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A METHOD FOR EVALUATING AND TESTING THE SHARPNESS OF POINTS

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A METHOD FOR EVALUATING AND TESTING THE SHARPNESS OF POINTS

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A Method for Evaluating and Testing the Sharpness of Points

Sharp points, capable of producing injury, are frequently found on consumer products, in areas accessible to casual contact. Casual contact may be defined as the contact that a child would make with the toy during unpacking, assembling, operating or in any other way playing with or using the product. Of particular concern, is the presence of sharp points on toys, which may be the result of poor design, poor quality control, or damage to the toy due to reasonably foreseeable abuse by children at play. The purposes of this study were to first define hazardous sharp points and on the basis of this definition develop a test instrument which differentiates hazardous sharp points from non-hazardous points.

Test Points

A point may be defined as a microscopic area forming the connecting surface to three or more macroscopic planes which intersect at a solid interior angle of less than 180°. As the angle of intersection or as the radius of the tip of a point decreases the tip of the object becomes sharper and requires less force to produce a penetration.

In order to investigate the relationship between the geometry and the sharpness of points, a set of 28 test points was manufactured. These points were made from 1/8" diameter by 1 1/2" long tool steel rods with one end machine ground to various combinations of angle and tip radii. The test points were ground to angles of 15°, 30°, 45°, 60°, 75°, 90°, and 120°. Tip radii selected were .002, .004, .008, .012, .016, .024, and .032 inches. Not all combinations of radius and angle were manufactured as the tips with large angles and radii were not expected to be hazardous points. The points used in the study are shown diagramatically in Figure 1, which shows both tip radius and angle of all points studied. This figure forms the basis of the test procedure and sharpness discussion which follows.

Test Procedure

Fifty men and fifty women of various ages and occupations were selected to evaluate the sharpness of the test points which were described and which are indicated schematically in Figure 1. They were instructed to start the test by feeling the duller points first and proceed to the sharper points. They were asked to judge which of the points were sufficiently dull for safe handling, and which were definitely too sharp for children's toys. The test points which were judged to be between the definitely sharp and the definitely dull categories were designated intermediate.

Results and Discussion

The following categories of sharpness were developed from the sharp point test data.

S - Sharp. More than two-thirds of the test subjects considered these points to be definitely hazardous. Less than 10% felt that they were sufficiently dull for safe handling.

SI - Sharp Intermediate. Between 40% and 70% of the test subjects judged that these points were definitely too sharp. Only 10% to 20% thought that these points were dull.

I - Intermediate. Opinions of the test subjects were distributed, 25% of the subjects considered them sharp, 35% considered them dull, and the remainder were undecided.

D - Dull. Over two-thirds of the people tested considered these points safe. Less than 10% felt that they were sharp.

The test results were substantially the same for people of different sex, age, and occupational groups. Using the above categories of sharpness, test results for all 100 subjects are summarized in Figure 1. For convenience, test data are arranged in diagonal rows so that as one moves upward to the right, points have a smaller (sharper) tip radius and if one moves upward to the left, points become smaller (sharper) in angle.

From the consensus of opinion, it appeared that points of the type designated S or SI constituted the greatest potential source of injury. Since these points may be delineated by the dotted line in Figure 1, it seems reasonable to look for factors common to members of this group which would distinguish them from the other points in the test set.

In Figure 2, the profiles are drawn for the SI points and the D points which border on intermediate points. A comparison of these profiles indicates that the greatest distinction between sharp and dull occurs at a depth of .015" from the tip. At this depth, the SI points are all within a .030" width, the D points are all outside a .040" width, and the intermediate points can be found somewhere between the two. This observation can be explained by the fact that skin and its supporting tissue deform somewhat when points are touched. This allows the penetrating force to be distributed over the area immediately behind the tip of the point. Therefore, as this area increases, both the sensation of sharpness and the ability to puncture diminish.

On the basis of experimental evidence obtained through a subjective evaluation of a series of known points, it appears that the relative sharpness or dullness of a point can be determined by its geometric configuration alone. From the consensus of opinion of the test subjects, it was decided that a point should be considered too sharp for safe

handling if it extends .015" with a width no greater than .030". It is necessary that the point have sufficient strength and rigidity to maintain its integrity when touched. Laboratory experiments with points made of wood and plastics indicate that a modulus of elasticity greater than 0.5×10^6 psi is necessary for a point to puncture under conditions of casual contact.

Point Testing Device

Since the depth-to-width ratio of a point was a principal determinant in the assessment of its sharpness or dullness, work was begun on the development of a device which could be used to test points. The result was the instrument shown in Figure 3. This instrument was a prototype and was designed to acccmmodate discs with various width slots through which points could be inserted. It also included a micrometer scale and spindle to allow adjustment of the depth of penetration of a point from the slot to the sensing head.

To operate this device, a test point is inserted through a slotted plate. The sensing head is advanced toward the test point by the micrometer spindle. A light in the sensing head indicates when contact has been made (see Figure 3). The degree of sharpness is determined by the depth-to-width ratio. The slotted opening permits testing of points that have an irregular conformation.

Based on the definition of sharpness, a point is considered sharp if it can penetrate .015" or more through a .030" wide slot (a depth to width ratio of 0.50). All of the points described as sharp and sharp-intermediate, in Figure 1, had depth-to-width ratios of 0.50 or greater.

In addition to being sharp, a point must be sufficiently rigid at the tip to cause a puncture. The microswitch located in the sensing head of the test instrument required a force of one-half pound, or more, for activation. It was found that a material with insufficient rigidity to activate this switch would not cause a puncture, even if made from an inherently rigid material and cut to a fine point. Experiments with steel wires of less than .030" diameter, cut at right angles to the length of the wire, indicated that these wires do not have sufficient strength and rigidity to operate the microswitch without bending. These cut wires do not appear sharp to the touch.

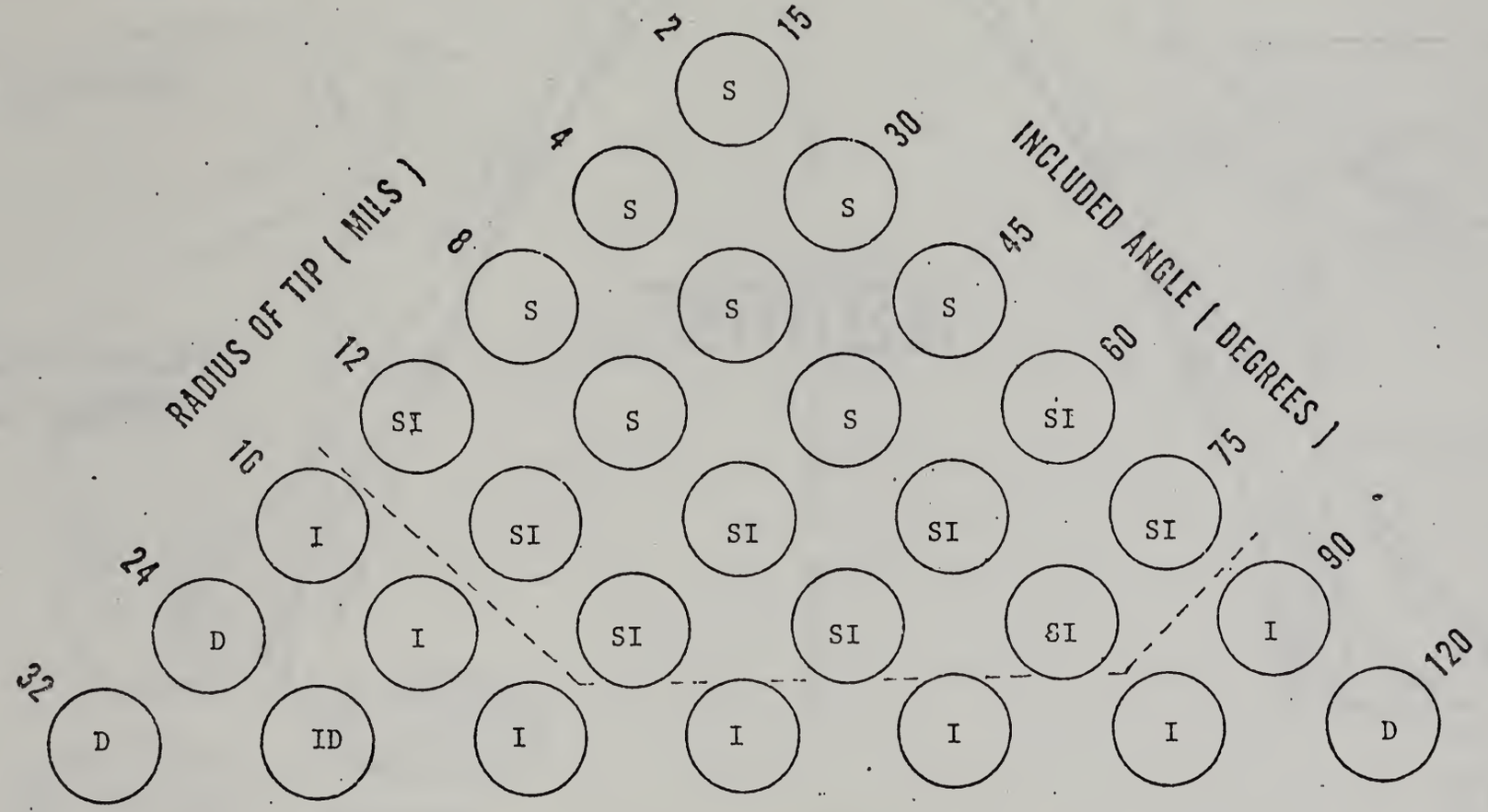
A pocket-size model of the point sharpness test instrument, which features convenient size, simple design, moderate production cost, and sturdy construction is illustrated diagrammatically in Figure 4. This instrument is designed for the use of inspectors in the field.

Conclusions

Sharp points that will penetrate on casual contact may be defined as those points which can extend at least .015" through a slot .030" wide, and with sufficient rigidity to exert a load of 1/2 pound without breaking or bending. A modulus of at least 0.5×10^6 psi is required.

A test instrument which is based on the definition of sharp points and which differentiates between sharp and dull points was designed and constructed.

SHARPNESS DETERMINATION



S - SHARP I - INTERMEDIATE D - DULL

Figure 1. Sharpness as determined by the consensus of opinion of 100 test subjects. Test results are summarized by the catagories of sharpness described in the text.

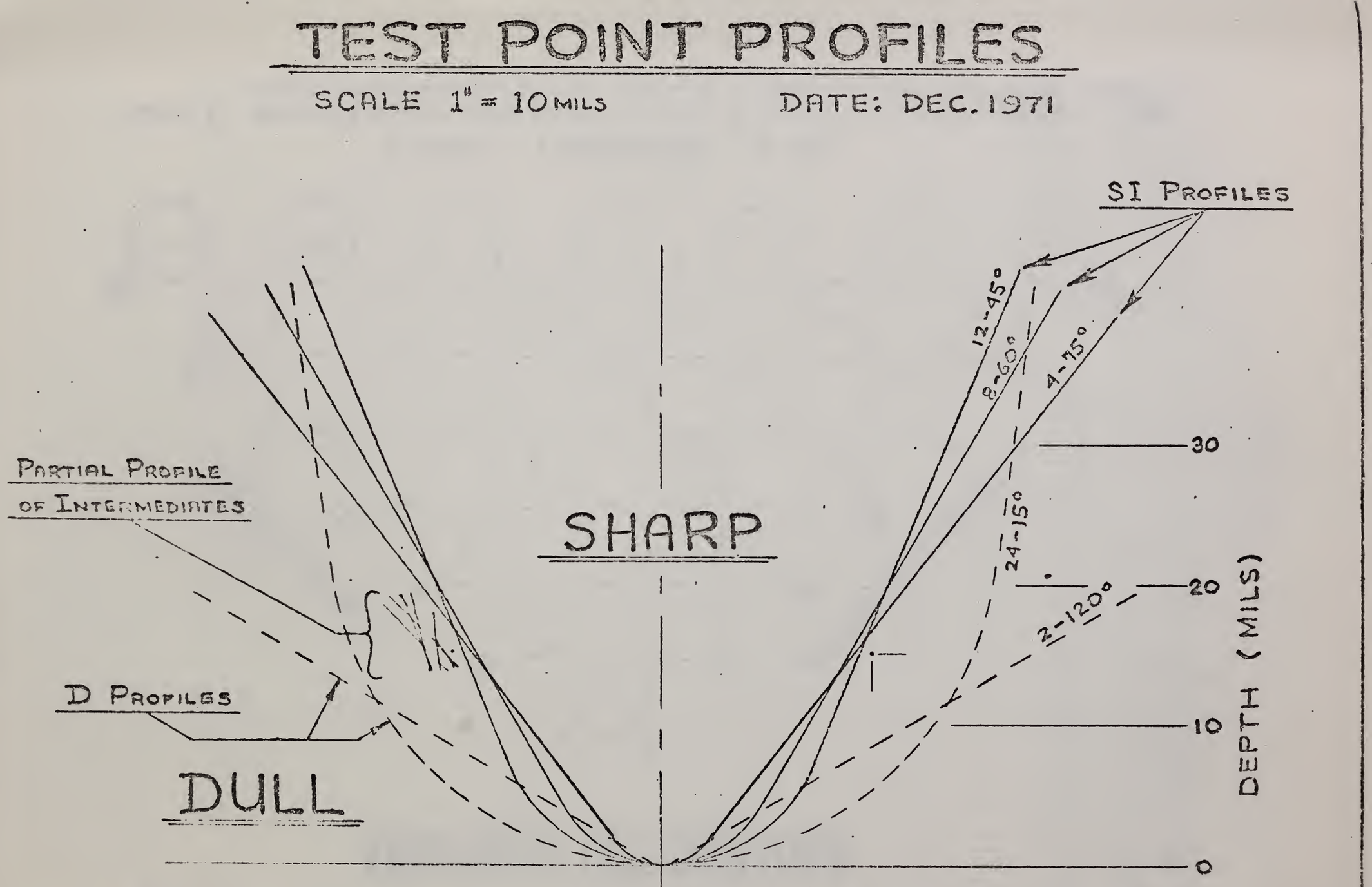


Figure 2. Profiles of the SI (sharp-intermediate) points and the D (dull) points, drawn at a magnification of 100 times, can be most easily distinguished geometrically at a depth of 0.015" from the tip of the point.

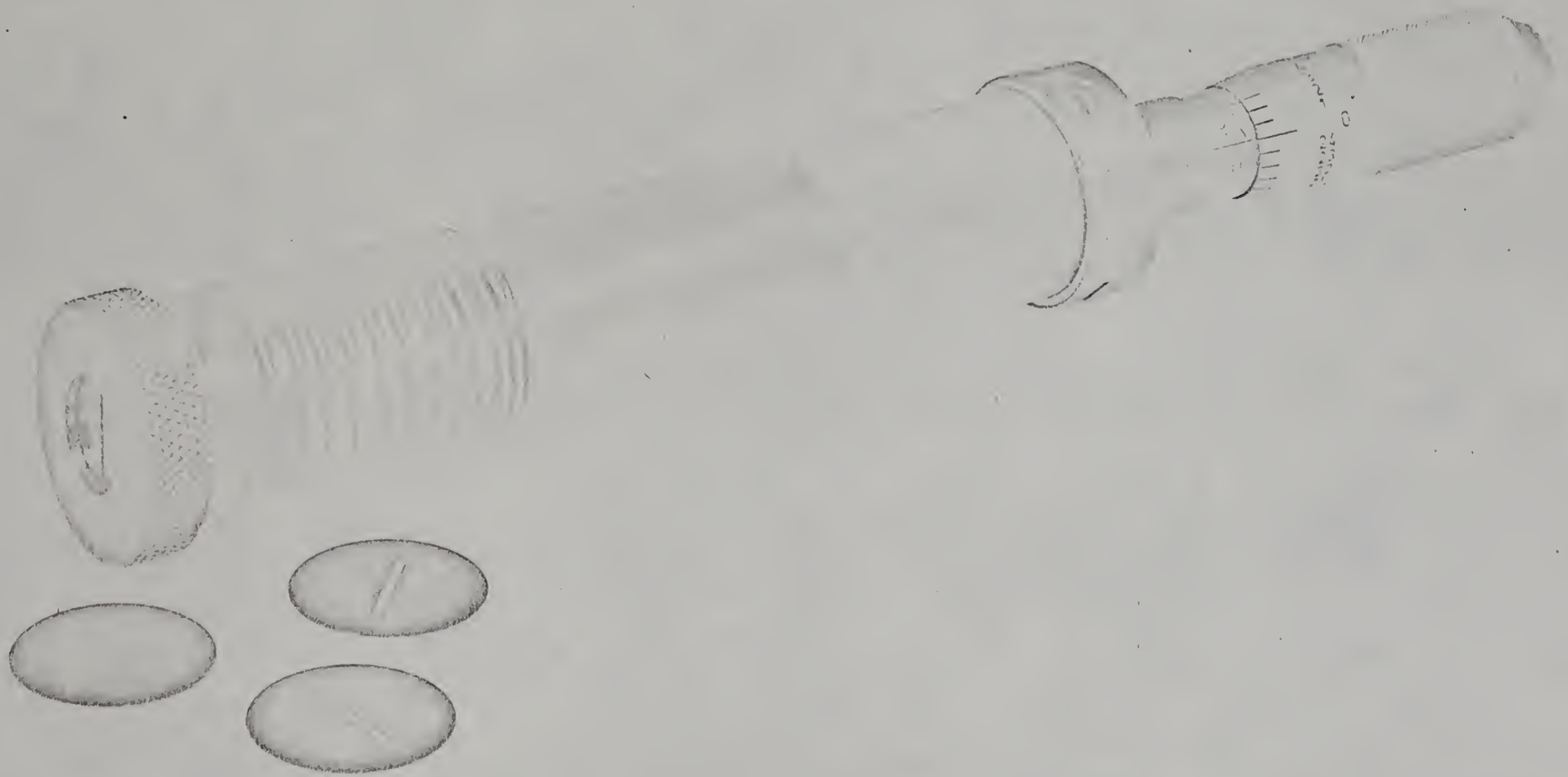


Figure 3. Prototype point sharpness test instrument.

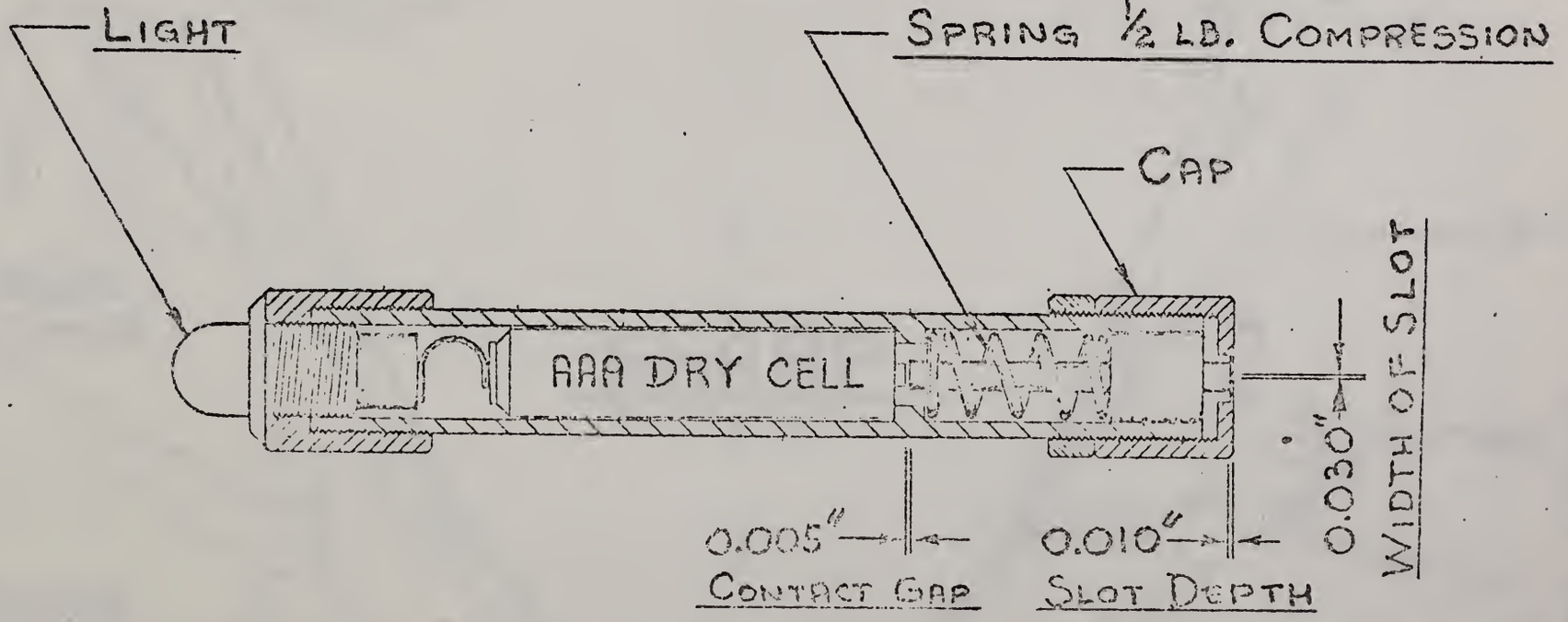


Figure 4. Cross sectional view of field inspector's point sharpness test instrument. Contact gap can be adjusted by rotating the cap which is calibrated for 0.001" increments of lateral motion. Total overall length 4 1/4".