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MAKING PRECISE NON-METALLIC SPHERES

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ABSTRACT

A method has been developed for making non-metallic spheres precise to at least ± .0001 inches. In addition, the technique for drilling holes as small as .010 inches in such substances has been perfected. The method and apparatus are described.

MAKING PRECISE NON-METALLIC SPHERES

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A method for producing spheres round to within two ten-thousandths of an inch, together with the technique of drilling small holes through them, has been developed. In view of the wide application of non-metallic spheres in research, and the difficulty of procuring them commercially, the process is presented for the use of those researchers who need but a few precise spheres.

The starting point of the method is patterned after the apparatus described by W. L. Bond.[1] (See Figure 1.) A 1" x 4" x 10" block of lucite was used as a frame. Two three-inch holes were lined with one inch Metalite cloth glued in place with Duco cement. A 3/16" hole was drilled tangentially to each drum and connected to an air line. Back plates were made of 3 ply 1/4" plywood with a one inch screen covered hole on the top for an air exit. One grinder was lined with #60 abrasive cloth and the other with #180. For .1875" quartz spheres, 1/4" sections were cut from a 6 mm rod and hand ground to a roughly spherical shape about 50 mils oversize. Running four at a time in the coarse grinder, these pieces, after an hour, were about 190 mils in diameter and 5 mils out of round. When more than four at once were tried, breakage was severe. For example, when ten were tried at one time, after ten minutes three had pulverized and two others had large flaws. At this point, the balls were transferred one at a time to the fine abrasive section for another 60 minute grind. Out of twenty-one spheres left after the final grinding, five were round within $\pm$ .0025 inch, five within $\pm$ .0005 inch, and eleven within $\pm$ .0002 inch. Of these last, four were undersize. Before the final step of hand lapping, small holes were drilled in the spheres with the technique described in the final paragraph of this report. The

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[1] W. L. Bond, Rev. Sci. Instr. 22, 5, 344 (1951).

appearance of the quartz in the various steps is illustrated in Fig. 2.

For the final lapping to the desired size, a .1875" steel ball bearing was driven into a lead brick to half its diameter, then removed. The hole was dusted with #600 carborundum grit and again the steel ball bearing was hammered into the hole and removed. The quartz spheres were then hand lapped in this hole from .1880 to .1875 ± .0001 inch. (See Figure 3.) The final measurements were taken on both a tool maker's micrometer and an optical comparator.

Commercial diamond drills were not available in sizes smaller than 1/16". Consequently, the quartz spheres were drilled by a "Rube Goldberg" drill press made by mounting a Handi-Grinder on a pair of parallel bars. Thus the necessary vertical reciprocating motion could be obtained with a minimum of side play. Spindle pressure was controlled by spring action. A period of five seconds proved adequate for obtaining efficient replenishment of the cutting abrasive. (See Figure 4.)

Mounting the spheres for drilling was found difficult. Several different jigs were made to hold the spheres while drilling but either the spheres broke in the jig or chipped around the entrance hole. The final method used was to glue the spheres to a lead brick with Duco cement. Several types of drills were tried including molybdenum, brass, copper, Kovar and soft steel tubing (27 gu. hypodermic needles). The brass and copper cut well, but were not strong enough mechanically. The molybdenum and steel tubing were so hard that diamond dust would not imbed itself in the metal and the drills wore out faster than they would cut. Kovar worked well and was used in all the drilling operations. To get a drill that was perfectly centered, (a requirement that was found necessary), a 90 mil rod of Kovar was mounted in the chuck and filed and sanded to correct shape and diameter while the motor was running. #600 grit carborundum powder was used at first for a cutting abrasive, but was hard to replensih and was slow drilling. #3 grit diamond dust was tried in an oil bath, and drilling time for a 3/16" quartz sphere was reduced from about 4 hours to less than one hour. The drilling speed of about 4 or 5 thousand rpm was obtained by

using a Variac on the drill motor. This speed reduced vibration and prevented the drill motor from overheating on continuous operation. Holes less than 10 mils diameter were drilled without difficulty to a depth of 3/16" using this method and equipment.

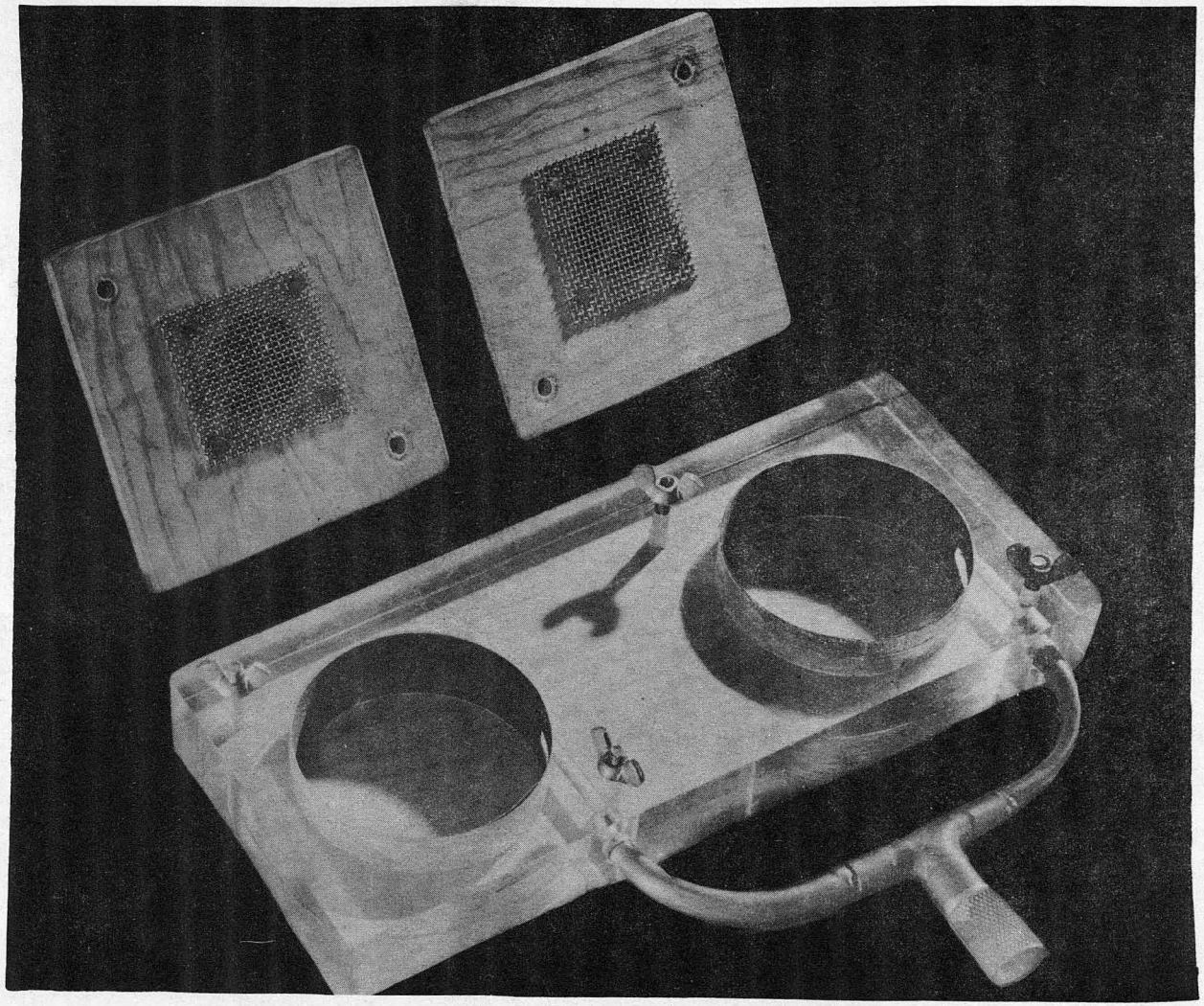

Fig. 1

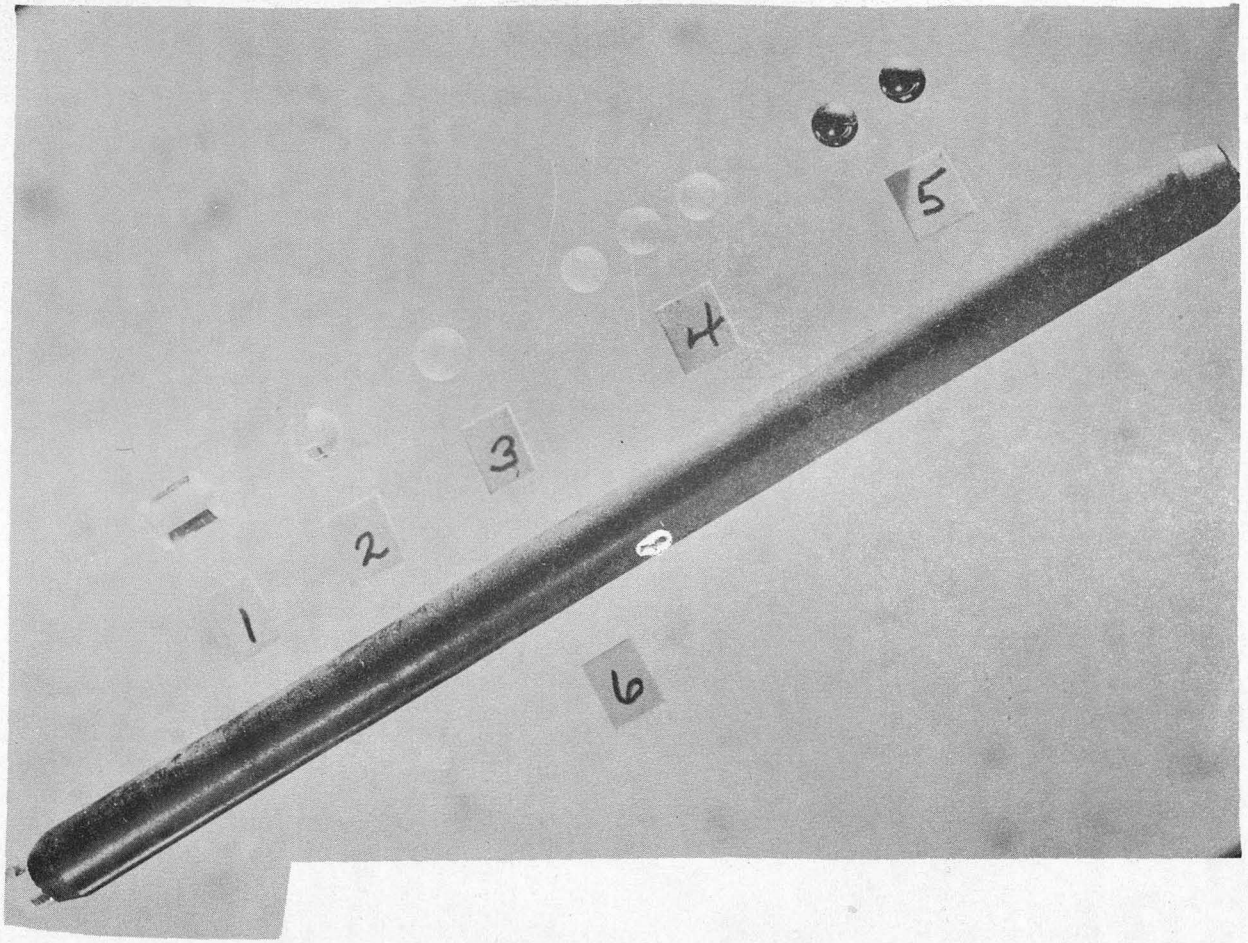

Fig. 2

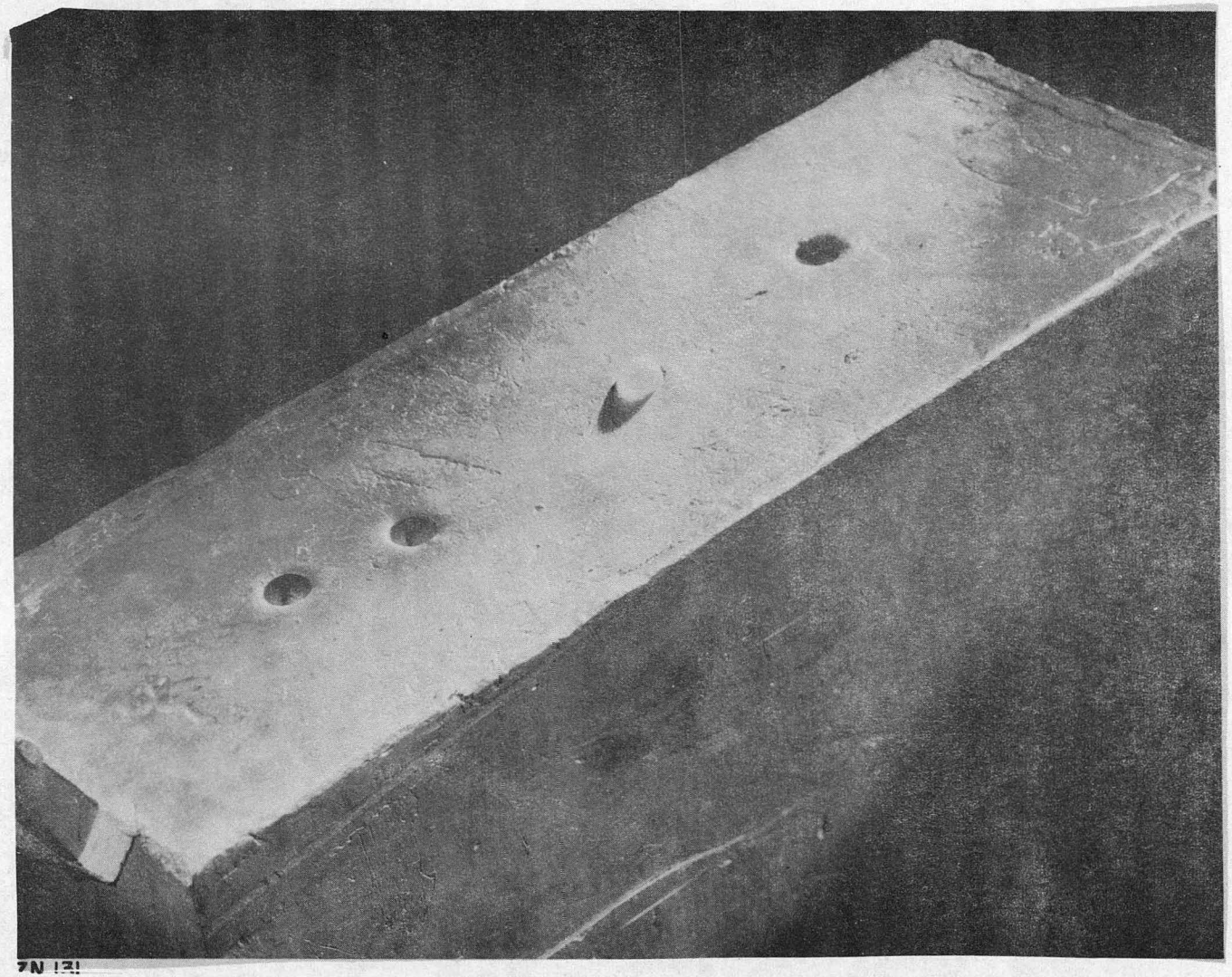

Fig. 3

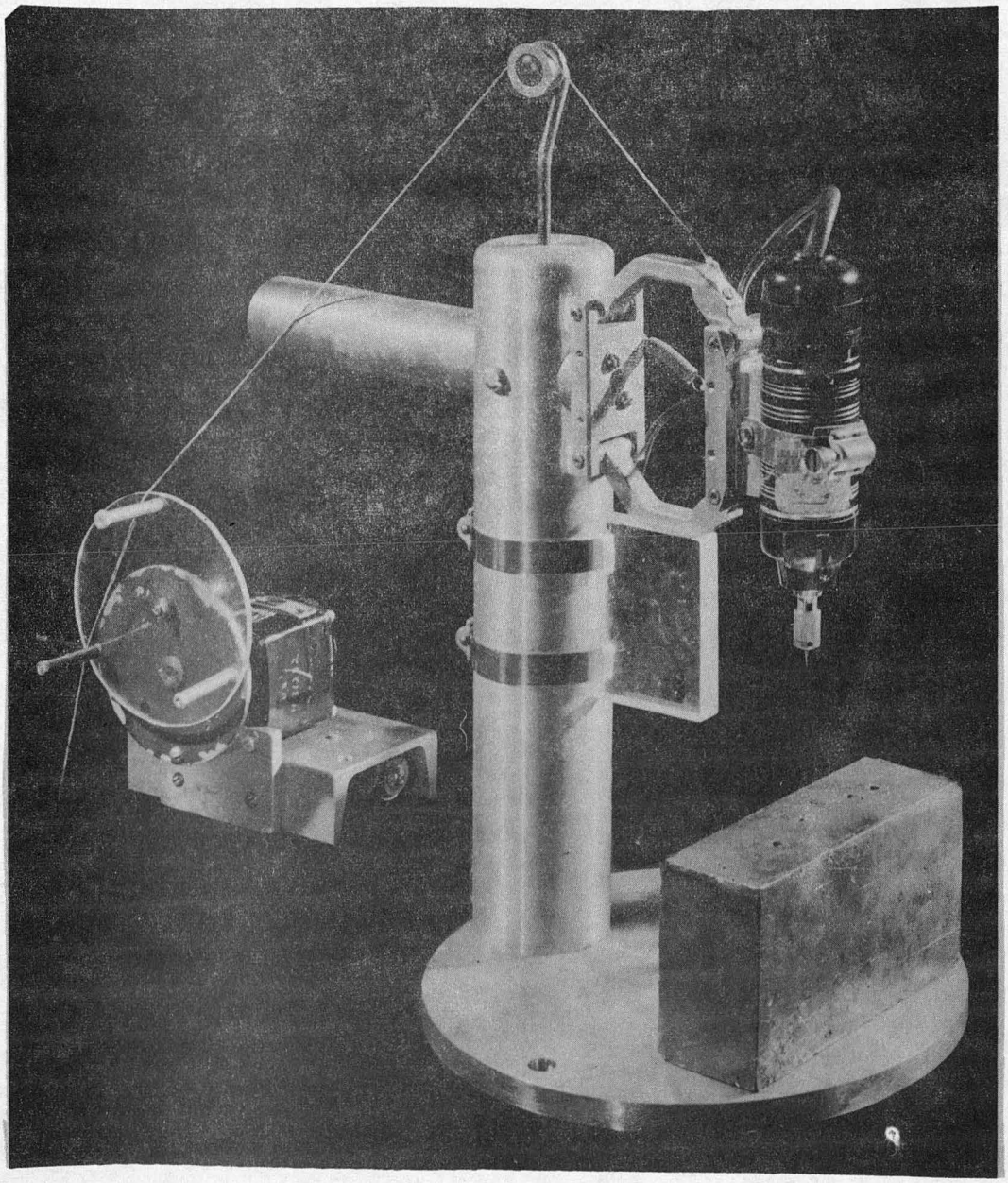

Fig. 4