June 22, 1965 A. VUNDERINK 3,190,728

APPARATUS FOR MELTING MATERIAL BY MEANS OF A FLAME OF ELEVATED TEMPERATURE

Filed May 10. 1961

Fig. 1

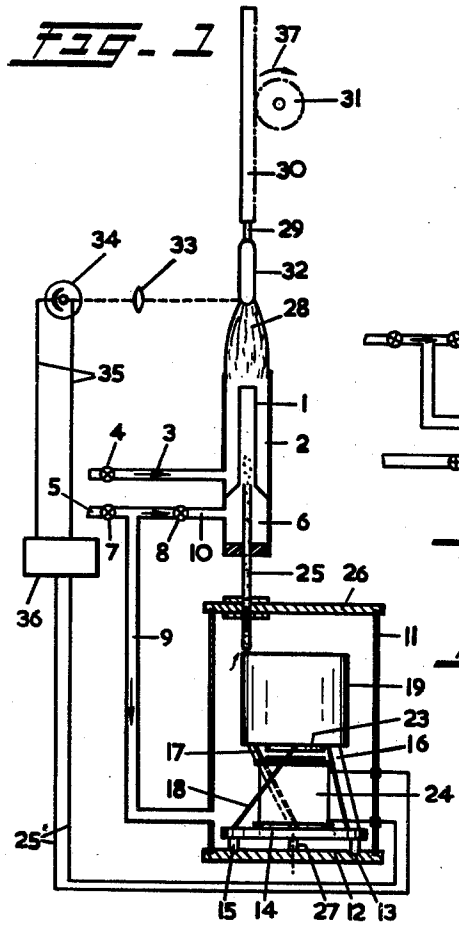



Fig. 5

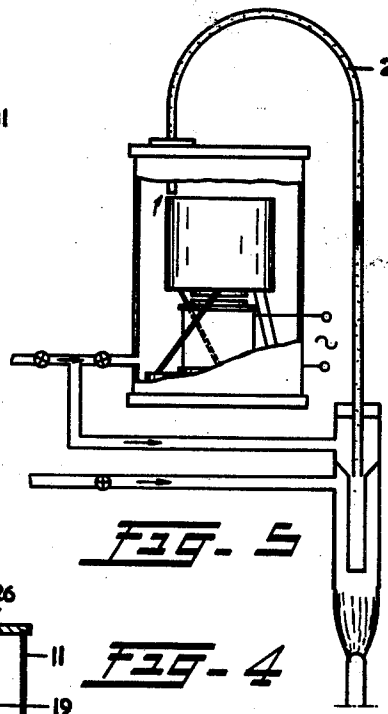



Fig. 4

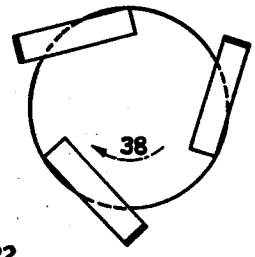
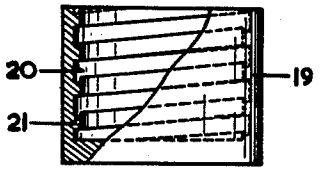



Fig. 2



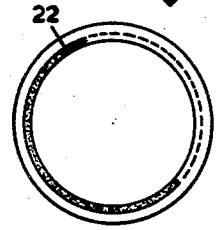




Fig. 3

ATE VUNDERINK INVENTOR.

BY

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3,190,728

# APPARATUS FOR MELTING MATERIAL BY MEANS OF A FLAME OF ELEVATED TEMPERATURE

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6 Claims. (Cl. 23—273)

The present invention relates to an apparatus for melting powdered material by means of a flame of elevated temperature and for precipitating said molten material, including a burner comprising two concentric tubes, the outermost of which is connected to a source of combustible gas and the innermost of which is connected to a source of oxygen, a powder dosing device communicating with the innermost tube and a catching surface movable relative to the burner in the longitudinal direction thereof, said catching surface being movable away from the burner by a driving means at such a rate that the distance between the mouth of the burner and the latest material precipitated on said catching surface remains constant.

Apparatuses of this type have long since been known.

The object of the method to be carried out by means of such apparatuses is to form a pear or rod-shaped body from powdered material having a high melting point, by melting the particles of the powder and by precipitating said molten particles on a catching surface, said pear or rod-shaped body consisting of a monocrystal of the desired material or a polycrystalline form of said material, in which the crystallites have a specific orientation.

Said method may be used for example for the manufacture of synthetic corundum and spinel.

One of the most important conditions that are to be satisfied if the method is to proceed satisfactorily, is that the rate of growth of the body to be formed is kept constant very accurately. Said rate of growth especially depends on the amount of powder supplied to the flame and is furthermore influenced by changes, if any, in the distance between the burner mouth and the surface on which the molten particles precipitate.

The object of the invention is to provide an apparatus which very favourably compares with the known apparatuses as regards the fulfillment of the conditions just mentioned.

To achieve this end the apparatus according to the invention is so formed that the powder dosing device comprises a closed housing communicating with the source of oxygen, which housing contains a powder supply vessel, a powder carrier having a powder supporting face which in plan view is narrow, elongated and tapers into a sharp point, a mean for continuously feeding powder from the powder supply vessel to the powder carrier and a discharge tube which passes through the wall of the housing and connects the interior of the housing with the innermost burner tube, the entrance of the discharge tube and the powder carrier being adjustably displaceable relative to each other.

The apparatus according to the invention may also be so designed that the powder supply vessel, the powder feeding means and the powder carrier are formed by a vertical hollow cylinder open at the upper side having a gutter shaped recess helically provided in its innerwall, which recess begins at the bottom of the cylinder and gradually terminates into the upper rim of the cylinder, which rim is located in a horizontal plane.

For elucidating the invention some embodiments will be described with reference to the accompanying drawings, in which:

FIG. 1 is a schematic showing of a first embodiment according to the invention in which the flame is directed upwardly;

FIG. 2 is a vertical section of the power vessel as shown in FIG. 1;

FIG. 3 is a plan view of the powder vessel according to FIG. 2;

FIG. 4 is a bottom view of the powder vessel according to FIGS. 2 and 3, in which more particularly the leaf springs supporting the powder vessel are shown;

FIG. 5 is an alternative embodiment in which the flame is directed downwardly.



The burner shown in FIG. 1 comprises an inner tube **1** and an outer tube **2** that are concentrically arranged relative to each other. A supply tube **3** coming from a source of a combustible gas (not shown) is connected to said outer tube **2**. Said conduit **3** is provided with a regulating valve **4**. A conduit **5** connected to a source of oxygen (not shown) and provided with a regulating conduit **7** branches into a conduit **10** and a conduit **9**. Conduit **10** leads to a chamber **6** which is in direct communication with the inner tube **1**. Conduit **9** leads to a powder dosing device to be described hereinafter.

By means of the regulating valve **7** the total amount of oxygen supplied can be regulated, said amount of oxygen being distributed over the conduits **9** and **10** by means of the regulating valve **8**.

The powder dosing device is accommodated in an entirely closed housing **11**. The oxygen conduit **9** communicates with the interior of the housing **11**. In the bottom **12** of the housing **11** a circular groove **13** is provided. A round plate **14** stands with four legs **15** in the groove **13**. Three obliquely arranged leaf springs **16**, **17** and **18** bear with their lower ends on the plate **14** and with their upper ends carry a powder vessel **19**. As appears from FIGS. 2 and 3 this powder vessel **19** is cylindrical and is provided with a bottom, but it is open at the upper side, so that this vessel can contain an amount of powder. In the innerwall of the powder vessel **19** a helical recess **20** is provided, the lower wall of which recess is gutter-shaped. Seeing that the powder vessel **19** has a flat horizontal upper side it will be clear that the gutter-shaped portion **21** at the upper side of the powder vessel gradually tapers into a curved point-shaped end shown at **22** in FIG. 3. Against the lower side of the vessel **19** a round plate of magnetisable material **23** is secured, while beneath said plate an electro-magnet **24** is arranged. If the electro-magnet **24** is energized via the leads **25'** the plate **23** functioning as an armature will be pulled downwardly over a certain distance, as a result of which the powder vessel **19** likewise moves downwardly of course. The springs **16**, **17** and **18** will slightly flex then which is attended by the displacement of the upper ends of said springs in horizontal direction, so that the powder vessel **19** not only moves downwardly, but in addition is rotated over a certain angle about its vertical axis.

The arrow **38** in FIG. 4—which is a bottom view of the powder vessel—shows the direction in which the powder vessel **19** rotates when it moves downwardly under the influence of the electro-magnet **24**. When the energizing current is interrupted the powder vessel moves upwardly again, while simultaneously it again rotates back about its vertical axis. If the powder vessel **19** contains an amount of powdered material, said material will in the first place be subjected to a centrifugal force, so that this material will move outwardly as far as possible, i.e. towards the recess **20**. As long as there is powdered material in the vessel **19** there will always be a winding of the recess **20** into which the powder will move. Now the nature of the movements of the powder vessel **19** is such that as a result of said movements the powder will be gradually moved upwardly through the helical recess **20**. Preferably the mass of the powder vessel **19** and the stiff-

ness of the leaf springs **16–18** are so chosen that the natural frequency of the vibrating powder vessel is adapted to the frequency of the current through the magnet coil **24** in order to thus obtain a sufficiently large amplitude. At the upper end of the vessel **19** the recess, as has been observed hereinbefore already, tapers into a point, so that the amount of powder which can be contained in the upper end of said reces gradually decreases. Seeing that the supply of powder from below always continues and as the tapering end of the recess and notably the gutter-shaped portion **21** thereof will be able to contain less and less powder, the powder that cannot be contained in said recess will fall back into the vessel **19** and join the supply of powder still present therein. The result is that there is an arcuate portion of the gutter **21** in which in various places along the arch different amounts of powder are available, while all the same in each place the supply of fresh powder regularly continues.

Above the end **22** of the gutter-shaped portion **21** there is a vertical tube **25** which passes through the upper wall **26** of the housing **11** and which ends adjacent the entrance to the innertube **1**. Oxygen supplied through conduit **9** can only escape from the casing **11** through tube **25**. When the oxygen enters the lower end of tube **25** an amount of powder from the portion **22** of the helical recess will be entrained. How much powder will be entrained in point of fact depends on it whether a broader or a narrower portion of the gutter-shaped winding **22** is located beneath the entrance of tube **25**. This depends in turn on the adjustment of the plate **14** which may be effected by turning it by means of an operating rod **27** extending from the housing **11** through the bottom **12** thereof. During the turning of the plate **14** the legs **15** on which it stands will move through the groove **13**. The amount of powder entrained by the oxygen passing through tube **25** can be controlled therefore in the first place by turning the vessel **19** relative to the tube **25** and in the second place by controlling the amplitude of the energizing current passed to the electro-magnet **24**, so that by unit-of-time more or less powder is passed upwardly.

The flame produced by the burner is schematically shown at **28**. Said flame entrains powder particles which will deposit on a catching surface **29**. Said catching surface **29** is secured to a driving means, schematically shown as comprising a toothed rack **30** which by means of a rotatable pinion **31** is adapted to be moved upwardly and downwardly in vertical direction.

The material precipitated on the catching surface **29** and gradually growing into the shape of a rod is shown at **32**. Adjacent the place where the molten material precipitates an optical system is arranged, said system being schematically designated by **33**. Said optical system **33** is so arranged and directed that it receives the light emitted by the molten material that has just precipitated. Said light is concentrated into a bundle by the optical system **33**, which bundle falls onto a photo-electric cell **34**. The electric current produced by the photo-electric cell **34** is passed through leads **35** to an electric feeding and regulating apparatus **36**. The alternating current produced by said apparatus **36**, which current as regards its amplitude depends on the current generated by the photo-electric cell **34**, is passed to the electro-magnet **24** by leads **25'**.

The operation of the apparatus is as follows:

Powder vessel **19** contains an amount of powder. Combustible gas flows via conduit **3**, the regulating valve **4** being entirely or partly open, to the outer tube **2** in which it rises upwardly. Oxygen flows through conduit **5**, the regulating valve **7** being entirely of partly open and regulating valve **8** occupying a certain position, so that therefore the oxygen enters the apparatus in two places. In the first place it enters chamber **6** and in the second place it enters housing **11**. From chamber **6** oxygen can escape in upward direction through the innertube **1**.



In chamber **6**, therefore, a weak flow in upward direction results. The oxygen which has entered housing **11** leaves this housing through tube **25**. The oxygen flowing upwardly through tube **25** will continuously entrain an amount of powder from that portion of the tapering gutter **22** that is located beneath tube **25**. The adjustment of a portion of gutter **22** beneath said tube is effected by manipulating the operating handle **27** so as to obtain a coarse adjustment of the amount of powder to be entrained. The accurate adjustment of the amount of powder to be entrained is effected by varying the amplitude of the energizing current of the electro-magnet **24**. Said energizing current is an alternating current originating from the feeding and regulating apparatus **36**.

As the material precipitates, initially on the catching surface **29** and afterwards on the material which has precipitated previously, the toothed rack **30** is gradually moved upwardly as a result of the rotation of pinion **31** according to arrow **37**. Now it is the intention, as has been stated before, that the distance between the burner mouth and the place of crystal growth remains very accurately constant. Now this is achieved by means of the optical system **33** in cooperation with the photo-electric cell **34**. The optical system is so arranged, that an image is obtained of the material that has precipitated most recently, as well as of the tip of the flame. As the flame emits relatively little light the total light intensity will be determined substantially exclusively by the growing crystal body. The intensity of the light received therefore is slight when the photo-electric cell **34** does not receive light from the place of growth of the crystal body and is large if such light is received. The latter case presents itself if the growing of the crystal should take place slightly too rapidly. In said case the rate of growth should be slightly decreased which can be effected by introducing less powder into the flame. This is effected because the increased intensity of the light received by the photo-electric cell **34** produces an electric current which so influences the feeding and regulating apparatus **36** that the current supplied by said apparatus for energizing the electro-magnet **24** will have a smaller amplitude.

The result thereof is that less powdered material is moved upwardly through the helical recess **20**, so that in consequence less powder is supplied to the portion of the gutter **22** above which the tube **25** is located. Seeing that a smaller amount of material is conveyed to said portion a smaller amount of powder will be entrained by the oxygen flowing through tube **25**, so that also the amount of powder entering the flame **28** will be smaller. With the total oxygen supply remaining equal the powder supply will decrease. Thus the rate of growth of the crystal will be slowed down, so that the place of crystal growth will move upwardly relative to the burner mouth and this will continue until the image formed by the optical system **33** has again the right configuration. Said control of the rate of growth by controlling the dosing of powder operates exceedingly accurately, so accurately in fact that the object contemplated can be fully achieved. As a result it is no longer necessary to employ the method which has been conventionally used so far and according to which differences in the rate of growth were compensated for by moving the catching surface temporarily more rapidly or more slowly upwardly. The conventional apparatuses for varying the speed of movement of the catching surface were relatively complicated and not very accurate.

In the apparatus under consideration the catching surface is moved upwardly at a constant speed and the rate of growth itself is adjusted by means of the dosing of powder.

FIG. 5 shows a portion of a similar appartus as the one shown in FIG. 1, in which, however, the flame is directed downwardly. This may be effected in a very simple manner by bending the powder discharge tube **25** through 180°, so that the stream of powder therefore is ultimately

directed vertically downwardly. The burner may then also be arranged upside down, so that the flame is directed downwardly.

I claim:

1. In apparatus for melting powdered material by means of a flame of elevated temperature and for precipitating said molten material in the form of a rod, including a burner comprising two concentric tubes, means to supply combustible gas to the outer of said tubes, means to supply oxygen to the inner of said tubes, powder dosing means including a closed chamber, conduit means having an inlet end in communication with said closed chamber and an outlet end in communication with said inner burner tube, a catching surface for precipitated material adjacent said burner and positioned in vertical axial alignment therewith, means to move said catching surface away from the burner in a vertical direction at a constant rate, means to supply oxygen under pressure to the closed chamber of the powder dosing means, powder supply means within said closed chamber, a trough-shaped powder-carrying channel means contained within said chamber and open along its length to said powder supply, said channel means terminating in a discharge portion having gradually reduced powder-carrying capacity, said discharge portion being positioned adjacent the inlet end of said conduit means to cause powder to be injected into said conduit means by the flow of said oxygen under pressure into said inlet end to support combustion at said burner, means to move powder into said channel means and toward said discharge portion, and means to vary rate of said injection of powder.

2. The invention as defined in claim 1, wherein means is provided to mount the inlet end of the conduit means and the discharge portion of the channel means in relatively movable relationship.

3. The invention as defined in claim 1, wherein vibratory mounting means is provided for the channel means to induce mevement of powder toward the discharge portion, and means is provided to vary the rate of said vibration.



4. The invention as defined in claim 1, wherein said powder supply means comprises an open-topped cylindrical vessel, and said powder-carrying channel is helically formed in the interior wall of said vessel.

5. The invention as defined in claim 4, wherein said conduit means is fixed and said vessel is mounted for relative movement about its vertical axis.

6. The invention as defined in claim 4, wherein vibratory mounting means is provided for said vessel to induce movement of powder toward the discharge portion of the channel means, and means is provided to vary the rate of said vibration.


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