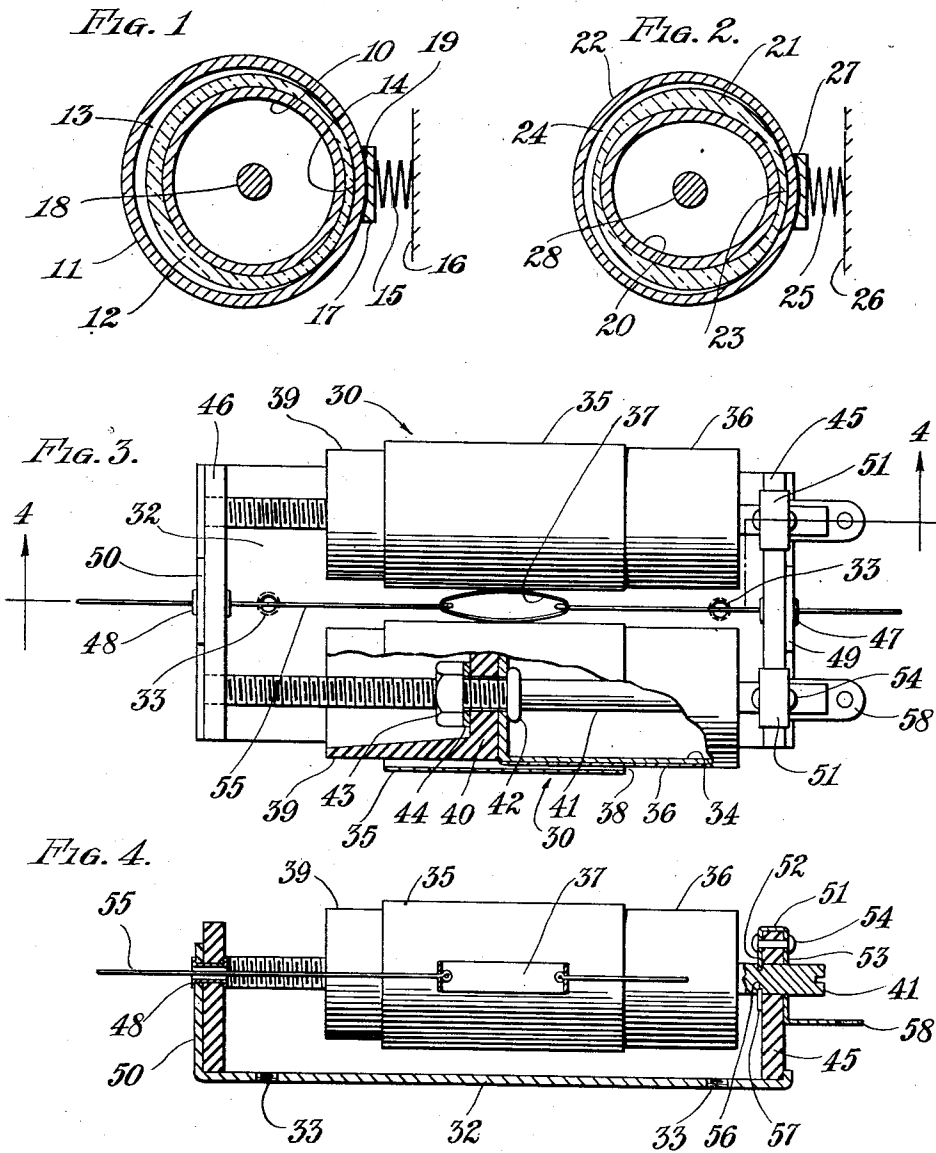


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P. ROBINSON
ELECTRICAL CONDENSER

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PRESTON ROBINSON
INVENTOR.

BY

Dorsey, Cole & Garner
ATTORNEYS

UNITED STATES PATENT OFFICE

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ELECTRICAL CONDENSER

Preston Robinson, Williamstown, Mass., assignor
to Sprague Specialties Co., North Adams, Mass.,
a corporation of Massachusetts

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The present invention relates to variable condensers and more particularly to novel improvements in tuning condensers of the type comprising interfitting tubular electrodes displaceable relative to each other.

In such condensers two spacially disposed conducting cylinders serve as the condenser electrodes and a dielectric layer is interposed between the same. Preferably, as disclosed in the copending application of Robert C. Sprague and Frank W. Godsey, Jr., Ser. No. 336,822, filed May 23, 1940, now U. S. Patent Number 2,324,178 issued July 13, 1943, the dielectric layer forms an integral surface coating of one electrode, and the electrodes and the coating are made to close tolerances in their coating dimensions, whereby the coating elements engage each other with a smoothly sliding fit, and the capacity of the condenser is varied from its minimum to its maximum value by laterally displacing one electrode with respect to the other.

While by observing the various requirements specified in the aforementioned application, such condensers can be made to very close capacity tolerances such as plus-minus 1% and even less in their minimum and maximum capacity value, maintenance of tolerances less than about plus-minus 5% it has been found considerably increases the manufacturing cost of such condensers.

However, a tuning gang consisting of condenser units varying as much as plus-minus 5% does not as a rule meet practical requirements.

It is the object of the present invention to maintain the inherent advantages of the above type of condenser units without requiring close tolerance limits in their manufacture and to promote means for their ready adjustment to close capacity tolerances.

A further object of the invention is to provide a new and improved adjustable condenser of the type having coaxial tubular electrodes.

These and further objects of the invention will appear as the specification progresses.

In the drawing forming part of the specification:

Figure 1 is a cross-sectional view (partly in schematic showing) of an adjustable condenser in accordance with the invention.

Fig. 2 is a cross-sectional view (partly in schematic showing) of another embodiment of the invention.

Fig. 3 is a partly sectionized top view of a condenser tuning assembly having adjustable con-

denser units made in accordance with the invention.

Fig. 4 is a side view taken along the line 4-4 of Fig. 3.

The condenser shown in Fig. 1 comprises as one electrode a hollow metal cylinder or sleeve 10 closed at one end, the second electrode being a metal cylinder 11 surrounding the electrode 10. Electrode 10 is supported in a shaft 18 journaled in a fixed bearing (not shown).

Interposed between the electrodes 10 and 11 is a dielectric provided in accordance with the invention as described hereinafter, and the capacity of the condenser is varied by laterally displacing the electrode 11 with respect to the electrode 10, and thereby varying the degree of engagement of these members. The capacity of the condenser is also variable within certain limits by rotating the electrode 10 about the shaft 18, as later to be more fully set forth.

The dielectric of the invention is a composite layer which by rotation of the shaft 18 is adjustable to different values of effective dielectric constant and effective thickness, providing for adjustability of the capacity of the condenser at any position of the electrodes 10 and 11 relative to each other. The composite dielectric layer consists of a solid layer 12 and an air layer or film 13.

The layer 12 consists preferably of a potassium lead silicate vitreous enamel as disclosed in the copending application of Stanley O. Dorst, Ser. No. 289,292, filed August 9, 1939 now U. S. Patent No. 2,290,947, issued July 28, 1942, and forms an integral coating on the electrode 10. The coating 12 may also consist of other suitable dielectric materials, for example of various kinds of vitreous enamels or of a non-vitreous dielectric material such as cellulose acetate, polysterene, hard rubber or the like.

According to the invention, the coating 12 is given a non-uniform thickness, for example, as shown in Fig. 1, by forming the coating as a sleeve of varying thickness, the outer cylindrical surface of which is eccentric with respect to the cylindrical surface of electrode 10. Such a coating may be applied in various ways, but preferably by cataphoretic deposition as disclosed in the copending application of Preston Robinson and Stanley O. Dorst, Ser. No. 316,032, filed January 27, 1940. The desired non-uniform thickness distribution of the coating is obtained by providing during the coating a corresponding non-uniform distribution of the current density in the cataphoretic coating cell.

As a rule, after its deposition the coating is fused, and furthermore, to obtain a true cylindrical surface free of all irregularities, the coated electrode is subjected to surface grinding, for example in a centerless grinder.

The coated electrode-dielectric element 10-12 is positioned within the surrounding electrode 11 with the surface of the dielectric 12 eccentrically disposed relative to the inner surface of electrode 11 whereby the air layer 13 formed between the coating surfaces of the dielectric 12 and the electrode is given a non-uniform thickness.

Preferably I so position the electrodes 10 and 11 with respect to each other that the electrode 11 and the coating 12 actually contact each other to form a line contact as indicated at 14.

To maintain such contact between the electrode 11 and coating 12 and at the same time permit free-sliding lateral movement of electrode 11 relative to the coated electrode 10-12, I provide a resilient biasing member, for example a helical spring 15, which is secured at one end to a base 16 and at its other end to a bearing plate 17 which abuts with a conforming concave surface 19 against the outer surface of electrode 11.

The capacity of the condenser is adjustable by rotating the coated electrode 10-12 through rotation of the shaft 18, thereby changing the effective dielectric constant and effective thickness of the composite dielectric of the condenser. Such rotation, as will be noted, causes a thicker or thinner portion of the coating 12 to contact at 14 with electrode 11 and at the same time displaces radially (i. e. sidewise) electrode 11 with respect to electrode 10, thereby changing the eccentricity between the electrodes. The capacity of the condenser is also adjustable through its full capacity range by lateral displacement of the electrodes 10 and 11 relative to each other, as previously pointed out.

While the above described condenser is shown as having all the elements 10, 11 and 12 cylindrical, non-cylindrical elements may also be used. For example, as shown in Fig. 2, one of the condenser electrodes is shaped as an elliptical cylinder and consists of an oval-shaped hollow metal sleeve 20, closed at one end and secured to a shaft 28 supported in a suitable fixed bearing (not shown).

Disposed on the electrode 20 is a dielectric coating 21 which consists preferably of an integral fused layer of vitreous material, but which may consist of other suitable dielectric materials, as previously pointed out. Coating 21 is given a non-uniform thickness distribution and this is provided by forming the outer surface thereof as a cylinder. As previously described, the coating is preferably applied by cataphoretic deposition and is thereafter surface-ground to provide a smooth cylindrical surface.

Surrounding the coated electrode 20-21 is a cylindrical metal sleeve 22 which serves as the second electrode of the condenser, and which is maintained in eccentric relationship with the coating 21, whereby between the electrode 22 and the coating 21 there is formed an air layer 24 of a non-uniform thickness distribution.

Preferably the coated electrode 20-21 and the electrode 22 are so positioned with respect to each other that a line contact 23 is obtained between these members, which contact is maintained by a resilient biasing member 25, for example a helical spring, secured at one end to a suitable base 26 and at its other end to a bearing

plate 27 which abuts and conforms with a concave surface against the outer surface of electrode 22.

To vary the capacity of the condenser for a given relative lateral positioning of the electrodes, the inner electrode is rotated about the supporting shaft 28 and the maximum capacity value is obtained, as is shown in Figs. 1 and 2, when the thinnest portion of the coating is placed in contact with the outer electrode.

In the arrangement shown in Fig. 2 the rotation of the electrodes relative to each other is about the axis of the surface of the dielectric coating 21 and accordingly, the dielectric layer 24 remains substantially constant in shape and form during said rotation.

In the embodiment of the invention shown in Fig. 1 the capacity of the condenser can be varied through its capacity range (one maximum and one minimum value) corresponding to a given lateral positioning of the electrode by one full revolution of the shaft 18, whereas in the embodiment shown in Fig. 2 this is accomplished by one-half revolution of the shaft 28. In practice as a rule the arrangement of Fig. 1 is preferred because it permits a more gradual and precise adjustment to the desired capacity of the condenser.

Figs. 3 and 4 show a tuning assembly embodying the condensers of the invention. The assembly shown comprises two condenser units 30 and 31 mounted on a common base 32 in a manner later to be more fully described. The base 32 is provided with tapped holes 33-33 adapted to receive suitable bolts (not shown) for mounting the assembly.

The condensers 30 and 31 are of identical construction and each comprises as one electrode a metal cylinder 34 and as the second electrode a hollow metal cylinder or sleeve 35 surrounding the electrode 34. Electrodes 34 and 35 are laterally displaceable relative to each other to vary the capacity of the condenser through the tuning range of the apparatus in which the assembly is used.

Interposed between electrodes 34 and 35 is a composite dielectric medium consisting of a solid layer 36 and an air layer 38. The layer 36 consists preferably of a vitreous dielectric material forming a fused integral cylindrical coating on the electrode 34 and is given a non-uniform thickness distribution by eccentrically disposing same on the electrode 34, for example as previously described in connection with the condenser of Fig. 1.

The air layer 38 has similarly a non-uniform thickness distribution and this is obtained by maintaining the electrode 35 in a line contact with the coated electrode 34, for example, by means of an elliptically shaped spring 37 of phosphor bronze or the like, which spring is secured to the outer surfaces of the electrodes 35-35 and exerts a separating force on these elements.

For the guiding of each sleeve electrode 35 in its lateral movement relative to the coated electrode 34-36, there is provided a guide 39 abutting against the closed end of electrode 34 and consisting of a low-loss insulating material such as hard rubber, "Bakelite," "Isolantite" or the like. Guide 39 is preferably hollow throughout its length except for the portion 40 abutting against the electrode 34. At their adjacent ends the electrode 34 and the guide 39 are provided with axial bores through which passes a spindle bolt 41 securing these members together by means

of an integral shoulder 42 which abuts against the closed end of the electrode and a nut 43 which abuts against the portion 40 of the guide. A lockwasher 44 is interposed between the nut 43 and the portion 40 to prevent loosening of the nut 43 by vibration or other mechanical shock.

Each condenser is supported within the assembly by means of its spindle bolt 41 and two mounting strips 45 and 46 which serve as fixed bearings for the bolt and for this purpose, the strips are provided with suitable bores through which the ends of the bolt 41 pass as a snug fit. Strips 45 and 46 consist of a suitable insulating material, for example of hard rubber, "Bakelite" or the like, and are secured to the base 32 by eyelets 47 and 48 respectively, passing through these members and through mounting brackets 49 and 50 consisting of extending portions of the base.

To prevent lateral movement of the bolt 41 relative to the mounting strips 45 and 46, there is provided a U shaped locking member 51 having portions 52 and 53 extending over opposite sides of the strip 45 and secured thereto by a rivet 54. The portion 52 is bifurcated to form arms 57-57, which engage an annular groove 56 provided in the spindle bolt 41 thereby fixedly positioning the bolt relative to the mounting strip 45.

The portion 53 extends into a terminal lug 58 serving as external electrical connection of electrode 34 and is provided with a suitable clearance hole through which extends bolt 41.

The two condensers 30-31 are simultaneously adjusted by the lateral and simultaneous displacement of their electrodes 35-35 relative to their electrodes 34-34. For this purpose there is provided a dial cord 55 (shown in portion) secured to the flexed ends of spring 37 and which cooperates with a suitable driving means (not shown). Cord 55 is guided in its movement through the assembly eyelets 47-48 through which it passes. The cord 55 also serves for the electrical connection to electrodes 35-35 and for this purpose consists preferably of copper braid.

Besides being simultaneously adjustable, each condenser of the assembly is independently adjustable by rotation of its bolt 41, thereby the degree of eccentricity between the electrodes of the condensers is changed and a thicker or thinner portion of coating 36 is placed in contact with electrode 35. This correspondingly varies the effective dielectric constant and effective thickness of the composite dielectric of the condenser.

The flexible spring 37 permits independent radial movement of either electrode 35, when the corresponding bolt 41 is rotated, and at the same time maintains both electrodes 35 in contact with its underlying dielectric coating 36.

By so individually and independently adjusting the capacity of either condenser of the assembly, the condensers of the assembly can be adjusted to identical capacities or to capacities having a predetermined difference, and this can be achieved within very close tolerances even if the condensers themselves are made to much wider tolerances.

A further advantage characterizing the condenser of the invention, whether used singly or as a unit of a tuning assembly, is that the inductance and/or stray-field of the condenser remains substantially unaffected when the capacity of the condenser is varied by rotating the inner and outer electrodes relative to each other. This advantage is obtained because there is no substan-

tial displacement of the current-carrying components of the condenser relative to each other when the capacity is so varied. For this reason, condensers in accordance with the invention are particularly suited for high-frequency applications when the effects of self-inductance and/or stray-fields must be kept to a minimum.

While I have described my invention by means of specific examples and in specific embodiments, I do not wish to be limited thereto for obvious modifications will occur to those skilled in the art without departing from the scope and spirit of the invention.

What I claim is:

1. An adjustable condenser comprising a tubular electrode, a dielectric layer having a non-uniform thickness distribution forming a coating on the surface of said electrode and having a cylindrical outer surface, a cylindrical electrode surrounding said coating and having its axis eccentrically positioned with respect to the axis of the coated electrode, said second electrode and said coating contacting each other along a line contact, means to maintain said line contact between said second electrode and the coating, means to vary the portion of the coating in contact with said second electrode to thereby vary the capacity value of the condenser, and means to laterally displace said electrodes relative to each other to also vary the capacity of the condenser.

2. An adjustable condenser comprising a cylindrical electrode, a dielectric layer forming a coating on said electrode and having a cylindrical outer surface having its axis eccentrically positioned with respect to the axis of the electrode, a cylindrical electrode surrounding said coating and having its axis eccentrically positioned with respect to the axis of the coated electrode, an air layer having a non-uniform thickness distribution interposed between the second electrode and the coating, a biasing member maintaining said second electrode in a line contact with said coating, means to vary the portion of the coating in contact with said second electrode, and means to laterally displace said electrodes relative to each other to vary the capacity of the condenser.

3. An adjustable condenser assembly comprising two condenser units, each of said units comprising a tubular electrode, a dielectric layer having a non-uniform thickness distribution forming a coating on said electrode, a tubular electrode surrounding said coating and contacting the same along a line contact and having its axis eccentrically positioned with respect to the axis of the coated electrode, a second dielectric layer having a non-uniform thickness distribution interposed between the outer electrode and the coating, means to maintain the outer electrode in contact with said coating, means to rotate the inner and outer electrodes relative to each other to vary the portion of the coating in contact with the outer electrode and to individually vary the capacity of each condenser unit, and means common to both condenser units to laterally move the outer electrode of each condenser relative to the inner electrode thereof to simultaneously vary the capacity of the condenser units.

4. An adjustable condenser assembly comprising two condenser units, each of said units comprising a substantially cylindrical electrode, a dielectric layer having a non-uniform thickness distribution, forming an integral coating on the electrode and having a substantially cylindrical outer surface, a substantially cylindrical electrode surrounding said coating and having its axis ec-

centrically positioned with respect to the axis of the coated electrode, an air layer having a non-uniform thickness distribution interposed between the outer electrode and the coating, a spring member secured to the surface of the outer electrode of each condenser unit maintaining each of the outer electrodes in contact with a portion of the enclosed coating, means to rotate each inner electrode relative to the outer electrode to vary the portion of the coating in contact with the outer electrode and to individually adjust the capacity of each condenser, and means secured to the outer electrodes to laterally displace the same relative to the inner electrodes to simultaneously vary the capacity of the condenser units.

5. An adjustable condenser comprising a tubular electrode, a dielectric layer having a non-uniform thickness distribution forming a coating on the electrode and having an outer surface substantially in the form of a right circular cylinder, a second tubular electrode surrounding said coating and having its axis eccentrically positioned with respect to the axis of the surface of the dielectric coating, a second dielectric layer having a non-uniform thickness distribution interposed between the dielectric coating and the second electrode, and means to rotate said electrodes relative to each other about the axis of the surface of the dielectric coating to vary the capacity of the condenser, said second dielectric layer remaining substantially constant in shape and form during rotation of the electrodes relative to each other.

6. An adjustable condenser comprising a tubular electrode, a dielectric layer having a non-uniform thickness distribution forming a coating on the electrode and having an outer surface substantially in the form of a right circular cylinder, a second tubular electrode surrounding said coating and having its axis eccentrically positioned with respect to the axis of the surface of the dielectric coating, an air layer having a non-uniform thickness distribution between the coating and the second electrode, and means to rotate said electrodes relative to each other about the axis of the surface of the dielectric coating to vary the capacity of the condenser, said air layer remaining substantially constant in shape and form during rotation of the electrodes relative to each other.

7. An adjustable condenser comprising a tubular electrode, a dielectric layer having a non-uniform thickness distribution forming a coating

on the electrode and having an outer surface substantially in the form of a right circular cylinder, a second tubular electrode surrounding said coating, having its axis eccentrically positioned with respect to the axis of the surface of the dielectric coating and contacting the same along a line contact, an air layer having a non-uniform thickness distribution between the coating and the second electrode, means to maintain the outer electrode in contact with said coating, and means to rotate said electrodes relative to each other about the axis of the surface of the dielectric coating to vary the capacity of the condenser, said air layer remaining substantially constant in shape and form during rotation of the electrodes relative to each other.

8. An adjustable condenser comprising an electrode having a cylindrical outer surface, a dielectric layer having a non-uniform thickness distribution forming a coating on the electrode and having an outer surface substantially in the form of a right circular cylinder having its axis eccentrically positioned with respect to the axis of the electrode, a second cylindrical electrode surrounding said coating and having its axis eccentrically positioned with respect to the axis of the surface of the dielectric coating, a second dielectric layer having a non-uniform thickness distribution interposed between the dielectric coating and said second electrode, and means to rotate said electrodes relative to each other about the axis of the surface of the dielectric coating to vary the capacity of the condenser, said second dielectric layer remaining substantially constant in shape and form during rotation of the electrodes relative to each other.

9. An adjustable condenser comprising a cylindrical electrode, a dielectric layer forming a coating on the electrode and having an outer surface substantially in the form of a right circular cylinder, a cylindrical electrode surrounding said coating and having its axis eccentrically positioned with respect to the axis of the surface of the dielectric coating, an air layer having a non-uniform thickness distribution between said coating and said second electrode, and means to rotate said electrodes relative to each other about the axis of the surface of the dielectric coating to vary the capacity of the condenser, said air layer remaining substantially constant in shape and form during rotation of the electrodes relative to each other.

PRESTON ROBINSON.