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M. OSNOS

2,054,659

ELECTRIC CONDENSER

Original Filed May 5, 1932

Fig. 1

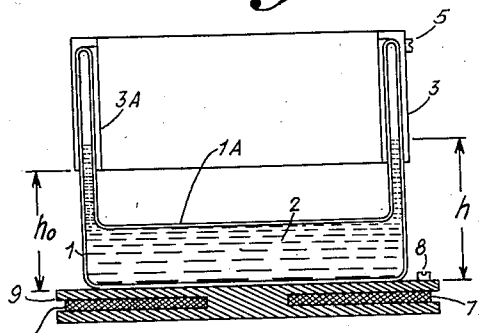


Fig. 2

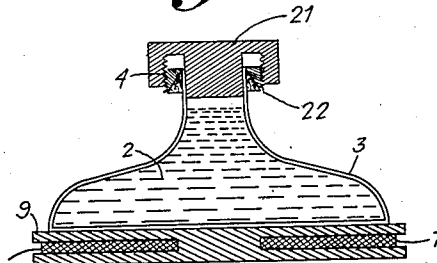


Fig. 3

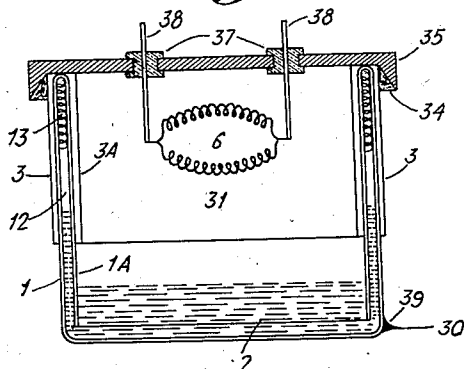


Fig. 6

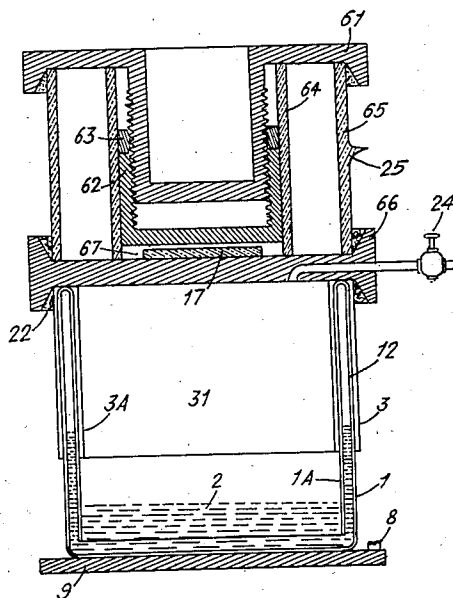


Fig. 5

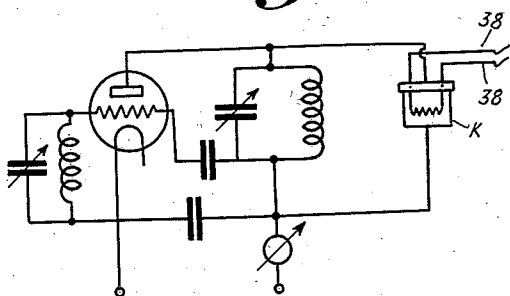
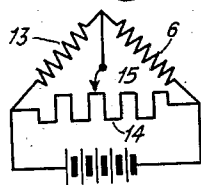


Fig. 4



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2,054,659

ELECTRIC CONDENSER

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609,401. Divided and this application October
4, 1934, Serial No. 746,803. In Germany July
2, 1931

5 Claims. (Cl. 171—327)

This invention relates to an improved electric condenser whose capacity varies very markedly with the temperature. A condenser of this invention is particularly adapted to use in a circuit for tuning the capacity of a vacuum tube transmitter, especially when short-waves are employed, and is to be controlled from a remote point or else for the purposes of stabilizing frequency of a valve transmitter controlled by the agency of a piezo-electric crystal.

This application is a division of my parent application Serial No. 609,401, filed May 5, 1932. This divisional application is particularly directed to the combination of a variable condenser and a piezo-electric crystal.

According to the invention a condenser of this kind is created so that its active surface or its inter-electrode distance, or else both, are adjusted or regulated by a fluid possessing a large temperature coefficient of expansion or else by a gas (say, air) or a combination thereof. It is then feasible to heat the liquid or the gas or a combination of both, for example, by means of electric heating to a more or less high degree, with the result that the capacity of the condenser is regulable or adjustable at will at any desired rate.

A number of practical embodiments are shown in the drawing, in which,

Fig. 1 is a vertical cross section of the improved condenser having double walls;

Fig. 2 is a vertical cross section of a simple modification of this condenser;

Fig. 3 is a vertical cross section of another modification of this condenser;

Fig. 4 is a wiring diagram of the heating system;

Fig. 5 is a wiring diagram of a vacuum tube transmitter employing this improved condenser, and

Fig. 6 is a vertical cross section of another modification of this improved condenser.

Referring to Fig. 1, 1 and 1A denote a double-walled (jacketed) glass vessel of cylindrical form whose space between the lateral walls is very small (say, $\frac{1}{2}$ to 1 mm. in radial direction) but comparatively large between the bottom or end surfaces.

The space or cavity between the bottoms of the two cylinders is filled entirely by a suitable liquid 2 such as mercury, for instance. The space between the shells is not filled at all or only up to a certain height or level h . But the entire space between the shells is suitably exhausted. The inner and the outer shell starting at a certain

level h_0 is coated with a highly conducting metal 3 and 3a, say, tinfoil.

The entire vessel is supported by a coil body 9, preferably made of metal which carries a winding 7 heated by current.

When the temperature of the liquid mercury increases its level will rise in the space between the lateral walls and there is formed a capacity between the liquid and the tinfoil coat.

It can be proved that the change in capacity of such a condenser is directly proportional to the variation in the temperature, indeed, it is possible to write with close approximation:

$$C - C_0 = K \cdot V_0 (T - T_0) \quad (1)$$

where T_0 and C_0 the temperature and capacity, respectively when the level of the column of the liquid between the lateral walls is flush with the lower edges of the tinfoil coats or slightly above them, T a higher temperature and C a correspondingly increased capacity, V_0 the volume of the liquid at temperature T_0 , K a constant which is a function of the nature of the liquid and of the dimensions of the container.

If the liquid consists of mercury having a coefficient of thermal expansion of say, 0.000181, if the distance between the surfaces of the shell = 1 mm., the wall thickness 1 mm., and if a kind of glass is used having a dielectric constant = 7, then with close approximation:

$$C - C_0 = 2.10^{-3} \cdot V_0 (T - T_0) \quad (2)$$

where C in cm., V_0 in cm. cu., and T in degr. C.

For short waves the capacitive reactance (capacitance) between the liquid and the metal plate 9 is very low so that the capacity according to Equation (2) comes to be close to that between the contacts 8 and 5.

Another simpler, though somewhat less favorable, embodiment is shown in Fig. 2, where 3 is a glass jar or bottle having a base or bottom considerably larger in area than the cross-section of the neck, and 21 a metallic electrode which can be screwed by means of a screw thread 4 on the collar ring or flange 22 so as to be at the correct distance above the liquid's level (mercury).

Now, if the liquid mercury is heated by means of the heater winding 7 wrapped around the body 9 the liquid will be caused to expand, the distance between its surface and the electrode 21 decreases, and the capacity increases.

Equation (2) shows, since the coefficient K is equal to 2×10^{-3} that a considerable volume V_0 must be provided in order that, in the presence of a moderate change in the temperature there

may be obtained an appreciable change in the capacity. This involves the drawback that the condenser must be made of considerable size so that it would occupy much space in the metal housing of the transmitter. Another point is that a large volume of the conducting liquid confined inside the sheet-metal casing would occasion serious losses where short waves are dealt with.

Now, this drawback can be obviated by that only part of the conducting liquid mercury is placed inside the sheet-metal housing, while the major part thereof is outside.

What follows further from Formula (2) is that

$$V_0 = 0.5 \frac{C - C_0}{T - T_0} \cdot 10^8 \quad (3)$$

In practice it will be found advisable to make the quantity

$$\frac{C - C_0}{T - T_0} = 1 \quad (4)$$

But it will be noted that V_0 even in the limiting case must be equal to 500 cu. cm. Assuming that the liquid is mercury, the weight thereof would be as much as $0.5 \times 13.6 = 6.8$ kilos. However, the volume of the conductive liquid may be appreciably reduced if for the actuation of the mobile electrode recourse is had to the thermal expansion of a liquid or gaseous substance which, while being nonconducting or but slightly conductive, possesses a high coefficient of thermal expansion.

An embodiment of this kind is shown in Fig. 3. The constituent parts of the device are as follows:

31 is a space within the glass vessel 1 which is filled either with liquid or with a gas (air) or with both, which though not conducting electricity, possesses a high coefficient of thermal expansion; 2 is a conducting liquid mercury, 3 and 3a tinfoil coats, 1 the cylindrical glass vessel with a double wall being open inside a short distance above the bottom, 35 a cover being cemented on the glass vessel 1, 9 a heater, 37 insulated leads to the heater body, 38 terminals for the latter, 39 a seal for the lead to the liquid electrode, 30 lead to the liquid electrode, 34 cementing of the cover 35, 12 space above the conducting liquid between the shells of the two cylinders. The space is either evacuated or contains a gas (air) of lower pressure than the pressure inside space 31. Optionally also a heater coil 13 for heating the space 12.

If the heater element 6 is heated electrically, the pressure inside space 31 will rise and also the mercury in space 12, and thus alter the capacity of the condenser.

If space 12 is small enough compared with space 31 it can be proved that the capacity of the condenser is nearly proportional to the temperature in the space 31, if space 12 is evacuated. But if the space 12 is not exhausted then the capacity of the condenser is proportional to the temperature and pressure difference between spaces 12 and 31.

Instead of the space 31 it would be possible also to heat the space 12, and then the capacity decreases with increasing heating current. It would also be feasible to heat both spaces though at different temperature, for it will be understood that the change in capacity, as already pointed out, is predicated only upon the temperature differences of the two spaces.

The difference in the temperatures of the two spaces may be regulated, for instance, by means of a bridge arrangement according to Fig. 4,

where, as previously, 6 and 13 the heater resistors of the spaces 31 and 12, while 14 denotes a potentiometer located at the control point whose voltage division is regulated by a slide contact 15. In case of differential heating the resistances and the cooling conditions of spaces 31 and 12 may be so chosen that the temperature of the ambient will exercise no influence upon the capacity so that the capacity is merely a function of the position of contact 14 (Fig. 4).

A condenser of the kind here disclosed could advantageously be employed for remote tuning of a valve transmitter, especially in case of short waves. A scheme of this kind is illustrated in Fig. 5 where the condenser k built along the lines of this invention is contained in the oscillation circuit of a transmitter and is adapted to be regulated by way of the heater lead 38, 38. The method here described for remote regulation could be used, inter alia, also for slow wobbling of the frequency, say, for the purposes of secret telegraphy. For the variable heating an A. C. of very low frequency, say, of 2 cycles per second could be employed.

A condenser as here disclosed could be used to advantage for automatic stabilization of the frequency of self-controlled valve transmitters. An embodiment of this kind is shown in Fig. 6. The constituent parts of this scheme are as follows:

61 denotes the top electrode of a crystal holder, 62 screw cap for adjusting the distance between the top electrode and the crystal, 63 a clamp ring, 64 a glass tubelet for holding the crystal, 65 glass cylinder, 66 bottom electrode of the crystal holder, 67 space for the crystal, 1 and 1a glass vessel having a double lateral wall being open on the inside a short distance above the bottom, 2 mercury or some other conductive liquid, 1 and 1a tinfoil coats, 12 space between the double lateral walls (evacuated or filled with gas or air), 22 cementing, 9 base plate or heater body and 8 lead to the liquid electrode, 24 air tube with cock for controlling air-pressure within glass vessel, 25 pumping nipple for evacuating the crystal holder, 31 space over the conducting liquid which is filled with a non-conducting liquid or with gas (air), 17 piezo-electric crystal which is cut along its electrical axis.

The arrangement Fig. 6 comprises essentially two main parts, to wit, a piezo-electric crystal 17 in an exhaust crystal holder, and a condenser whose capacity according to the invention is subject to pronounced alterations with the temperature in such a way that its capacity increases with growth of the temperature.

The operation of the arrangement is as follows:

A piezo-electric crystal cut out of the mother crystal along the electrical axis ordinarily has the property that its natural wave-length grows with growing temperature. A condenser, on the other hand, which is connected in series or in parallel relation to the crystal and whose capacity increases with the temperature has the property of reducing the frequency of the circuit containing the quartz crystal. If the dimensions of the condenser and the crystal or crystal holder have been judiciously chosen, both actions may be made to neutralize each other so that any change in the temperature of the ambient will exercise no influence at all upon the frequency of the crystal circuit or only very slightly so. Hence, by the aid of an arrangement as shown in Fig. 6 the frequency of a crystal circuit and thus also the

frequency of the transmitter valve controlled by the crystal can be stabilized automatically.

I claim:

5 1. An electric condenser adapted for high frequency circuits comprising a condenser having a container with double walls, for retaining a liquid possessing a high co-efficient of expansion, said condenser being located below and connected in series with a piezo-electric crystal for remotely
10 tuning a vacuum tube transmitter.

2. A condenser comprising an insulating casing having a double wall open at a relatively short distance from the bottom of said casing, a metallic coating on the walls of said casing, a conducting
15 liquid within said container, an electrode closing the top of said container, a piezo-electric crystal located on said electrode, a second insulating casing surrounding said piezo-electric crystal, and a second electrode above said piezo-electric crystal.
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3. A condenser comprising an insulating casing having a double wall open at a relatively short distance from the bottom of said casing, a metallic coating on the walls of said casing, a conducting

liquid within said container, an electrode closing the top of said container, a piezo-electric crystal located on said electrode, a second insulating casing surrounding said piezo-electric crystal, a second electrode above said piezo-electric crystal, and an adjustable metallic member arranged with said second electrode for closing said insulating casing. 5

4. A condenser comprising an insulating casing having a central electrode and two outer electrodes, a piezo-electric crystal located between said central electrode and at least one of said other electrodes. 10

5. A condenser comprising an insulating casing having a double wall open at a relatively short distance from the bottom of said casing, a metallic coating on the walls of said casing, a conducting liquid within said container, a central electrode and two outer electrodes closing said container, a piezo-electric crystal located between said central electrode and at least one of said outer electrodes. 15 20

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