

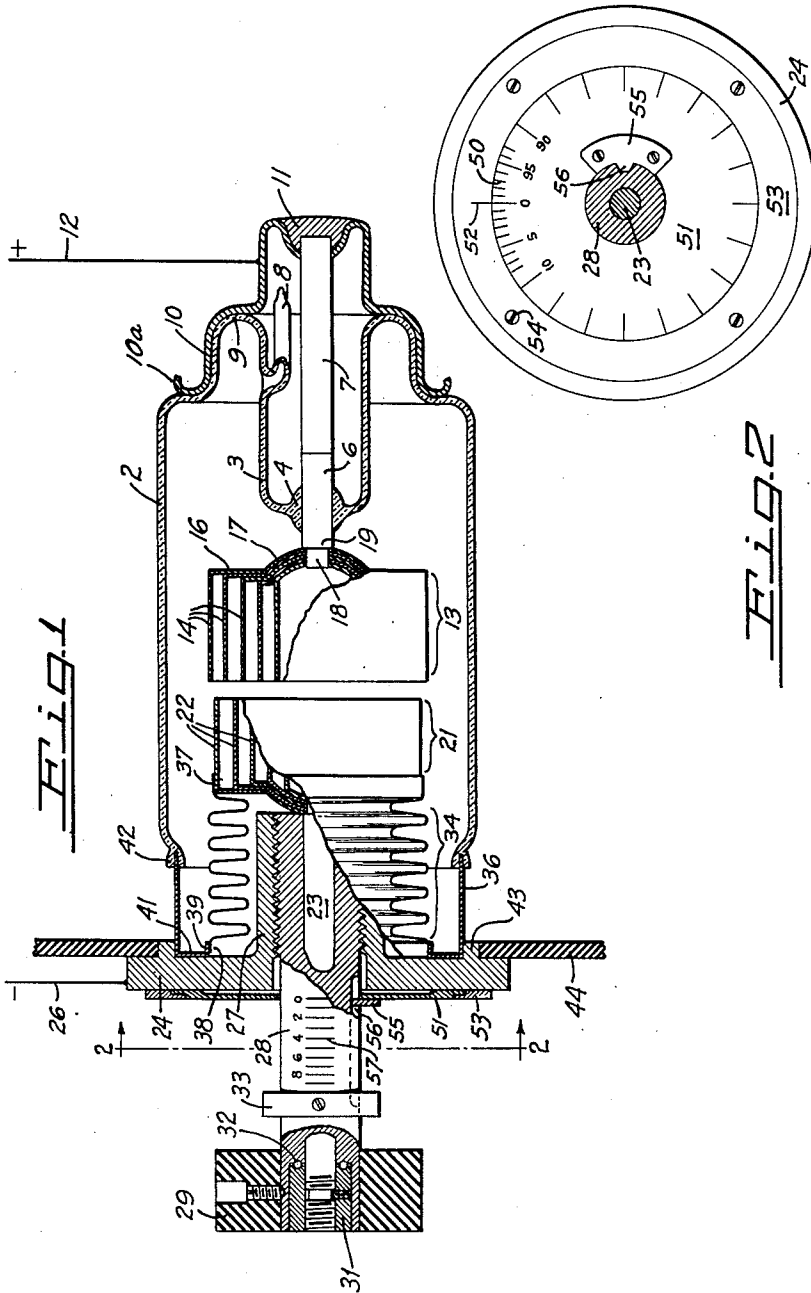
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J. E. JENNINGS

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VARIABLE VACUUM CONDENSER

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INVENTOR
Jo Emmett Jennings

BY
Charles S. Evans
HIS ATTORNEY

UNITED STATES PATENT OFFICE

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VARIABLE VACUUM CONDENSER

Jo Emmett Jennings, San Jose, Calif., assignor to Jennings Radio Mfg. Co., San Jose, Calif., a copartnership comprising Jo Emmett Jennings and Calvin K. Townsend as general partners and Arthur Nelld and Kenneth V. King as limited partners

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1

My invention relates to condensers, and particularly to condensers disposed in an evacuated housing or envelope.

One of the broad objects of the invention is the provision of a variable vacuum condenser. Other objects include the provision of such a condenser characterized by high current carrying capacity, low corona loss, low power loss factor, wide capacitance change, low minimum capacity, and maximum voltage ratings with minimum distributed capacity.

Viewed mechanically it is also among the objects of my invention to provide a variable vacuum condenser which is self contained, light in weight, of rugged construction with unlimited life expectancy, and without internal insulators, or springs. Still another object is the provision of a condenser structure having simple mounting means at one end only, and including means for rapid and accurate setting and resetting.

The invention possesses other valuable features, some of which with the foregoing will be set forth at length in the following description where that form of the invention which has been selected for illustration in the drawings accompanying and forming a part of the present specification is explained. In said drawings, one form of the invention is shown, but it is to be understood that it is not limited to that form, since the invention as set forth in the claims may be embodied in a plurality of forms.

Referring to the drawings: Figure 1 is a plan view of my vacuum condenser. Much of the structure is shown in horizontal axial section. Figure 2 is a vertical sectional view taken in the plane indicated by the line 2—2 of Figure 1. The view includes an elevation of the vernier dial by which the condenser plates may be accurately set or reset.

The advantages and superior values of vacuum condensers are well recognized, as are also the wider fields of usefulness of variable condensers. The problem however of constructing a vacuum condenser which is variable over a wide range of capacity, and which at the same time lends itself to commercial production and general use, poses several problems which, I believe, have never before been successfully met.

A primary problem, and the most difficult one, is the establishment of a physical connection with and control of the movable condenser plate or electrode, which is within the vacuumized envelope or tube, by control means which are on the outside of the envelope. Other but lesser problems are of course involved in reduction to the very minimum, of joints in the envelope where

2

leaks might develop, and a minimum of parts, especially moving parts, within the envelope.

I have met the primary problem by the use of a bellows-like, metallic structure to close one end of the envelope, such structure being interposed between the interior electrode or movable condenser plate and the exterior control means. Movement of the electrode over a wide range is therefore permitted by the collapse or expansion of the bellows folds, while the vacuumized envelope remains intact.

In detail, my condenser comprises a generally tubular body or envelope 2 of glass closed at one end by the usual reentrant flare 3, ending in the bulge 4, which surrounds and is sealed to the tungsten stem 6, which thus extends through and is sealed to the envelope wall. The tungsten stem is preferably provided with a copper extension 7 which with the tungsten stem thus provides one of the leads for connecting the condenser into a circuit. A tubulation 8 for evacuating the envelope usually extends from the flare; and this and the end 9 of the envelope are protected by the cap 10, sealed thereover. The dished end of the cap into which the copper stem extends is filled with lead 11 to insure full electrical contact between the stem and the cap through which connection is made to the circuit conductor 12 by any suitable means such as a spring clip. Corona loss is reduced by curling over the peripheral edge 10a of the cap as shown.

Rigidly fixed on the inside of the envelope on the inner end of the stem 6, are the condenser plates of the fixed electrode 13. These plates comprise a plurality of cylindrical shells 14, of progressively smaller diameter, and evenly spaced concentrically about the central axis. Because the plates must be held in position with great accuracy, means are provided for centering them securely and precisely on the end of the tungsten stem 6. This is accomplished by forming each cylindrical shell 14 with a bottom 16 having a central apertured bulge 17. The aperture fits snugly over the reduced end 18 of the stem, and the first shell to be applied seats against the shoulder 19. Additional shells as required are assembled on the stem end, each nesting with high precision in the preceding one. The complete condenser plate assembly is then brazed to fasten the parts permanently together.

Axially aligned with the fixed electrode 13 is a similar structure 21 of concentric shells 22 fixed on a stem 23, and comprising the movable condenser plates or electrode of the instrument. The shells of the movable electrode are shorter than those of the fixed electrode, and their diam-

eters are such that the two sets of plates may be nested together or interleaved with equal spacing between shells and without touching at any point. In the drawing, the shells are shown with considerable distance between them, but it will be understood that actually they are very close together, the separation of the interleaved shells may be of the order of .040" with a capacity up to 50,000 volts.

Means are provided for mounting the stem 23, and moving it with its connected electrode axially toward and from the fixed electrode. Arranged on the metal mounting plate 24, on which the entire structure is supported and to which the circuit lead 26 is connected, is a cylindrical flange 27, concentric with the main axis of the instrument, and threaded on the inside to fit the threaded spindle or control screw 28. The spindle has a bore extending axially therethrough of such size as to provide a stable running fit for the stem 23.

A knob 29 of insulating material, fixed on the outer end of the control screw, provides means for rotating it; and a collar 31, fixed on the outer end of the stem, and having a thrust bearing 32 interposed between it and the control screw, prevents the stem moving inwardly under atmospheric pressure and provides a frictionless bearing when the spindle is turned. A stop collar 33 on the control screw sets a limit for its inward movement.

Means are provided for mounting the glass envelope on the plate 24 and for hermetically closing the adjacent end of the envelope. Such closing means includes the movable electrode, a bellows structure 34, the collapse and expansion of which accompanies the corresponding movement of the movable electrode, and a copper sealing ring 35 between the bellows and adjacent edge of the glass envelope.

Such bellows structure comprises a generally cylindrical copper shell, rolled or pressed to wrinkle-fold the shell wall into a series of connected annular corrugations having as a whole, considerable axial flexibility with substantial resistance to lateral stresses.

The annular flange 37 at one end of the bellows is soldered around its outer peripheral edge to the adjacent corner edge of the movable electrode 21; and the annular flange 38 at the other end is soldered around its outer peripheral edge to the inner flange 39 of the mounting ring 41, which is continued in an outer flange constituting the sealing ring 35, which is joined by a glass-to-copper seal 42 to the edge of the glass envelope.

Thus the bellows 34 is interposed between the movable electrode structure and the glass portion of the envelope; and may be regarded as closing the end of the envelope with means which expands and contracts with the movement of the electrode to which it is connected.

The mounting ring 41 is soldered to the mounting plate 24 within the flange 43, which also serves to position the instrument in the supporting panel 44.

Since the envelope is vacuumized, air pressure against the back of the movable electrode 21 tends to expand the bellows and move the electrode to the point of greatest penetration within the fixed electrode; that is, to maximum capacitance of the instrument. The degree of such penetration and therefore the capacity of the instrument may be readily varied by turning the knob 29 to rotate the control screw 28, which

carries the stem 23 and its connected electrode. Means are provided for indicating the position of the control screw axially, and rotatably in the flange 27, and by relation, the corresponding position of the movable electrode relative to the fixed electrode. By calibrating such indicia, the capacitance of the instrument for any given setting is known. Thus setting the instrument for a predetermined capacity or resetting it after change, is readily and accurately done.

Fixed for rotation with the control screw 28, but not axially movable with it is a dial 51, divided around its periphery into equal numbered graduations 50 of arbitrary value. One hundred such graduations may be used and are read by reference to an index line 52 on the retaining ring 53. This ring is concentric with the screw 28, and is fixed by screws 54 to the face of the mounting plate 24. It provides a bearing in which the dial 51 is journaled. A key plate 55 is fixed to the dial, and a lug 56 projects therefrom into a keyway formed in the spindle.

Formed on the surface of the control screw between the stop-collar 33 and the face of the dial are graduations comprising short lines 57, spaced apart a distance equal to the pitch of the threads of the control screw 28. The arc of each line lies in a plane perpendicular to the axis of the screw. These lines are also given arbitrary identifying numbers as shown; and conveniently, 0 identifies the first line nearest the dial. The arrangement should be such that this 0 line should register with the face plane of the dial 51; and the 0 line of that dial should register with the index line 52, when the control screw has been turned back for maximum separation of the two electrodes, as shown in Figure 1.

The control screw graduations should correspond to the number of turns it makes to interleave the electrodes to the greatest extent, the stop collar 33 engaging the face of the key plate, and the 0 line on the dial registering with the index line 52, when the movable electrode is at the maximum penetration in the fixed electrode. Thus a glance at the control screw and dial graduations indicates values by which the exact position of the movable electrode relative to the fixed electrode may be known, and by calibration of these values, the capacitance for any setting.

Certain advantages accrue when the envelope is filled with an inert gas such as nitrogen. If under overload shorting across the electrodes occurs and metal is vaporized, there is less effect than when such vaporizing occurs in a vacuum, and substantially no change is observed in calibrated values.

It will be clear that because of the small amount of metal requiring degassing within the envelope, evacuation time is reduced. Heating such metal parts in an induction furnace to accomplish degassing is correspondingly simplified.

I claim:

1. In a variable condenser a vacuumized envelope, a bellows including a wall closing one end of the envelope, a fixed condenser plate in the envelope, a metallic stem sealed in the envelope wall for mounting the fixed condenser plate and to form a lead outside the envelope, a second condenser plate arranged in the envelope on one side of the bellows wall and supported thereby, and means on the outside of the envelope on the opposite side of the bellows wall and operatively connected therewith for moving the second condenser plate.

2. In a variable condenser a vacuumized en-

5

velope, a bellows including a wall closing one end of the envelope, a fixed condenser plate in the envelope, a metallic stem sealed in the envelope wall for mounting the fixed condenser plate and to form a lead outside the envelope, a second condenser plate arranged in the envelope on one side of the bellows wall and supported thereby, and means on the outside of the envelope on the opposite side of the bellows wall and operatively connected therewith for moving the second condenser plate and providing a lead electrically connected thereto.

3. In a variable condenser a vacuumized envelope, a bellows including a wall closing one end of the envelope, a fixed condenser plate in the envelope, a metallic stem sealed in the envelope wall for mounting the fixed condenser plate and to form a lead outside the envelope, a second condenser plate arranged in the envelope on one side of the bellows wall, a metallic stem for moving the second condenser plate and disposed exteriorly of the bellows wall, a threaded spindle in which the last named stem is rotatably mounted, and a base structure in which the threaded spindle may be rotated to axially move the last named stem and its associated condenser plate.

4. In a variable condenser a vacuumized envelope, a bellows including a wall closing one end of the envelope, a fixed condenser plate in the envelope, a metallic stem sealed in the envelope wall for mounting the fixed condenser plate and to form a lead outside the envelope, a second condenser plate arranged in the envelope on one side of the bellows wall, a metallic stem for moving the second condenser plate and disposed exteriorly of the bellows wall, a threaded spindle in which the last named stem is rotatably mounted, and a base structure on which the envelope is mounted and in which the threaded spindle may be rotated to axially move the last named stem and its associated condenser plate.

5. In a variable condenser a vacuumized envelope, a bellows including a wall closing one end of the envelope, a fixed condenser plate in the envelope, a metallic stem sealed in the envelope wall for mounting the fixed condenser plate and to form a lead outside the envelope, a second condenser plate arranged in the envelope on one side of the bellows wall, a metallic stem for moving the second condenser plate and disposed exteriorly of the bellows wall, a threaded spindle in which the last named stem is rotatably mounted, a base structure in which the threaded spindle may be rotated to axially move the last named stem and its associated condenser plate, and a ball thrust bearing interposed between the last named stem and the threaded spindle.

6. A variable condenser comprising a vacuumized envelope, a metallic stem sealed in and extending through the envelope wall, a fixed electrode mounted on the stem inside the envelope, a movable electrode inside the envelope and part of which forms part of the envelope wall, a bellows also forming part of the envelope wall and interposed between the movable electrode and the remaining part of the envelope wall, a metallic stem fixed to the movable electrode and extending exteriorly of the envelope, a base structure for mounting the envelope, and means inter-

6

posed between the base structure and the last named stem for moving the last named stem and its connected electrode.

7. A variable condenser comprising a tubular glass vacuumized body, a generally tubular metallic bellows disposed within one end of the glass body and with adjacent edges of tubular body and bellows sealed together, a metal end plate closing the opposite edge of the bellows, a metal stem fixed on the plate, a base structure for mounting the glass body, means interposed between the base structure and the stem for moving the stem axially, a fixed stem extending through and sealed in the tubular body at a point spaced from the bellows, and condenser plates disposed on the end plate and fixed stem.

8. In a variable condenser comprising a tubular vacuumized body, a generally tubular metallic bellows disposed within one end of the vacuumized body and with adjacent edges of tubular body and bellows sealed together, a metal end plate closing the opposite edge of the bellows, a metal stem fixed on the plate, a base structure on said body through which said stem extends, means interposed between said tubular member and said base structure limiting the axial inward movement of said stem due to atmospheric pressure exerted thereagainst, and means for moving said stem axially outwardly against said atmospheric pressure.

9. In a variable condenser, a vacuumized envelope, a bellows including a wall closing one end of the envelope, a fixed condenser plate assembly in the envelope, a metallic stem sealed in the envelope wall for mounting the fixed condenser plate and to form a lead outside the envelope, a second condenser plate assembly arranged in the envelope on one side of the bellows wall, each of said condenser plate assemblies including a plurality of concentric nested shells adapted to be interleaved with each other, a metallic stem for moving the second condenser plate assembly and disposed exteriorly of the bellows wall, a threaded spindle in which the last-named stem is rotatably mounted, and a base structure in which the threaded spindle may be rotated to axially move the last-named stem and its associated condenser plate assembly.

JO EMMETT JENNINGS.

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