

March 1, 1938.

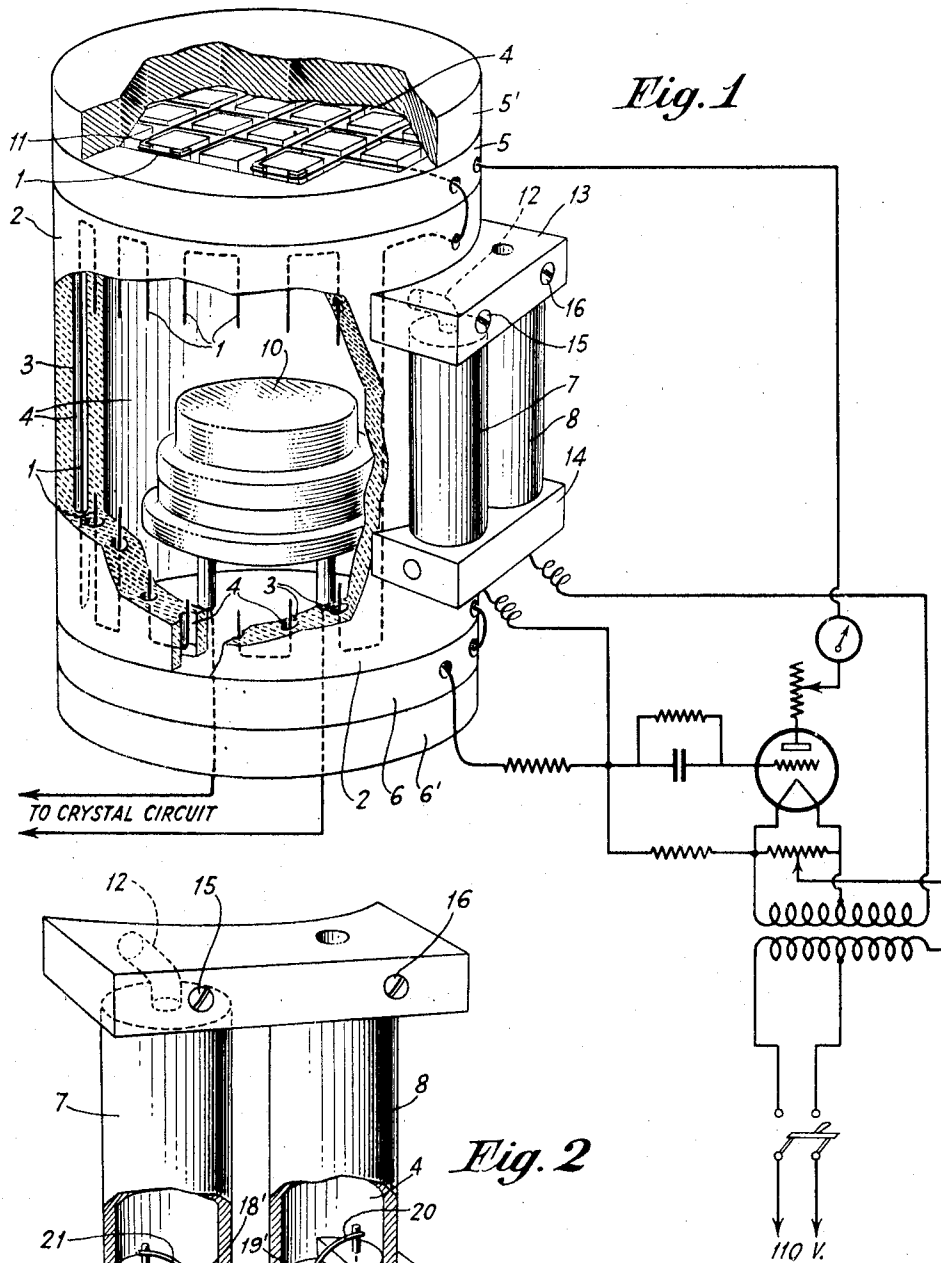
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2,109,874

CRYSTAL HEATER AND REGULATOR

Filed Feb. 1, 1936

3 Sheets-Sheet 1



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Fig. 3

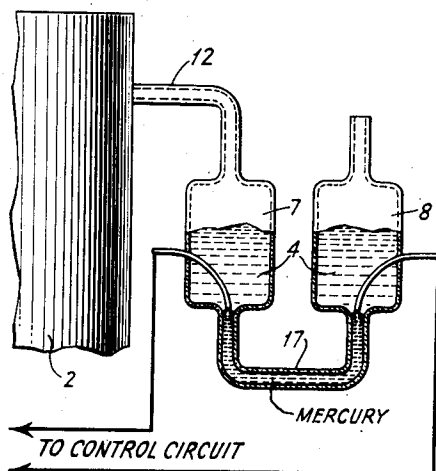


Fig. 5

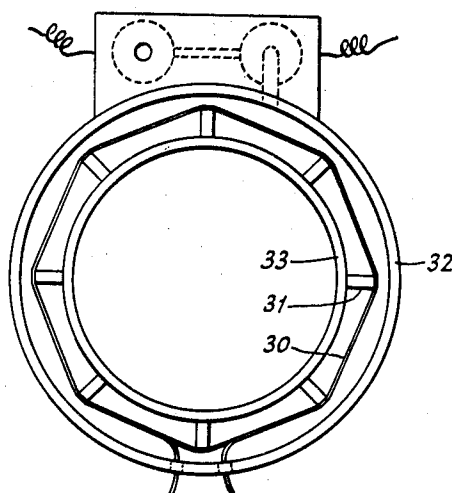


Fig. 4

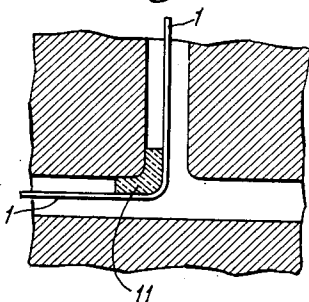
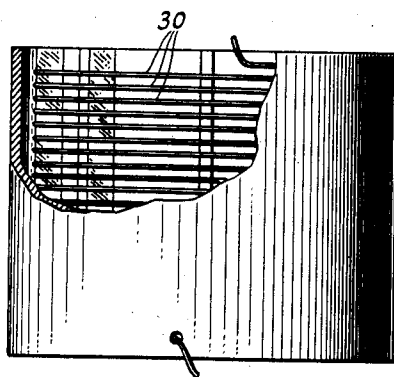


Fig. 6



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3 Sheets-Sheet 3

Fig. 7

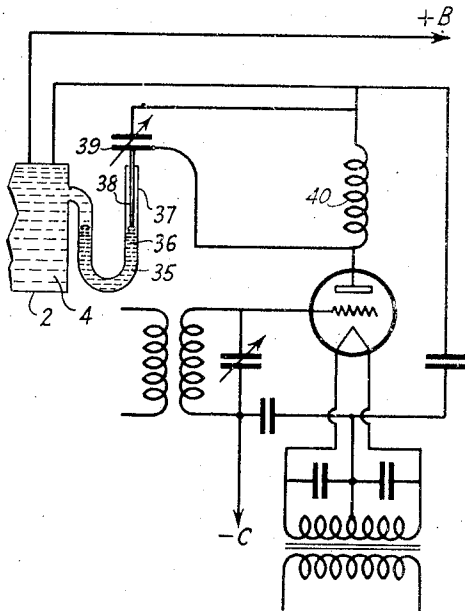


Fig. 8

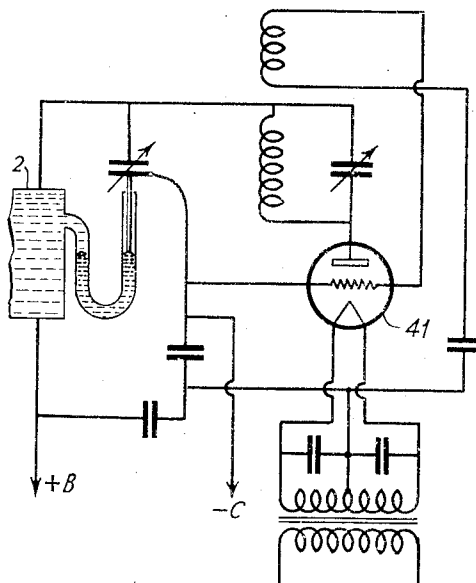


Fig. 9

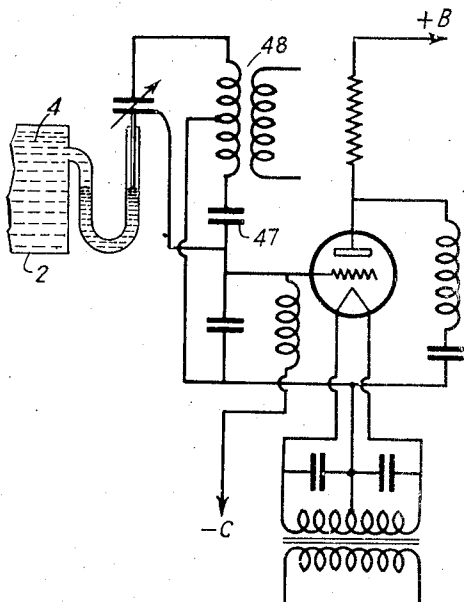
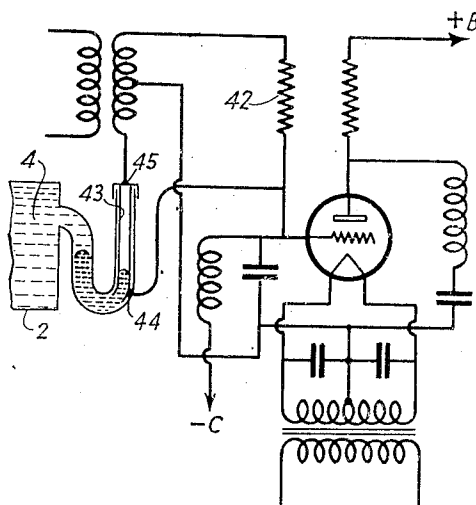


Fig. 10



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CRYSTAL HEATER AND REGULATOR

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Application February 1, 1936, Serial No. 61,865

10 Claims. (Cl. 219—19)

This invention relates to the art of radio frequency control and deals specifically with the regulation of temperature control of piezo-electric crystal ovens or containers.

5 An object of this invention is to simplify and improve the temperature regulation of piezo-electric crystal holders.

Another object of this invention is to provide a rugged piezo-electric crystal container which will be slow to respond to changes in the ambient temperature due to its massive construction and the container wall thickness.

A feature of this invention is the utilization of the heating medium as a thermal regulator and is based upon the principles of thermal expansion of fluids and Pascal's principle in obtaining a large change in fluid level in a small tube when only a small pressure is exerted in a large container filled with a fluid with which the smaller tube is connected.

In temperature regulators known to the prior art it has been the general practice to heat the air in a chamber, the heated air in turn heating the thermal regulator which controlled the heating current either directly or through a relay. As it is generally well known that air is a poor conductor of heat it is evident that there is a lag between the heating of the air and the heating of the regulator. Also there is a lag between the cooling of the air and the cooling of the regulator. This lag causes an over-travel in the heating cycle and results in an inconsistency of temperature which causes frequency vacillation.

This invention reduces the over-travel or lag in the heating cycle to a negligible factor which results in an improved consistency of frequency.

Briefly, by this invention there is maintained a substantial even temperature by eliminating the lag between the heating of the air and the heating of the regulator. The heat being conducted from the heating element to a cylindrical metallic wall of substantial thickness by means of an electrically non-conducting fluid. This fluid also serves as an actuating part of the temperature regulator.

This invention will be more thoroughly understood by reference to the accompanying drawings in which

Figure 1 is a perspective view partly in section of the improved temperature regulator of this invention,

Figure 2 is an enlarged detailed view in perspective also partly in section showing the external temperature regulating system,

Figure 3 is a detailed diagram showing the

functional arrangement of the temperature regulating system of Figure 2,

Figure 4 is an enlarged detailed sectional view showing the method of insulating the heater wires within the container,

Figure 5 is a sectional view of the heater arrangement shown in a modification of Figure 1,

Figure 6 is an elevation of Figure 5 partly in section, to show the arrangement of the heater wires within the container walls,

Figure 7 is an amplifier circuit diagram embodying this invention,

Figure 8 is an oscillating circuit diagram embodying the regulator of this invention,

Figure 9 is a tube circuit diagram in whose grid circuit there is located a neutralized filter, the neutralizing condenser being actuated by the temperature regulator of this invention,

Figure 10 is a circuit diagram of another modification of a neutralized filter embodying the temperature regulator of this invention.

Referring now in detail to Figure 1 the heating wires 1 are shown by the sectionalized portion of the container 2 to be contained within a number of axial apertures 3 which are filled with a non-conducting fluid 4. The non-conducting fluid is preferably one having good insulating qualities and a moderate high coefficient of expansion such as glycerine, castor oil, liquid paraffin, kerosene, carbon tetra-chloride and the like. These axial apertures or tubes in the walls of cylinder 2 are also arranged in corresponding openings in the top disk-like portion 5 and the bottom disk-like portion 6 of container 2. Suitable cover members 5' and 6' are provided to protect disk-like portions 5 and 6. When the assembly of the device is complete, the liquid entirely fills all the tubes as the presence of any air would render this invention inoperative. Located substantially in the center of the outside of the container 2 are arranged two parallel columns 7 and 8 (see also Figures 2 and 3). The purpose of these columns is to provide storage space sufficiently large so that any expansion or contraction of the fluid in the walls of the cylinder 2 and the top and bottom portions of the containers 5 and 6 may be taken care of. Column 7 is at all times completely filled with a non-conducting fluid which also fills the tubes of container 2. Column 8, on the other hand, is only partly filled with a fluid, the other portion being filled with a small quantity of mercury, likewise column 8 is normally open to the atmosphere. Within a central portion of container 2, there is located a piezo-electric crystal holder 10 or any other de-

vice whose temperature is desired to be maintained substantially constant. The heater wires 4 are all connected in series and are spaced as shown by Figure 4, by spacing members 11 which are in the form of small angles insulating the heater wire from the metal walls at such points where it is necessary to bend the heater wire around corners. The insulator 11 should be of any suitable material which will not be attracted mechanically by the action of the fluid and which will not be dissolved in the fluid, thus causing the insulating qualities of the fluid to be lower. The size and shape of these spacing members are such as to maintain suitable clearance between the heater wires and the side of the apertures 3.

As shown in Figures 2 and 3, the heating wires are arranged with the circuit interrupting and closing device. This device is of the type having a mercury contact making and breaking a circuit arrangement which is actuated by the pressure of the heater fluid transmitted through the passage 12 to the fluid filling tube 7 which is preferably in the form of a glass tube. A second tube 8 is positioned parallel with respect to tube 7 and is supported between the support members 13 and 14 which are attached to the sides of cylinder 2 by any suitable means such as bolts 15 and 16. The lower supporting member 14 is provided with a communicating aperture 17 and also two smaller apertures 18 and 19. These smaller apertures 18 and 19 communicate between aperture 17 and a shallow reservoir 18' and 19' in the bottom of tubes 7 and 8. In the normal operation of this device, the mercury fills the apertures 17, 18, 19 and a small globule which is located in the reservoir of tubes 7 and 8 connects with a terminal 20 which makes contact with the mercury at 19'. Another terminal 21 is located within tube 7 and is terminated at 18'.

The operating of this device is as follows:

When the temperature in the heater rises after the proper regulating adjustments have been made, the non-conducting fluid in the walls of the heater expands and exerts pressure in the tube 7 of the circuit interrupting device. This pressure displaces the level of the mercury in tube 18, thus opening the circuit at the upper end of 18'. As the fluid contracts due to a fall of temperature the mercury is drawn back in the aperture 18 and contact is again made. This control circuit actuates an external relay such as a thyatron vacuum tube or any other suitable relay device.

The modification shown by Figures 5 and 6 is generally similar to Figures 1 to 4 inclusive, except that the heater wires 30 are in the form of a helical coil arranged by insulating spacing members 31 located within the space formed by outer and inner containers 32 and 33. This modification is not as complicated as that of the construction mentioned above and is generally sufficient for most all practical purposes.

Referring now to the wiring diagrams, Figures 7 to 10 inclusive, the pressure of the expanding fluid is arranged within a suitable U-shaped tube 35 to unbalance the mercury level, one column comprising one side of a condenser which may be used to vary the heating current in any suitable manner. This modification may be employed to vary the magnitude of the heating current or actually interrupting the heating circuit as mentioned above.

Referring now in detail to Figure 7, there is shown an amplifier circuit which is provided with a suitable U-shaped tube 35 containing mercury 36. The outer end 37 of the U-shaped tube con-

tains a light weight plunger 38 which rests upon the surface of the mercury so that volumetric variations in the expanding fluid will cause a movement of the mercury and the support plunger 38. The upper end of plunger 38 carries a movable part 39 which forms a plate of a small trimming condenser incorporated in a circuit 40 tuned for normal radio frequencies. If this tuned circuit is adjusted to a given point on one side of the tuning curve then any movement of the condenser plate 39 will cause a change in the tuning. The nearer the trimming condenser causes the plate circuit to be in perfect tune, the smaller will be the direct plate current. This direct plate current is also arranged to act as the heating current. Conversely, an opposite movement of the condenser will cause an increase in the direct plate current so that it will be possible to adjust the U-shaped tube assembly so that a constant heating current may flow which will generate sufficient heat to exactly balance the heat dissipating from the unit. Any tendency of the temperature within the unit to change will be compensated for by a change in the heating current.

The diagram shown in Figure 8 is that of an oscillating circuit using a small trimming condenser mentioned above with reference to Figure 7 for obtaining partial neutralization of an oscillating circuit when the condenser is located in a position such that the tube 41 is nearly neutralized, the tube will then oscillate weakly and draw a heavy direct current which is also the heating current for the control device. A change in the level of the mercury 36 due to the expansion of the fluid in the control device which also changes the neutralization to form values further removed from close neutralization will cause the tube to oscillate stronger and draw smaller direct current, thus reducing the heat from the heater element.

The circuit arrangement shown in Figure 9 is that of a tube circuit in whose grid circuit there is located a neutralized filter, the neutralization condenser mentioned above being actuated by the mercury level by means of expansion of the fluid in the control device. When the condensers on each side of the secondary of radio frequency transformer 48 are unbalanced there will be an excitation on the grid of the tube so that the tube will then conduct, drawing current which passes through the heater element. As the capacity of the variable condenser approaches the capacity of a fixed condenser 47 on the opposite side of the transformer secondary, the current impulse will be balanced out and the tube will not draw any load, thus causing a change in the heat from the heater current as there is no excitation and no current passing through the tube.

In the circuit diagram shown in Figure 10, another neutralized filter arrangement is located in the grid circuit of a tube whose plate current passes through the heater element in this circuit arrangement. Instead of the capacities being on each side of the secondary of the radio frequency transformer, there is a fixed resistance 42 on one side, the other side being a variable resistance within the U-shaped tube, the inner walls of which are metallized at 43 so that the inner surface is a high resistance conductor. When the expanding fluid causes an unbalance in the mercury column the mercury will then cause a change in the resistance between its terminals 44 and 45, one of which is located at the top of the U-tube and the other in contact with the mercury at all times. As in the circuit diagram of Figure 9, when

this combination is unbalanced, the tube draws a load current and when the resistances closely approach a balance the tube current is then cut off.

By these circuit diagrams it has been shown how a modification of this invention may be utilized to control the temperature by means of electron discharge devices other than those of the thyatron type relay circuits. It is to be pointed out that a functional feature of this control device is that the heater element is located in the fluid container 2 whose coefficient of expansion is large compared with that of the actual actuating element of the regulating thermostat itself.

This invention should not be limited to the specific modifications described but only by such limitations as are clearly imposed in the appended claims.

We claim:

1. A temperature regulating device comprising a container, a plurality of apertures within the walls of said container, heater wires located within said apertures, a non-conducting fluid surrounding said wires and in fluid communication with an expanding fluid type of temperature regulating device located external of said container, an external current supply for heating said wires, said regulating device electrically connected with said heater wires and said external electrical supply circuit to control the temperature within said container.

2. A temperature regulating device comprising a metallic container, a plurality of axial apertures within the walls of said container, heater wires located within said apertures, said wires being spaced from said container by a plurality of insulating members, a fluid surrounding said wires and said insulating members and in fluid communication with a fluid expanding type of heat regulating device located external of said container, said heat regulating device connected with said heater wires and an external source of current to control the temperature within said container by the expansion and contraction of said fluid.

3. A temperature regulating device comprising a metallic container, a plurality of apertures within the walls of said container, heater wires located within said apertures, electrical means for heating said wires, a fluid expanding type of heat regulating device located external of said container, said regulating device comprising two parallel arranged tubes, the top end of one of said tubes being in fluid communication with said container, and the top end of the other tube being open to atmosphere, an electrical contact member located at the bottom of both of said tubes, and a fluid passage connecting said tubes together, a quantity of mercury in said fluid passage and arranged to make electrical contact with both contact members, fluid communication means between the container and said temperature regulator, said heat regulating device being electrically connected with said heater wires and an external electrical supply source to control the temperature within said container.

4. A temperature regulating device comprising a metallic container, a plurality of cylindrical apertures within the walls of said container, heating wires located within said cylindrical apertures, electrical means for heating said wires, a fluid expanding type of temperature control device wherein said heating wires are surrounded by the fluid of said temperature control device, said fluid serving as one element of said fluid

expanding temperature control device, said device being located external of said container, said fluid expanding temperature control device being connected with said heater wires and an external source to control the temperature within said container.

5. A temperature regulating device comprising a metallic container, a plurality of apertures within the walls of said container, a heating element within said apertures, an expanding fluid surrounding said heating element and serving as one element of a thermostat and a means for conducting heat to the walls of said container, means for heating said wires, a heat regulating device located external of said container, said heat regulating device connected with said heater wires and an external device to control the temperature within said container.

6. A temperature control device comprising a cylindrical container, a heating element located in a plurality of apertures within said container, said heating element being in combination with a fluid expanding type of circuit opening and closing device, a fluid surrounding said heater wires, said fluid being in fluid communication with said opening and closing device so that compensation will result from a tendency of any change in the ambient temperature to cause a change in the temperature in the space within said control device.

7. A temperature control device comprising a container, a heating element located within said container, a fluid expanding type of heat regulating device located external of said container comprising a U-shaped tube containing mercury, a float member floating on the top of said mercury, a tuned circuit connected with said heat regulating device to regulate the heat within said container by means of a variable trimming condenser incorporated in said tuned circuit said trimming condenser having a fixed and movable plate the movable plate being secured to said float member to vary the condenser in the tuned circuit upon a change in temperature.

8. A temperature control device comprising a container, a heating element located within said container, a fluid expanding type of heat regulating device located external of said container comprising a U-shaped tube containing mercury, a float member floating on the top of said mercury, an oscillator circuit connected with said heat regulating device to regulate the heat within said container by means of a variable trimming condenser incorporated in a tuned circuit of said oscillator, said trimming condenser having a fixed and movable plate, the movable plate being secured to said float member to vary the condenser in the oscillating circuit upon a change in temperature.

9. A temperature control device comprising a container, a heating element located within said container, a fluid type of heat regulating device and a heat supply source located external of said container, an electron tube circuit comprising a neutralized filter, a U-shaped tube forming a metallized resistor being actuated by the expansion of the fluid within said control device, said resistor being arranged in the grid circuit of said electron discharge tube so that the tube plate circuit is made responsive to vary said heat supply source.

10. A temperature control device comprising a container, a heating element located within said container, a fluid type of heat regulating device located external of said container, a U-

shaped tube containing mercury, a float member floating on top of said mercury, a neutralized filter, a fixed condenser, a variable condenser having fixed and movable plates, the movable plate being joined to said float member, a grid circuit of an electron discharge device arranged

whereby the capacity of said condenser unbalances the filter circuit and plate current passes through the heater element to control the temperature within said container.

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