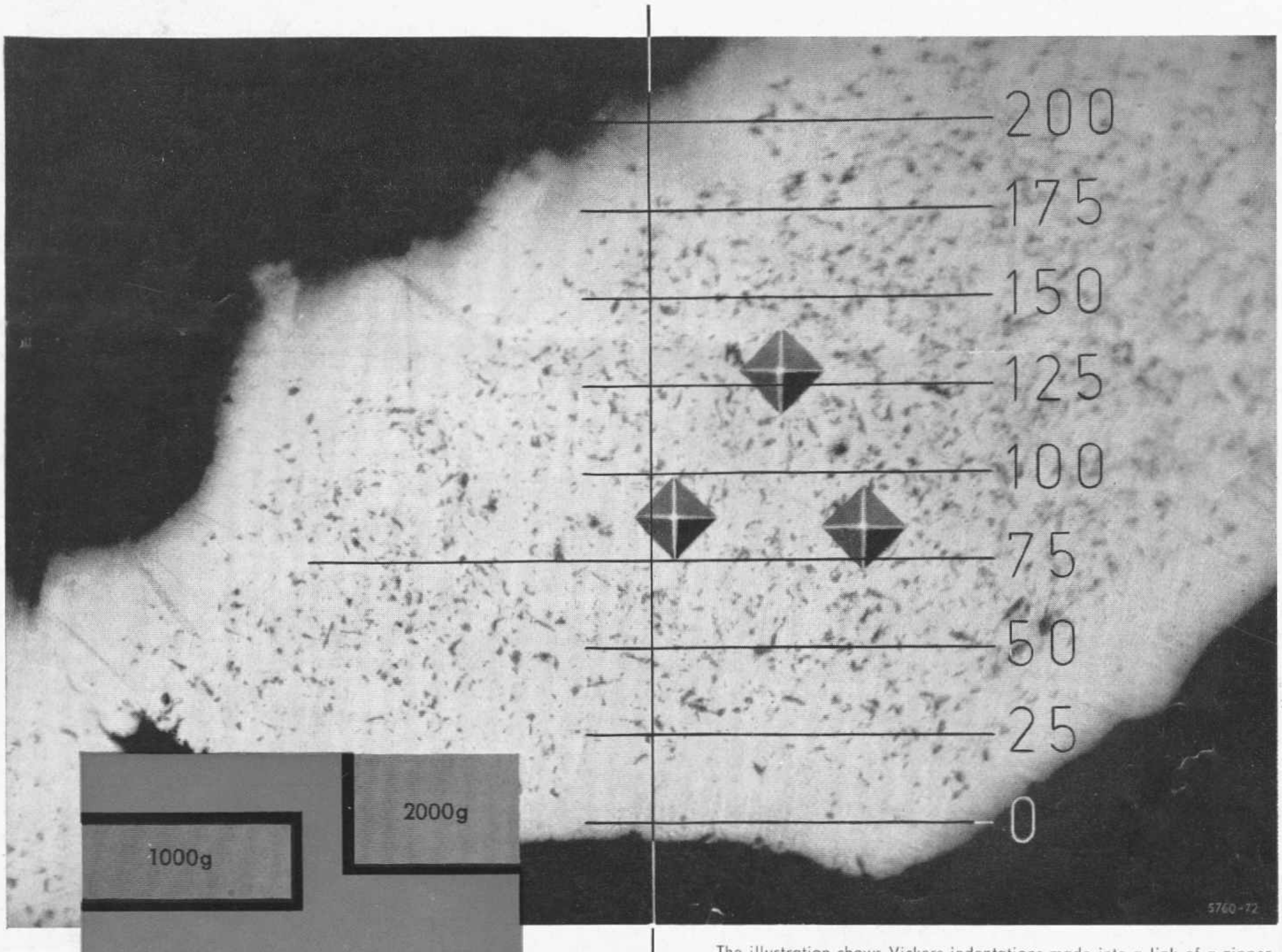
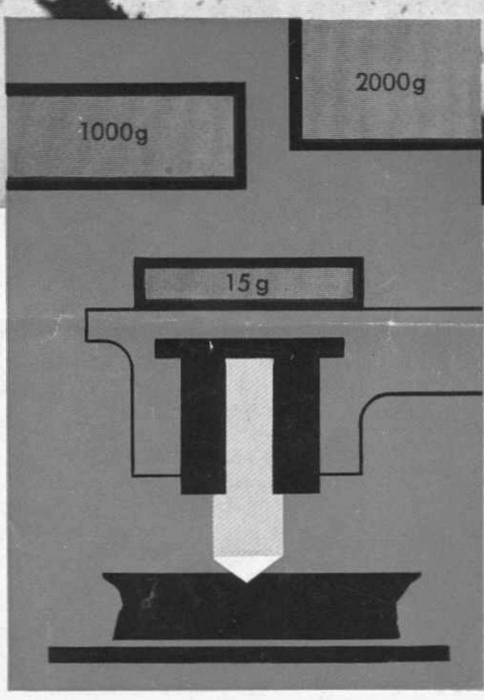
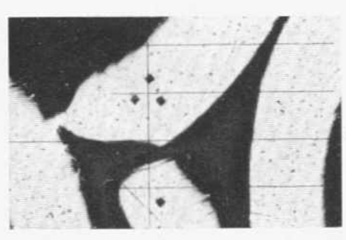




The illustration shows Vickers indentations made into a link of a zipper.
The test specimen has been embedded in plexiglas.
Above: 400× magnification (measuring objective)
Lower: 100× magnification (scanning objective)



Hardness tester

MINILOAD

72-1c/Engl.

Hardness tester MINILOAD

Load range from 15 gm. to 2000 gm.

The instrument is particularly well adapted to testing small parts, thin strata, and foils. By reason of its spotting certainty measurement can be made on the cutting edges of tools, on watch wheel spindles, and on needle points.

Advantages of the MINILOAD Hardness Tester

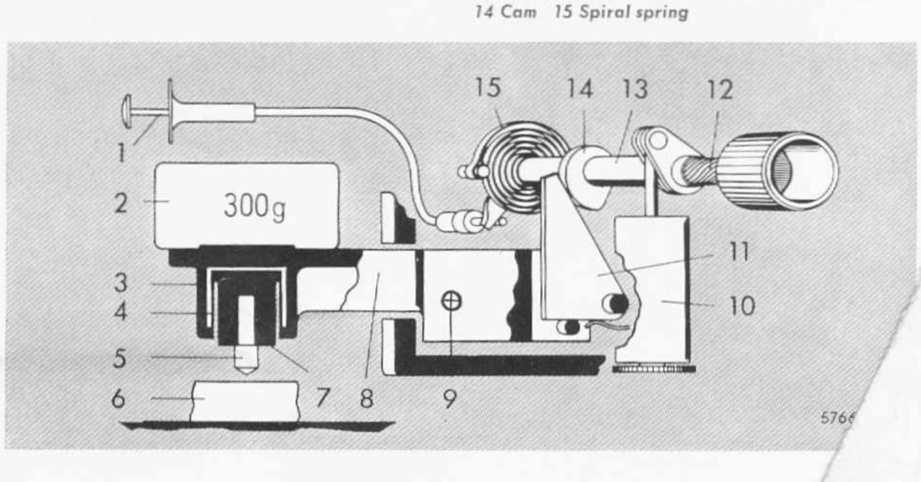
Load range from 15 gm. to 2000 gm.
Exchangeable diamonds for Vickers and Knoop tests and for scratch hardness testing.
High spotting certainty.
Slippage compensation of indenting body.
Small dimensions.
Instrument may be placed on workpiece.
Vibrationless working cycle of hardness test mechanism.
Variable magnification.
Precision measuring ocular with internal reading.

Weight and Dimensions:

Standard Model

Size of measuring stage	4¾ × 4¾ in.	120 × 120 mm
Maximum height of work	6 in.	150 mm
Field of view at 100× magnification	0.07 in.	1.8 mm
Field of view at 400× magnification	0.02 in.	0.45 mm
Total net weight	44 lbs.	approx. 20 kg
Dimensions of carrying case	31 × 25 × 23 in.	78 × 63 × 58 cm

Schematic diagram of the hardness testing equipment



1 Wire release 2 Weight 3 Guard fitting 4 Steel wires 5 Indenting body 6 Work 7 Indenting body seat 8 Load lever 9 axis of load lever 10 Oil damper 11 Cam follower 12 Flexible shaft 13 Camshaft 14 Cam 15 Spiral spring

Hardness Testing Methods

Within the field of engineering the characteristics of the material from which an object is made are of paramount importance.
One of the most instructive testing processes is hardness testing, for the hardness value permits important conclusions regarding the workability and wear resistance of materials, thus placing the relationship of supplier and user on an objective basis.
Of a number of such testing methods which have been devised, the Vickers hardness test has come widely into use because it embraces the whole technical hardness range and offers a number of decisive advantages as compared to other methods of testing.

Vickers Hardness

The Vickers hardness is determined by producing an indentation in the surface of the work by means of a pyramid-shaped diamond and optically measuring this indentation. The Vickers diamond has a square base surface. The apex angle between the opposed pyramid surfaces is 136° while the depth of penetration equals the seventh part of the indentation diagonal.

Stating the test load P in grams and the mean value d of the indentation diagonal in μm, the Vickers hardness is found by the formula:

$$HV\ (kg/sq.\ mm) = \frac{1854.4 \cdot P}{d^2}$$

Knoop Hardness

Similar to the Vickers test is the Knoop hardness test. The Knoop pyramid diamond has a rhombic base surface. The ratio between the two diagonals of this surface is 7 : 1 and the depth of penetration is only about one thirtieth of the longitudinal diagonal. The angles between the opposed pairs of edges are 172° 30′ and 130°, respectively.

Stating the test force P in grams and the length l of the longer diagonal in mm, the Knoop hardness is found by the formula:

$$HK\ (kg/sq.\ mm) = \frac{14\,230 \cdot P}{l^2}$$

Using the same test force, the Knoop pyramid produces a diagonal of approximately three times the length and an indentation of two thirds the depth of penetration of that produced by the Vickers pyramid. Longer indentations are favorable for harder materials because of the increased accuracy of reading, while shallower indentations are better suited to very thin layers.

Scratch Hardness

In addition to the indentation hardness, which is closely related to the tensile strength of materials, the resistance of materials to wear from grinding and scoring is of technological importance. Measurement of these properties is effected by scratch testing with a special diamond of a form adapted to the specific task at hand. In this test, use is made of cone-pointed diamonds of 90°, 120°, and 150° apex angles respectively, and also of pyramid-shaped diamonds with 120° included angle.

Ordinarily, as for instance in the case of glass, this hardness is referred to a basic scratch width of 10 μm. For softer materials or very thin layers, another reference scratch width may be assumed. The scratch hardness test is also employed for rapidly determining the depth of casehardening on a ground spot of the work.

Test load

The test load will depend upon the thickness of the workpiece, the intended function of its surface and its hardness. While hardness testers working with heavy loads give a mean value for extended structure regions, small hardness testers can also be used for examining structure details or very tenuous layers, and in particular, surface layers down to a thickness of 1 μm.

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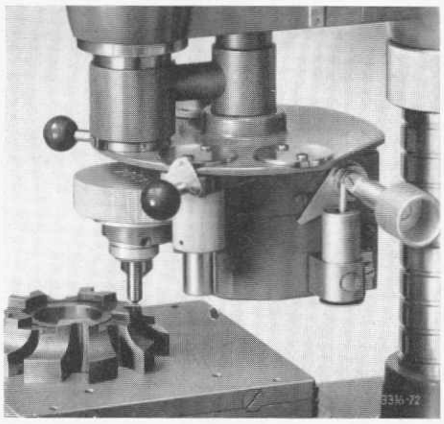
Technical Description



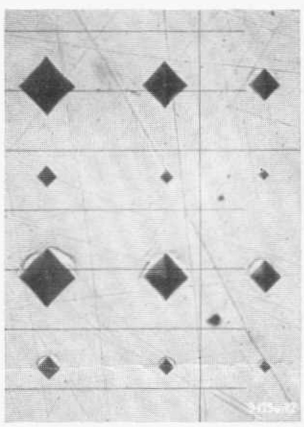
Indenting unit with Vickers diamond in position

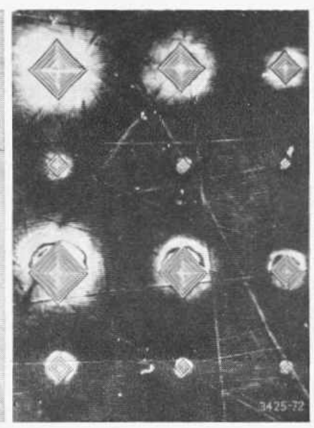
The MINILOAD Hardness Tester consists of a stand, the microscope tube with precision measuring ocular and the hardness test unit with the mount for the diamond.
The base plate of the stand is fitted with a column to which is attached the microscope arm. The arm can be moved up or down along the column for setting to the approximate height with the aid of a steeplead thread, and can be clamped in any position. It can also be swung around the column for testing work too large to be placed on the base plate (see illustration on page 5).

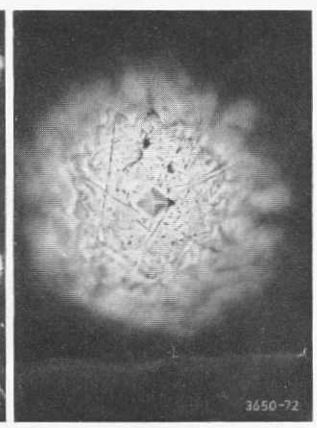
The microscope has an inclined ocular tube and vertical adjustment is achieved by means of a rack-and-pinion motion. Fine focusing is effected with a knurled ring placed midway along the tube. For illumination, an 8 V, 0.6 amp. incandescent bulb is used, which is connected to the light line over a transformer accompanying the instrument. Light is projected onto the work through an incident illuminator contained in the tube, and which gives bright-field illumination.
All optical components are coated to reduce reflection.

Ordinarily, in locating the indenting body on the work a more or less marked lateral movement of the holding device arises, depending upon the design of the instrument, causing the indenting body to be displaced sidewise. By this displacement, distortion is caused in the indentation, in the form of one-sided bulges which lead to false test results (see illustration below). To avoid this source of error the MINILOAD is equipped with a slippage compensation, consisting of a spring seat for the indenting body, which thereby counter-acts the lateral thrust, and also affords a measure of protection against accidental damage to the diamond.

The downward movement of the lever which carries the indenting body is effected by a spring, while the indenting velocity is regulated by an oil damper (see illustration on page 2). When the diamond is mounted the revolver is automatically locked, thus precluding damage caused by careless operation. A compound stage which forms part of the standard oufit, may be mounted on the base plate.







Indentations in steel, produced with loads of 300, 200, 100, 50, 25 and 15 gm. Lower rows without deformation compensation (larger and deformed indentations). Upper two rows with deformation compensation. One interval of scale equals .025 mm.

At right, interference photos of indentations in view at left. Photograph clearly shows, below, the bulges of the unilaterally deformed indentations, and the upper two rows with deformation compensation.

Example of extraordinary locating accuracy Vickers indentation on tip of phonograph needle. Diagonal of indentation: 1 μm.

Photographic Equipment

A photographic attachment may be installed on top of the measuring ocular. It consists essentially of a slide changer for the LEICA and a camera holder with a built-in optical intermediate system. The slide changer is a simple to use device for focusing on a ground glass screen. The ocular image appears in the 24×36 mm field of view of the ground glass screen and is observed through a magnifier.
Thus focus, illumination and field of view may be checked, whereupon the LEICA is indexed into the position occupied by the magnifier and the film exposed.
The sleeve surrounding the ocular is provided with openings permitting focusing of the ocular on the built-in scale also when the photographic attachment is in place.
Two spring clamps situated below the ocular, one of which carries the supplementary illuminator 8 V 0.6 amp. for the ocular scale, hold the photographic attachment securely in place on the ocular.

Measurement of Vickers and Knoop Indentations and of the sratch widths

Vickers indentations are measured with the greatest accuracy by means of the LEITZ precision measuring ocular, the single hairline of which permits exact settings, excluding personal error. The scales are arranged in the field of vision, thereby assuring rapid and positive reading. Two objectives of primary magnification of 10× and 40×, respectively, and which together with the precision measuring ocular yield a total magnification of 100× and 400×, respectively, may be alternately indexed into the optical axis of the instrument. The indenting mechanism and the two objectives are attached to a disk-type turret.

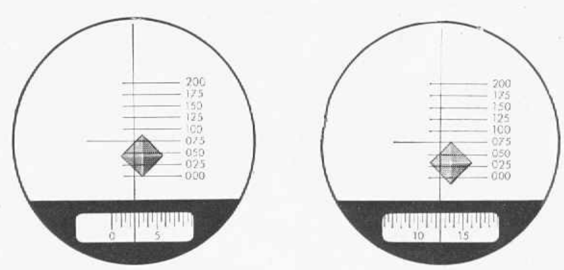
The spotting scale (the graduation in the center of the ocular field) is divided into 25 μm intervals for the 40-power measuring objective. Intermediate values are measured by displacing this line with the externally located set screw. The result is read on the measuring scale (in the lower part of the field), which is divided into 0,5 μm intervals, so that a displacement of 0.1 μm can still be estimated.

To measure the diagonals of the hardness indentation, the spotting scale is aligned with the indentation by turning the ocular till the numbered lines are at right angles to the diagonal to be measured. By turning the stage micrometer screw, – or, when no stage is used, the motion screw for the measuring (lower ocular) scale – one corner of the indentation is displaced till it touches one of the numbered lines. The scale is now read, and the screw is advanced until the opposite corner of the indentation is in contact with the closest scale graduation. The difference between this and the preceding reading, plus the number of intervals, gives the diagonal length.*

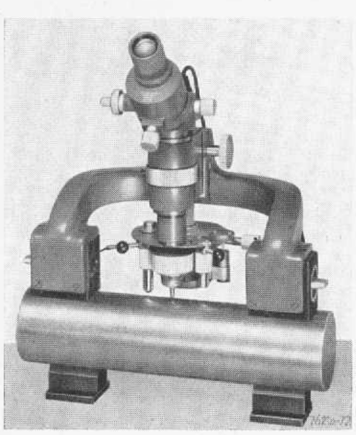
Measurement of the scratch width is effected by setting the spotting scale graduations parallel to the edges of the scratch. With the aid of the measuring scale screw, the two edges of the scratch are now successively brought into coincidence with a number line, and the width of the scratch determined as the difference between these two measuring scale settings.

* Tables give the Vickers or Knoop hardnesses as function of the diagonal lengths and of the applied weight.

Hardness tester swung around for testing larger work pieces.



First reading: 2.5 μm = 0.0025 mm
Second reading: 75 μm + 12.5 μm = 87.5 μm = 0.0875 mm
Difference: 0.0850 mm



Model for Placement on Large Workpieces

A special type MINILOAD Small Hardness Tester can be placed directly on large parts, both plane and cylindrical, such as large castings, steel structures, machine beds, rolls for the paper industry with a minimum diameter of 100 mm (4 inches). Built-in magnets, which may be engaged or disengaged, hold the instrument securely on magnetic materials; the bracket also permits the use of belts for holding the instrument on non-magnetic workpieces.

Attached to the special bracket are a microscope tube with precision measuring ocular as well as the Hardness Tester proper. Elements of the Standard Model can, if desired, be used. Adaptation of these parts must be carried out at the factory.

Mounting Fixtures

The MINILOAD Hardness Tester offers substantial advantages when the hardness of finish-machined, hardened and ground tools is to be determined. As the indentations produced are, thanks to the small loads used, so small as to be invisible to the naked eye, the hardness test is virtually "non-destructive" when performed with the MINILOAD. Owing to the positiveness of the instrument, it is also possible to measure the hardness of the cutting edge proper. As many such tools or work pieces are comparatively large, the MINILOAD Hardness Tester is swiveled 180° around the column and the entire instrument placed on a special base plate, common to both the MINILOAD and the fixture for holding the part being inspected. Special fixtures to suit the various kinds of parts to be inspected are available.

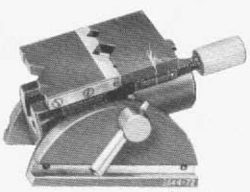


Fig. 1.

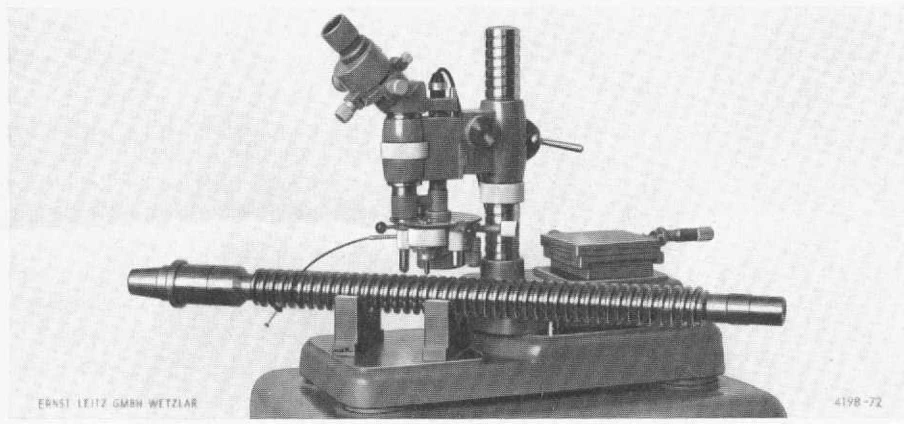


Fig. 2.

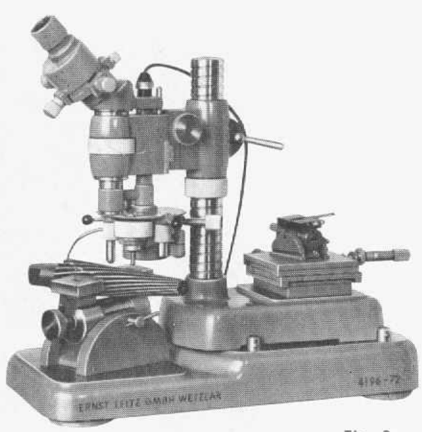


Fig. 3.

Fig. 1 **The tiltable specimen mounting fixture** for specimens which are to be measured in cross section, such as sheet metal, wires, bearing points, needle points and the like, is equipped with two removable jaws which are moved in opposite directions in their dove-tail ways by means of a single threaded spindle. The surface of the one jaw is tiltably arranged and adjusts automatically to complete contact with the surface of the other jaw or of the specimen. The specimen mounting fixture may be tilted about the axis of the threaded spindle and inclined toward either side, so that all planes may be arranged horizontally for testing. The unit can, of course, be locked in any setting. The complete mounting fixture is attached to the compound measuring stage by means of four clamps.

Fig. 2 **V-blocks** for inspecting shafts, cylindrical parts, lead screws etc. mounted on the **Large Base Plate** for the MINILOAD Hardness Tester. The large base plate is also required for the following two mounting fixtures:

Fig. 3 **A universal mounting fixture** is available for mounting cylindrical tools or parts without bore, such as twist drills and straight or taper reamers. The jaws of the fixture are moved in opposite directions by means of a single spindle and swivel freely in the horizontal plane, thereby adapting themselves automatically to tapered surfaces as well. The mounting fixture may be tilted about the spindle axis and inclined in both directions and may, of course, be locked in any position. In the illustration above, a taper reamer is shown mounted in this fixture. On the measuring stage of the instrument is seen the tiltable specimen mounting fixture.

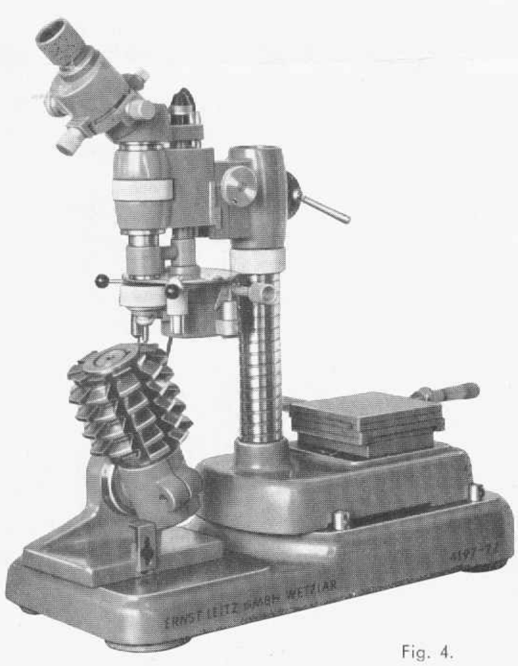


Fig. 4.

Fig. 4 **Tilting mount** for inspecting hobs. This mounting may be swivelled a full 180°. The equipment includes 5 different mounting arbors enabling every type of hob or cutter head to be mounted. A scale graduated for direct reading to 5° permits setting of the part being inspected.

Working Procedure

The first move is to place one of the following weights, included with the instrument, in position (**1**): 25, 50, 100, 200 or 300 gm. The basic weight of the indenting lever is 15 gm.

Before positioning the work, the indenting body must always be raised by turning the knurled handle of the flexible shaft clockwise (**7**).

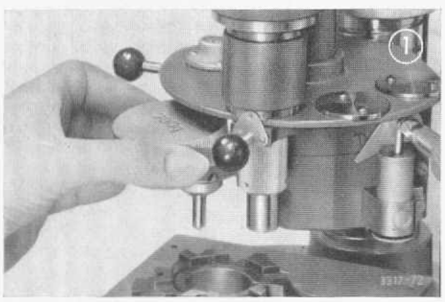
For finding spots on the object which are suitable for indentation, the low-power objective is used. The work is brought into position by means of the micrometer spindles of the compound stage (**2**). When this is done, the higher-power objective is indexed into position (**3**).

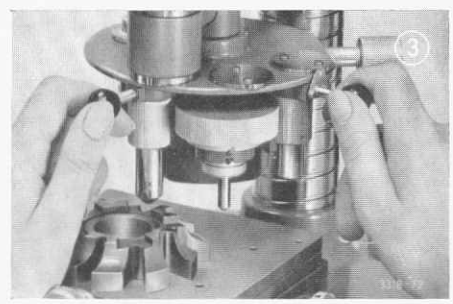
When the specimen is in sharp focus, the ocular micrometer is set on zero and the indenting body is indexed into position (**4**).
Now the wire release is manipulated (**5**).

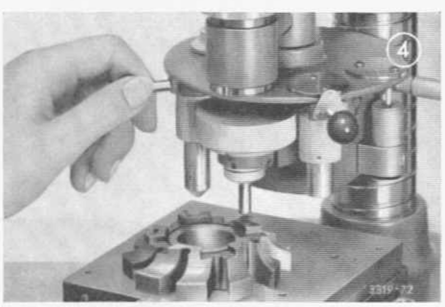
The spring thus freed slowly seats the indenting body on the object (**6**), and locks the revolver. After the usual delay of about 10 sec. the indenting body is again raised by turning the knurled handle clockwise (**7**) which simultaneously cocks the movement spring. Next the objective is indexed, and the cross hairs in the ocular are centred over the indentation by means of the ocular manipulation screws (**8**). The location of the indentations thus produced will be exact within 2 to 3 μm of the selected spot.

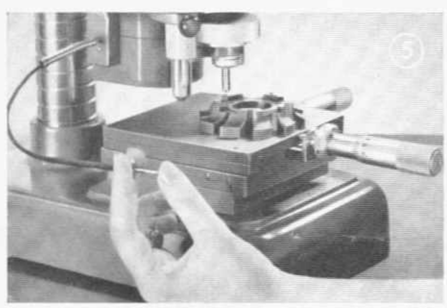
For scratch hardness testing, the indenting body with the scratch diamond is lowered onto the work, and the front micrometer spindle of the stage slowly turned counter-clockwise.

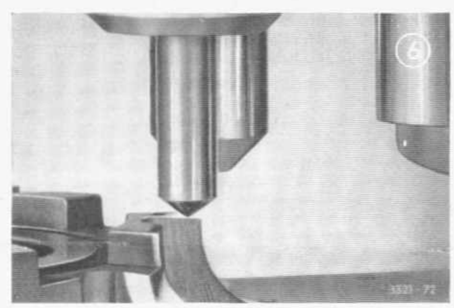
For further details refer to instruction booklet 72-5.

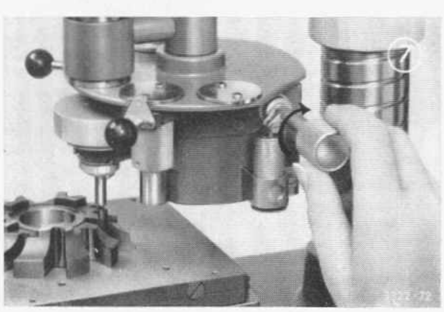


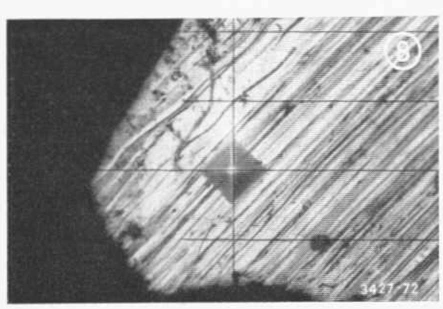












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