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APPARATUS FOR GROWING WHISKERS

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Fig. 1.

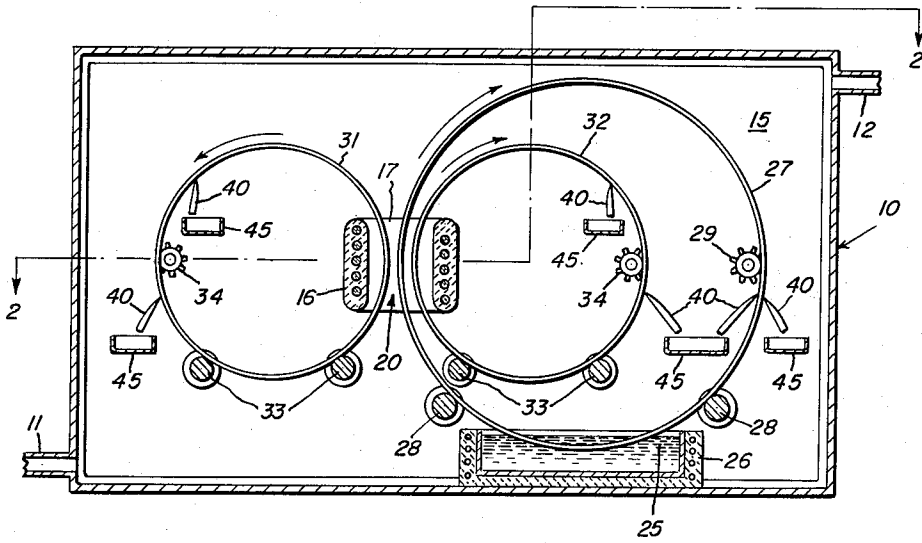


Fig. 2.

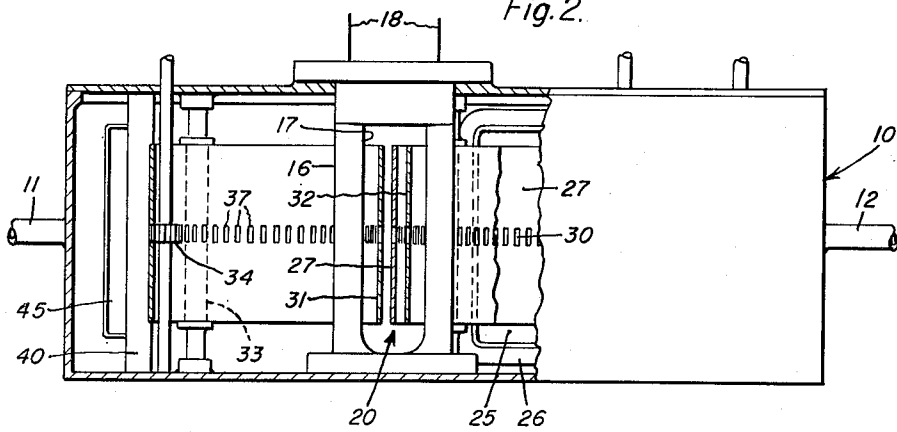
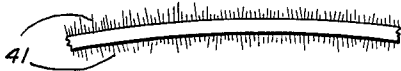


Fig. 3.



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**APPARATUS FOR GROWING WHISKERS**

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This invention relates to apparatus for continuously growing metal or metal oxide single crystals or whiskers.

Until the advent of the present invention, the production of metal or metal oxide whiskers, that is, single crystals of these materials grown from the vapor phase, has been limited to batch-type operations in which extremely limited quantities of whiskers were produced during any given operation. The necessity for operating in this fashion resulted in prohibitively high manufacturing costs, thereby rendering use of the whiskers economically impossible.

It is a principal object of this invention to provide an apparatus for continuously producing single crystal whiskers from the vapor phase.

It is a further object of this invention to provide an improved apparatus for producing metal and/or metal oxide whiskers under conditions more economical than those utilized heretofore.

Other objects and advantages of this invention will be in part obvious and in part explained by reference to the accompanying specification and drawings in which:

FIG. 1 is a somewhat schematic section through an apparatus constructed in accordance with the present invention;

FIG. 2 is a view, part in section and part in full, taken along the lines 2-2 of FIG. 1; and

FIG. 3 is an enlarged fragment of the whisker growth substrate member showing the manner in which whisker growth occurs.

Broadly, the apparatus of the present invention utilizes enclosure means which define a closed whisker growth chamber which has suitable openings for control of the atmosphere present in the chamber. Mounted within the enclosure means, or in other words, within the whisker growth chamber, are heating means capable of vaporizing the material to be used for whisker growth. Also contained within the whisker growth chamber is at least one growth substrate body which is suitably mounted for continuous movement through the hot, vaporizing zone created by the heating apparatus. The final elements of the apparatus are a source of whisker material and a carrier member which functions to transport the material into the heating apparatus for vaporization and subsequent deposition upon the growth substrate means.

The construction of the apparatus can best be seen by referring to FIG. 1 of the drawings wherein the numeral 10 indicates an enclosure means having an inlet opening 11 and an outlet opening 12. The enclosed chamber defined by member 10 can be referred to as the whisker growth chamber 15 since the vaporization and growth of whiskers occurs entirely within this chamber.

Mounted within chamber 15 are heating means, here shown as an induction furnace 16, which is secured to the side walls of enclosure 10 in the manner illustrated in FIG. 2 of the drawings. This furnace has a generally rectangular-shaped opening 17 and can be connected to a source of power by means of the electrical wires 18. Furnace 16 defines a heated zone 20 in which vaporization of source material is effected.

Source material 25, that is, the material to be grown into whiskers, is transmitted to the heated zone 20 from a suitable source such as the electrically heated crucible 26 by means of a carrier member 27 which is mounted within the growth chamber for movement from the cru-

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cible 26 through the heated zone 20. Carrier member 27 is shown in the drawings as being a generally cylindrical-shaped member open at both ends and held for rotation by a pair of idler rolls 28. The carrier is driven by a drive sprocket 29 which engages suitably formed apertures 30 in the body of carrier 27. Thus, by driving the sprocket 29 in a clockwise position, as viewed in FIG. 1, the carrier 27 will similarly rotate in a clockwise direction so that it contacts the material 25 contained in crucible 26 prior to the time it enters the heated zone 20 of furnace 16.

Since the vaporized material requires a substrate to deposit upon and grow into whisker form, a pair of growth substrate means 31 and 32 have been provided. These elements are also of generally cylindrical shape and extend through the rectangular aperture 17 and heated zone 20 of furnace 16 in the manner indicated. Both are supported by idler rolls 33 and are driven by drive sprockets 34 similar to drive sprocket 29 used in connection with carrier member 27. These sprockets 34 engage suitable apertures 37 formed in the growth substrate cylinders 31 and 32.

The final elements necessary to make the process a continuous one are scraper means which are shown in the drawings as blades 40. There are two such blades for each of the growth substrate bodies, since the whiskers grow from both of the surfaces thereof. The manner in which whisker growth occurs can best be seen in FIG. 3 of the drawings where whiskers 41 are shown growing from the opposed surfaces of one of the cylindrical substrate bodies. Collecting trays 45 have been provided beneath each of the scraper blades 40 to collect the whiskers as they are removed from the surfaces of the growth substrate cylinders.

It will be readily appreciated that the present apparatus can be used to produce whiskers of many different types of material. The composition of the whiskers grown will be dependent only upon such factors as the source material, the atmosphere used, the operating temperature, etc., according to practices followed in the known batch processes. For example, alumina whiskers can be produced by placing a quantity of aluminum metal in the crucible 26 where it is maintained in molten condition. The heated zone 20 of furnace 16 would then be placed at a temperature of from about 1300° C. to 1600° C., a temperature of 1500° C. being highly desirable, and the growth chamber 16 continuously supplied with hydrogen having a dew point on the order of -50° F. Since the aluminum requires oxygen to form alumina whiskers, the dew point of the atmosphere is maintained at a level insuring some water vapor. The flow rate of the hydrogen would normally be on the order of 3 c.f.h., although this rate is not particularly critical. Once these conditions have been fulfilled, carrier 27 is rotated, as are substrate cylinders 31 and 32, so that the molten aluminum picked up by carrier 27 can be vaporized in zone 20 and deposited, in whisker form, on the surfaces of cylinders 31 and 32. The deposition will actually occur within the hot zone so that by the time the whiskers have reached scrapers 40, they will be in condition for removal. The whiskers and any other deposits which may have occurred on cylinders 31 and 32 will be totally removed by scrapers 40 and deposited in the collecting trays 45.

Whiskers of other compositions can be grown in the same manner merely by controlling the temperatures and atmospheres. Metal whiskers, for instance, can be produced by using a dry atmosphere or a vacuum so that oxidation of the metal does not occur during vaporization and growth.

Although the present invention has been described in connection with preferred embodiments, it is to be

understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An apparatus for continuously producing metal or metal oxide whiskers comprising, enclosure means defining a whisker growth chamber and including openings providing for the passage of a selected controlled atmosphere into said growth chamber, heating means positioned within said whisker growth chamber defining a vaporizing zone in which the selected whisker material is vaporized, means including a carrier member mounted within said growth chamber for movement through the vaporizing zone to introduce a supply of whisker material thereinto, growth substrate means mounted within said chamber for continuous movement through the vaporizing zone to provide a base from which crystals may grow, and scraper means mounted in operative relationship with respect to the surfaces of said growth substrate means to effect removal of whiskers therefrom.

2. An apparatus for continuously producing metal or metal oxide whiskers comprising, enclosure means defining a whisker growth chamber and including openings providing for the passage of a selected controlled atmosphere into said growth chamber, heating means positioned within said whisker growth chamber defining a vaporizing zone in which the selected whisker material is vaporized, means including a carrier member mounted within said growth chamber for movement through the vaporizing zone to introduce a supply of whisker material thereinto, generally cylindrical growth substrate means mounted within said chamber for continuous movement through the vaporizing zone to provide a base from which crystals may grow, and scraper means mounted in operative relationship with respect to the surfaces of said generally cylindrical growth substrate means to effect removal of whiskers therefrom.

3. An apparatus for continuously producing metal or metal oxide whiskers comprising, enclosure means defining a whisker growth chamber and including openings providing for the passage of a selected controlled atmosphere into said growth chamber, electrical resistance heating means positioned within said whisker growth chamber and defining a vaporizing zone in which whisker material is vaporized, means including a continuous carrier mounted to carry a supply of whisker material from a source thereof through the heated vaporizing zone, growth substrate means mounted within said chamber for continuous movement through the vaporizing zone to provide a base from which whiskers may grow, and scraper means mounted in operative relationship with respect to the surfaces of said growth substrate means to effect removal of whiskers therefrom.

4. An apparatus for continuously producing metal or metal oxide whiskers comprising, enclosure means defining a whisker growth chamber and including openings providing for the passage of a selected controlled atmosphere into said growth chamber, heating means secured to said enclosure means within said whisker growth chamber defining a vaporizing zone in which whisker material is vaporized, a source of whisker material contained within said growth chamber, a generally cylindrical carrier rotatably mounted in contact with the supply of whisker material, generally cylindrical growth substrate means rotatably mounted within said chamber for continuous movement through the vaporizing zone to provide a base from which whiskers may grow, and scraper means mounted in operative relationship with respect to the surfaces of said cylindrical substrates to effect removal of whiskers therefrom.

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