, to which electrical connections may be made, is shown fastened to the bushing 2 by means of the nut 18. This terminal connects through the bushing 2 and the shaft 3 to the vane 6. A terminal 19 riveted to the case 11 serves to make electrical connection through the case to the fabric 7 saturated with electrolyte.

Referring now to the Figures 3 and 4, the condenser is designated generally at C and comprises a rectangular aluminum case 20 which has placed in contact with its bottom the fabric 21 saturated by the electrolyte 22. A bent strip 23 of suitably resilient metal, preferably of hard rolled aluminum or of aluminum fastened to a similarly bent strip of bronze or stainless steel, is fastened to the insulating shelf or ledge 24 by means of a rivet 25. The convex surface of the aluminum sheet 23 is adjacent to the surface of the fabric 21. A suitable insulating shoulder washer 26 serves to insulate the rivet 25 and its associated terminal 27 from contact with the case 20. A block of insulating material 28 is placed above the curved metal strip 23.

An insulating cover 29 is crimped on and sealed to the metal case 20 in the manner shown. A hollow threaded bushing 30 is fastened through a hole in the cover 29 by means of a nut 31 and its head 32. The inside of the bushing 30 is also threaded to take a compression screw 33. The screw 33 impinges upon the upper surface of the insulating block 28. An operating knob 34 fastened to the exterior end of this screw 33 by means of the set screw 35, serves to rotate the screw 33 and thus urge the block 28 downward.

As the block 28 is forced downward by the screw, it flattens out the curved metal strip 23 so that the latter makes a progressively greater area of contact with the fabric 21. This gradual increase in the area of contact between the saturated fabric 21 and the metal strip 23 results in a continuously increasing capacity. When the knob 34 is turned so as to retract the screw 33 the strip flexes upwardly, due to its inherent resiliency, and has a gradually decreasing area of contact with the fabric 21, resulting in a gradual decrease of capacity.

The terminals 27 and 36 provide respectively for contact with the contact strip 23 and the metal case 20. The screw 33 is preferably of such a steep pitch of thread that approximately a single turn will serve to change the area of contact of 23 from a minimum to a maximum, thus covering the entire range of variable capacity with approximately a single turn of the knob 34. The insulating sheets 28 and 29 are preferably made of a laminated phenolic condensation product, such as bakelite. The end of the screw 33 which impinges against the insulating block 28, has a small projection 37 fitting into a depression in the block 28, whereby the latter is held in alignment within the case.

In the Figure 5 is shown the last stage of a vacuum tube amplifier with a variable condenser as just described, shunted across the audio transformer primary and the plate circuit of said amplifier tube.

The vacuum tube 37 shown in Figure 5, is of the so-called pentode type commonly used in the last stages of the audio amplifier of a radio receiver. The control grid 38 of this tube is connected to receive the input signals from the preceding stage. A bias voltage is put in series with this input circuit by the battery 39. The plate 40 of this tube is connected through the primary 41 of the output transformer to a positive potential of 250 volts. This positive potential is also applied to the so-called space charge grid 42 of the tube. The output of the transformer 41 is usually connected to a loud speaker to reproduce the signals received by the radio receiver. The plate 23 of the variable condenser C shown in Figure 3 is connected to the plate side of the transformer 41 and, therefore, is also at the high positive potential. The opposite plate or the case of the condenser is connected to ground.

The plate current of the tube 37 contains the various frequencies of the signal of the input. The higher frequencies of this plate current are by-passed by the condenser C to a degree depending upon the amount of capacity in the condenser C. Thus when the condenser C has its maximum capacity, the greatest number of the higher frequencies are cut off and the lower notes will predominate in the output of the amplifier and be reproduced by the speaker. As the capacity of C is diminished, more and more of these high frequencies are allowed to go through the speaker and, thus, the quality of the tone output of the speaker is varied.

It will be noticed from the manner in which the condenser is connected into the circuit, that the aluminum plate is always at a positive potential with respect to the opposite plate of the condenser. This results in the formation of the film over this plate and gives the high capacity effect desired in the manner well known in electrolytic condensers. As the area of the aluminum plate 23 in contact with the fabric 21 is increased, the area of the film formed on the aluminum plate is increased and, thus, the capacity of the condenser is increased.

The variable condenser shown in Figure 1 may equally well be used as the by-pass condenser in the circuit of Figure 5. In this application the rotatable vane 6 of Figure 1 is connected through terminal 17 to the plate circuit or the circuit of high positive potential, while the case of the unit is connected through terminal 19 to ground.

Figure 6 shows another form of this variable condenser adapted to give even higher maximum capacity than the forms previously described and also adapted to use a liquid electrolyte instead of the fabric saturated with electrolyte. The reason for the higher possible maximum capacity is apparent from the fact that the use of a liquid electrolyte instead of the saturated fabric allows a capacitative film to be formed on both sides of the plate 47 thus increasing the available area of the plate 47. Referring to Figure 6, the enclosing case of the condenser unit consists of the two halves 44 and 45. This case can be made of aluminum or some other suitable metal that

will not be affected by the electrolyte. The two halves of the case are hermetically sealed together at 46 by means of a suitable cement or by soldering. The aluminum vane 47 is rigidly fastened at its center to a recessed portion of the case 44 and is insulated therefrom by means of the insulating washers 48, 49 and 50 held by the rivet 51. The peripheral portion of the plate is spaced from the casing and if desired semi-circular insulating spacers 44' and 45' may be interposed between the peripheral portion of the plate 47 and the adjacent parts of the casing.

The insulating washer 49 is preferably of rubber, in order to form a tight seal against the case 44. The part 45 of the case is riveted at its center to the shaft 52 as indicated at 52' and the shaft 52 passes rotatably through the threaded bushing 53. A pin 54 is driven into the shaft and co-operates with shoulders 53' on the end of the bushing to limit the rotation of the shaft to 180 degrees. The condenser case is partly filled with the liquid electrolyte, whose level is shown at 55. The threaded bushing 53 is clamped to the panel 56 by means of the nut 57, which serves as a mounting arrangement for the condenser. An operating knob 58 is fastened by means of the set screw 59 to the exterior end of the shaft.

As the knob 58 is rotated, the condenser plate 47 is brought gradually further and further below the surface of the electrolyte 55. This is accomplished by rotating the entire condenser by means of the shaft and knob 58. As more and more of the plate 47 is immersed beneath the level of the electrolyte 55 a larger and larger area of film is formed on 47 and the capacity of the condenser correspondingly increased. The maximum capacity of the condenser is obtained when the knob is turned 180 degrees and the maximum area of the plate 47 is beneath the surface of the electrolyte 55.

A terminal 60 fastened under the head of the rivet 51 and the terminal 62 riveted to the head of the bushing 53 serve to make electrical connections to the aluminum plate 47 and the case of the condenser, respectively. Since the terminal 60 rotates with the case of the condenser, it is necessary to fasten to it a suitable flexible lead 61, to allow for this rotation.

Corresponding parts of the condenser of Figure 6 are shown in Figure 7 in an end view opposite to the end on which the knob and shaft are attached.

The condensers so far described in this specification have employed a film forming electrode immersed variably, or in variable area of contact with, a suitable electrolyte. The condenser last described and illustrated in Figures 6 and 7 is also well adapted to employing a liquid dielectric of high dielectric constant. There are a number of organic liquids having a very high dielectric constant. A particularly suitable one is nitrobenzene, which has a dielectric constant of the order of 50. The use of a dielectric liquid in Figure 6 would result in a range of variable capacity in the condenser of 50 to 1, the minimum capacity occurring when the plate 47 is in the position shown in Figure 6 and the maximum occurring when the plate 47 has its maximum area immersed beneath the level of the dielectric liquid. The use of a high dielectric constant liquid instead of the film forming electrolyte has the advantage that the condenser does not have to be subjected to a polarizing potential to form a dielectric film.

The invention claimed is:

1. A condenser comprising an enclosing casing, a liquid electrolyte in said casing, means supporting said casing in fixed position, a shaft extending into the casing, means for supporting said shaft for rotative movement, and a plate made of a film forming material fixed to the shaft and rotated therewith to vary the area of the plate which contacts with the electrolyte.

2. A variable condenser comprising a fabric saturated with a suitable electrolyte, an electrode in electrical contact with said fabric, a film forming electrode supported for shifting movement relative to the fabric whereby the area of contact between said film forming electrode and said saturated fabric may be varied and consequently the capacity of the condenser may be smoothly varied in infinitesimal steps.

3. A variable condenser including a liquid electrolyte, means to hold the electrolyte and to form an electrode of the condenser and a film forming electrode whose contact with the electrolyte may be controllably varied from a minimum area to a maximum area whereby the capacity of a condenser may be continuously adjusted over a corresponding range.

4. A variable condenser comprising a film forming electrode, a second electrode in electrical contact with a fabric saturated with a suitable electrolyte and means for controllably varying the area of contact of said film forming electrode with said saturated fabric, whereby the area of film and consequently the capacity of said condenser may be smoothly varied in infinitesimal steps.

5. A variable condenser comprising a tight enclosing case; a film forming electrode fastened in an insulated manner to the inside of said case; a liquid electrolyte within said case; a second electrode constituted by the walls of said case in electrical contact with said electrolyte; means for rotating said case, whereby a variable area of said film forming electrode may be immersed beneath the surface of said electrolyte and the electrical capacity between said electrodes may be controllably varied.

6. A variable condenser comprising an enclosing case; a liquid electrolyte within said case; an electrode capable of forming a dielectric film over its surface when in contact with an electrically charged with respect to said electrolyte, a second electrode constituted by the walls of the enclosing case in contact with said electrolyte and means for controllably varying the area of said first mentioned electrode in contact with said electrolyte, whereby the electrical capacity between said electrodes may be controllably varied.

7. A condenser comprising a completely enclosed, liquid tight casing, an electrode within said casing, a second electrode comprising a conducting wall of said casing, a liquid within the casing, said liquid having the property of providing a desirable capacitive relation between said electrodes when interposed therebetween, and means for effecting relative rotating adjustment between said electrodes to vary the extent to which at least one electrode is juxtaposed to the liquid.

8. A condenser comprising a completely enclosed, liquid tight metal casing, at least one wall of which constitutes a plate of the condenser, a cooperable condenser plate in said casing, a liquid in said casing cooperable with said plates to provide a dielectric therebetween, at least

one of said plates being rotatable to vary the area of the plate presented to the liquid and consequently to vary the capacity of the condenser from minimum to maximum.

9. A condenser comprising a metal casing having an opening, a plate of insulating material closing said opening, a piece of fabric fastened to a metal wall of the casing, a liquid electrolyte in said casing saturating said fabric, a film forming metal plate mounted in said casing for shifting movement so that the area of the plate engaged with the fabric may be varied, means for shifting said plate and terminals connected to the casing and the plate.

10. A condenser comprising a hollow disk-like metal casing having opposed side walls and a peripheral wall structure connecting said side walls, said casing being liquid tight, said side walls constituting plates of the condenser, an intermediate metal wall in said casing disposed between, insulated from and secured to said side walls, said intermediate wall having an extent less than that of the side walls, a terminal connected to said side walls and a terminal connected to said intermediate wall, and a liquid in said casing and cooperable with said walls to provide a dielectric therebetween, the extent of contact of the liquid and the walls varying as the casing is rotated and means for rotating the casing.

11. A condenser comprising a liquid tight metallic casing supported for rotation, a segmental metal plate supported within and insulated from the casing, terminals connected to the casing and said plate, a liquid in said casing adapted to coact with the walls thereof and with said plate to provide a dielectric between said plate and said walls, and means for rotating said casing.

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