April 3, 1956 J. E. JENNINGS ET AL 2,740,926

VACUUM VARIABLE CONDENSER

Filed Nov. 20, 1951

Fig. 1

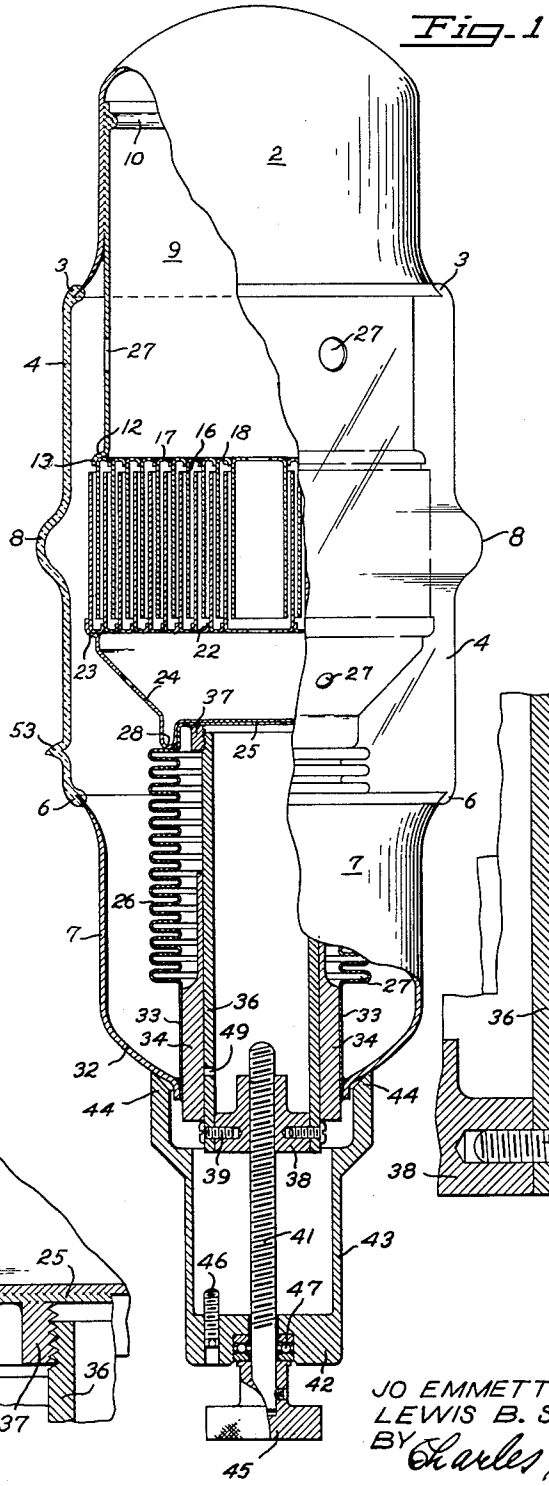


Fig. 2

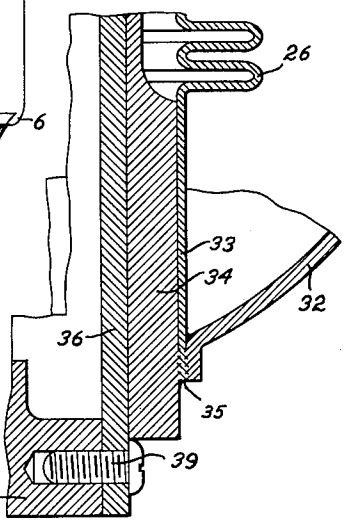
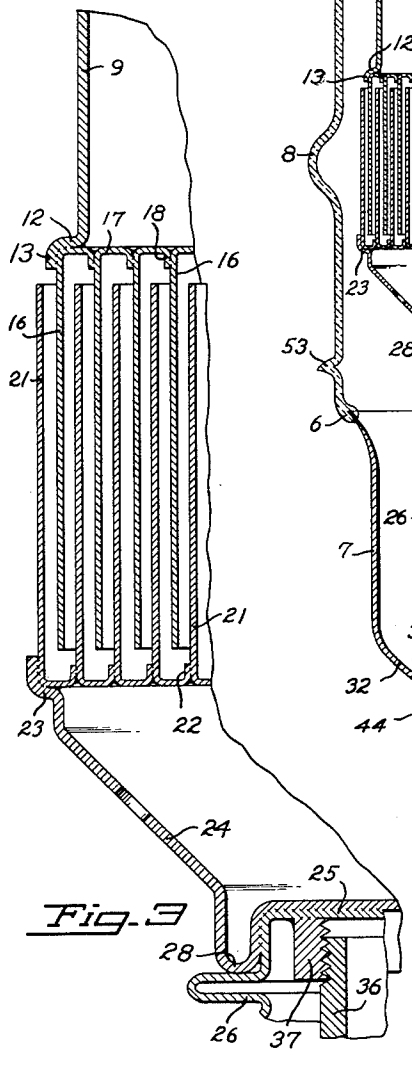


Fig. 3



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VACUUM VARIABLE CONDENSER

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Application November 20, 1951, Serial No. 257,392

8 Claims. (Cl. 317—245)

Our invention relates to vacuum variable condensers: and this application is a continuation-in-part of our copending application Serial Number 128,438 filed November 19, 1949.

Among the objects of our invention are the provision of a vacuum variable condenser characterized by light weight and small size, and by such rigidity of construction as to minimize mechanical resonances, together with large terminal electrodes to permit rapid dissipation of heat under heavy load, and an arrangement and proportion of parts which facilitate and permit a high degree of precision in manufacture without corresponding increase in cost.

Another object is a vacuum variable condenser in which atmospheric pressure is utilized to move the plates together and hold them rigidly in position against adjustable stop means.

Another object of the invention is the provision of a structure and method of assembly, in a vacuum variable condenser, by which the use of brazing heat to unite parts including the bellows, may be drastically reduced, and therefore the destructive effects of high heat on the bellows and other parts, greatly reduced or avoided.

Still other objects include the provision of means having electrical characteristics which include high current carrying capacity, with low internal resistance, high voltage capacity with minimum power factor loss, wide capacity shifts with consequent large ratio of change, lessened distributed capacity and low inductance, low external corona loss, and equalized electrostatic stresses.

In addition to the above our vacuum variable condenser has many other objects, 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 drawing 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 an elevation of our vacuum variable condenser, partly in vertical half section. Figure 2 is a vertical half section of a portion of the condenser, the parts shown being the right hand side (per Figure 1) of the bellows and long slide bearing supporting the movable plates. Figure 3 is a vertical half section of a portion of the left hand side of the plates showing the shape and mounting of both the fixed and movable set of plates.

One of the primary requirements in the building of a condenser such as that illustrated in the drawings, is the designing of the parts for ready and reasonably low cost assembly into a sturdy structure possessed of requisite mechanical precision and with the desired electrical characteristics. In the following description we have treated our condenser as it is made with copper plates and copper mounting parts.

We have found the best approach to solution of such

a problem, to be the adoption of a cylindrical motif for nearly all the parts, which are arranged with reference to a central axis. Such parts lend themselves most easily to precision manufacture and assembly into the complete unit.

Referring first to Figure 1, the vacuumized shell or envelope of my condenser includes a cylindrical metal end cap 2 of relatively large diameter, and joined by a vacuum tight metal-to-glass seal 3 to the glass cylinder 4, which at the other end is joined by the seal 6 to the end cap 7. The bulge 8 around the middle of the glass cylinder marks the location of the joint between the two halves of the cylinder. It will be understood that cooperating parts of the condenser are assembled in each half, and the halves then coalesced along their free edges to form the complete envelope or shell shown in Figure 1.

Snugly fitting into the end cap 2 is a cylindrical mounting shell 9. An internally extending bead 10 is formed near the end of the shell; and the external annular groove thus formed is filled with a silver solder wire before the shell is pushed into place in the cap. Subsequent heating brazes the two parts together, the solder running throughout the joint between cap and shell to unite the two in a rigid structure. The projecting free end of the shell is turned outwardly to form a radial flange 12, carrying the cylindrical flange 13. This double flange formation not only aids in preserving the cylindrical integrity of the part, but also forms a secure and concentric seat for mounting the fixed plates of the condenser. Another function of the shell is the stiffening and reinforcing of the cap, since the cap forms one of the terminals, and in the snug holding clip, must carry that stress in addition to atmospheric pressure.

In the open end of the flanged mounting shell 9 the unit assembly of fixed condenser plates 16 is disposed. The plates are cylindrical shells arranged concentrically; and it is to be noted that the largest of the shells is substantially the same diameter as the mounting shell 9, which thus provides a broad, stable base for the condenser plate shells. Each plate shell in axial section, is L-shaped at one end, being formed in dies with a short inturned radial flange 17 which carries on its inner edge the short reentrant cylindrical flange 18, brazed to the adjacent shell as best shown in Figure 3. The unit of assembled concentric shells is brazed within the seat flange 12—13. Thus is formed an exceedingly rigid structure, with a high degree of accuracy of spacing about the concentric axis and capable of rapid assembly with attendant reduction in costs.

The importance of concentric accuracy and of structural stability is difficult to overemphasize, since the interleaved movable plates 21 of the condenser, each with its reentrant flange 22 are also similarly concentrically disposed and brazed together and within the flanged seat 23 of the conical mounting shell 24 by which the movable plates are mounted on the mobile end 25 of the bellows 26. Both the mounting shell 24 and the mounting shell 9 are provided with large perforations 27 as shown to permit easy cleaning and prevent the trapping of reaction products and air in inaccessible pockets that would prevent complete evacuation.

Preferably the mobile end of the bellows, which is cylindrical, fits snugly into the annular bead 28 and is brazed therein. The bead not only provides an accurate, easily formed seat for the mobile end, but also adds stability and strength which prevents vibration and distortion of the conical shell.

Because of physical limitations in the drawing, the plates of the condenser are necessarily shown with a degree of thickness and as spaced apart a considerable distance. Actually they are very thin and very close together for reasons relating to the capacity of the con-

denser; and unless great rigidity and a high degree of accuracy in mounting and in movement is attained, objectionable changes in electrical characteristics and capacity of the instrument or even shorting across the plates is inevitable. Our economically reached high accuracy design which permits attaining and keeping the electrical characteristics and rugged dependability desired goes to the very root of our invention.

The fixed end of the bellows is connected to the cap 7 to complete the vacuumized chamber in which the plates lie. This is done by extending the conical end 32 of the cap inwardly to tight engagement with the end of the bellows sleeve extension 33, which snugly surrounds the thickened end of the bearing tube 34. The three parts 32, 33 and 34 are then brazed together at their juncture 35, as best shown in Figure 2, thus providing a wide and vibration-free bearing or slideway for the cylindrical thick walled hollow stem 36, by which the movable plates 21 are given their axial movement. The bearing tube and stem are preferably of a copper alloy such as brass or bronze and are of substantial thickness as shown. These qualities and a stem diameter of about one-third the diameter of the largest condenser plate 21, provides the lateral breadth of mounting needed to insure rigid stability and freedom from vibration.

The stem 36 is rigidly attached at its inner end to the mobile end 25 of the bellows, preferably by threading it into the annular flange 37 concentrically disposed on the inside of the bellows end and brazed thereto. Closing the outer end of the cylindrical stem is the head 38, held in place by screws 39, which as shown in Fig. 1, also act as safety stops to prevent the stem 36 from entering the bearing tube 34 to a point where the bellows and shells would be damaged. The center of the head is bored and threaded to receive in snug engagement the threaded operating shaft 41, journaled for rotary but not axial movement in the head 42 of the terminal 43, which has a peripheral edge 44 bearing against the conical end of the cap 7; and forms a hood around the exposed outer ends of the stem 36 and bearing tube 34.

A knob 45 is fixed on the outer end of the operating shaft so that it can be turned to adjust the movable plates, the stop screw 46 limiting the separating movement of the plates.

Atmospheric pressure is of course always exerted against the stem to force it inwardly, moving the plates 21 into interleaved relation with the fixed plates. This pressure is carried by the thrust bearing 47, preferably of ball type, interposed between the shaft 41 and the terminal hood by placing it in a recess in the head immediately under the knob. Our condenser is connected in the circuit in which it is to be used by clips or other suitable means arranged to engage the cap 2 at one end and the cap 7 at the opposite end.

An aperture 49 is made in the side of the hollow stem to permit insertion of a stop pin, in the event it is necessary to renew the head 38 or the shaft 41. With the pin in place, the bellows is prevented from uncontrolled expansion into the envelope with a resultant crushing together of the shells.

The method of forming and brazing the two assembly units of condenser plates and base plate in order to secure a high degree of accuracy and rigidity and prevent vibration and distortion is very important. Except for variation in diameters to permit interleaving of the plates in final assembly in the complete instrument, the method is similar for each unit. Since heat necessary for brazing is destructive, especially to the bellows, if too long continued, it is highly important in the production of an accurate, rugged and durable implement to subject the parts to as little heating as possible. The plates and the bellows are subjected but once to the high temperature necessary for secure brazing.

The fixed plates 16, preferably of copper, are assembled on a grooved jig, the flanged ends uppermost and

fitting together tightly enough to permit handling as a unit. The face formed by the assembled flanges then receives a finely divided silver solder conveniently applied in a volatile vehicle such as ethyl alcohol; and the mounting shell 9, also of copper, is applied with its seat flange over and around the outer shell. This assembly is then subjected to heat to melt the solder which runs into all the joints between the parts, and leaves them rigidly connected and one continuous piece of metal. Silver solder is placed in the groove 10; and the assembly pushed into the cap 2, which has previously been sealed to its half of the glass envelope 4. The application of heat locally opposite the solder, does not raise the temperature of the condenser plates objectionably, but unites the cap and mounting shell, the solder spreading throughout the joint between them.

The mobile plates 21 are similarly assembled together and in the junction cone 24. Silver solder is applied within the bead 28 and the closed end of the bellows seated therein. A ring of solder wire is then placed around the seat ring 37 which is threaded on a carbon jig and inserted in the bellows. This entire assembly is then subjected to sufficient heat (of the order of 1350° F.) to melt the solder and unite all of the pieces into one continuous piece of metal.

This assembly is then aligned by the use of suitable jigs, in the conical end 32 of the cap 7, which has previously been sealed to its half of the glass envelope; and the bearing tube 34 pushed into the open end of the bellows. The three parts are then heated locally at their juncture 35, and united with silver solder. The two unit assemblies are mounted in axial alignment, and the glass parts united in accordance with known practice. The threaded end of the stem 36 is next coated with a low melting point solder and turned into the seat ring (where it is fixed by the oxidation of the solder during the subsequent bake-out procedure), the head 38 having first been fixed in place. The hood 43 and related parts including the operating shaft 41, are assembled to complete the mechanical structure. The combined bake-out and evacuation of the envelope to an extremely high degree is followed by sealing off from the pump at the tubulation 53.

It will be noted from the above description that a structure of great rigidity and stability results. It is also apparent that there is provided extensive metallic conductors for the flow of heat to broad external surfaces where it may be radiated into the air. Thus our construction is such that it can carry six to eight times the amperage load possible in the best of earlier types; and we are able to use cylindrical condenser plate shells up to 5 inches in diameter, with capacities up to 2000 mmfds.

In use, an electrostatic field is set up between the plates which causes a heavy alternating pull on the plates in synchronism with the cycle frequency. This tends to cause a physical vibration which can wreck the condenser within a few seconds if it occurs. It is one of the most important features of our construction, that this disastrously destructive vibration is wholly prevented; and very high efficiency and capacity obtained in a relatively small unit. For example one of our condensers built as here explained and having a capacity of 125 amperes at 15,000 volts is only 15¼ inches long by 6⅛ inches in diameter of glass envelope. We find an almost perfect linearity of capacity change. During use, at maximum capacity, the temperature of the terminal caps does not exceed 140° F.

In summary our new construction is relatively simple and therefore less costly to manufacture. By only one heating, the life of the bellows is greatly prolonged and therefore also the life of the condenser. Because of the relatively wide proportions and rigid mountings of the opposed fixed and movable units, destructive vibration is prevented. The result of these features is extremely

high capacity, with much higher voltage and much higher amperage than has been obtained by any previous construction of comparable size.

We claim:

1. In a vacuum condenser, an evacuated envelope having a cylindrical, metallic end wall forming a hollow evacuated external terminal electrode of the condenser, a hollow evacuated metallic cylindrical mounting shell brazed within the cylindrical wall and having a free end extending into the envelope, the free end of the mounting shell forming an annular flanged seat of substantially the same diameter as the external electrode, an outer cylindrical condenser plate brazed within the flanged seat, and a plurality of successively smaller cylindrical condenser plates arranged concentrically within the outer plate, each plate of the plurality being brazed to and supported by the immediately preceding larger plate.

2. In a vacuum condenser, an evacuated envelope having a cylindrical metallic end wall forming a hollow evacuated external terminal electrode of the condenser, a hollow evacuated metallic cylindrical mounting shell fixed within the cylindrical wall and having a free end extending into the envelope, an outer cylindrical condenser plate fixed to the free end of the mounting shell, and a plurality of successively smaller cylindrical condenser plates arranged concentrically within the outer plate, each of the smaller plates being fixed to and supported solely by the next larger condenser plate.

3. In a vacuum condenser, an evacuated envelope having a cylindrical metallic end wall forming a terminal electrode of the condenser, a cylindrical mounting shell fixed within the cylindrical wall and having a free end extending into the envelope, an outer cylindrical condenser plate fixed to the free end of the mounting shell and having its adjacent edge portion extending inwardly and cylindrically to provide a reentrant cylindrical flange, and a plurality of successively smaller cylindrical condenser plates, each plate except the smallest having a reentrant cylindrical flange and arranged concentrically within the outer plate, each of the smaller plates being fixed solely to the reentrant flange of the next larger condenser plate.

4. A condenser plate assembly comprising a plurality of successively smaller concentric cylindrical shells, each shell except the smallest having an edge portion turned inwardly towards the adjacent next smaller shell and downwardly along said smaller shell to provide a cylindrical reentrant flange tightly engaging the next smaller shell, and a metal fused between the contiguous portions of the shells to fix them in a continuous metallic assembly.

5. A condenser plate assembly comprising a plurality of successively smaller concentric cylindrical shells, each shell except the smallest having an edge portion turned inwardly towards the adjacent next smaller shell and downwardly along said smaller shell to provide a cylindrical reentrant flange tightly engaging the next smaller shell, a mounting shell having at one end an annular flanged seat in which the assembled concentric shells are engaged, and a metal fused between the contiguous portions of the shells to fix them in a continuous metallic assembly.

6. In a vacuum condenser, an evacuated envelope having a cylindrical metallic end wall forming a terminal electrode of the condenser, a metallic bearing tube extending into the envelope and continuous with the end wall, a metallic bellows around the bearing tube and continuous with the end wall and closed at its inner end, a stem slidably mounted in the bearing tube and fixed at its inner end to the closed end of the bellows, a conical metallic mounting shell fixed at its small end on the closed end of the bellows and flaring out within the envelope to a flanged annular seat, an assembly of concentric cylindrical condenser plates fixed in the annular seat, and means including a screw shaft for moving the stem in the bearing tube.

7. In a vacuum condenser, an evacuated envelope having a cylindrical metallic end wall forming a terminal electrode of the condenser, a metallic bellows continuous with the end wall and extending into the envelope and closed at its inner end, a conical metallic mounting shell having at its small end means forming an annular seat in which the closed end of the bellows is fixed, said mounting shell flaring out within the envelope to a flanged annular seat, an assembly of concentric cylindrical condenser plates fixed in the flanged annular seat, and means within the bellows and interposed between the mounting shell and the metallic end wall to move the condenser plates.

8. In a vacuum variable condenser, a terminal cap having a cylindrical reentrant portion, a concentric cylindrical sleeve integral with the reentrant portion and providing a concentric cylindrical slideway, a bellows enclosing the slideway and integral at one end with the reentrant portion and closed across the opposite end, a stem axially slideable in the slideway and within the bellows and fixed to the closed end of the bellows, a conical shell seated concentrically on the closed end of the bellows, a plurality of condenser plates mounted on the conical shell, and screw means for axially moving the stem in the slideway.

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