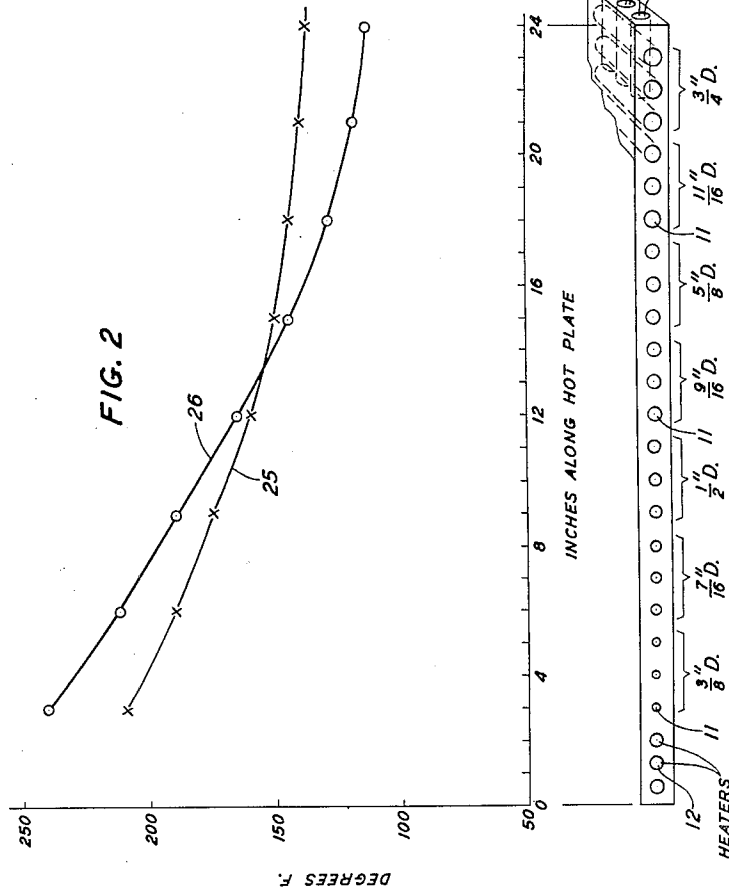
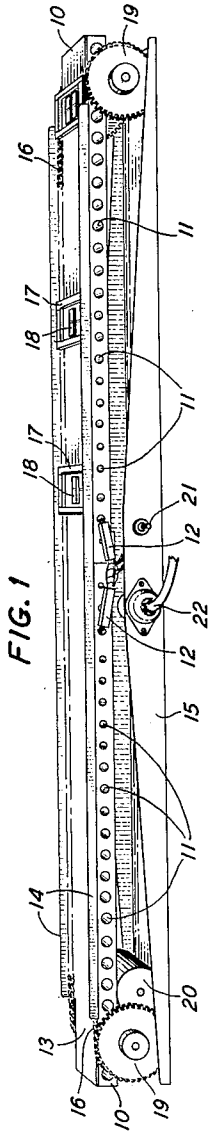


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HEATING APPARATUS
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HEATING APPARATUS

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This invention relates to heating apparatus and more particularly such apparatus of the conveyer type for gradient heating of synthetic crystals.

In the preparation of piezoelectric crystal devices, it is often required that the crystals be provided with wires to be suitable for use in an electrical system. The wires may serve as electrical leads for the crystals or as means for supporting a crystal while still allowing the crystal to vibrate in performing its required function. These wires may be attached to the crystal by a relatively small adhesive coated plate and some solder as disclosed in my copending application, Serial No. 68,221, filed December 30, 1948. In mounting the wire on the crystal, sufficient heat must be applied to melt the solder and it has been found that when such heat is applied, the crystal is subject to thermal stresses and thermal shock such that the crystal may become fractured in whole or in part, and is therefore rendered unfit for the service required. Crystals made of synthetic material have been found to be very fragile and quite susceptible to thermal shock. Illustrative of such a synthetic crystal is one commercially known as EDT which is grown from seeds in a solution of ethylene diamine tartrate ($C_6H_{14}N_2O_6$). Thus, if an EDT crystal is to have wires attached to it, there is danger that the crystal will be fractured by thermal shock or that the shock will cause small particles of the crystal material to be thrown off from the body of the crystal, thus rendering the crystal unsuitable for the electrical purpose desired. This is particularly likely in the manufacture of EDT crystal devices, as it is a characteristic thereof that they may fracture and then the visible manifestation of the fracture disappear, so that it is only after an electrical test that it can be ascertained that the crystal is not suitable. This delicacy and lack of resistance to thermal shock can be understood when the rather remarkable temperature expansion characteristic of EDT crystals is considered. Such crystals have a high positive expansion characteristic in one direction, +90 parts in 10^6 per $^{\circ}C.$, as against a negative coefficient of -12 parts in 10^6 per $^{\circ}C.$, in a perpendicular direction. It is this temperature expansion property that is the source of trouble in handling as the crystal fractures if subject to sudden uneven heating or cooling. This property even limits the rapidity with which a change in temperature can be made in measuring the temperature coefficients and is the source of trouble in attaching wires to the crystal sur-

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face, whether by cementing as before noted, or in some other way, as by the wire penetrating the crystal plate, as disclosed in my copending application, Serial No. 68,222, filed December 30, 1948.

It is an object of this invention to provide for gradient heating of synthetic crystals, whereby they may be simply and evenly heated or cooled.

It is a further object of this invention to provide a simple and adjacent conveyer type gradient heating which has a minimum number of operating parts and does not require a large amount of space.

These other objects are attained in one illustrative embodiment of this invention in which a solid metal plate of a material having a high thermal conductivity is used as a base plate. The plate has a heater located at one end and a system of holes drilled through the plate transversely and varying in size in the direction of the cooler end away from the heater. These holes by increasing the radiant surface of the heater plate effect a controllable temperature gradient per unit length from the hot end to the cool end of the plate.

In accordance with one feature of this invention, the radiant surface of the base is increased with distance from a heater element, whereby more heat can be conducted away and thereby equally reduce the temperature.

In accordance with a further feature of this invention, the surface is increased by drilling holes transversely through the base plate, whereby passage of air currents through the holes is enabled to allow a rapid convection of heat away from the base plate.

In accordance with a further feature of this invention, additional holes may be drilled into the end or bottom of the base plate at the extremity away from the heating element, whereby even greater convection of heat may be obtained.

In accordance with a further feature of this invention, two such plates may be placed adjacent each other with the heater portions joined together, whereby one plate may be used for gradient heating and the other for gradient cooling.

In accordance with a still further feature of this invention, conveyer means are provided whereby the crystal and crystal fixtures slowly and evenly traverse the base plate from the cool portions to the heater portion where suitable operations may be performed upon them.

An understanding of the arrangements con-

templated by this invention and of the operation thereof and appreciation of the above noted and other desirable features may be gained from consideration of the following detailed description and accompanying drawings in which:

Fig. 1 shows two conveyer-type gradient heaters illustrative of one embodiment of this invention, the two being joined together providing a continuous heating and cooling conveyer plate.

Fig. 2 is a graph of the temperature of the heater plate for the illustrative embodiment shown in Fig. 1 and of the temperature of a plain unapertured plate as plotted against the distance along the hot plate. The apertures drilled through the plate of Fig. 1 are also shown plotted against the distance along the plate.

Referring now to the drawing, a heater block or base plate 10 of a material having a high thermal conductivity, such as aluminum, has apertures 11 extending through the narrow width of the plate. Two heater blocks 10 are shown joined together in Fig. 1. A heater element 12 extends into an aperture 11 of each plate adjacent the point of junction. The apertures, which may be drilled through the plate, are of different sizes, the diameter of the apertures increasing in size towards both ends of the plates 10. By increasing the diameter of the apertures with increase of distance away from the heater elements 12, the radiant surface of the base plate 10 is increased, whereby more heat can be conducted away. The apertures 11 are preferably drilled all the way through the block 10 so that there may be air currents passing through the block rather than just dormant air pockets, with no vortex or turbulence, as would result if the apertures were not drilled all the way through the plate. A channel 13, which may be of brass and which has side portions 14, covers the two heater blocks 10 and provides a surface over which the crystals can be conveyed. A base flange 15 upon which the heater block is supported is provided with narrower flange portions at its ends rather than at its center adjacent the heater elements to provide for more air space for the dissipation of heat.

The mechanism for moving the crystals evenly along the hot plate may comprise, as shown, a pair of chains 16 on which are placed frames 17 which serve as carriages for the crystals 18 or for crystal holders, not shown. The chains 16 are engaged by sprockets 19 at each end of the flange 15. One sprocket 19 is rotated through a gear mechanism, not shown, by a motor 20. A switch 21 is provided on the flange 15 for the motor 20 and an electrical connection 22 is provided for the motor and heater elements.

In the operation of this conveyer hot plate, the crystal plate with its holder is first placed at the cooler end of the hot plate and brought up gradually by the mechanical drive to the hot center portion where the crystal plate and holder can be temporarily removed in order to be worked on, such as for the attachment of the adhesive or the soldering of the lead wires onto the crystal plate. The equipment for these operations may advantageously be placed adjacent to the center of the conveyer plate, shown in Fig. 1, and may in fact be directly attached to it and be right above the center portion. Or the equipment may be at a distance and the crystals stored in a heat reservoir, as a constant temperature oven. In one embodiment that has been used, the two hot plates are separate, the heating plate conveying the

crystal with its holder into a heat reservoir where its temperature may be maintained constant until the operations are to be performed upon it. Then after being worked upon, the crystals may be placed on the second or cooling plate and brought down to a lower temperature from which natural cooling to room temperature may safely occur.

It has been found advantageous to place the crystals in heavy fixtures in which the crystals stay during all subsequent operations upon the crystals until they are prepared for use. With such fixtures, the mass of fixture has sufficient heating capacity to slow down the cooling so that a separate cooling plate may not be required. However, it is still necessary to use a heating plate and a heat reservoir in which to store the crystals before working upon them.

Fig. 2 shows a graph of the temperature along the heater plate of Fig. 1 with distance from the heater element 12. The lower portion of this curve 23 could have been dropped to approximate even more closely a straight line and thereby a more uniform rate of heating by drilling holes at that region through the bottom of the plate to effect natural draft and ventilation. In the illustrative embodiment of Fig. 1, however, such a uniform gradient was not required. Line 25 on this graph shows the temperature gradient along the equivalent aluminum base plate in which no holes have been drilled. As is apparent from the graph, the temperature difference between the cool portion of the plate and the heater element is far less and would be insufficient for gradient heating of synthetic crystals.

The aperture sizes 11 for the illustrative embodiment shown in Fig. 1 are also plotted in Fig. 2 against distance along the hot plate, the actual diameters being as indicated. The apertures in this embodiment were drilled in groups of threes, each aperture being one inch apart from the next. This particular arrangement is merely illustrative of one possible means of increasing the radiant surface of the hot plate with increase of distance from the heater element. The diameters of the apertures were chosen in this instance for convenience of drilling and may be varied as desired without departing from the scope of this invention. As shown in Fig. 2, additional apertures 11 are drilled into the end of the hot plate at its farthest distance from the heater element to increase the cooling surface. In Fig. 2 these apertures are shown extending into the heater plate a sufficient distance to intersect two of the transverse apertures.

The heater plates need not be placed in ovens or otherwise be protected from ambient temperature variations as work on synthetic crystals, such as EDT, is done in air conditioned rooms in which the temperature and the humidity are carefully controlled. If the gradient heaters are to be used in places subject to ambient temperature variations and to variations in air convections, provision may be made for positioning the heaters in ovens and cooling them by a controlled forced draft.

It is to be understood that while the radiant surface area of the heater block has been disclosed as increased from the heater element to the end of the block by means of apertures in the sides of the block, this is merely illustrative of one possible arrangement and that the radiant surface may be increased in other ways. For example, the sides or the bottom may be formed in undulating curves of greater amplitude distant from the heater element, the curves preferably

being formed on a trapezoidally shaped heater block.

It is also to be understood that the above-described arrangements are illustrative of the application of the principles of this invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In a device for heating small articles, a bed of heat conducting material having a plurality of apertures in the sides thereof, and heater means positioned in one of said apertures, said apertures being of increasing size extending away from said heater means.

2. In a device for preparing small articles for work at elevated temperatures, a flat elongated block of heat conducting material having a plurality of apertures extending therethrough, a heater element positioned in one of said apertures, the apertures adjacent said heater aperture being smaller than the apertures distant therefrom whereby heat is more rapidly conducted away from said block at the distant apertures, and means associated with said block for conveying the articles along the surface thereof.

3. In a device for preparing small articles for work at elevated temperatures, an elongated block of heat conducting material, said block having a plurality of apertures extending through the width thereof, a heater element positioned in one of said apertures, said apertures being of increasing size from said heater element to one end of said block, each aperture being of at least equal size with the preceding one nearest said heater element, whereby an even temperature gradient is obtained along the block between said end and said heater element, and means for conveying the articles along said block from said larger to said smaller aperture regions of said block.

4. In a device for preparing small articles for work at elevated temperature, a flat elongated block of heat conducting material having apertures therein, said apertures being smallest at the center thereof and larger towards each end, heating means positioned in one of said apertures at the center thereof, and means associated with said block for conveying the articles along said block.

5. In a device for heating crystals for work at elevated temperatures, a flat elongated aluminum block having apertures extending through the width thereof and apertures extending into one end thereof, a heater element positioned in one of said apertures distant from said end, the apertures adjacent said heater aperture being smaller than said apertures towards said end whereby an even temperature gradient along said block is obtained, and means associated with said block for conveying the crystals along the surface of said block at an even rate.

6. A device in accordance with claim 5 wherein said means comprises a pair of conveyor chains, a frame attached to said chains for carrying said crystals, and drive means for imparting motion to said chains.

7. In a device for preparing small articles for work at elevated temperatures, a flat elongated block of heat-conducting material, heater means, means for establishing a substantially straight temperature gradient in said block comprising means defining a plurality of apertures extending through the width of said block, said heater means being positioned in one of said apertures, said apertures being of increasing size from said heater means to one end of said block, said means for establishing said gradient also comprising means defining a plurality of apertures extending into said one end of said block and communicating with the largest of said first apertures, whereby the surface area of said block is increased away from said heater means to allow more conduction of heat away from said block, and means for conveying the articles along said block from said one end towards said heater means.

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