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THE AMERICAN MINERALOGIST, VOL. 45, JULY–AUGUST, 1960

INTERFERENCE FIGURES OF LARGE CRYSTALS IMMERSED IN A SPHERE OF LIQUID

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It is frequently necessary to determine rapidly and non-destructively the approximate orientation of a non-cubic single crystal which either due to its mode of preparation or subsequent treatment is lacking in regular external crystallographic form. A typical example is a corundum boule. Although the orientation can be determined roughly by simply rotating the crystal in air between two crossed polarizers, the conditions for observation can be considerably optimized by immersion of the crystal in a refractive index oil and making the determination under a microscope. If one can then rotate the crystal in a simple way, it is possible to find the orientation by obtaining a centered interference figure. It has been found that with a small spherical flask, all of these conditions can be easily met. The simplicity and usefulness of the technique suggests it may be of interest to others.

The glass spheres should be perfect in shape and free of mold marks, striae and bubbles. The most perfect bulbs experimented with were blown by hand, by Wilmad Glass Co., Buena, N.J., and made of borosilicate glass. Fig. 1A shows a sphere of 40 ml. capacity, 4.5 cm. diameter. Sometimes a chemist's boiling flask is found in stock, which is good enough for the purpose. Fig. 1B shows such a sphere of 33 ml. capacity, 4.0 cm. diameter. To determine the effect of mold marks, we have used two different sizes of machine-made bulbs of a soda-lime-silica glass blown in a two-piece mold. These are General Electric Company bulbs, designation G12-1, 3.9 cm. diameter, 26 ml. capacity, Fig. 1C; and designation G9A2, 3.0 cm. diameter, 11 ml. capacity, Fig. 1D. These bulbs can be used for many purposes despite distortion in certain directions.

The problem of filling the sphere completely with liquid is solved by using a capillary in the stopper as in the ordinary pycnometer. In the combination 1B the stopper is made of teflon, which is not affected by the immersion liquids, and it contains two holes, one for the brass holder

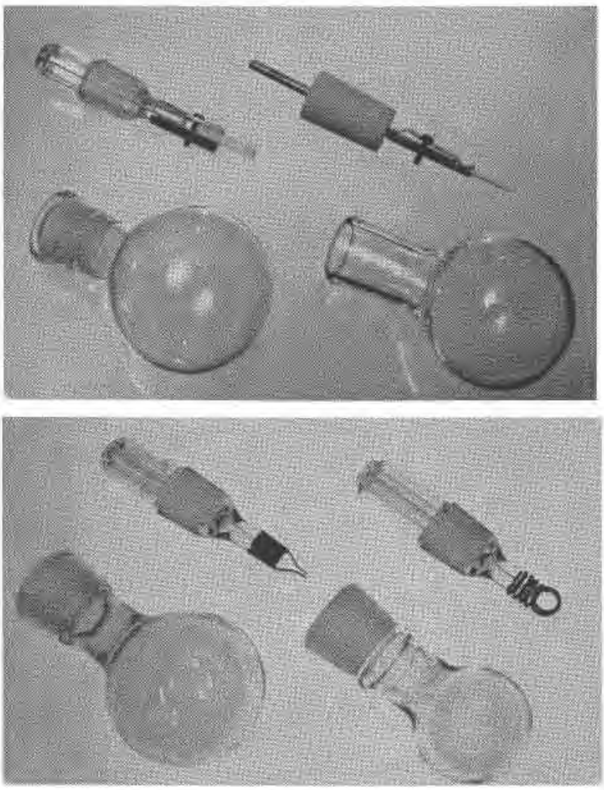

FIG. 1. Various types of glass spheres and stoppers.

rod, and the other a capillary of 1 mm. bore. The stopper is machined to fit the neck of the flask, of volume 33 ml. In the combination 1A, the ground glass stopper with capillary of 1 mm. bore fits into a ground glass neck. The ground joint is 14 mm. in diameter at the mouth and 12 mm. long, and is attached to a section of clear tubing of about the same length, which was blown with the sphere. The volume of the sphere is about 40 ml. and the wall thickness roughly 1 mm.

The glass stopper is made in two distinct steps. First a length of capillary tubing is sealed centrally in the stopper by means of two ring seals.

Then an extra section of capillary is attached to the lower ring seal, blowing a small bubble in the capillary at the junction. This procedure prevents excess cracking of the stopper during the sealing operation.

The metal specimen-holder is made to fit snugly over the fire-polished capillary as shown in 1A, C and D. In 1A the holder is made of brass, split in four segments to give spring contact around the capillary tube and it has one movable jaw actuated by a screw. In 1C, the movable jaw has been replaced by a bronze spring clamp. In 1D the holder is made entirely of a stiff spring of wire, about 1 mm. in diameter. In 1B the holder is made of a brass rod to which is attached a flat brass plate with a bronze flat spring.

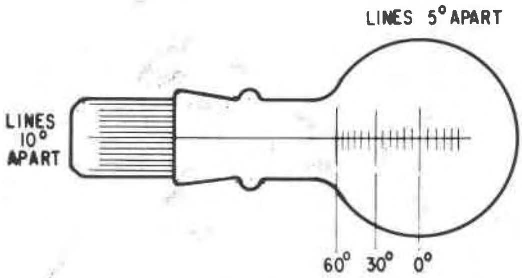

FIG. 2. Sphere and stopper with reference marks.

For the permanent location of the center of the interference figure relative to the geometry of the specimen, it is necessary to have a system of reference marks. By means of a small indexing fixture, scribe marks were made on the surface of the sphere and the stopper as shown in Fig. 2. The sphere is marked with short lines, 5° apart, which are actually parts of great circles, with a common center located at the center of the sphere. The longer line at the center of the drawing is situated at 0° when the device is in the horizontal position. The stopper is marked with parallel lines 10° apart. The scribe marks were actually made on the waxed surfaces of the glass parts, and made permanent by etching with an HF solution and made more visible by inking. A line on the stopper can be matched with the long line traversing the short cross lines on the sphere.

The stopper with holder and specimen in place should be lowered slowly into the container part filled with liquid, having a refractive index preferably close to that of the crystal specimen. Entrapped air and superfluous liquid are removed, leaving the specimen in a completely filled sphere. The excess liquid is wiped away, and the glass surface should be cleaned with a suitable liquid solvent such as Xylene to leave the sphere surface clean and transparent.

A rubber pad used by chemists on evacuated filter flasks (Filtervac made by Alfred Bicknell Associates, Cambridge, Mass.) has a central hole of 3 cm. diameter lined on one side with a raised edge, forming a conically shaped rubber orifice, suitable for the support of the glass sphere on the microscope stage. The filled sphere converges the light from the concave mirror into the specimen held at the center, hence the sub-stage converging lens is not necessary. The objective needs to be of low power and preferably of long focal length. The polarizer, analyzer, and Bertrand lens are used in the normal manner.

The sphere can be rotated in many directions very quickly, and the interference figure can be followed very readily, and made to shift with change in crystal position. By holding the stopper firmly, the spherical part can be turned in the ground glass joint until the optical figure is located over the row of grid lines. The angle of tilt from the horizontal can be determined, and the corresponding line on the neck of the flask. By this means the location of the optical figure is oriented with respect to the position of the crystal in the sphere, and this location can be maintained after the stopper and specimen are removed from the sphere.

For beginners a very cheap combination can be made by using a boiling flask, with a metal holder held in a rubber or cork stopper. A clean capillary can be made by inserting a hypodermic needle in the stopper. The swelling of the rubber and the resulting discoloration of the liquids are draw-backs.

This spherical device should make a good learning tool for students before using the Universal Stage.

The help and interest of R. C. DeVries are gratefully appreciated.

After this idea was put into practice, it was learned that E. Leitz, Inc., has a "Waldermann Hollow glass sphere" for the examination of gem stones.

THE AMERICAN MINERALOGIST, VOL. 45, JULY-AUGUST 1960

A NEW MINERAL-PICKING APPARATUS

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Two types of mineral-picking apparatus have been described by Murthy (1957) and Kauranne (1957). The present authors have made a new model which we believe is easier to build, and in certain respects is more serviceable.