

Aug. 8, 1933.

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1,921,433

CONSTANT TEMPERATURE APPARATUS

Filed May 5, 1930

2 Sheets-Sheet 1

FIG. 1

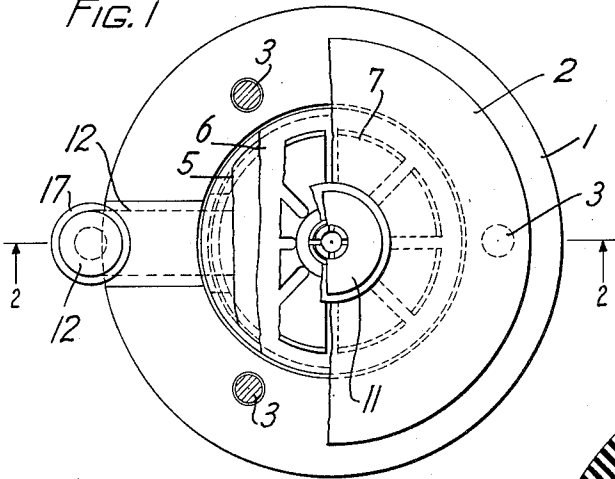


FIG. 3

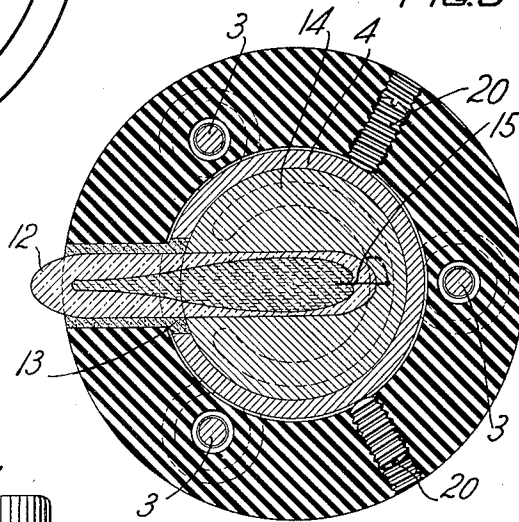


FIG. 2

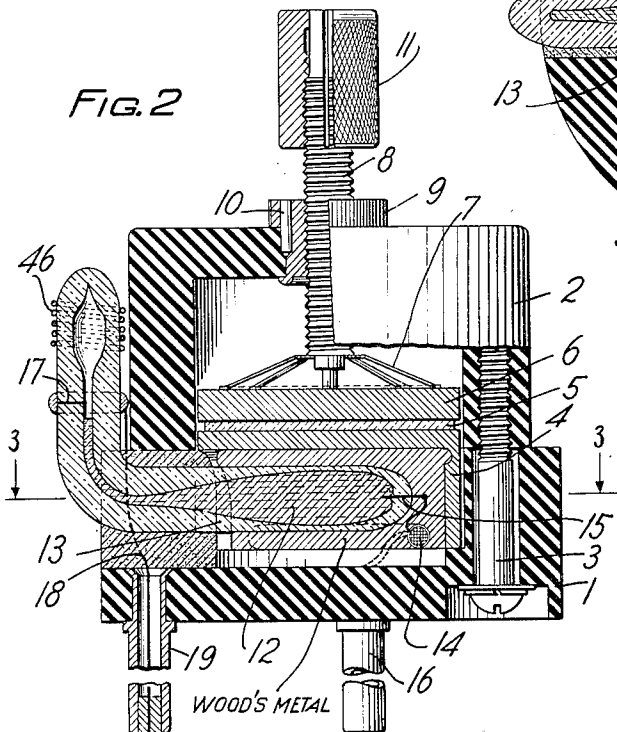
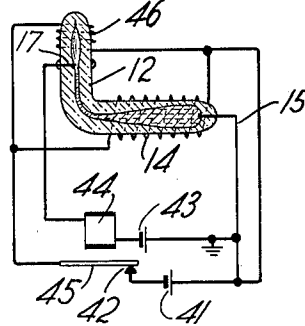


FIG. 4



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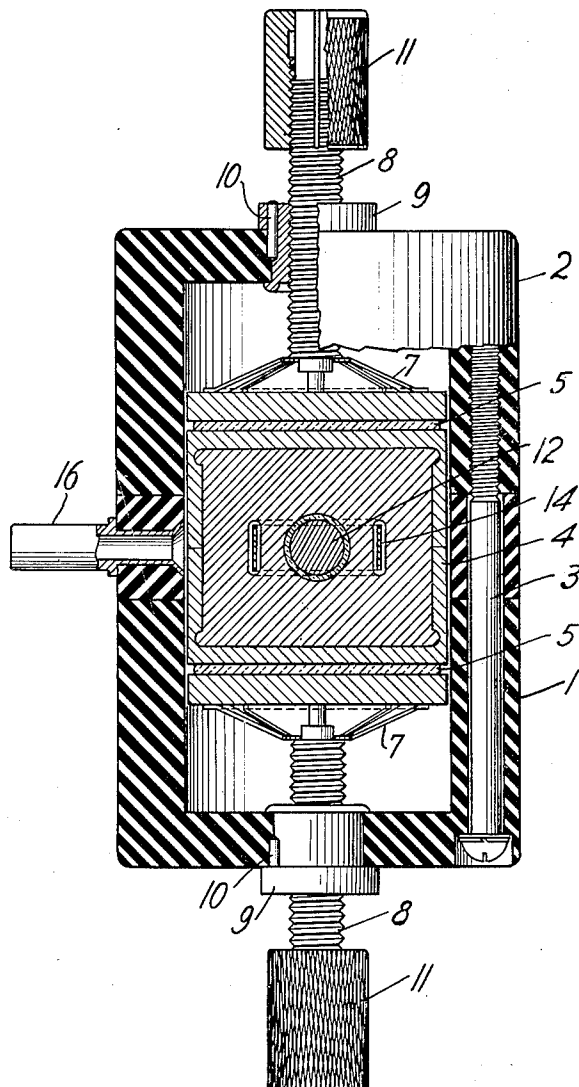
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FIG. 5



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CONSTANT TEMPERATURE APPARATUS

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Application May 5, 1930. Serial No. 449,735

10 Claims. (Cl. 171-327)

This invention relates to constant temperature apparatus and particularly to such apparatus for use with radio transmitters on air craft.

An object of this invention is to provide means for controlling the temperature, and hence the frequency of vibration, of a piezo-electric device within narrow limits.

Another object of this invention is to provide a holder for a piezo-electric crystal or other object whose temperature it is desired to maintain constant, which shall be small in size, light in weight, rugged in construction, and efficient in operation, and shall at the same time be strictly portable, and which may be subjected to sudden changes of temperature, atmospheric pressure, or humidity, or to rough handling, without adversely affecting its efficiency of operation.

A feature of this invention is the provision of heating means and temperature responsive means embedded in Wood's metal or other low melting point conductive material.

In the design and construction of a radio transmitter for use on air craft, particularly airplanes, all of the conditions enumerated above are important factors to be considered, and this invention therefore relates particularly to radio transmitters for use on air craft.

It is a still further object of this invention to provide means for avoiding the effect of condensation of mercury vapor on the inner walls of the thermostat above the mercury column when a mercury-in-vacuum-thermostat is used.

To accomplish this a separate heating coil is wound around the exposed end of the thermostat, so that this end is maintained at a temperature which will prevent the condensation of the mercury vapor along its walls. This heating coil may be separate from the main heating coil, or it may be connected in series or in parallel therewith. The necessary and sufficient condition is that enough heat be supplied to the exposed end of the thermostat at the proper time to prevent the condensation of the mercury vapor.

In the drawings:

Fig. 1 is a plan view, partly in section, of a constant temperature crystal holder built in accordance with the principles of this invention.

Fig. 2 is a cross section along line 2-2 of Fig. 1;

Fig. 3 is a cross section along line 3-3 of Fig. 2;

Fig. 4 is a diagram of a circuit which may be used to control the temperature; and

Fig. 5 is a side elevation, partly in section, of

a constant temperature crystal holder for two crystals.

In the operation of any device for maintaining constant temperature by the operation of a temperature responsive element in association with heating means, there is a range of temperature within which the heating means will be in operation during the portion of a cycle of operation when the temperature of the device is increasing, and will not be in operation during the portion of a cycle when the temperature is decreasing. If the heating element is in intimate thermal association with the temperature responsive device there will be a minimum of thermal lag between the two, that is, the responding element will be brought into operation with a minimum of delay after the temperature of the heating element falls to the point of desired operation having in mind the ultimate purpose of thereby controlling the temperature of the device as a whole and particularly the crystal or the like, and will similarly be brought into operation with a minimum of delay after the temperature of the heating element rises to the opposite extreme. If such a condition is maintained, that is, if there is such intimate thermal association, the period of operation of the heating element will be shortened, and the temperature of the element to be controlled may be maintained within prescribed limits with less thermal insulation to isolate it from the ambient atmosphere. The weight, and particularly the size, of the constant temperature device may therefore be considerably reduced. The invention also embodies the complementary principle of providing the closest possible thermal contiguity between the responding element and the element the temperature of which is immediately to be controlled. In the present instance this control element is the lower electrode of the crystal, or, where the device as a whole is a double crystal unit, the corresponding lower electrodes of the two crystals. With respect to this relationship between the responding element and the electrode the conditions pointed out in numbered paragraph (5) of the article by Clapp "Temperature control for frequency standards" in the December 1930 Proceedings of the Institute of Radio Engineers are satisfied, the crystal electrode, in the present instance, corresponding with the heat distribution wall referred to by Clapp. By the structure herein disclosed, relating the three elements whose temperature relations are significant, the various theoretically correct oper-

ating conditions are satisfied with a minimum of bulk and mass and with comparative ease in assembly. In copending application of Stallard, Serial No. 449,703, filed May 5, 1930, there is being claimed the means for achieving the intimate temperature relationship between the responding element and the controlled element that is embodied in the more comprehensive arrangement of the present invention.

10 A cup shaped base or mounting member 1 preferably of insulating material is provided with a cover 2, which is secured to the base by bolts 3. Within said base is an inverted cup 4 which serves as the lower electrode for a piezo electric crystal 5. An upper electrode 6 rests on the piezo electric crystal and is retained in position by a spring 7 which is mounted upon the end of a screw 8 threaded in a bushing 9 which is held in fixed engagement with the cover by a key 10. A chuck 11 mounted on the screw 8 provides means for making electrical contact to the upper electrode.

The cup 4 contains a thermostat 12 and a heating coil 14 embedded in a material having a low melting point and good heat conducting properties, preferably Wood's metal. The assembly of these elements is accomplished as follows: The cup is placed upright and the thermostat and heating coil placed in position, the thermostat protruding through an aperture 13 in the wall of the cup. The aperture surrounding the thermostat is then filled with plastic material such as plaster of Paris, which is allowed to harden, and the cup is filled with molten Wood's metal, which is allowed to cool and harden. The cup is then placed in position in the base, the thermostat projecting through an aperture therein. This aperture is then filled with plastic material, which may be the same kind of material used before, and the base is ready for assembly with the rest of the structure. A contact element 15 in the bottom of the thermostat makes contact with one end of the heating coil. The other end of the heating coil is connected with a plug 16 projecting through the base member. The thermostat has also a contact element 17, which is connected by means of a lead 18 to a second plug 19, similarly projecting through the base member. These plugs are provided to facilitate replacement of the holder in case a change of frequency is desired or in case of a breakdown. The lower thermostat contact 15, the end of the heating coil to which it is connected, and the lower electrode are at a common ground potential, so that suitable connections may be made to electrical apparatus to be associated with the device to complete separate circuits through the heating coils, thermostat, and across the electrodes. A third plug may be provided for a lead to make this ground contact. Set screws 20, shown in Fig. 3 are provided to maintain the cup assembly more securely in position.

65 In the thermostat used in connection with the crystal holder described above, the expedient was first tried of introducing an inert gas above the column of mercury to prevent displacement of the mercury when the device was subjected to jolts. It was found that when the device received a severe jolt a globule of mercury would separate from the column and a layer of the gas under pressure would interpose itself between the globule and the main column. The pressure of the gas and the surface tension of the mer-

cury were sufficient to prevent the globule from rejoining the column, and the operating temperature of the thermostat was accordingly increased. To obviate this difficulty the thermostat was evacuated.

Aircraft are subject to great variations in temperature. Man has adapted his wings to all conditions of weather, and the crystal holder may be called upon to operate at temperatures from 120° F., or perhaps even higher, to temperatures encountered on a polar flight. The desideratum is to maintain the temperature of the crystal constant independent of, and in spite of, changes in the ambient temperature. This means, of course, a constant temperature which shall be higher than, or at least as high as, the extreme upper limit of ambient temperature to be encountered in operation. When the pressure above the column of mercury is removed, the boiling point of the mercury decreases. Some of the mercury in the tube is vaporized when there is a difference in the temperature of the mercury and the exposed end of the thermostat. Whenever such a temperature difference is encountered, and more particularly at low ambient temperatures when the upper end of the thermostat is exposed, the mercury will evaporate and condense on the walls of the exposed part of the thermostat, thus completing a process of distillation. This reduces the quantity of mercury left in the main body, and materially changes the operating temperature of the thermostat. This effect prevents the use of a mercury-in-glass thermostat unless it can be prevented. No other type of thermostat at present known is suitable for use in such apparatus, so that unless this effect can be prevented temperature control under certain types of adverse weather conditions is impossible.

Fig. 4 illustrates a circuit and apparatus designed to avoid the above effects and which may be used in connection with the apparatus described above. A battery 41 provides current to the main heating coil 14, which may be wound around the bulb of the thermostat, and to the auxiliary heating coil 46, which may be wound around the upper end of the thermostat, when the contact 42 is closed. These heating coils are here shown in parallel although, as before explained, alternative arrangements may be used. A battery 43 in series with the thermostat supplies current to a relay 44 when the circuit through the thermostat contact is completed. Relay 44 attracts its armature 45, breaking the circuit through the heating coils and shutting off the heat. The temperature then begins to fall and the circuit through the thermostat is broken. Armature 45 is then released, a circuit through the heating coils is again completed, and heat is supplied as before. A common battery for the two circuits may of course be used.

Fig. 5 shows a modified form of crystal holder in which the elements similarly numbered are the same as in the figures heretofore described. That is, a cup-shaped base 1 is provided with a cover 2 which is secured to the base by bolts 3. Two cups 4 serve as electrodes for crystals 5. Outer electrodes are retained in position by springs 7 which are mounted upon the ends of screws 8 threaded in bushings 9 which are held in fixed engagement with the base and cover, respectively, by keys 10. Chucks 11 mounted upon the screws 8 provide means for making

electrical contact to the outer electrodes. Cups 4 contain a thermostat 12 and heating coil 14 embedded in Wood's metal, or a substance having similar properties, as before. Plug 16 is provided as before, and similar plugs may be provided for the other electrical connections mentioned in connection with the previous description. The two cups 4 are fitted together so that the bottom of each cup serves as an electrode for a crystal. This apparatus may be assembled in a number of ways. For example, the heating coil and thermostat may be placed in position with the thermostat protruding through a hole in the walls of the cups, half of the hole being cut from each cup, leaving a small air space around the sides of the thermostat. A small hole similarly cut may be provided in the opposite side of the cups. The cups may be fastened securely together in any suitable manner, and the apparatus placed in a container of molten Wood's metal so that the metal is forced into the hole last mentioned until it fills the cups. The holes may then be stopped in any suitable manner until the Wood's metal has cooled and hardened.

An advantage of this crystal holder is that a spare crystal may be provided with a very small increase in the size or weight of apparatus. Suitable switching means may be included in the apparatus associated with the crystal holder so that on the failure of one crystal the other crystal may be switched into the circuit. As the other crystal will be maintained at the same temperature as the one which has been previously operating, the circuit will continue to function as before. The spare crystal may be of a different frequency if desired.

What is claimed is:

1. Temperature regulating means comprising a mass of metal, a heating element and a temperature responding element embedded in said mass and therefore in maximum-heat-transfer relation thereto, and means for controlling the operation of said heating element in response to variations in said responding element.

2. A piezo-electric crystal holder comprising a hollow member, a mass of Wood's metal in said hollow member, and a thermostat and heating element embedded in said Wood's metal.

3. A piezo-electric crystal holder comprising a hollow element, a mass of conducting material of low melting point as compared with the ma-

terial of said hollow element contained in said hollow element, and a temperature responding element and a heating element, embedded in said conducting material.

4. A piezo-electric crystal holder comprising a mounting member, an electrode filled with Wood's metal mounted on said mounting member, a thermostat and a heating coil embedded in said Wood's metal, and leads from said heating coil and said thermostat connected with jacks in said mounting member.

5. Temperature regulating means comprising a heating element, a temperature responding element, and a fusible conducting material cast around said elements for maintaining intimate thermal relation therebetween.

6. A piezo-electric crystal holder comprising a hollow member, heating means and temperature responding means within said hollow member, and means filling said hollow member for providing intimate thermal relationship between said heating means and said responding means.

7. A piezo-electric crystal holder comprising a plurality of electrodes, a mass of thermally conductive material in thermally conductive relation with one of said electrodes, a thermostat in thermally conductive relation with said conductive material, means for heating said conductive material, and auxiliary heating means connected with said thermostat.

8. A piezo-electric crystal holder comprising a heat responding element, a heating element at one end thereof, and an auxiliary heating element surrounding the other end of said heat responding element.

9. A piezo-electric crystal holder comprising a plurality of electrodes, a plurality of crystals between said electrodes, and means within said holder for maintaining said crystals at the same temperature comprising a heating element and a temperature responsive element embedded in thermally conductive material having a low melting point as compared with the material of said electrodes.

10. A piezo-electric crystal holder comprising a plurality of electrodes, a plurality of crystals between said electrodes, and means for maintaining said crystals at a constant temperature comprising a heating element and a temperature responsive element embedded in thermally conductive material within said holder.

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