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STRETCHING CORUNDUM CRYSTAL

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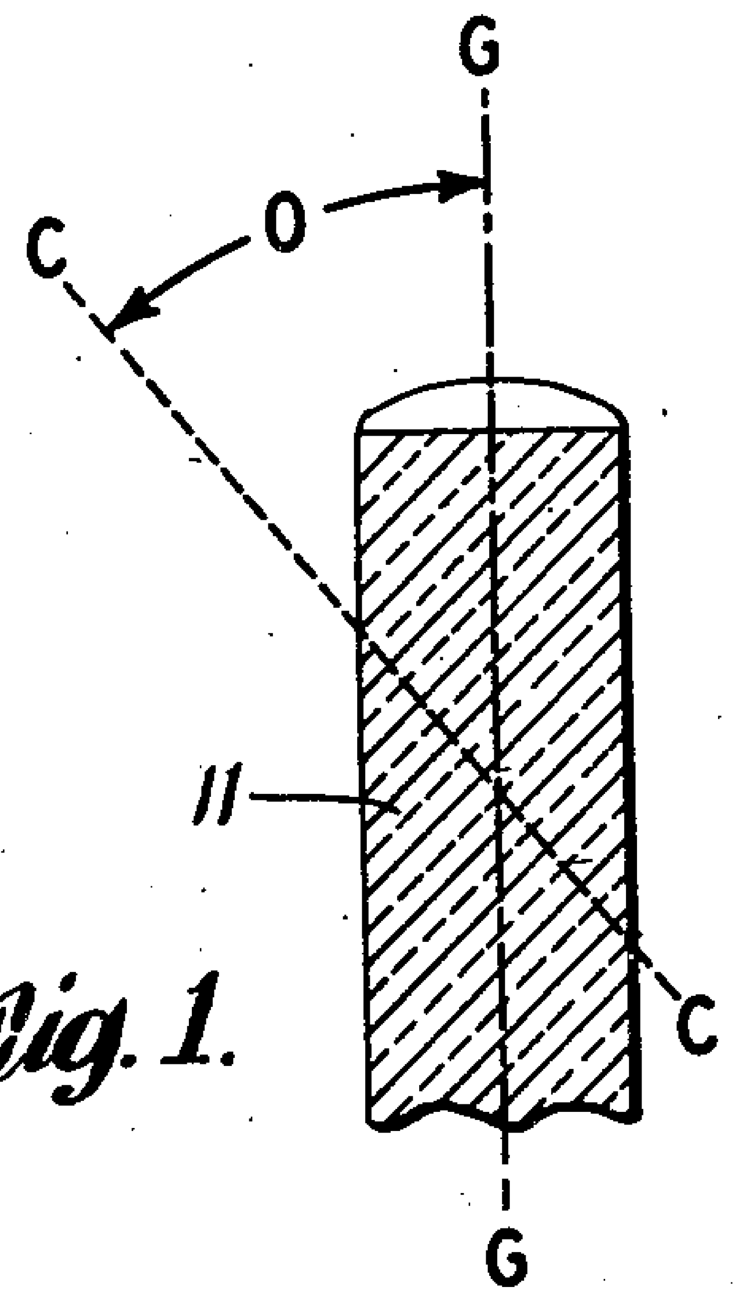


Fig. 1.

Fig. 4.

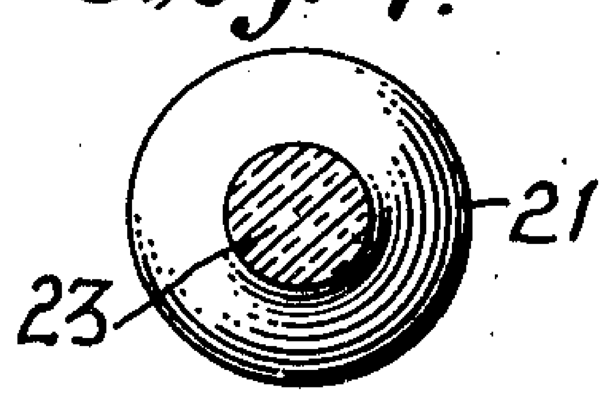


Fig. 3.

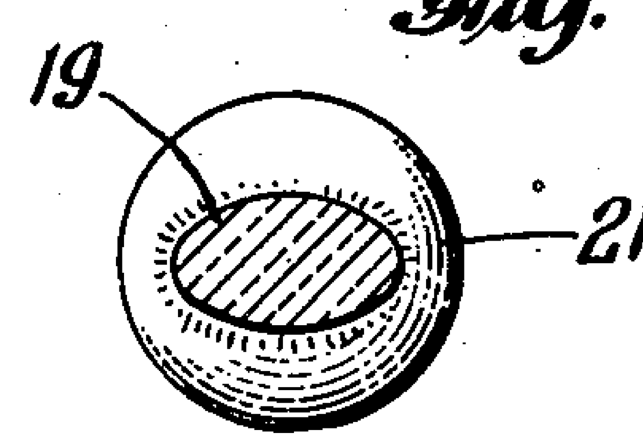
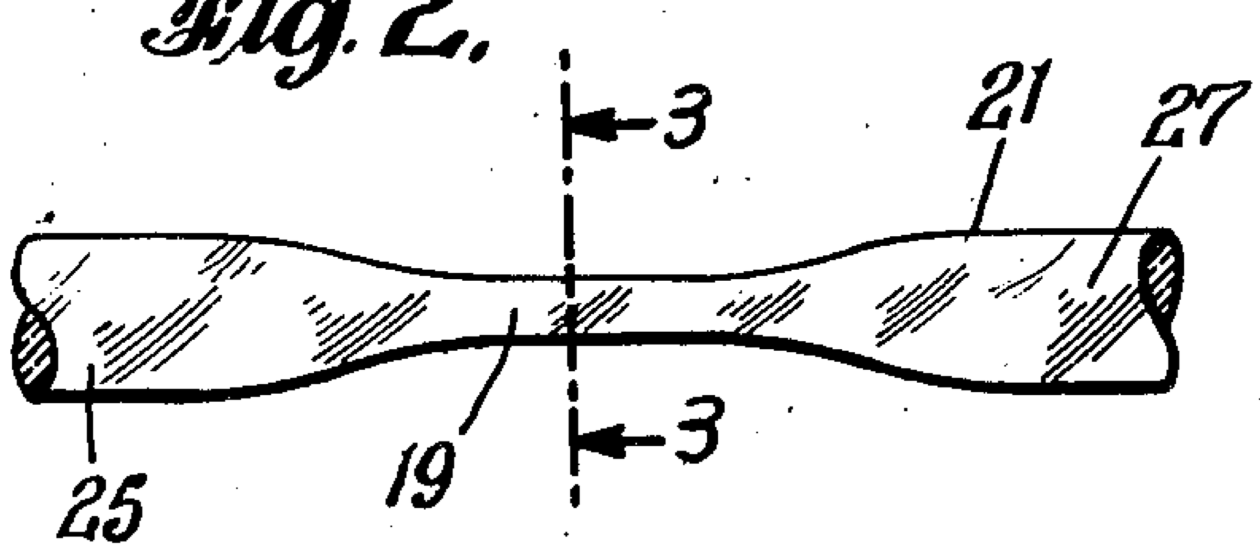


Fig. 2.



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STRETCHING CORUNDUM CRYSTALS

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3 Claims. (Cl. 49—77)

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This invention relates to hot stretching unicrystalline precious and semiprecious stone bodies composed of corundum and, more particularly, to hot stretching thin rods of corundum. The invention is also concerned with novel stretched unicrystalline corundum articles of manufacture.

Corundum crystals, both natural and synthetic, have long been used for jewel bearings, and as gems, heretofore having been formed into various shapes by mechanically cutting, grinding, and polishing them. Such mechanical operations are slow, tedious, and expensive. Furthermore, the number of shapes which may be produced is strictly limited to those having a relatively simple contour.

The principal object of the present invention is the provision of a novel method of hot forming unicrystalline precious stone bodies composed of corundum by stretching them. Another object is the provision of a novel method for stretching a corundum body to form a neck portion of circular cross section.

Another object of the invention is the provision of a stretched corundum rod having a neck of circular cross section.

The above and other objects, and the novel features of the invention, will become apparent from the following description, having reference to the figures of the accompanying drawing, wherein:

Fig. 1 is a vertical sectional view of a corundum rod illustrating the meaning of optical orientation with respect to the C-axis;

Fig. 2 is an elevational view showing a stretched corundum rod;

Fig. 3 is an enlarged cross-sectional view taken along the line 3—3 of Fig. 2; and

Fig. 4 is an enlarged cross-sectional view through the stretched portion of a corundum rod which has been reheated after stretching.

Unicrystalline synthetic corundum bodies are composed predominantly of alumina, with which sometimes are incorporated small amounts of coloring materials such as chromium oxide for rubies, or iron oxide and titanium dioxide for blue sapphires. Corundum is grown synthetically as large diameter boules, and as long substantially cylindrical thin rods by the well-known method of passing alumina powder through a gas flame and accumulating the resulting fused alumina on a suitable support.

In its broader aspects, our novel method of hot forming single crystals of corundum by deforming them comprises heating to its softening temperature at least a portion of such a crystal,

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and deforming the heated portion, which is in a state of plasticity, by applying force thereto. Best results can be obtained by selecting a crystal of known and controlled orientation for hot forming. The operator can recognize when the moment to apply force has arrived by the color of the crystal and by its resistance to deformation when exploratory efforts at deformation are made. Deformation is generally accomplished when the crystal is at a readily recognizable white heat. Actual temperature measurements with an optical pyrometer have shown that the temperature necessary for stretching varies with the rod diameter. However, for corundum rod, the minimum temperature for manually stretching is about 1700° F. Corundum rods of 0.090 inch diameter require a temperature of about 2400° F., and 0.130 inch rods require a temperature of about 2530° F. for manual deformation. These temperatures are considered accurate to ±100° F.

When synthetic corundum bodies are hot formed by deforming them in the manner described briefly above, the heated portions also are usually simultaneously glossed by the heat of the flame, which seems to melt superficially the crystallites on the surface of the body and cause the melted portions to coalesce into a smooth and glossy surface. It is not certain that heat glossing actually occurs in the described way, as it may occur by solid diffusion. It is possible, however, to hot form the bodies at temperatures so low that no heat glossing occurs.

Corundum crystallizes in the hexagonal system and has a single principal optic or C-axis, represened on the rod 11 of Fig. 1 by the line C—C, which lies in the direction in which light may be passed through the crystal without being doubly refracted. The term "optic orientation," when used with reference to corundum in this application, refers to the angle O included between the C-axis and the longitudinal or growth axis G—G of the synthetic corundum rod as shown in Fig. 1.

It has been found that an important relation exists between the orientation of corundum bodies and their behavior in hot forming operations. Since the optic orientation in the deformed portion of a corundum rod changes during deformation, the resulting product has the original orientation in the undeformed portion or portions, but the deformed portion has an orientation differing from the adjacent undeformed portion or portions. However, the resultant products have substantially continuous crystallographic properties throughout, i. e. the change in crystallographic properties through the deformed portion is gradual rather than abrupt.

Heating of unicrystalline corundum bodies for deformation is ordinarily accomplished in a gas flame projected from a standard blowpipe, similar to a glass blower's torch. A suitable flame is desirably formed by burning a mixture of oxygen, natural gas, and air, but any other suitable combination of fuel gas and oxygen may be used. The flame itself should be broad enough so that at least one inch of the material to be worked can be heated to its plastic temperature. It is advantageous to heat the single crystals in a gas flame of the type described, but it is apparent that they may be heated in other ways, such as by a gas furnace, or an electric arc device, without departing from the principles of the invention.

Specifically, the method of the invention involves grasping the ends of a body, such as a rod of corundum, heating a portion intermediate the ends to its softening temperature, and applying tension to the softened portion by pulling the ends in opposite directions. The softened portion of the rod then necks down to form a neck section of reduced diameter and flat elliptical cross section which gradually reduces to a ribbon as stretching continues, as shown at 19 on the rod 21 of Figs. 2 and 3. By cutting off the unstretched end portions 25 and 27, a corundum ribbon is obtained. If stretching is continuous, the neck will break before any great extension is obtained. It has been found, surprisingly, that this elliptical ribbon-like neck assumes a symmetrical shape of substantially circular cross-section when reheated in the flame, as shown at 23 in Fig. 4. Corundum can be stretched into the shape of a long thin hair-like filament by repeatedly stretching the rod a relatively small amount to form a flat ribbon, reheating to provide a symmetrical cross-section, and then stretching again until a filament of the desired thinness and length is obtained.

Clear corundum rods (white sapphire) become milky and opaque in the stretched portion while remaining clear and non-milky in the unstretched end portions. According to one theory, this is due to the breakdown of the crystal lattice into fine crystal blocks having nearly parallel sides.

It has been found most advantageous to stretch corundum rods wherein the optic orientation is between 20 degrees and 60 degrees. If a rod having an initially high optic orientation is stretched, only a very small amount of stretching is possible because the optic orientation in the stretched neck portion increases with stretching and may rise above the upper limit of 60 degrees. With rod sections having optic orientations below 20 degrees it is difficult to apply sufficient tension so that the component of the shear stress in the basal plane of the crystal is sufficient to start the stretching.

Rods which have been stretched in this manner are useful as thread tensioning posts and thread guides in textile mills because of their high resistance to the abrasive action of the thread, and because the hollow formed by the neck acts as a groove within which the thread may run. The heat resistance and mechanical strength of filaments of corundum and spinel also are so great that such filaments would be useful as supporting elements in vacuum tubes. Moreover, the thin filaments can be coiled while hot to form small diameter springs having good elasticity and resilience, as well as good resistance to chemical action.

Products fashioned from corundum by the method of the invention have undiminished resistance to chemical corrosion, refractoriness at high temperatures, mechanical strength, and hardness. Furthermore, such products are mechanically stronger than similar products which have been mechanically cut or ground from solid gem bodies, because the highly flame-glossed surfaces existing on the finished products eliminate the notch effect due to microscopic scratches on the surfaces of mechanically worked bodies. Articles hot formed from corundum by the stretching process described herein are more rapidly and less expensively fabricated than would be possible by mechanical cutting, grinding, and polishing operations.

What is claimed is:

1. A method comprising heating to plasticity at least a portion of a unicrystalline corundum rod; stretching such portion by applying tension thereto, thereby forming a ribbon-like neck; and rendering said neck substantially circular in cross-section by reheating said neck.

2. A method for stretching a thin unicrystalline rod of corundum to a greater extent than can be accomplished in one continuous stretching operation, which method comprises heating a portion of such a rod to plasticity; stretching such portion by applying tension thereto, thereby forming a neck having an elliptical cross-section; converting said neck to a circular cross-section by reheating said neck; and then stretching said neck to a greater length while heated to plasticity.

3. A unicrystalline corundum rod having an optic orientation between 20 and 60 degrees, said rod having two clear non-milky spaced sections of relatively large diameter and a neck of reduced diameter and circular cross-section between said sections and merging smoothly therewith, said neck having a glossy scratch-free surface and a milky appearance.

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