

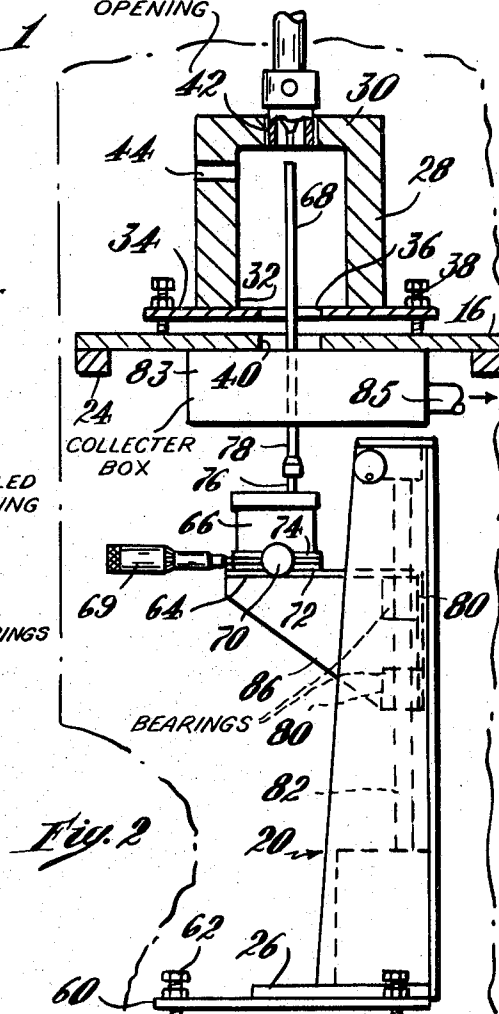
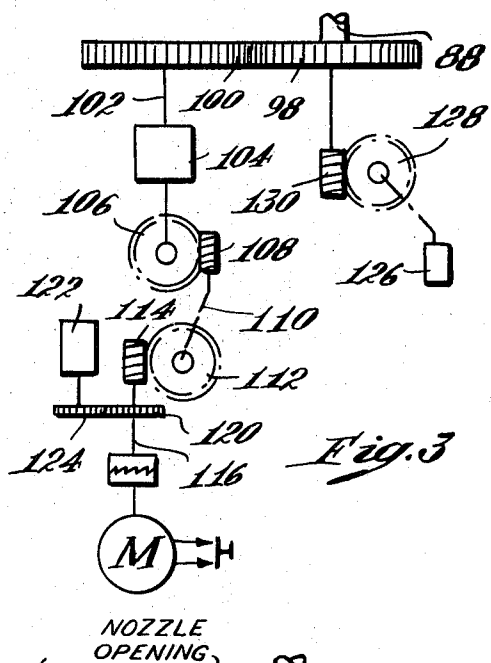
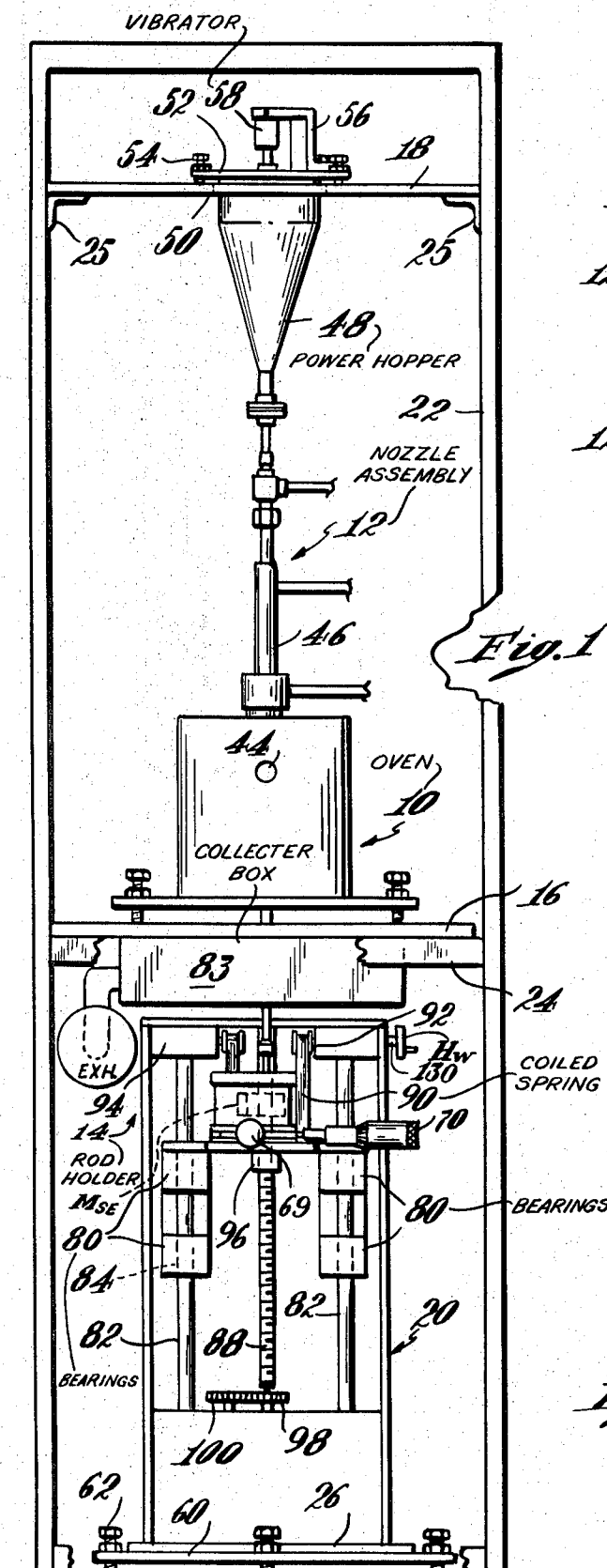
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CRYSTAL GROWING APPARATUS

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CRYSTAL GROWING APPARATUS

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ABSTRACT OF THE DISCLOSURE

A crystal growing apparatus comprising a refractory furnace in which one end of a refractory rod is held and within which there is a nozzle by means of which molten crystal forming material is deposited on the rod. The crystal forming material is in the form of powder and is liquefied in an oxygen-hydrogen flame at the end of the nozzle. As the crystal grows at the end of the rod the latter is retracted.

BACKGROUND OF THE INVENTION

Apparatus for practicing the Verneuil's method of producing synthetic crystals has been used for some time; however the design of such apparatus does not depart substantially from laboratory equipment and is not suitable for the production of crystals on a commercial scale. More especially, such apparatus is not readily adjustable for use by unskilled operators and the entire structure is hung on a single supporting column so that it is very sensitive to disturbance by vibrations produced either through its own operation or from outside which is highly detrimental to uniform crystal growth.

SUMMARY

The principal object of this invention is to provide an apparatus capable of producing artificial or synthetic crystals on a commercial basis without need for skilled operators and, as herein illustrated, this apparatus comprises independently mounted supports, a furnace mounted on one of the supports, a holder mounted on a second one of the supports by means of which one end of a refractory rod is supported in the furnace for deposition of molten crystal forming material thereon, the holder being movable on its support to withdraw the rod as the crystal grows, means for effecting movement of the holder, a nozzle mounted on a third one of the supports with its discharge end in the furnace in a position of alignment with and spaced from the end of the rod for depositing molten crystal material on the end of the rod, a source of crystal forming material connected to the nozzle, and a vibrator mounted on the third support operable to effect a uniform discharge of crystallizable material to the nozzle. The furnace comprises a hollow refractory cylinder closed at one end and open at the other set on its open end on its support. The closed end of the furnace contains a central hole through which the nozzle extends and the support on which the cylinder rests contains a hole through which the rod extends upwardly into the cylinder. There is means on the first support for adjusting the level of the nozzle, means on the second support for adjusting the level of the furnace, and means on the third support for raising and lowering the rod holder to move the end of the rod toward and away from the nozzle and for adjusting the lateral position of the rod holder to align the end of the rod with the end of the nozzle. The support for the rod holder comprises a rigid platen and is mounted for movement along a path forming an extension of the axis of the nozzle on rigid guides. There is means for nullifying the mass of the platen with

respect to its path of movement and means for effecting movement of the platen. The guides are transversely spaced rods and the platen has vertically spaced bearing members slidably engaged with the rods. The means for nullifying the mass of the platen comprise springs connected to the platen and to the support therefor which counterbalances its weight. The means for effecting movement of the platen comprise a lead screw, a ball nut associated therewith, and a motor for effecting rotation of the ball nut so as to rotate the screw.

The invention will now be described in greater detail with reference to the accompanying drawings wherein:

FIG. 1 is a front elevation of the crystal growing apparatus with the front panel of the cabinet within which it is situated omitted;

FIG. 2 is a side view as seen from the right side of FIG. 1 with the cabinet omitted, with the nozzle omitted and with the furnace and furnace support shown in section; and

FIG. 3 diagrammatically shows the driving mechanism.

Referring to the drawings, the apparatus comprises essentially an oven 10 within which crystallizable material is deposited in a molten condition on the end of a refractory rod, a nozzle assembly 12 to which crystallizable material is fed in powdered form and from which it is discharged in a molten condition onto the end of the refractory rod in the furnace, and a refractory rod holder 14 for supporting the refractory rod so that it may be withdrawn relative to the nozzle as the crystal grows. The components 10, 12 and 14 are mounted on supports 16, 18 and 20. The supports 16 and 18 are mounted in spaced parallel relation to the inside of a cabinet structure 22 which is comprised of sheet metal, is substantially rectangular in horizontal section, and is provided with a panel at the front (not shown) which may be swung open to permit access to the operating parts. The support 16 rests upon transversely extending, spaced parallel bars 24 and the support 18 rests upon transversely spaced angles 25. The support 20 is provided with a base or footing 26 which rests on the floor independently of the footing of the cabinet. The only connection between the supports 16 and 18 is through the walls of the cabinet and as stated above there is no connection between the support 20 and either of the supports 16 and 18. The reason for mounting the component parts 10, 12 and 14 relatively independently of each other as contrasted to such apparatus as has heretofore been available is to isolate the components so that the vibration of one will not be transmitted to the other, particularly the vibration which is produced by the vibrator which is used, as will appear hereinafter, for insuring uniform flow of the crystallizable material to the nozzle and vibration which might possibly be produced by the motor and driving means employed to retract the refractory rod as the crystal grows, or to the mere running of the motor, or to manipulation of the apparatus by an operator.

The furnace 10, as shown in FIG. 2, is a hollow refractory cylinder 28 having a closed upper end 30 and an open lower end 32 and rests with its open end on a rigid plate 34. The plate 34 contains a central opening 36 and is supported by three screws 38 on the support 16 which contains an opening 40 directly below the opening 36 and concentric therewith. The closed end of the furnace has a centrally located hole 42 for reception of the nozzle with a slight clearance between the exterior surface of the nozzle and the hole so that any vibration transmitted to the nozzle by the aforesaid vibrator will not be transmitted to the furnace. A peep hole 44 is formed in one side of the furnace wall at about the level of the upper end of the refractory rod where the crystal is being formed to enable an operator to view

the crystal and if its growth is not proceeding satisfactorily to permit making adjustments.

The nozzle assembly 12 comprises a nozzle 46 to which crystallizable material is supplied from a funnel-shaped hopper 48 and to which oxygen and hydrogen are supplied through conductors to effect melting of the crystallizable material at the discharge end of the nozzle, the latter being located in the hole 42 just above the upper end of the rod upon which the crystal is to be grown. The nozzle assembly 46 is suspended in position at the lower end of the funnel 48 and the latter extends through an opening 50 in the support 18 and is secured to an adjusting plate 52 provided with three adjusting screws 54. A bracket 56 is fastened to the plate 52 and supports a vibrator 58 which is operative to effect vibration of the funnel 48 and thus to deliver the powdered crystallizable material uniformly to the nozzle.

The support 20 is in the form of a pedestal which stands on its own footing 26 independently of the cabinet as mentioned above and is adjustable by means of a plate 60 provided with adjusting screws 62. A platen 64 is mounted on the pedestal for movement vertically and a holder 66 for the refractory rod 68 on which the crystal is to be grown is mounted on the platen for movement therewith and for adjustment transversely thereof forwardly and rearwardly by a micrometer screw 69 and from side to side by a micrometer screw 70. Preferably interlocking tongue and groove plates 72 and 74 fixed respectively to the platen 64 and the holder 66 provide for securing the holder 66 to the platen 64. A short pin or stud 76 fixed in an upright position to the holder provides support for the lower end of a hollow refractory rod or tube 78 which extends upwardly therefrom through the hole 40 in the support 16, the hole 36 in the plate 34 and into the furnace to a point just below the discharge end of the nozzle.

The platen 64 extends forwardly from the pedestal 20 in cantilever fashion, being supported at its rear end by transversely spaced pairs of bearings 80 slidably mounted on transversely spaced, parallel posts 82 fixed at their upper and lower ends to the pedestal. The bearings 80 are axially elongate to provide for maximum stability and to minimize binding and are provided with bushing sleeves 84 for sliding engagement with the rods 82, the latter having threaded exterior surfaces to minimize friction. Triangular-shaped bracket plates 86 extend forwardly from the bearings beneath the edges of the platen 64 to provide for maximum rigidity.

Between the lower side of the support 16 and the top of the support 20 there is a collector box 83 containing vertically subjacent holes aligned with the hole 40 in the support 16 through which the rod 78 passes. A duct 85 at the back provides for connecting the box to an exhaust fan to remove powdered material which is not melted and falls to the bottom of the furnace in solid form.

A lead screw 88 is provided for effecting vertical movement of the platen 64 and to minimize vibration or uneven movement of the platen and hence of the refractory rod as it is backed off or adjusted, the mass of the platen and of the holder is substantially nullified by a pair of normally coiled springs 90 which apply an upward force to the platen and holder which substantially counterbalances their weight. These springs 90 are flat and are coiled at one end about spools 92 which are fastened to the blocks 94 in which the upper ends of the rods 82 are secured and at their other ends to the rear end of the platen. The springs 90 normally tend to coil up and are extended by downward movement of the platen. To further minimize the possibility of uneven or nonuniform movement and/or vibration the lead screw 88 extends through a ball nut 96 secured to the underside of the platen substantially midway between the axes of the shafts 82 so that rotation of the screw draws the nut 96 and hence the platen downwardly thereon. Rotation of the screw is effected by meshing gears 98 and 100. The gear 98 is fixed to the lower end of the screw and the gear 100

is connected as will now appear to a drive motor M. A train comprising a shaft 102 to which the gear 100 is secured, a magnetic clutch 104, a worm wheel 106, a worm 108, a shaft 110, a worm wheel 112, a worm 114 and shaft 116 drivably connect the gear 100 to the motor M. The shaft 116 has on it a gear 120 and a tachometer 122 provided with a gear 124 which meshes with the gear 120 provides for insuring uniform speed. A potentiometer 126 provided with a gear 128 in mesh with a worm 130 on the lead screw takes up any backlash which may occur.

The motor M is started and stopped by a push button type of switch which initiates and continues operation of the motor so long as it is held depressed. Optionally, the screw may be rotated by a hand wheel HW fixed to a shaft 130 which in turn has a worm gear meshing with the screw 88.

In addition to withdrawal of the tube 78 during formation of the crystal, the tube may optionally be rotated and to this end there is provided in the holder 66 a spring or electric motor MSE for rotating the stud 76 at a predetermined speed about its vertical axis.

The apparatus as thus described is designed primarily to enable commercial manufacture of crystallizable material as distinguished from merely laboratory techniques and as related above has been designed to maintain a minimum amount of interdependence between the support for the various components of the apparatus thereby to eliminate the transmission of vibration from one part to another which is so detrimental to the formation of uniform crystal structure. The several adjustments necessary to align the nozzle and the crystal supporting rod are easily accessible and easy to manipulate to effect an initial preparation of the apparatus for crystal growth and to effect minor adjustments during the growth. The apparatus is of comparatively simple construction, easy to maintain and is housed within a compact cabinet so as to keep it intact and also secure the operator from accidental contact with the furnace which operates at a relatively high temperature and could cause serious burns.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. In a crystal growing furnace, the combination of a nozzle and support by means of which the crystal producing material is adapted to be deposited on the end of a refractory rod mounted on the support with said end confronting the nozzle, said support being movable relative to the nozzle to maintain the distance between the nozzle and said end of the rod substantially constant during growth of the crystal, comprising a rigid platen on which the rod is mounted with said end lying on an extension of the axis of the nozzle, rigid guides on which the platen is mounted for movement along a predetermined path maintaining said end on said extension of the axis of the nozzle, means for nullifying the mass of the platen with respect to its path of movement, means for effecting movement of the platen, transversely spaced, parallel, vertically disposed guides, vertically spaced bearing members on the platen slidably engaged with said guides, said platen being supported by its bearings on said guides in a horizontal position for movement up and down relative to the nozzle, spring means connected to the platen counterbalancing the weight thereof, and means connected to the platen at a point located symmetrically with respect to the guides operable to effect vertical movement of the platen.

2. Apparatus according to claim 1, wherein said axially spaced bearings are axially elongate and contain bushing members for sliding engagement with the guides, and said guides having hardened surfaces cooperable with said bushings to minimize frictional resistance to movement of the platen.

3. Apparatus according to claim 1, comprising a jig

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on the platen mounting a stud, a fixture mounted on the jig with one end engaged with the stud and the other end situated between the platen and the nozzle, said other end being adapted to hold a ceramic body upon which the crystal is to be grown, and means on the platen operable to shift the jig transversely to bring the ceramic body into a position in which the axis of the nozzle is located substantially at the center of its upper surface.

4. Apparatus according to claim 1, comprising a pair of meshing gears, one of which is fixed to the lead screw, and means for effecting rotation of the other gear including a drive shaft, a motor for effecting rotation of the drive shaft, a tachometer for controlling the speed of the motor, and a pair of meshing gears, one of which is mounted on the drive shaft and the other on the tachometer shaft.

5. In a crystal growing furnace, the combination of a nozzle and support by means of which the crystal producing material is adapted to be deposited on the end of a refractory rod mounted on the support with said end confronting the nozzle, said support being movable relative to the nozzle to maintain the distance between the nozzle and said end of the rod substantially constant during growth of the crystal, comprising a rigid platen on which the rod is mounted with said end lying on an extension of the axis of the nozzle, rigid guides on which the platen is mounted for movement along a predetermined path maintaining said end on said extension of the axis of the nozzle, means for nullifying the mass of the platen with respect to its path of movement, means for effecting movement of the platen, transversely spaced,

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vertically disposed posts fixed rigidly at their upper and lower ends in spaced relation with their vertical axes parallel to the axis of the nozzle, vertically spaced bearings spaced transversely of the platen at one end thereof, said bearings being slidably mounted on said posts and supporting the platen at one end in a horizontal position for vertical movement, a pair of normally coiled springs secured at one end and connected at their other ends to said platen, said springs counterbalancing the weight of the platen, and a lead screw operably associated with the platen operable to raise and lower the platen, the axis of the lead screw being parallel to the axes of the guide posts.

6. Apparatus according to claim 5, comprising a pair of meshing gears, one of which is fixed to the lead screw and the other of which is connected to a source of power by means of which the screw means is rotated.

7. Apparatus according to claim 5, comprising a ball nut secured to the platen providing the driving connection between the screw and platen.

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