Sept. 24, 1963 R. F. BURCH, JR 3,104,502

APPARATUS FOR GRINDING SPHERICAL BODIES

Filed July 17, 1962

Fig. 1

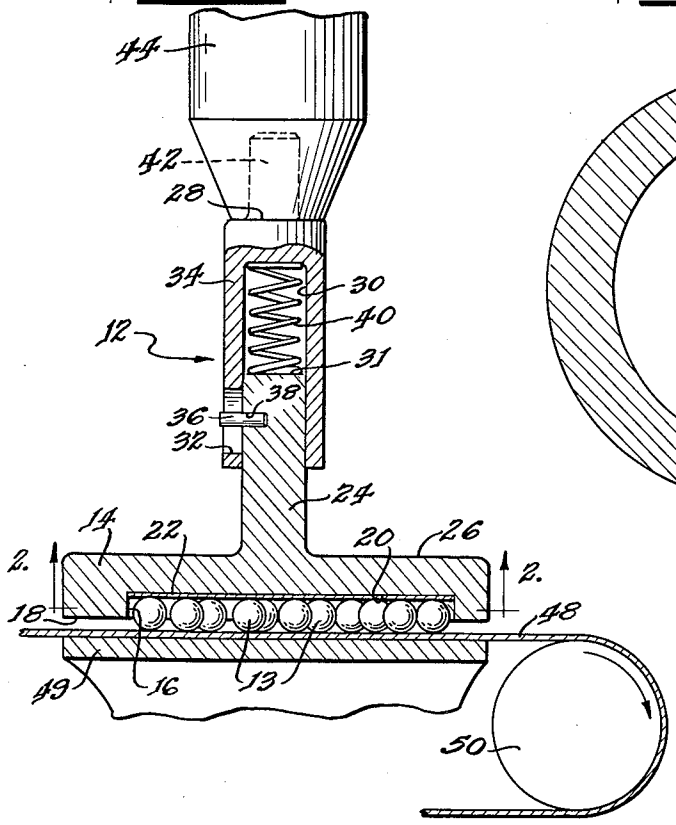


Fig. 2

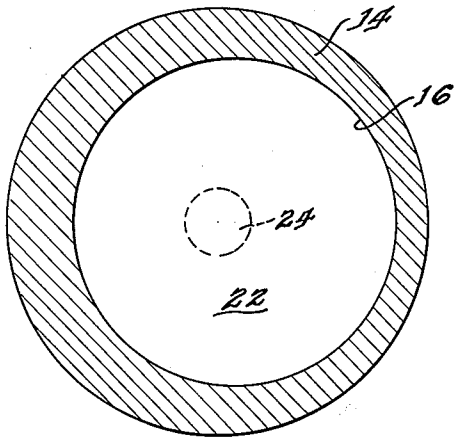


Fig. 3

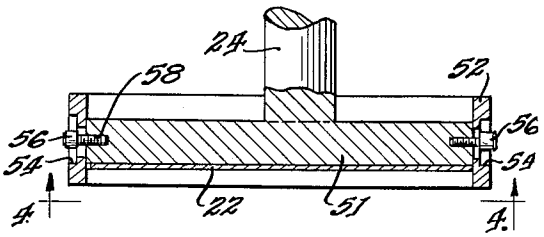
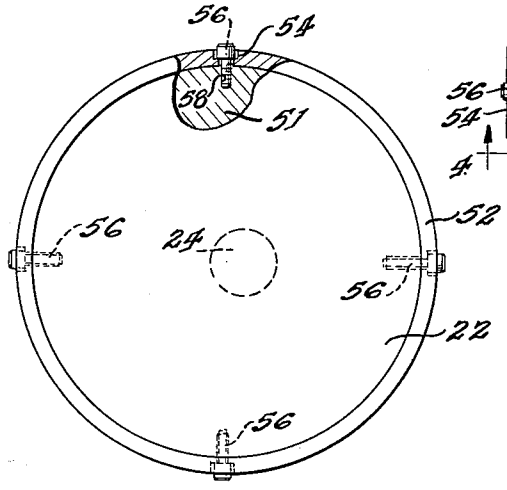


Fig. 4



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APPARATUS FOR GRINDING SPHERICAL BODIES

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This invention relates to an inexpensive apparatus capable of accurately grinding spherical bodies from relatively rough and angular shapes.

Spherical bodies are manufactured for various uses such as ball bearings and the like. Considerable effort has been expended to make ceramic shapes for use as nuclear reactor fuel. For some reactors such as the Pebble Bed Reactor it is desired to have spherical UO_2 bodies.

Heretofore, ceramic spheres have been obtained by the time-consuming process of tumbling and screening. This eventually produces spherical bodies but without control of uniformity in size.

Machines for shaping spherical bodies usually have at least one rotating turntable which has many carefully machined grooves, or an abrasive turntable which has a grinding surface carefully dressed in the shape of multiple grooves. Such machines frequently are very expensive and are designed to handle bodies that are already nearly spherical.

The apparatus of the present invention is capable of grinding spherical UO_2 bodies from irregularly shaped single crystals of UO_2, and to grind each to within 0.0002 in. of a true geometrical sphere.

It is an object of this invention to provide inexpensive equipment for accurately grinding ceramic spheres, which equipment may be powered by conventional laboratory equipment.

Another object of this invention is to provide apparatus for grinding spheres to a uniform size.

It is also an object of this invention to provide an apparatus for producing ceramic spheres rapidly and in quantity.

It is also an object of this invention to provide a type of apparatus which may be used for either grinding irregular shapes to spherical bodies or for polishing spherical bodies of uniform size.

Other objects and advantages of this invention will be apparent from the description and the drawings in which:

FIG. 1 is an elevational view of the apparatus partly in section;

FIG. 2 is a sectional view taken on the line 2—2 of FIG. 1;

FIG. 3 is an elevation view partly in section of another embodiment of this invention; and

FIG. 4 is a plan view of the embodiment as shown in FIG. 3 taken on the line 4—4 of FIG. 3.

As shown in FIG. 1, a spring-biased eccentric jig 12 imparts a rotational motion to spherical bodies 13. The jig 12 has a horizontal flat circular disk 14 with a circular recess 16 (shown also in FIG. 2) in a bottom face 18 of the horizontal disk 14. The recess 16 is eccentric to the periphery of the disk 14. A flat base 20 of the circular recess 16 is covered with an abrasive material 22 which is preferably a paper or cloth backed silicon carbide disk cemented in place. A vertical shaft 24 is attached axially to an upper face 26 of the disk 14, eccentrically to the recess 16 and concentrically to the periphery of the disk. A chuck adapter 28 has an axially positioned shaft recess 30 which receives a top end 31 of the vertical shaft 24. A longitudinal guide slot 32 positioned in a side wall 34 of the adapter 28 slidably receives a stop

pin 36 which is positioned in a radial pin recess 38 in the shaft 24. A compression spring 40 is positioned axially in the shaft recess 30 bearing against the top end 31 of the shaft 24, urging the shaft 24 in the direction of the disk 14. The spring 40 absorbs vertical displacement of the disk 14 during initial phases of grinding when angular objects such as ceramic crystals are being rough ground. A spindle 42 forms an extension of the adapter 28 for insertion into a chuck 44 of a conventional drill press which is not shown.

A horizontal abrasive surface 48 movable in a horizontal direction as indicated by the arrow in FIG. 1 is supported by a platform 49 and is driven by a roller 50. For this purpose a conventional belt sander with a silicon carbide coated belt driven by a standard electric motor (not shown) is satisfactory. For purposes of this invention, it is desirable to control the speed of the belt sander motor, and this may be accomplished by using an electric motor with a variable speed suitable to the particular type of grinding involved. A slow grinding speed is desirable for the rough grindnig of coarse crystals, a faster grinding speed is desirable for work with more nearly perfect spheres and for polishing the accurately ground surfaces of finished spheres. Coarse abrasives are used preferably for both the abrasive material 22 and the horizontal abrasive surface 48 for rough grinding operations, while finer abrasives are used in both locations for final grinding and polished operations.

An alternate embodiment of this invention is shown in FIG. 3 wherein the horizontal circular disk (alternate form) 51 is surrounded by a gauging rim 52. Axial slots 54 in the rim 52 permit axial adjustment of the rim 52 relative to the disk 51 to increase or decrease the depth of the recess formed thereby below the disk 51. Cap screws 56 positioned in the axial slots 54 are seated in circumferentially spaced radial holes 58 in the edge of the disk 51, which holes are threaded to receive the cap screws.

In this alternate embodiment the size of spheres is gauged approximately by the depth of the recess underneath the horizontal disk 51. That is, for larger spheres it is desirable to use a deeper recess, while for smaller spheres a shallow recess is necessary. In the first embodiment for a given depth of the recess 16, the distance between the bottom face 18 of the horizontal disk 14 and the abrasive surface 48 is an approximate gauge of sphere size.

In both embodiments the ultimate limit for sphere size may be controlled by termination of the grinding and/or polishing operations when the shaft 24 reaches a fully extended position relative to the chuck adapter 28. Reproducible sphere size may be obtained in this manner as successive batches of spheres are ground. Otherwise, sphere size may be controlled by interrupting the grinding operation to measure sphere diameters periodically.

It is an essential feature of this invention that the recess under the horizontal disk be nonconcentric with respect to the center of the shaft 24. In the first embodiment as shown in FIGS. 1 and 2, the center of the recess 16 is radially displaced somewhat from the center of the disk 14 which is also the center of the shaft 24. In the alternate embodiment shown in FIGS. 3 and 4 the center of the shaft 24 is radially displaced from the center of the disk 51. This displacement may be (but is not limited to) about one eighth of an inch. This displacement has proven to be sufficient and effective in grinding spheres ranging in finished size from about an eighth of an inch in diameter to about one quarter of an inch in diameter.

The apparatus of this invention may be used for grind-

ing a single sphere, or may be used for grinding a plurality of spheres, the only restriction being that the spheres should not be tightly packed in the recess.

The combination of rotary movement of the spring-biased eccentric jig **12** with the horizontal unidirectional movement of the horizontal abrasive surface **48** brings a multiplicity of complex rolling and turning forces to bear on the shapes to be ground. This has been unusually effective in rapidly producing uniformly sized and accurately shaped spheres.

These movements coupled with the spring-biased movement of the shaft **24** have been proven to be unusually effective for shaping spheres from such rough and angular materials as uranium oxide single crystals, high density polycrystalline uranium dioxide, yttrium oxide, and magnesium oxide. This is not intended to exclude the shaping of metals such as are commonly used to form ball bearings and the like.

It will be understood that the invention described herein may be modified within the scope of the appended claims.

What is claimed is:

1. An apparatus for grinding spherical bodies, comprising: a disk having a shallow circular recess in one face thereof; a shaft extending from the opposite face of said disk eccentrically to said recess; means acting through the shaft to rotate the disk about the axis of the shaft; a member having a flat abrasive surface positioned parallel to the one face of the disk and in spaced apart relationship thereto; resilient means attached to said shaft for urging the disk axially in the direction of the member; and means for imparting linear, unidirectional movement to said member while said disk is in rotation.

2. An apparatus for grinding spherical bodies, comprising: a horizontal disk having a circular recess in a bottom face thereof, said recess having a flat base; abrasive material secured to the base of the recess; a vertical shaft axially attached to a top face of said disk eccentrically to the recess; a chuck adapter having a shaft recess slidably receiving a top end of said shaft, said adapter containing resilient means for urging the shaft in the direction of the disk; guide means in said adapter for limiting axial movement of said shaft and for causing rotation of the adapter to produce rotation of the disk; and a member having a horizontal abrasive surface positioned below and parallel to the circular disk and in spaced apart relationship thereto, said member being adapted for linear, unidirectional horizontal movement in the plane of the surface while the circular disk is subjected to rotary movement.

3. An apparatus for grinding spherical bodies, comprising: a horizontal disk having a circular recess in a bottom face thereof, said recess having a flat base; abrasive material secured to said flat base; a vertical shaft axially attached to a top face of said disk eccentrically to said recess; a member having a horizontal abrasive surface positioned below and parallel to the bottom face of the circular disk and in spaced apart relationship thereto; a chuck adapter having a shaft recess slidably receiving a top end of said shaft, said adapter having a longitudinal guide slot in a side wall thereof; a stop pin secured to said shaft and extending into said guide slot so as to transmit rotation of the adapter to the disk and to limit movement of the disk toward the member; a compression spring positioned axially in said shaft recess in forcible contact against the top end of said shaft; and means for imparting variable, linear, unidirectional horizontal movement to said member in the direction of the plane of said abrasive surface while said disk is in rotation.

4. An apparatus for grinding spherical bodies, comprising: a horizontal circular disk; a gauging rim adjustably attached about the edge of the disk and projecting below the bottom of the disk so as to form therewith a circular recess, the depth of said recess being manually changeable depending on the diameter of spherical bodies to be ground; abrasive material secured to the bottom of said disk; a vertical shaft attached to the top of said disk eccentrically to the recess; a member having a horizontal abrasive surface positioned below and parallel to the bottom face of the circular disk and in spaced apart relationship thereto; a chuck adapter having a shaft recess slidably receiving a top end of said shaft, said adapter having a longitudinal guide slot in a side wall thereof; a stop pin secured to said shaft and extending into said guide slot for transmitting rotation of the adapter to the disk and limiting movement of the disk toward the member; a compression spring positioned axially in said shaft recess in forcible contact against the top end of said shaft; and means for imparting variable, linear, unidirectional horizontal movement to said member in the plane of said abrasive surface while said disk is in rotation.

5. The apparatus of claim 4 in which the gauging rim has a plurality of circumferentially spaced axial slots and a screw in each of said slots, said screws threadedly engaging circumferentially spaced radial holes in the edge of the disk.

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