Instruction Manual

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1. Applicability

The Universal Horizontal Metroscope is an opto-mechanical length measuring instrument for direct measurement and difference measurement. Its applicability is extraordinarily wide due to the basic bed of universal design and expansion for many measuring and checking purposes. The following measuring operations are possible with our Universal Horizontal Metroscope:

(1) Outside measurement for
objects with flat parallel measuring faces,
objects with spherical measuring faces,
cylindrical objects in vertical position,
cylindrical objects in horizontal position

(2) Inside measurement for
objects with flat parallel measuring faces,
bores by means of inside measuring frames,
bores by means of a measuring device with magic eye

(3) Thread measurement for
internal threads,
external threads

2. Specification

	equipment with Abbe measuring element	equipment with difference measuring device
graduation value of measuring graduation (eyepiece reading)	1 µm	1 µm
apparent distance between graduation lines of measuring graduation (eyepiece reading), approx.	6 mm	1 mm
measuring ranges	0···100 mm	± 100 µm

	equipment with Abbe measuring element	equipment with difference measuring device
applicability to outside measurement		
without slip gauges	0...100 mm	-
with slip gauges	0... 450 mm	
with center stand (center height 100 mm) according to length or diameter of the test object, up to	200 mm	
applicability to inside measurement		
with small inside measuring frames (depth of insertion up to 12 mm)	10...200 mm	
with big inside measuring frames (depth of insertion up to 50 mm)	30...200 mm	
with measuring device with magic eye	1...50 mm	
in case of thin-walled workpieces	1...60 mm	
applicability to thread measurement		
maximum outer thread diameter	200 mm	
maximum inner thread diameter		
with small inside measuring frames (depth of insertion up to 12 mm, maximum outer diameter 160), from minor diameter of	14 mm	
with big inside measuring frames (depth of insertion up to 50 mm, maximum outer diameter 160 mm), from minor diameter of	35 mm	

	equipment with Abbe measuring element	equipment with difference measuring device
data of the adjustable object table		
height setting range	0...105 mm	
setting range in y-direction	0...25 mm	
tilt about y-axis	$\pm 3^{\circ}$	
table plate rotation	$\pm 4^{\circ}$	
maximum loadability	12 kg	
holding lengths		
slip gauge holder no. 2	0...100 mm	
slip gauge holder no. 3	100...200 mm	
V-type slip gauge holder no. 1	0...100 mm	
v-type slip gauge holder no. 2	80...200 mm	
measuring forces		
normally, approx.	150 or 250 g	200 g
for measuring device with magic eye	0	-
maximum error of the instrument		
for outside measurement		
with measuring unit with spherical zones no more than	$\pm(1+\frac{L}{200})\mu m$ 1)	$\pm 0.5\,\mu m$ 2)
with measuring unit with flat face no more than	$\pm(1.2+\frac{L}{200})\mu m$ 1)	$\pm 0.7\,\mu m$ 2)
for inside measurement no more than	$\pm(1.5+\frac{L}{200})\mu m$ 1)	$\pm 1\,\mu m$ 2)
weights		
instrument with Abbe measuring element and countersleeve, approx.	80 kg	

	equipment with Abbe measuring unit	equipment with difference measuring device
instrument with difference measuring device, approx.		15 kg
dimensions, approx.		890 mm x 350 mm x 500 mm

1) L = measured length [mm]

a) If an error chart is used, the variable member is $\frac{L}{1{,}000}$.

b) If only one graduation line is used, i.e. in case of difference measurement, the error for outside measurement amounts only to 0.8 µm or 1 µm, for inside measurement only to 1.3 µm.

2) Prerequisite: No difference in temperate and expansion coefficient between test object and standard

3. Description

3.1. Principle of measuring

The principles formulated by Prof. Ernst ABBE in 1890 have strictly been considered to ensure the required high accuracy of the Universal Horizontal Metroscope.

These principles are as following:

(1) Any measurement, no matter whether by contact setting or by setting the line of sight, must always be based on a length graduation with which the length to be measured is directly compared.

(2) The measuring apparatus must be arranged so that the length to be measured is the straightlihed continuation of the graduation used as a scale.

(Z. Instrumentenkunde, vol. X [1890])

Measuring operations with the Universal Horizontal Metroscope are generally performed directly by comparing the test object with a

precision glass scale whose graduation lines are observed in a microscope. The glass scale is positively connected to a measuring sleeve and arranged in its longitudinal axis so that the glass scale necessarily participatesany axial displacement of the sleeve. These displacements are indicated in the microscope and read by the operator as measured values.

3.2. Design of the instrument

3.2.1. Basic bed with adjustable object table (Figs. 1, 2, 3)

The basic bed (15) carries the measuring devices. Its shape meets all demands for the avoidance of deflections so that test objects even with weight of 7 kg can be placed on the adjustable object table (3) without any influence on the result of measuring.

The basic bed is carried by three footscrews (8) resting in the baseplates (9). These screws permit the instrument to be levelled with respect to the box level (4). The front end of the basic bed carries handwheel (12) for table height adjustment. The survey scale (11) behind the handwheel has a graduation value of 0.5 mm. Screws (10 and 14) serve for limiting the table height adjustment. Screw (14) is used for limiting the upper table position, screw (10) for limiting the lower one. Clamping knob (13) serves for securing the adjusted height of the adjustable object table. The lighting unit is switched on and off with switch (16). The small handwheel (7) atuates a compensating unit in the basic bed (15). This compensating unit warrants easy movabiiity of table height adjustment at different weight of test objects.

Bore (24) in the rear of the basic bed serves for locating the carrying column of the magic eye or tailor-made completing units. Clamping screw (23) serves for fastening the carrying column. Sockets (19, 20, and 21) are provided for connection to the mains (21), to the lighting equipment (19), and to the measuring device with magic eye (20). Fuse (22) for the lighting equipment has been arranged under the sockets.

The left-hand section of the basic bed contains the transformer for connection to 220 V a.c., the middle one the transmission elements for table height setting. The horizontal sliding faces (1 and 5) serve for location of measuring element, measuring slide, and sleeve slides. The vertical faces (2 and 6) are stops for locking these elements. The sliding blocks of attached elements are running in the two oblique slots (17).

The adjustable object table (3) has two lateral slots (18) into which the points of fastening screws of the electrically insulated table and of the center stand are screwed, and two slots (25) for fastening the object clamps. The adjustable object table has the following moving possibilities required for exact measurement:

Height setting 0···105 mm

Handwheel (12) and survey graduation (11) serve for setting a defined position which must be secured by tightening of clamping knob (13).

Setting in y-direction 0···25 mm

This is possible by turning the setscrew (29) whose graduation value amounts to 0.01 mm.

Tilt by ± 3°

The table can be tilted about the horizontal y-axis which runs transversely with the measuring equipment. Lever (28) must be actuated for this purpose. Clamping lever (27) serves for securing the table in its desired position.

Table plate rotation by ± 4°

Lever (26) serves for turning the table plate of the adjustable object table (3) about the z-axis which is perpendicular to the axes x and y.

Free travel in measuring (x) direction 18 mm

The table plate rolls on balls in x-direction whereby the test object can set itself between the two measuring points (measuring faces) with absolute freedom. In addition, the necessary contact

between measuring and countersleeve by the test object is always warranted. This presupposes the table plate to be approximately in middle position for measuring operations. This table plate position is visible by the index lines (30).

3.2.2. Abbe measuring element (Figs. 4 to 7)

The Abbe measuring element (116) contains the measuring sleeve (37), the spiral microscope (49) as the indicating device, and the lighting equipment (36). The Abbe measuring element with its slide is shifted on the left-hand sliding faces of the basic bed and clamped with clamping knob (43) in any desired position. The housing (45) of the Abbe measuring element is positively connected to slide (42) by the hexagon socket head screws (54). The measuring sleeve (37) runs in the housing without backlash and with minimum friction on ball bearings. The lighting equipment (36) is screwed into the small receptacle with internal thread. Clampscrew (47) serves for locking the measuring sleeve in a defined position.

The measuring sleeve (37) contains the glass scale with millimeter graduation along 100 mm. Capnut (39) serves for fastening spacing elements on the measuring sleeve. The cord end of the applied weight is fastened to holder (38) in case of inside measurement and to holder (51) in case of outside measurement. An angular sheet (55) carries the two rollers (50 and 53) over which the cord of the weight is running. The measuring sleeve can be moved if holder plate (52) is seized. Sleeve movement is limited by the stop pin (46) which can be shifted and, by screw (44), locked. Rubber cushions (41) reduce the hard shocks by the measuring sleeve. Tangent screw (35) serves for sensitively shifting the measuring sleeve in axial direction. This tangent screw cannot be actuated unless the red mark on switchknob (48) is upward directed, i.e. toward the observer. Due to the high scaling-down ratio of the tangent screw, the measuring sleeve moves slowly on-

ly. Friction gears transform the circular movement of the driver plate into the axial movement of the measuring sleeve.
The lighting equipment contains (36) the lampholder which is screwed in with knurled ring (34). It carries a miniature lamp L 6.3 V 0.3 A (33). The supply line (31) with plug (32) to be inserted into the socket in the basic bed connects the lighting equipment and the transformer. The lighting equipment (36) serves for lighting the glass scale (40).
The spiral microscope (49) indicates the measured value so that it can be read. Graduation lines and figures of the scale appear black with light green background in the field of vision of the spiral microscope. Three different graduations are visible in the spiral microscope:

(1) the stationary horizontal tenth graduation numbered from the left to the right from 0 to 10,
(2) the double line spiral (virtual concentric circles),
(3) the circular tousandth graduation.

The elements for quick (60) and slow (61) motion permit the spiral and thousandth graduation to be turned together. The order of reading will be found in paragraph 8. Drive knob (56) which can be locked with a clamping knob serves for zeroing. Turning the eyepiece mount (59) permits the eyepiece to be adjusted according to the observer's eye.

3.2.3. Countersleeve (Fig. 12)

The countersleeve (tailstock) offers a fixed measuring point (contact face). It is shifted with its slide (68) on the right-hand sliding faces (5) of the basic bed and locked with clamping knob (69) in any desired position. The sleeve tube (66) can axially be shifted in its holding bore and locked in any desired position by tightening clamping knob (65). Turning of setting knob (67) moves the measuring bolt (63) axially. The measuring bolt (63) which

holds the correspondingly required measuring attachment can be adjusted with the two screws (64 and 70) so that the measuring faces are parallel to each other if measuring attachments with flat face are used.

3.2.4. Center stand (Fig. 13)

The center stand (74) serves for the location of centered test objects between the workholding centers (73). These centers have a solid center (75) and a hollow center (76) each. The centers can be shifted and locked in the desired position by clampscrews (72). Knurled rings (71) warrant reliable shift. The center stand is applied to the adjustable table and fastened in the lateral table grooves with fastening screws (77).

3.2.5. Inside measuring device with magic eye

The inside measuring device with magic eye consists of the electrically insulated table (Fig. 14), indicating unit with magic eye (Fig. 15), carrying arm (Fig. 17), and measuring ball insets (Fig. 16). The inside measuring device with magic eye serves for measuring bores with diameters of 1···50 mm without measuring force.
The electrically insulated table (Fig. 14) has a table plate (79) which is electrically insulated against table carrier (86) by the insulating plate (83). Table and insulating plates have a recess (82) permitting measuring ball insets to be approached to the object bore even from below. The electrically insulated table carries the test object, smaller test objects via spacing ring (80). The electrically insulated table is placed on the adjustable table and fastened in the lateral table slots by stop and fastening screws (85 and 87). The level (84) on the table carrier (86) serves for precisely levelling the table. Receptacle (78) and pin plug serve for connection between the electrically insulated table and the in-

dicating unit. Object clamps for fastening the tested object can be introduced into the slots (81).
The indicating unit with magic eye (Fig. 15) has a carrying column (90) holding the housing (88) with the built-in magic eye (89) and located in the bore on the rear of the basic bed. Pin plug (91) and a receptacle serve for the connection between indicating unit and the electrically insulated table. Screwable plug (92) to be screwed into a socket in the basic bed connects the indicating unit to the transformer. (For replacing the magic eye, unplug the connections and take the indicating unit from the basic bed. Loosen the fastening screw, remove the base housing, and replace the magic eye by a new one of type EM 11. The indicating will be ready for use again after the base housing has been fastened.)
The carrier arm (Fig. 17) must be fastened to the measuring sleeve and carries the measuring ball insets. It is pushed with its bore (99) to the long spacing element on the measuring sleeve and fastened with clamping knob (100). The measuring ball insets to be introduced into spacing element (97) are pulled by fastening screw (96) into the conical holder bore (98).
The measuring ball insets (Fig. 16) serve for bore measuring by means of the measuring device with magic eye. The value engraved on the insets is the effective measuring ball diameter which differs from the actual measuring ball diameter by the thickness of the air layer which permits the magic eye already to response during the measuring operation. This effective diameter is determined by the use of calliper block gauges in the same way as the diameter is determined during a practical measuring operation. Contact between measuring ball and test object closes a circuit which is indicated by the magic eye lighting up.

3.2.6. Inside measuring device with inside measuring frames

The inside measuring device with measuring frames consists of two

small and two big inside measuring frames, a sleeve for the small inside measuring frames, and two setting rings.
The inside measuring frames serve for the necessary connection between test object and measuring device in case of inside measuring operations. The two different frame pairs (small and big) permit various inside measuring operations in consideration of the depth of insertion. The small inside measuring frames (128 Fig. 28) have been provided for inside measurement of 10···200 mm at maximum insertion depth of 12 mm. They are fastened with clampscrews (137) to the measuring bolts of measuring sleeve (37) and adjustable countersleeve (127). The big inside measuring frames (130 Fig. 29) serve for inside measuring operations of 30···200 mm at maximum depth of insertion of 50 mm. They are fastened with clampscrews (139) to the spacing element on the measuring sleeve and countersleeve.
The sleeve for small inside measuring frames (Fig. 38) is adjustable and used instead of the countersleeve (see paragraph 3.2.3.) for inside measuring operations with the small measuring frames. The small inside measuring frame is then fastened on measuring bolt (151) of the adjustable sleeve.
Setting rings (129 Fig. 28) have diameters of 14 mm and 50 mm and serve as setting standards for inside measuring operations with measuring frames.

3.2.7. External thread measuring device

The external thread measuring equipment consists of measuring wire holders, thread measuring wires with eyelets, and measuring attachments with flat face of 8 mm and 14 mm in diameter.
The measuring wire holders (120 Fig. 33) are set to the big spacing element (122) on the measuring sleeve or to the sleeve tube (66) of the countersleeve. Holder bars (142) can be shifted in the holders and clamped by screws (141).
The thread measuring wires with eyelets (143 Fig. 33) are cylindrical and have an eyelet with cord. This cord connects the measuring wire

to a holder plate into which the wire diameter has been engraved. The holder plates are pushed on the holder bars (142) of measuring wire holders that the measuring wires hang free.

3.2.8. Internal thread measuring device

The external thread measuring equipment consists of an attachable table with object clamp, V-type block gauge holders, and V-type block gauges.
The attachable table (111 Fig. 37) is placed on the adjustable object table and fastened in the lateral slots of the object table by means of fastening screws (147). The attachable table carries an object clamp for fastening the test object on the table plate. The table plate is horizontally "floating" to all sides and permits the measuring balls to position themselves in the thread without forced action.
The v-type gauge block holders (124 Fig. 32) serve for holding one pair of V-type gauge blocks and one parallel gauge block which are used as a setting gauge.

3.2.9. Other accessories

Other accessories for the Universal Horizontal Metroscope are measuring attachments, weight units, and spacing elements.
Measuring attachments (Fig. 18) with measuring faces of different shapes materialize the points or lines of contact between measuring faces of test objects and device as required for all measuring operations. Selection of the measuring attachment depends on the shape of test object surfaces to be measured.

test object measuring face	measuring attachment required
flat	with spherical cap
cylindrical	with knife-edge face
spherical	with flat face

The measuring surfaces of all these measuring attachments are of

carbide metal so that wear is very low. The measuring attachments are pushed on the measuring bolts of measuring sleeve, countersleeve, dial indicator, or spacing elements. When the spherical (contact) face of the measuring attachment has contact with the end face of the measuring bolt, tighten with screw (105).
The weight units (121 Fig. 21) serve for generating the measuring force of 150 p or 250 p. The cord of the weight unit must be fastened to holder (51 Fig. 6 or 38 Fig. 5) of the measuring sleeve according to the type of measuring (inside or outside).
Spacing elements (122 and 123 Fig. 21) connect the measuring sleeve and the correspondingly required measuring attachment in case of outside measuring or serve for fastening the big inside measuring frames in case of inside measuring operations.

3.3. Completing units and elements

3.3.1. Difference measuring device

The difference measuring device serves - especially in case of series measurement - for determining a difference in length with respect to a standard. It consists of a dial instrument MO 1/100 (with lighting and lifting units), and countersleeve to be changed over, one measuring and one sleeve slide, two pairs of inside measuring frames, two gauge block holders, and two measuring legs.
The dial instrument MO 1/100 (165 Fig. 41) operates according to the principle of autocollimation and serves as a measuring element. The graduation which can be watched in the eyepiece (177) travels, when the measuring bolt is moved, along a fixed index and thus permits the deviation between test object and rated value directly to be read.
For outside measuring, the countersleeve to be changed over (171 Fig. 41) holds a measuring attachment, for inside measuring one of the two small or big inside measuring frames whereby it forms the

the fixed reference point required for measuring. The measuring bolt of the countersleeve can be lifted by approx. 8 mm in inside and outside measuring so that the test objects can conveniently be interchanged without varying the adjustment of the instrument.
The measuring slide (163 Fig. 41) carries the dial indicator MO 1/100 (165). This slide is arranged on the left-hand sliding faces (1) of the base bed and locked with screw (176).
The sleeve slide (167 Fig. 41) carries the countersleeve to be changed over (171). It is arranged on the right-hand sliding faces of the basic bed and locked with clampscrew (185).
The inside measuring frames are fastened with clampscrews on the shank of the dial instrument MO 1/100 and of the countersleeve to be changed over. The big fixed inside measuring frame is already one part of the standard equipment of the Universal Horizontal Metroscope.
Gauge block holders and measuring legs, in conjunction with parallel gauge blocks, are used as setting gauges for inside measurement. Gauge blocks and measuring legs are composed in one of the gauge block holders.

3.3.2. Pitch measuring device

The pitch measuring device permits the pitches of inside and outside threads directly to be measured. It can be used together with all base beds of the Universal Horizontal Metroscope having a manufacturing number above 1535.
Layout and use of the pitch measuring device are described in a separate instruction manual (leaflet no. 24-G 1/236-2).

3.3.3. Surface thermometer

The use of surface thermometers is advisable to detect temperature differences between test object and metroscope and to maintain constant reference temperatures during measuring (detailed leaflet no. 24-120-2).

4. Unpacking and erecting the instrument

The Universal Horizontal Metroscope is shipped in two special shipping cases. One of them contains the base bed, the other one the accessories (Fig. 20).
Unpacking and erecting of the instrument require the following operations:

(1) Take off the covers of the two special shipping cases.
(2) Take the accessories (112 Fig. 20) out of the special shipping case, deposit them on a table, carefully take off the protective paper (utmost care is required for optical elements in particular), and use a clean linen cloth to remove the grease from bright parts until only a very thin film is left.
(3) Screw the fastening screws out of the bottom of the special shipping case containing the basic bed.
(4) Take out the basic bed and place it transversely on the special shipping case (not on the ground or on a table).
(5) Screw the three footscrews (8 Fig. 1) in the special shipping case into the free threaded holes of the base bed (15).
(6) Set the base bed with baseplates (9) on the provided table.

Now remove the securing plate for the adjustable object table (3 Fig. 1) which has been marked with red colour as following (Fig. 19):

(7) Loosen fastening screws (210 and 213).
(8) Turn the eccentric rubber disks (209 and 214) that the table plate can be moved.
(9) Entirely unscrew securing screws (203, 204, and 211).
(10) Entirely unscrew securing screws (202, 205, and 212) but hold the small block which is held by the screws in position.
(11) Entirely turn out securing screws (206 and 217).
(12) Push the two knurled screws (207 and 216) upward with your thumbs and lift the total securing plate from the basic bed. Take care that the plate moved with knurled knob (216) does not damage the level (4 Fig. 1) underneath.

The securing plate is attached in the reversed order. Securing elements covered with red lacquer belong to the instrument and must therefore be preserved carefully.

Complete the instrument by attaching the Abbe measuring element and sleeve slide as following:

(13) Attach the Abbe measuring element (116 Fig. 22) from the left on the left-hand sliding face of the basic bed and take care that sliding block (132) is in the slot (17).

(14) Bring the Abbe measuring element approximately into the middle of the left-hand portion of the basic bed.

(15) Tighten clampscrew (43).

(16) Push the sleeve slide (68 Fig. 12) from the right onto the right-hand sliding face (5) of the basic bed. Take care that the sliding block is in appropriate position.

(17) Tighten clamping screw (69).

(18) Push in the sleeve tube (66) approximately to the middle.

(19) Turn the sleeve tube that adjusting screw (64) is directed upward and adjusting screw (70) to the front, i.e. to the observer.

(20) Tighten clampscrew (65).

(21) Fasten the lighting equipment with its knurled ring (34) on the reception of the Abbe measuring element and connect its plug (32 Fig.4) to socket (19 Fig. 2).

The instrument is ready for use after the instrument plug has been connected to the 220 V a.c. socket (21 Fig. 2).

Make sure that the instrument is reliably grounded.

5. Adjusting the measuring attachments

The measuring attachments must be adjusted to avoid heavy measuring errors. This is done after the Abbe measuring element and the countersleeve have been set up.

Adjustment requires the following operations:

(1) Fasten measuring attachments (Fig. 18) by clampscrew (105) to measuring bolts (133 and 63 Fig. 23).

(2) Hold the measuring sleeve (37) with your left hand in position at holder plate (52) and loosen clampscrew (47).

(3) Make the measuring sleeve slowly travel to the right until the two measuring attachments are in contact.

(4) Check whether the measuring sleeve can reliably be moved back in addition by the measuring distance (measuring size of the test object).

If the measuring sleeve moved to the extreme right has not yet contact, proceed as following:

(5) Loosen clampscrew (43).

(6) Carefully shift the Abbe measuring element to the right until the measuring attachments touch each other and the millimeter lines (0, 1, 2, 3, 4, 5, etc) appear in the spiral field within the field of vision of the spiral microscope.

(7) Again tighten clampscrew (43).

If measuring is to be performed with the initial value 0.0000, bring the measuring attachments to contact as following:

(1) Actuate the tangent screw (61 Fig. 7) to set the indexing arrow of the spiral microscope (49) to the value 00 of the circular thousandth graduation (see Fig. 8).

(2) Loosen clampscrew (47 Fig. 23).

(3) Slowly move the measuring sleeve to the right.

(4) Loosen clampscrew (43).

(5) Shift the Abbe measuring element to the right or to the left until the zero line of the graduation in the spiral microscope (49) is inside the spiral field.

(6) Again tighten clampscrew (43).

(7) Actuate setting knob (67) until the zero line of the graduation coincides with 0 of the horizontal tenth graduation and

is symmetrically in the double spiral (see Fig. 8).

5.1. Adjusting the measuring attachments with flat face or knife-edge face

To facilitate the adjustment of measuring attachments with small flat face (diameter 2 mm) or with knife-edge faces, a gauge block with measuring length of 1···3 mm should be arranged between the measuring faces of the abovementioned measuring attachments. Observe one millimeter line in the spiral microscope eyepiece. If the upwards directed adjusting screw (64 Fig. 12) of the sleeve tube (66) is turned, the millimeter line in the field of vision travels from left to right or in opposite direction and changes its direction of travel at a defined position in spite of constant direction of rotation. Adjusting screw must no more be varied (64) if this point of reversal has been found. Thus, the measuring attachments have been adjusted in vertical direction parallel to each other. Analogously adjust horizontally by turning adjusting screw (70).

5.2. Adjusting the measuring attachments with spherical cap

The measuring attachments with spherical cap must be adjusted in the horizontal and vertical planes that the two measuring attachments touch each other approximately in the middle of their measuring faces.
For contact setting, first turn the upwards directed adjusting screw (64 Fig. 12) in the sleeve tube (66) in clockwise or counterclockwise direction and watch the vertical travel of the contact point from the front. Stop turning if the point of contact is approximately in the middle of the two spherical zones. Then perform the same procedure in horizontal direction by turning the adjusting screw (70) and observing from above.

The adjusting procedure can be facilitated, even if a magnifier is used, by white paper held behind or under the measuring attachments.
The measuring attachments with spherical cap can also be adjusted as specified in paragraph 5.1.

6. Setting the initial value

The initial value is that size to be adjusted in the spiral microscope which must be subtracted from the read measured value for calculating the measured length of a test object. This value must newly be defined or determined prior to a measuring operation after any variation in counter sleeve setting or shift of the Abbe measuring element. Any resulting value or the value 0.0000 can be chosen as initial values. The former one results from the corresponding position of the Abbe measuring element relative to the countersleeve position. The advantage is quick adjustment which is possible without shift of Abbe measuring element or countersleeve. However, an initial value differing from zero has the result that the length indicated in the spiral microscope is not directly the length of the object but this length increased by the initial value. If the initial value is 0.0000, the spiral microscope will consequently indicate the measured size of the object directly. Additionally, objects of different lengths (up to 100 mm) can be measured without arithmetical operation if this initial value is used.
After the initial value has been determined, do not shift the measuring element and the countersleeve during a series of measurements and do not vary the adjustments of drive knob (56 Fig. 7) or setting knob (67 Fig. 12).
Before setting the initial value, turn driveknob (56) to make the measuring head (58 Fig. 7) and baseplate (57) coincide that the travelling range of zeroing can be utilized entirely.

6.1. Setting an arbitrary initial value

The following operations are necessary for setting an arbitrary initial value:

(1) Actuate driver knob (60 Fig. 7) or driver plate (61) until the 00 line of the circular thousandth graduation coincides with the indexing arrow (watch the field of vision of the spiral microscope [49] through the eyepiece).
This setting is used to round the initial value to whole millimeters. It is not urgently required but facilitates the following calculation.

(2) Actuate the setting knob (67 Fig. 12) of countersleeve (66) to take the millimeter line coarsely between the double line of the spiral.

(3) Loosen clampscrew (62 Fig. 7).

(4) Turn driveknob (56) to bring the millimeter line symmetrically between the double line of the spiral.

(5) Again tighten clampscrew (62).

(6) Read and log the indicated initial value according to paragraph 9.1.

(7) Retract the measuring sleeve (37 Fig. 6) and tighten it with clampscrew (47).

6.2. Setting the initial value 0.0000

The following operations are necessary for setting the initial value 0.0000 (Fig. 8):

(1) Loosen clampscrew (47 Fig. 6).

(2) Slowly make the measuring sleeve (37) travel to the right,

(3) Loosen clampscrew (43 Fig. 5).

(4) Shift the Abbe measuring element until the measuring attachments touch each other and the zero line of the glass scale (40) is visible in the field of vision of the spiral microscope (49).

(5) Refasten clampscrew (43).

(6) Turn driver knob (60 Fig. 7) or driver plate (61) to adjust the circular thousandth graduation that its 00 line coincides with the indexing arrow.

(7) Turn the setting knob (67 Fig. 12) on the countersleeve (66) to bring the zero line of the millimeter graduation between the double line of the spiral which simultaneously encloses the 0 line of the horizontal tenth graduation.

(8) Loosen clampscrew (62 Fig. 7).

(9) Use driver knob (56) to bring the zero line of the millimeter graduation symmetrically between the double line of the spiral.

(10) Again tighten clampscrew (62).

(11) Move the measuring sleeve (37 Fig. 6) back and clamp it with screw (47).

7. Aligning the test object

The position of measuring faces of a test object relative to the measuring axis influences the measured result. Consequently, the following demands must be met to avoid errors:

(1) The flat parallel measuring faces (inside or outside) of a test object must horizontally and vertically be perpendicular to the axis of measurement.
Therefore, find the point of reversal in the horizontal plane according to paragraph 7.1.1. and in the vertical plane according to paragraph 7.2.1.

(2) In cylinder measurements (inside or outside) the axis of measurement must pass through the center of curvature and the axis of the cylinder must be perpendicular to the axis of measurement.
Consequently, find the point of reversal according to paragraph 7.1.2. for vertically held cylinders and according to paragraph 7.2.2. for horizontally held ones.

(3) In case of test objects with spherical measuring faces, the axis of measurement must pass through the center or centers of curvature.
Consequently, align the test object horizontally and vertically according to paragraph 7.3. that the points of contact are approximately in the middle of the flat faces of measuring attachments.

7.1. Point of reversal at horizontal positioning

7.1.1. Test objects with flat parallel faces of measuring and horizontally positioned cylinders

The following operations are required for aligning these objects in the horizontal plane:

(1) Loosen clampscrew (47 Fig. 24).

(2) Make the measuring sleeve (37) slowly travel to the right (for outside measurement) or to the left (for inside measurement) until measuring sleeve and countersleeve touch the object.

(3) Actuate lever (26) to bring the adjustable object table (3) in the horizontal plane to the right or to the left. This shifts the measuring sleeve (37) axially. This movement becomes clearly visible by the travel of millimeter lines of the glass scale in the eyepiece of the spiral microscope (49).

(4) Stop the movement when you find that point in the field of vision at which the millimeter lines reverse their direction of travel (point of reversal).

The measured faces of the test object are now horizontally perpendicular to the axis of measurement.

7.1.2. Vertically positioned cylinders and bores

The following operations are required for aligning these objects in the horizontal plane:

(1) Loosen clampscrew (47 Fig. 24).

(2) Make the measuring sleeve (37) slowly travel to the right (for outside measurement) or to the left (for inside measurement) until measuring sleeve and countersleeve (66) touch the test object.

(3) Turn setscrew (29 Fig. 26) to shift the adjustable object table in y-direction until the measuring attachments touch the cylinder at its vertices (diameter) and the points of contact are

in the middles of knife edges or flat faces.

The following operations are advisable since the point of contact between cylindrical object and measuring attachment is not easily visible if measuring attachments with small knife edge (107 Fig. 18) or flat face with diameter of 2 mm are used:

(4) Turn setscrew (29 Fig. 24) while observing the movement of millimeter lines of the glass scale in the eyepiece of the spiral microscope (49).

(5) Stop the turning movement of the setscrew when the millimeter lines stop (cylinder touches the knife edge or flat face of the measuring attachments).

(6) Use the graduation of setscrew (29) to determine the length of the distance within which the millimeter lines stand still.

(7) Turn the setscrew by half the length of this distance in clockwise or counterclockwise direction.

The vertices of the cylindrical object to be measured now touch the middles of the flat faces or knife-edge faces.

7.2. Point of reversal in the vertical plane

7.2.1. Test objects with flat parallel faces of measuring, cylinders in vertical position, and bores

The following operations are required for aligning these objects in the vertical plane:

(1) Loosen clampscrew (47 Fig. 24).

(2) Make the measuring sleeve (37) slowly travel to the right (for outside measurement) or to the left (for inside measurement) until measuring sleeve and countersleeve (66) touch the object to be measured.

(3) Loosen clamping lever (27).

(4) Carefully move lever (28) while watching the travel of millimeter lines in the eyepiece of the spiral microscope (49).

(5) Stop to move lever (28) when the millimeter lines reverse their

direction of travel (point of reversal).

(6) Secure this position of the adjustable object table (3) by actuating the clamping lever (27).

The measured faces of the object are now vertically perpendicular to the axis of measurement.

7.2.2. Cylinders in horizontal position

The following operations are required for aligning these objects in the vertical plane:

(1) Loosen clampscrew (47 Fig. 27).

(2) Make the measuring sleeve (37) slowly travel to the right until measuring sleeve and countersleeve touch the test object.

(3) Actuate handwheel (12) to set the adjustable object table in height until the measuring attachments touch the cylinder at its vertices (diameter) and the points of contact are in the middles of knife edges or flat faces.

The following operations are advisable since the point of contact between cylindrical object and measuring attachment is not easily visible if measuring attachments with small knife edge (107 Fig. 18) or flat face with diameter of 2 mm are used:

(4) When turning handwheel (12 Fig. 27), watch the movement of millimeter lines of the glass scale in the eyepiece of the spiral microscope.

(5) Stop to turn the handwheel when the millimeter lines stop (cylinder touches the knife edge of flat face of measuring attachments).

(6) Use the survey graduation (11) to determine the length of the distance within which the millimeter lines stand still.

(7) Turn handwheel (12) by half the amount of this distance in clockwise or counterclockwise direction.

The vertices of the cylindrical object to be measured now touch the middles of the flat face or knife edge.

7.3. Aligning the test object with spherical faces of measuring

The following operations are required for aligning these objects:

(1) Loosen clampscrew (47 Fig. 23).

(2) Make the measuring sleeve (37) slowly travel to the right (hold it by its holder plate [52]) until the measuring attachments of the measuring sleeve and countersleeve touch the object.

(3) Actuate setscrew (29) until the adjustable object table (3) has been shifted transversely to the direction of measuring that the contact points between test object and measuring attachments viewed from above are approximately in the middle (axis of measuring) of the measuring faces of both measuring attachments.

(4) Actuate handwheel (12) to lift or lower the test object until the points of contact viewed from the front are again in the middle of the measuring faces of both measuring attachments.

Operations (3) and (4) can be facilitated if white paper is held behind or under the points of contact or a magnifier is used.

8. Measuring the test object

8.1. Spiral microscope indication

When the lighting equipment (36 Fig. 5) is switched on, graduations and figures (Fig. 8···11) mentioned in paragraph 3.2.2., "Spiral microscope", are visible in the eyepiece of the spiral microscope (Fig. 7). For setting the spiral microscope to the value of measuring, the eyepiece has two graticules:

(1) a stationary graticule with

a) a thick horizontal double line in whose range the corresponding scale line is symmetrically set between a double line of the spiral and read,

b) a tenth graduation numbered from left to right from 0 to 10 for indication of tenths of a millimeter,

c) an indexing arrow for the circular graduation;

(2) a rotary graticule (axis of rotation outside the field of vision) with

a) a circular graduation of 100 intervals, numbered at every five graduation lines, for indicating the hundredth and thousandth parts of a millimeter,

b) a double-lined Archimedes' spiral rotating with the circular graduation; its ten double turns have a spiral lead of the apparent size of 0.1 mm.

Two of the big, vertical, and numbered millimeter lines of the scale graduation are always (except in case of zeroing and up to approx. 0.4 mm) in the field of vision of the spiral microscope. The value to be read is indicated by the millimeter line in the spiral field. This millimeter line must be set symmetrically between the double line of the spiral by actuation of driver knob (60 Fig. 7) or driver plate (61). This symmetrical setting must always be performed within the horizontal tenth graduation numbered from 0 to 10. The position of the millimeter line within the tenth graduation then informs about the value of tenths of a millimeter. Use the smaller of the two values between which the millimeter line is situated. In case of doubt, consider the position of the indexing arrow for hundredths and thousandths.

8.2. Sequence of reading

Reading is possible after the millimeter line of the glass scale in the spiral field has been set symmetrically between the double line of the spiral, i.e. coarsely with driver knob (60 Fig. 7) and sensitively with driver plate (61). The reading sequence is as following:

reading	description	examples of reading Fig. 8	Fig. 9	Fig. 10	Fig. 11
1st partial reading	Reading of whole millimeters This is the number whose pertaining millimeter line is symmetrically enclosed by the double line of the spiral.	0	37	53	94
2nd partial reading	Reading of tenths of a millimeter They are indicated by the lower of the two possible figures of the tenth graduation or, at coincidence with the tenth line, by its figure.	0.0	0.0	0.1	0.9
3rd partial reading	Reading of hundredths and thousandths They result from the spiral position and are indicated by the indexing arrow on the circular graduation.	0.000	0.000	0.075	0.099
4th partial reading (estimation)	Estimation of fractions of thousandths They result from the position of the indexing arrow between two thousandth lines of the circular graduation.	0.0000	0.0008	0.0005	0.0003
Total reading	Estimated values in brackets	0.000(0)	37.000(8)	53.175(5)	94.999(3)

The total reading is equal to the measured size if the selected initial value was 0.0000 (in case of outside measurement) or the actual value of the setting ring (in case of inside measurement).
In case of any other initial value, the measured size is the difference between total reading and initial value.
Several repetitions of the measuring operation with following averaging permit the measured size to be determined with higher precision. If a correction due to existing scale errors is necessary, correct this average.

8.3. Considering scale errors

Every instrument is equipped with a test certificate for the glass scale. It informs about the tenthousandths of a millimeter by which the graduation lines differ from their rated value (distance to scale line zero).
When measuring with the initial value 0.0000, take the error listed for the corresponding millimeter line in the spiral field from the table of the test certificate and add it to the total reading in consideration of the sign.

Examples:

mean read value [mm]	error according to test certificate [0.1 µm]	mean corrected value [mm]
37.0008	+ 3	37.0011
53.1755	+ 10	53.1765
94.9993	- 12	94.9981

When measuring with an initial value differing from zero, arithmetical errors should be avoided by correcting the read values according to the test certificate before the differences are calculated.

Example:

mean read value [mm]		error according to test certificate [0.1 µm]	mean corrected value [mm]
measured value	98.6439	+ 9	98.6448
initial value	13.2965	- 11	13.2954
difference			85.3494

9. Outside measurement

Outside measurement requires the following equipment:

Basic bed

Adjustable object table

Abbe measuring element

Countersleeve

Short or long spacing element

Weight unit for measuring force of 150 p or 250 p

2 measuring attachments with spherical zone
(for objects with flat parallel faces of measuring)

2 measuring attachments with flat face of 2 mm, 8 mm, or 14 mm in diameter
(for objects with spherical faces of measuring)

2 measuring attachments with small or big knife edge
(for cylindrical objects)

in case of need:

Clamps

Packing gibs

Gauge blocks
(In case of measured sizes above 100 mm, the glass scale of the measuring sleeve is connected to the gauge block.)

9.1. Test objects with flat parallel or spherical faces of measuring and cylinders in vertical position

For measuring objects with flat parallel faces of measurement, objects with spherical faces, and cylindrical objects in vertical position, complete the equipment for the instrument erected according to paragraph 4. as following:

(1) Fasten the short (123 Fig. 21) or long (122) spacing element with cap nut (39 Fig. 5) to measuring sleeve (37). The long spacing element is in general used for smaller sizes to be measured since the measuring element need not be shifted to the right so far during setting-up and the adjustable object table

can be brought into a higher position.

(2) Clean measuring bolts (133 and 63 Fig. 23) and measuring attachments (Fig. 18) with benzine. (Take care that the front faces of the measuring bolts and the spherical faces at the bore end of measuring attachment are absolutely clean that measuring errors due to non-reliable contact are avoided.)

(3) Slip on the required measuring attachments and fasten them with clampscrew (105) on the measuring bolts.

(4) Hang the desired weight unit (122 Fig. 21) for measuring force of 150 p or 250 p on holder (51 Fig. 6).

(5) Arrange the cord of the weight unit on rollers (50 and 53) and allow the weight to hang free.

After having composed the required equipment, arrange the object to be measured:

(6) Bring the adjustable object table (3 Fig. 23) transversely to the direction of measurement approximately into middle position. This means that setscrew (29) should be set between 10 and 15 (middle position = 12.50).

(7) Use benzine to clean the table plate and the object faces to be measured.

(8) Arrange the packing gibs (131 Fig. 24) longitudinally or transversely to the measuring direction on the table plate. (They are required only in case of small lengths to be measured or if the object is to be measured nearly up to the contact face.) Rings (Fig. 25) are suitable as packing elements for balls, prisms for cylindrical objects with spherical end faces.

(9) Arrange the object approximately in the middle of the table or on the packing gibs or on other packing elements.

(10) Fasten the object by means of clamps (118 Fig. 24) which are adjustable in the slots (25 Fig. 3). Lightweight objects must be fastened particularly well while it is sometimes possible to leave heavy objects unfastened.

(11) For uniformly setting the object table height even in case of heavy objects (up to 7 kg), turn the small handwheel (7 Fig. 23) clockwise until the movement in height is easy and smooth when handwheel (12 Fig. 1) is actuated for lifting and lowering the adjustable object table. Clampscrew (13) must be released beforehand.

(12) Adjust the table in height so that the measuring faces of the test object have the same height as the measuring attachments.

(13) Lock this special height position of the adjustable object table (3) by turning clampscrew (14) in clockwise direction.

The following operations are necessary for setting-up the Abbe measuring element and the countersleeve:

(14) Bring the table plate into its middle position, i.e. shift it in the direction of measurement that the upper line of index mark (30 Fig. 24) is approximately in the middle between the lower two lines.

(15) Lock measuring sleeve (37) with clampscrew (47).

(16) Loosen clamping knob (69 or 65 Fig. 12).

(17) Shift sleeve slide (68) or sleeve tube (66) or both until the measuring attachment touches the right-hand measuring face of the object.

(18) Again tighten clamping knob (69 or 65).

(19) Turn handwheel (12) to lower the adjustable object table (3 Fig. 1) until the object to be measured is under the measuring sleeve (37 Fig. 23). Take it from the object table if it is so big that it is still in the range of adjustment of the measuring sleeve even in the lowest position of the object table.

(20) Loosen clampscrew (47), take holder plate (52), and make the measuring sleeve (37) slowly run to the right.

(21) Adjust the measuring attachments according to paragraph 5.

(22) Set the initial value according to paragraph 6.

(23) Reattach and fasten the object according to operations (9) and

(10) if it had to be removed according to operations (19).

(If possible, bring the object into its initial position.)

Measuring requires the following additional operations:

(24) Align the faces of measurement according to paragraph 7.

(25) Determine the size of measurement according to paragraph 8.

9.2. Cylindrical objects in horizontal position

The location of cylindrical objects in horizontal positions requires the equipment to be completed by the center stand (Fig. 13). This center stand permits centered cylindrical objects - maximum diameter 200 mm, maximum length of cylinder 80 mm, maximum center distance 200 mm - to be held and measured. Measurement of cylindrical objects requires the instrument erected according to paragraph 4. to be completed as following:

(1) Use handwheel (12 Fig. 1) to bring the adjustable object table (3) into its highest position. Loosen clampscrew (13) beforehand.

(2) Insert workholding centers (73 Fig. 13) in the center stand (74) and fasten them with clampscrews (72).

(3) Turn fastening screws (77) clockwise up to stop.

(4) Place the center stand on the adjustable object table (axis of workholding centers transversely to the axis of measuring) and tighten fastening screw (77).

(5) The center stand must easily be movable in the direction of measuring after fastening.

(6) Fasten the short (123 Fig. 21) or long (122) spacing element with cap nut (39 Fig. 27) on the measuring sleeve (37).

(7) Use benzine to clean the measuring bolts (133 and 63 Fig. 23) and measuring attachments (Fig. 18).

(8) Not applicable.

(9) Push a measuring attachment with big (106 Fig. 18) or small knife edge (107) on each of the two measuring bolts that the

knife edges are perpendicular to the cylinder jacket lines.

(10) Fasten the measuring attachments with their clampscrew (105).

(11) Suspend the desired weight unit (121 Fig. 21) for measuring force of 150 p or 250 p from holder (51 Fig. 6).

(12) Arrange the cord of the weight unit on rollers (50 and 53) and allow the weight to hang free.

After the equipment has been composed, locate the object to be measured as following:

(13) Loosen clampscrews (72 Fig. 13).

(14) Shift the workholding centers (73) until the centered cylindrical object can conveniently arranged between the workholding centers.

(15) Fasten the object between the solid (75) or hollow (76) centers.

(16) Shift the workholding centers together with the test object until the point to be measured on the cylinder is in the axis of measurement.

(17) Retighten clamping screws (72). Make sure that the object can rotate about its axis easily but without axial backlash.

(18) For uniformly setting the object table height (and, thus, the center stand fastened on it) even in case of heavy objects (up to 7 kg), turn the small handwheel (7 Fig. 27) clockwise until the movement in height is easy and smooth when handwheel (12) is actuated for lifting and lowering the adjustable object table.

(19) Adjust the table height that the measured distance approximately passes through the center of cylinder curvature.

The following operations are required for setting-up the Abbe measuring element and the countersleeve:

(20) Bring the table plate into its middle position, i.e. shift it in the direction of measuring that the upper line of index mark (30 Fig. 3) is approximately in the middle between the lower two lines.

(21) Lock the measuring sleeve (37 Fig. 27) with clampscrew (47).
(22) Loosen clampscrews (69 or 65).
(23) Shift the sleeve slide (68) or sleeve tube (66) or both until the measuring attachment touches the right-hand face of measurement of the object.
(24) Retighten clampscrews (69 or 65).
(25) Lower the adjustable object table (3 Fig. 1) by turning handwheel (12) until the object is under the measuring sleeve (37 Fig. 27). The object must be taken out of the center stand (74) if it is so big that it is still in the range of adjustment of the measuring sleeve even in bottom position of the object table.
(26) Loosen clampscrew (47), take holder plate (52 Fig. 5), and make the measuring sleeve (37) slowly run to the right.
(27) Adjust the measuring attachments according to paragraph 5.
(28) Adjust the initial value according to paragraph 6.
(29) Again fasten the object in the center stand if it had to be removed according to operation (26). If possible, bring the object again into its initial position.

Measuring requires the following additional operations:

(30) Align the object according to paragraph 7.
(31) Determine the cylinder diameter (size of measurement) according to paragraph 8.

10. Inside measurement

Inside measurements are possible only as difference measurements above 10 mm. This means that the measuring instrument must be set up prior to measurement relative to a reference or setting standard. This is done for the Universal Horizontal Metroscope with a setting ring whose bore diameter has been stated down to 0.1 µm (with possible measuring error or ± 0.5 µm).

10.1. Objects with flat parallel faces of measurement and bores

This kind of inside measurement requires the following equipment:

Basic bed
Adjustable object table
Abbe measuring element
Countersleeve (for big inside measuring frames)
Adjustable sleeve (for small inside measuring frames)
Setting ring, diameter 50 mm
Small inside measuring frames
(for measured lengths above 10 mm at maximum depth of insertion of 12 mm)
Big inside measuring frames
(for measured lengths above 30 mm at maximum depth of insertion of 50 mm)
Short spacing element (for small inside measuring frames)
Long spacing element (for big or small inside measuring frames)
Weight unit for measuring force of 150 p or 250 p
in case of need:
Clamps
Packing gibs

For inside measurement on objects with flat parallel faces of measuring and bores, complete the equipment composed according to paragraph 4. as following:

(1) Fasten the short (123 Fig. 21) or long (122) spacing element with cap nut (39 Fig. 5) on the measuring sleeve (37).
(2) Slip the big inside measuring frames (130 Fig. 29) on the long spacing element at the measuring sleeve and the countersleeve tube and fasten them with clampscrews (139).

Measurement with the small inside measuring frames requires the following additional preparations:

(3) Loosen clampscrew (65 Fig. 12).
(4) Extract sleeve tube (66) from sleeve slide (68).
(5) Arrange the adjustable sleeve (Fig. 38) for the small inside

measuring frames in the sleeve slide that index mark (149) is upward directed.

(6) Slip the small inside measuring frames (128 Fig. 28) on the measuring bolt of measuring sleeve (37) and on the measuring bolt of the adjustable sleeve (127) that clampscrew (137) is facing toward the observer and the frame opening is downward directed.

(7) Align the inside measuring frames so that nose (135) is in the milled portion (136).

(8) Tighten clampscrews (137).

We supply the adjustable sleeve for small inside measuring frames with adjustment to the center of the corresponding instrument. The adjustment must be checked or the sleeve readjusted only in case of subsequent supply or after setting of adjusting screws (64 and 70). This is done as following:

(9) Loosen clampscrews (144 Fig. 35).

(10) Take measuring insets (145) out of frames (128).

(11) Mutually approach the measuring frames as close as possible to bring their bores to alignment.

(12) Fasten an arbour with diameter 1.5 mm h 6 in the bore of the left-hand frame and slightly tip on the right-hand frame to find the direction into which adjustment is necessary.

(13) Adjust the sleeve by actuating the four screws (150 Fig. 38). Every two opposing adjusting screws (upper and lower for height, frontal and rear for lateral direction) must be actuated at the same time and in the same direction of rotation.

(14) Stop the adjustment if the mandrel fastened in the left-hand measuring frame can easily be introduced into the free bore of the right-hand measuring frame.

(15) Take out the arbour, again insert measuring attachments (145 Fig. 35), and fasten them by clampscrews (144).

Fore bore measurement, check the measuring frame adjustment by measuring two setting rings (first with diameter 14 mm, then with diameter 50 mm). These two measuring operations require the temperature to be considered. The resulting corrected measured value must not differ from the value engraved on the measured setting ring by more than ± 1.5 µm. Otherwise repeat the adjustment of measuring frames, i.e. operations (9) to (15).

(16) Suspend the desired weight unit (121 Fig. 21) for measuring force of 150 p or 250 p from holder (38 Fig. 5).

(17) Arrange the cord of the weight unit on rollers (50 and 53 Fig. 6) and allow the weight to hang free.

Attach the setting ring after the required equipment has been composed:

(18) Fasten packing gibs (131 Fig. 28) on the adjustable object table.

(19) Apply the well cleaned setting ring (129) approximately in the table center to the packing gibs (131) that index lines (138) point into the direction of measuring.

(20) Fasten the setting ring with clamps (118).

(21) For uniformly setting the object table in height even in case of heavy objects (up to 7 kg), turn the small handwheel (7 Fig. 1) until the movement in height is easy and smooth when handwheel (12) is actuated for lifting and lowering the adjustable object table. Loosen clampscrew (13) beforehand.

The following operations are required for setting-up the Abbe measuring element and the countersleeve:

(22) Actuate handwheel (12) to bring the adjustable object table (3 Fig. 23) into its lowest position.

(23) Move the measuring sleeve (37) to the right that the inside measuring frames are absolutely free to be inserted in the bore of the setting ring when the object table is lifted.

(24) Lock the measuring sleeve (37) with clampscrew (47).

(25) Turn handwheel (12) to bring the setting ring into the neces-

sary height position. Secure with clampscrew (13 Fig. 1).This height position must be selected so that the measuring operation is performed approximately in the middle of the setting ring since the engraved value refers to the diameter in the middle third of the ring.

(26) Bring the table plate into its middle position, i.e. shift it in the direction of measuring that the upper line of index mark (30 Fig. 29) is approximately in the middle between the the lower two lines.

(27) Loosen clampscrew (69 Fig. 12).

(28) Shift the sleeve slide with sleeve and inside measuring frame that the measuring face of the right-hand measuring frame is touching the right-hand bore wall of the setting ring.

(29) Retighten clampscrew (69).

(30) Loosen clampscrew (47 Fig. 6), take holder plate (52), and make the measuring sleeve slowly travel to the left until the measuring face of the left-hand inside measuring frame is touching the left-hand bore wall of the setting ring.

(31) Align the faces of measurement of the setting ring (corresponding to the test object) according to paragraph 7.

(32) Analogously adjust the actual value of the setting ring (corresponding to the initial value) according to paragraph 6.

After having adjusted the actual value of the setting size as initial value, the Abbe measuring element (116 Fig. 23) and the countersleeve (66) must no more be shifted during a series of measurements and the driver knob (56 Fig. 7) and setting knob (67 Fig. 23) no more varied in position.

(33) Move the measuring sleeve (37) back and lock it with clampscrew (47).

(34) Take off setting ring (129 Fig. 28) and apply and fasten the object to be measured in accordance with operations (19) to (21).

The following additional operations are required for measuring:

(35) Align the measuring faces of the test object according to paragraph 7.

(36) Determine the size of measuring of the object according to paragraph 8. in consideration of the actual value of the setting gauge.

10.2. Bore measuring by means of measuring equipment with magic eye

Inside measurement by means of the measuring equipment with magic eye requires the following equipment:

Basic bed
Adjustable object table
Abbe measuring element
Electrically insulated table
Measuring equipment with magic eye
Carrier arm with measuring ball insets
Conical inset for reducing the table bore (for measuring very small rings)

For such inside measurement, erect the instrument according to paragraph 4.. and complete it in the manner described hereafter:

The sequence of operations depends on the fact whether the measuring balls for measurements are introduced into the object bore from above or from below.

measuring ball introduced into the bore from above	operation	measuring ball introduced into the bore from below
Turn handwheel (12 Fig. 30) to lift the adjustable object table until the upper end of its vertically sliding slide has approximately the same height as the upper end of the prismatic guide.	(1)	Turn handwheel (12 Fig. 30) to bring the adjustable object table into its lowest position.

measuring ball introduced into the bore from above	operation	measuring ball introduced into the bore from below
Screw back the fastening screw (87) of the electrically insulating table (Fig. 14).	(2)	Fasten the long spacing element (122 Fig. 21) with cap nut (39 Fig. 30) on measuring sleeve (37).
Carefully apply the electrically insulated table to the table plate of the adjustable object table. Level (84) is directed to the front.	(3)	Introduce the measuring ball inset (Fig. 16) required for measuring into the holder bore (98 Fig. 17) of the carrier arm and tighten it well with fastening screw (96 Fig. 17).
Tighten fastening screw (87). The points of screws (85) must pass into the slots (18 Fig. 2) of the adjustable object table.	(4)	Push the carrier arm with its bore (99) on the long spacing element that the measuring ball is upward directed. Fasten with clampscrew (100).
Introduce the shank of carrying column (90 Fig. 15) of the indicating device up to stop into holder bore (24 Fig. 2) and fasten it with clampscrew (23) released beforehand in case of need.	(5)	Screw back the fastening screw (87 Fig. 30) of the electrically insulated table (Fig. 14).
Push pin plug (91 Fig. 15) into receptacle (78 Fig. 14) in the electrically insulated table and the screwable plug (92 Fig. 15) into socket (19 Fig. 2) and screw it.	(6)	Carefully - to protect the measuring ball from damage - apply the electrically insulated table from above to the adjustable object table. Level (84) is directed to the front.

measuring ball introduced into the bore from above	operation	measuring ball introduced into the bore from below
Fasten the long spacing element (122 Fig. 21) with cap nut (39 Fig. 30) on measuring sleeve (37).	(7)	Tighten fastening screw (87). The points of screws (85) must pass into the slots (18 Fig. 2) of the adjustable object table.
Introduce the measuring ball inset (Fig. 16) required for measuring into holder bore (98 Fig. 17) of the carrier arm and tighten it well with fastening screws (96 Fig. 17).	(8)	Release table locking by actuating clamping lever (27 Fig. 30).
Push the carrier arm with its bore (99) on the long spacing element that the measuring ball is downward directed, and fasten with clampscrew (100).	(9)	Actuate the lever for table tilt (28) to level the electrically insulated table according to level (84).
Release table locking by actuating clamping lever (27 Fig. 30).	(10)	Lock this table position with clamping lever (27).
Actuate the lever for table tilt (28) to level the electrically insulated table according to level (84).	(11)	Turn handwheel (12) to bring the table into its highest possible position. Fastening screw (96 Fig. 17) must be supported on the table plate of the adjustable object table.
Lock this table position with clamping lever (27).	(12)	Limit this movement in height toward the upper end by tight-

measuring ball introduced into the bore from above	oper-ation	measuring ball introduced into the ball from below
		ening clampscrew (14 Fig. 1) to prevent the carrying arm from running against the table plate if handwheel (12) is actuated later on.
Loosen clampscrew (47).	(13)	Introduce the shank of carrying column (90 Fig. 15) of the indicating device up to stop into holder bore (24 Fig. 2) and fasten it with clampscrew (23) released beforehand in case of need.
Shift measuring sleeve (37) and turn setscrew (29) until the measuring ball is approximately in the middle of table plate (79) in the directions x and y.	(14)	Push pin plug (91 Fig. 15) into receptacle (78 Fig. 14) in the electrically insulated table and the screwable plug (92 Fig. 15) into socket (19 Fig. 2) and screw it.

After the required equipment has been composed, attach and center the object to be measured:

(15) Use benzine for thoroughly cleaning the test object, table surface (79 Fig. 30), and measuring ball inset (Fig. 16) to warrant reliable electric contact when the measuring ball inset is touching the test object.

(16) Apply and coarsely center the test object (i.e. bring the measuring ball approximately into the bore axis), and fasten it well with clamps (118 Fig. 30).

(17) Actuate handwheel (12) to set the object in height that the measuring ball is approximately on the level of half the bore height.

(18) Lock this position in height with clampscrew (13).

(19) Loosen clampscrew (47).

(20) Actuate tangent screw (35) to make the measuring ball touch the bore wall.

(21) The magic eye (89 Fig. 15) indicates the contact: the four light green wedges first begin to flicker and grow when the measuring ball is moved on.

(22) Turn tangent screw (35 Fig. 30) through a very short distence into opposite direction until the light wedges have again become smaller.

(23) Turn setscrew (29) until the magic eye responds, i.e. until the measuring ball has contact with the bore wall. It is advisable to set only a very light contact between measuring ball and bore wall (magic eye is flickering only) to avoid the risk of shifting the test object or breaking the small measuring ball.

(24) In this contact position, read and log the value indicated by setscrew (29).

(25) Carefully turn the setscrew into opposite direction until the magic eye again responds (flickers).

(26) Read and log also this value.

(27) Calculate the mean value of the two readings.

(28) Adjust setscrew (29) to this value.

The test object has thus been centered. This means that the line of measurement passes through the bore center. The very measuring operation requires the following additional operations:

(29) Actuate tangent screw (35) to establish the necessary contact between measuring ball and object wall (magic eye is brought to response).

(30) In this position, set the spiral microscope (49) according to paragraph 8., read it, and log and correct the value.

(31) Turn the tangent screw (35) into opposite direction up to con-

tact with the opposite end of the object bore, i.e. until the magic eye responds again.

(32) Again set the spiral microscope (49), read it, and log and correct the value.

(33) Calculate the bore diameter of the test object. It results from the difference of the two corrected readings plus the measuring ball diameter.

The following example serves for illustrating the operations (30), (31), and (32):

setting	reading	scale error for line ( )	corrected reading
1	85.3176 mm	(85) + 0.0002 mm	85.3178 mm
2	71.8742 mm	(71) - 0.0005 mm	71.8737 mm
difference between corrected readings			13.4441 mm
diameter of the measuring ball used			2.9438 mm
bore diameter of the measured object			16.3879 mm

11. Thread measuring

11.1. External threads

The effective diameter of external threads is measured with the "three wire measuring method".

In this case of measurement, flat parallel measuring faces are used for measuring the distance generated by tangential planes which are applied to the measuring wires and which are parallel to the axis of thread and to each other. This distance is the test size M or the M-value. Our thread chart leaflet 24-T 125-2 contains charts with the M-values for the most commonly used standardized threads and all theoretical fundamentals for the three wire measuring method as well as instructions for calculating the required measuring wire diameter and M-values for threads which are not listed in the chart leaflet.

For the Universal Horizontal Metroscope, thread measuring wires with

eyelets (143 Fig. 32) are used. The measuring wire diameter which depends on the type and pitch of threads to be measured will be found in the thread chart leaflet.

External thread measuring requires the following equipment:

Basic bed

Adjustable object table

Abbe measuring element

Countersleeve

Long spacing element

Weight unit for measuring force of 150 p or 250 p

Center stand

Holder for measuring wires

Measuring attachment with flat face of 8 mm diameter

Measuring attachment with flat face of 14 mm diameter

Thread measuring wires with eyelets

Gauge blocks in case of need.
(In case of measured sizes above 100 mm, the glass scale of the measuring sleeve is connected to gauge blocks.)

External thread measurement requires the instrument to be erected according to paragraph 4. and to be completed as following:

(1) to (7): analogously to paragraph 9.2.

(8) Push the measuring attachment with flat face of 8 mm diameter (103 Fig. 33) on the measuring bolt of the long spacing element (122) and the measuring attachment with flat face of 14 mm diameter (102) on the measuring bolt of sleeve tube (66).

(9) Not applicable.

(10) to (29): analogously to paragraph 9.2.

Fastening of the thread measuring wires requires the following operations:

(30) Move the measuring sleeve (37 Fig. 23) to the left and tighten it with clampscrew (47).

(31) Push holder bars (142 Fig. 33) into the corresponding bores of measuring wire holders (120) and fasten them with clampscrews

(141).

(32) Push one measuring wire holder each on the long spacing element (122) at the measuring sleeve and on the sleeve tube (66) of the countersleeve.

(33) Suspend the thread measuring wires with eyelets (143) required for measuring from holder bars (142) on the measuring wire holders so that the single measuring wire hangs close to the measuring attachment with flat face of 8 mm diameter.

(34) Actuate handwheel (12 Fig. 1) to set the adjustable object table that the threaded object is touched approximately by the centers of measuring faces of the measuring attachments whereby the line of measuring passes through the center of curvature.

(35) Move the center stand with object to be measured to the right and bring the two thread measuring wires hanging in front of the flat face of the 14-mm measuring attachment (102 Fig. 33) into to adjacent thread gaps.

(36) Loosen clampscrew (47 Fig. 23).

(37) Make the measuring sleeve (37) slowly travel to the right.

(38) Introduce the single measuring wire into that thread gap of the object which opposes the two others in the middle.

(39) Let the measuring attachment with 8-mm flat face and the measuring attachment with 14-mm flat face touch the measuring wires in the test object.

The following additional operations are required for measuring:

(40) Align the test object according to paragraph 7.

(41) Determine the effective diameter = M-value (size to be measured) according to paragraph 8.

In case of errorless effective diameter, the measured M-value must correspond to the value found in the thread chart leaflet 24-T 125-2 and corrected. Deviations from the theoretical M-value can normally be regarded with sufficient accuracy as deviations of the

effective diameter from the rated value if the errors of thread angle and thread lead are in their normal limits.

11.2. Internal threads

The effective diameter of internal threads is measured as a difference with the two ball measuring method.

With this measuring method, the deviation of the test object from the value "X" is determined. This "X-value" represents the distance between two outer thread angles opposing each other with offset of half the amount of lead. This value has an indirect relation to the effective diameter.

Measurement of internal threads requires an additional internal thread measuring equipment. The initial value is set by means of a setting gauge used as a reference and setting prototype and composed of block gauges and V-type gauges.

The measurement of internal threads requires the following equipment:

Basic bed

Adjustable object table

Abbe measuring element

Countersleeve

Short or long spacing element

Weight unit for measuring force of 150 p

Small inside measuring frames

Sleeve for small inside measuring frames

Big inside measuring frames

Internal thread measuring equipment

consisting of

- Attachable table for internal thread measuring with object clamps
- V-type gauge holder no. 1
- 1 pair of V-type gauges 55° (special order)
- 1 pair of V-type gauges 60°

5 pairs of thread measuring balls for small inside measuring frames, namely

1 pair, diameter 0.8 mm (short layout), only for difference measurement relative to thread gauge rings with minor diameters above 11 mm

1 pair, diameter 0.8 mm (long layout), for direct and difference measurement for minor diameters above 14 mm

1 pair, diameter 1.35 mm, for direct and difference measurement with minor diameter above 13 mm

1 pair, diameter 1.8 mm, for direct and difference measurement with minor diameter above 16 mm

1 pair, diameter 2.3 mm, for direct and difference measurement with minor diameters above 18 mm

6 pairs of thread measuring balls for big inside measuring frames, namely

1 pair, diameter 0.8 mm (short layout), only for difference measurement relative to thread gauge rings with minor diameters above 31 mm

1 pair, diameter 0.8 mm (long layout), for direct and difference measurement with minor diameters above 35 mm

1 pair, diameter 1.35 mm, for direct and difference measurement with minor diameters above 35 mm

1 pair, diameter 1.8 mm, for direct and difference measurement with minor diameters above 35 mm

1 pair, diameter 2.3 mm, for direct and difference measurement with minor diameters above 35 mm

1 pair, diameter 3.175 mm, for direct and difference measurement with minor diameters above 38 mm

For the measurement of internal threads, erect the instrument according to paragraph 4. and complete it as following:

(1) Place the attachable table for internal thread measurement (111 Fig. 37) on the table plate of the adjustable object table.

(2) Tighten fastening screw (147) which must be directed to the right.

(3) Fasten the short (123 Fig. 21) or long (122) spacing element (depending on the type of inside measuring frames, namely the short or the long ones, which are used for measuring) on the

measuring sleeve (37 Fig. 37).

(4) Select the small or the big inside measuring frames (128 or 130 Fig. 21).

(5) Loosen clampscrew (144 Fig. 35) on the inside measuring frames.

(6) Substitute thread measuring balls (145) for standard measuring insets. The required measuring ball diameter will be found in the thread charts (paragraph 14.) or can be calculated with the following formula:

$$d_K\,[mm] = \frac{P}{2}\,[mm]\cos\frac{\alpha}{2}$$

wherein

P [mm] = thread lead

α [°] = thread angle

(7) Again tighten clampscrew (144).

(8) Push the small inside measuring frames on the measuring bolt of the small spacing element and of the sleeve for small measuring frames or the big inside measuring frames on the long spacing element and on the sleeve tube of the countersleeve. Clampscrews (137 or 139 Fig. 29) must be directed upward, the frame openings to the front.

Compose and attach the setting gauge as following:

(9) Fasten one pair of V-type gauges (55° or 60° according to the thread angle to be measured) and one gauge block with measuring length of 20···50 mm in a V-type gauge holder (124 Fig.32)[1].

(10) Push the clamping portion of the holder to the right-hand V-type gauge and weill tighten clampscrew (146 Fig. 35).

(11) Tighten the screw for pressing the gauge combination to the left-hand contact face of the holder. This screw is situated on the front of the V-type gauge holder.

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1) A gauge block combination with the value $E_X' = X - (a + b)$, however, is preferably used for the following measurement (E_X' = length of the gauge block combination; a, b = V-type gauge constants engraved on the V-type gauges, X = rated value of the thread diameter).

(12) Bring the attachable table for internal thread measurement (111) into its deepest position and arrange the thus composed setting gauge on its table plate that the line limited by the two Vees is approximately in the middle of the table.

(13) Tighten the setting gauge with object clamp (119).

The following operations are required for setting-up the Abbe measuring element and the countersleeve:

(14) Loosen clamping knobs (43 and 69 Fig. 23).

(15) Move the Abbe measuring element (116) and the sleeve slide (68) with the inside measuring frames (128 or 130 Fig. 21) together until the distance between the two thread measuring balls (145 Fig. 35) is smaller than the length of the gauge block and that it is approximately in the middle of the table.

(16) Again tighten the clampscrews.

(17) Fasten the weight unit for measuring force of 150 p to holder (38), arrange its cord on rollers (50 and 53 Fig. 6), and allow the weight to hang free.

(18) Lift the attachable table for internal thread measurement (111 Fig. 35) until the Vees of V-type gauges (140) have the same height as the thread measuring balls.

(19) Bring the horizontally carried and universally movable table plate into its middle position, loosen clampscrew (47 Fig. 6), and make the measuring sleeve (37) slowly travel to the left.

(20) If required, shift the attachable table in y-direction with setscrew (29 Fig. 35) to introduce the thread measuring balls (145) into the Vees.

(21) Slightly tilt the adjustable object table by actuating lever (28) until the point of reversal is arrived at.

(22) Tighten clamping lever (27).

Thus, the plane generated by the two V-type gauges (140) is parallel to the axis of measuring.

(23) Adjust the actual value of the setting gauge (corresponding to the initial value) analogously to paragraph 6.

To avoid arithmetical work, the center distance of the prototype $X_N = E_X + a + b$ should preferably be set as the initial value. If a gauge block combination $E_X' = X - (a + b)$ is used, take the value X from a chart (see paragraph 14.) and set it as the initial value. The formula $X_N = E_X + a + b$ is the basis also for calculation of X-values of the charts. Herein: E_X = measuring length of the gauge block; a, b = Vee-constants engraved on the V-type gauges.

After the actual value of the setting gauge has been adjusted as the initial value, do not shift the Abbe measuring element (116 Fig. 23) and the sleeve slide (68) during a series of measurements and do not vary the positions of driver knob (56 Fig. 7) and of setting knob (67 Fig. 23).

(24) Move the measuring sleeve (37) to the right and tighten it with clampscrew (47).

(25) Take the setting gauge from the attachable table for internal thread measurement.

Measuring requires the following additional operations:

(26) Lift or lower the attachable table (111 Fig. 37) until the distance between thread measuring balls and table plate amounts to approximately half the outer diameter of the threaded ring (test object).

(27) Bring the table plate into middle position and arrange the threaded ring so that the measuring balls are inserted in the threaded bore.

(28) Tighten the object to be measured.

(29) Loosen clampscrew (47 Fig. 6).

(30) Make the measuring sleeve (37 Fig. 37) slowly travel to the left and shift the table plate with the test object that the thread measuring balls are incorporated into two thread gaps of the test object which are opposing each other with offset by

half the amount of lead. The threaded ring must adjust without any force.

(31) Slightly lift and lower the test object with handwheel (12 Fig. 1) to find the point of reversal. The line of measuring thus passes through the center of curvature of the thread, i.e. the line passes through the diameter of the ring.

(32) Determine the thread diameter = X-value (size to be measured) according to paragraph 8. Consider the actual value of the setting gauge.

In case of errorless thread diameter, the measured X-value (X_P = thread diameter of the object) must coincide with the X-value taken from a chart (paragraph 14.) or calculated with the following formula:

$$X = D_2 + \frac{P}{2} \cdot \cot\frac{\alpha}{2} + \frac{P^2}{8} \cdot \frac{1}{D_2 + \frac{P}{2} \cdot \cot\frac{\alpha}{2} - \frac{d_K}{\sin\frac{\alpha}{2}}} \text{ [mm]}$$

wherein

D_2 [mm] = thread diameter
P [mm] = lead
α [°] = thread angle
d_K [mm] = diameter of thread measuring balls used

In case of initial values of any size selected, scale reading A_1 corresponds to the center distance of the prototype $X_N = E_X + a + b$ and reading A_2 to the setting at test object X_P. The difference between the two readings $A_2 - A_1$ is then the amount B by which the center distance of the object X_P differs from the center distance of the prototype X_N: $X_P = X_N + B = E_X + a + b + B$.

If X_N has been set as the initial value, the measured value X_P corresponds to the amount B which must then only be compared with the chart value X.

If the chart value X has been set as the initial value, the difference between test object reading and the initial value is equal to

the deviation from the chart value X and, thus, of the thread diameter from its rated value (while thread angle and thread lead must have the specified values).

12. Measuring objects of the same kind

Measuring objects of the same kind is possible with
outside measurement of any type,
inside measurement of objects with flat parallel faces of measuring and bores,
external thread measurement.

Equal objects can be measured with the same setting (i.e. with the same initial value). This is based on the following prerequisites:
No displacement of the Abbe measuring element (116 Fig. 23) and of the sleeve slide (68) with sleeve tube (66),
no variation of the positions of driver knob (56 Fig. 7), setting knob (67 Fig. 12), and adjusting screws (64 and 70).
After having changed the object to be measured, set it and determine its size to be measured according to the corresponding paragraph (9.1., 9.2., 10.1., or 11.1.).
The initial value must newly be determined if the measuring element or the countersleeve must be shifted due to different size of an object of the same kind. Adjustment of the measuring attachments, however, is maintained.

13. Difference measuring equipment

13.1. Unpacking and erecting

The following operations are required for unpacking and erecting the difference measuring equipment:

(1) Remove the cover of the special shipping case (160 Fig. 39).

(2) Unscrew all securing latches (e.g. 166) and carefully take out the components.
(3) Shift the measuring slide (163) approximately to the right-hand end of the left-hand sliding face of the basic bed.
(4) Tighten clamping knob (176 Fig. 41).
(5) Push a precision dial instrument MO 1/100 (165) into the holder bore of the measuring slide (163) and align it so that convenient observation through eyepiece (177) is possible.
(6) Tighten clampscrew (180).
(7) Push the measuring attachment on the measuring bolt up to stop and fasten it with its clampscrew.
(8) Fasten the lifting unit (169) on the chucking shank of the dial instrument MO 1/100 so that the nose of feeler lever almost touches the shoulder of the measuring attachment.
(9) Connect the lighting equipment (190 Fig. 42) to the socket on the rear of the basic bed.
(10) Push the sleeve slide (167 Fig. 41) to the left-hand end of the right-hand sliding face of the basic bed.
(11) Tighten clampscrew (185).
(12) Push the changeover countersleeve (171) up to the red ring (182) into the holder bore of the sleeve slide.
(13) Tighten clampscrew (181).
(14) Place the measuring attachment on the measuring bolt of the countersleeve up to stop and fasten it with its clampscrew.
(15) Adjustment of measuring attachments see paragraph 5.

13.2. Zero setting

The countersleeve to be changed over serves, in conjunction with the difference measuring equipment, as a fixed stop especially for measuring external and internal threads. Additionally, it permits the measuring attachment on the sleeve to be lifted from the object without varying the zero setting. The following operations are required for zeroing the difference measuring equipment:

(1) Bring the setscrew (184 Fig. 41) of the changeover countersleeve approximately into the middle of its setting range.
(2) Turn the setting drum (183) of the countersleeve up to stop:
counterclockwise for outside measurement,
clockwise for inside measurement.
(3) Bring the prototype or the selected object to be measured between the measuring faces of the two measuring attachments.
(4) Set switch (16 Fig. 1) to "on".
(5) Actuate setscrew (184 Fig. 41) until the measuring graduation watched through the eyepiece (177) is close to zero.
(6) Use tangent screw (179) to set the measuring graduation precisely to zero.
(7) Actuate the lifting device (169) several times and perform at least one test setting (without object to be measured) with setting drum (183).
(8) Correct possible deviations from zero with tangent screw (179).
Setscrew (184) must no more be adjusted after the end of this zero setting operation.
(9) Actuate setting drum (183) to lift the measuring attachment of the countersleeve from the prototype or test object:
clockwise for outside measurement,
counterlockwise for inside measurement.

13.3. Inside measuring frames for the difference measuring equipment

The difference measuring equipment includes one pair of big and one pair of small inside measuring frames. Two of them have been provided with a contact lever (192 Fig. 42). They are arranged and tightened on the dial instrument MO 1/100, the other two on the changeover countersleeve up to stop. Beforehand, equip the dial instrument MO 1/100 with a measuring attachment with flat face of 2 mm

in diameter (without lifting device). If the inside measuring frame (173) with contact lever (192) has been slipped on up to stop and tightened, the two white line marks must coincide (193) if the measuring graduation of the dial instrument MO 1/100 is close to zero (exact zero indication is not necessary). In other cases, use pin wrench (195 Fig. 43) to adjust the stop ring (194) correspondingly. This unique checking operation can be facilitated by zero setting with any object to be measured.
Setscrew (191 Fig. 42) serves for regulating the measuring force. Clockwise turning means reduction of the measuring force. The measuring operation is the same as for inside measurement.
Gauge blocks are used as setting prototypes for indirect (precision) measurements. Its combination is completed by wrung measuring legs and held in the gauge block holder. The measuring legs are symmetrically projecting whereby adjustment to the defined middle size of gauge blocks is possible by measuring from both sides.

14. Thread charts (internal threads)

X-values for

Metric ISO thread	TGL 7907	(coarse thread)
Metric ISO fine pitch thread	TGL 7907	(pitch 4 mm)
Metric ISO fine pitch thread	TGL 7907	(pitch 3 mm)
Metric ISO fine pitch thread	TGL 7907	(pitch 2 mm)
Metric ISO fine pitch thread	TGL 7907	(pitch 1.5 mm)
Metric ISO fine pitch thread	TGL 7907	(pitch 1 mm)
Whitworth thread	TGL 0-11	
Whitworth thread 2	TGL 0-240	

Metric ISO thread according to TGL 7907 (coarse thread)

nominal diameter mm	P mm	d_K mm	D_2 mm	x mm
16	2.00	1.35	14.701	16.469
18	2.50	1.35	16.376	18.590
20	2.50	1.35	18.376	20.585
22	2.50	1.35	20.376	22.580
24	3.00	1.8	22.051	24.702
27	3.00	1.8	25.051	27.696
30	3.50	1.8	27.727	30.816
33	3.50	1.8	30.727	33.810
36	4.00	2.30	33.402	36.928
39	4.00	2.30	36.402	39.923
42	4.50	2.30	39.077	43.040
45	4.50	2.30	42.077	46.035
48	5.00	3.175	44.752	49.154
52	5.00	3.175	48.752	53.149
56	5.50	3.175	52.428	57.265
60	5.50	3.175	56.428	61.260
64	6.00	3.175	60.103	65.375
68	6.00	3.175	64.103	69.371

Metric ISO thread according to TGL 7907
(fine pitch thread with pitch P = 4 mm)

Ball diameter d_K = 2.30 mm

nominal diameter D mm	D_2 mm	x mm
42	39.402	42.918
45	42.402	45.915
48	45.402	48.911
52	49.402	52.907
55	52.402	55.905
56	53.402	56.904
58	55.402	58.903
60	57.402	60.902
62	59.402	62.900
64	61.402	64.899
65	62.402	65.899
68	65.402	68.897
70	67.402	70.896
72	69.402	72.895
75	72.402	75.894
76	73.402	76.894
80	77.402	80.892

Metric ISO thread according to TGL 7907
(fine pitch thread with pitch P = 3 mm)

Ball diameter d_K = 1.8 mm

nominal diameter D mm	D_2 mm	x mm
30	28.051	30.691
33	31.051	33.687
36	34.051	36.683
39	37.051	39.680
40	38.051	40.679
42	40.051	42.678
45	43.051	45.676
48	46.051	48.674
50	48.051	50.673
52	50.051	52.672
55	53.051	55.671
56	54.051	56.670
58	56.051	58.669
60	58.051	60.669
62	60.051	62.668
64	62.051	64.667
65	63.051	65.667
68	66.051	68.666
70	68.051	70.666
72	70.051	72.665
75	73.051	75.665
76	74.051	76.664
80	78.051	80.664

Metric ISO thread according to TGL 7907
(fine pitch thread with pitch P = 2 mm)

Ball diameter d_K = 1.35 mm

nominal diameter D mm	D_2 mm	x mm
18	16.701	18.465
20	18.701	20.461
22	20.701	22.458
24	22.701	24.456
25	23.701	25.455
27	25.701	27.453
28	26.701	28.452
30	28.701	30.451
32	30.701	32.450
33	31.701	33.449
36	34.701	36.448
39	37.701	39.447
40	38.701	40.446
42	40.701	42.446
45	43.701	45.445
48	46.701	48.444
50	48.701	50.444
52	50.701	52.443
55	53.701	55.443
56	54.701	56.442
58	57.701	58.442
60	58.701	60.442
62	60.701	62.441
64	62.701	64.441
65	63.701	65.441
68	66.701	68.441
70	68.701	70.440
72	70.701	72.440
75	73.701	75.440
76	74.701	76.440
78	76.701	78.440
80	78.701	80.439

Metric ISO thread according to TGL 7907

(fine pitch thread with pitch P = 1.5 mm

Ball diameter d_K = 0.8 mm

nominal diameter D mm	D_2 mm	x mm
13	12.026	13.349 4)
13.5	12.526	13.848 4)
14	13.026	14.347 4)
14.5	13.526	14.846 4)
15	14.026	15.345 4)
16	15.026	16.344
17	16.026	17.343
18	17.026	18.342
19	18.026	19.341
20	19.026	20.340
21	20.026	21.339
22	21.026	22.339
23	22.026	23.338
24	23.026	24.337
25	24.026	25.337
26	25.026	26.336
27	26.026	27.336
28	27.026	28.336
30	29.026	30.335
31	30.026	31.334
32	31.026	32.334
33	32.026	33.334
34	33.026	34.334
35	34.026	35.333
36	35.026	36.333
37	36.026	37.333
38	37.026	38.333
39	38.026	39.332

nominal diameter D mm	D_2 mm	x mm
40	39.026	40.332
41	40.026	41.332
42	41.026	42.332
43	42.026	43.332
44	43.026	44.332
45	44.026	45.331
46	45.026	46.331
47	46.026	47.331
48	47.026	48.331
49	48.026	49.331
50	49.026	50.331
51	50.026	51.331
52	51.026	52.331
55	54.026	55.330
56	55.026	56.330
58	57.026	58.330
60	59.026	60.330
62	61.026	62.330
63	62.026	63.330
64	63.026	64.329
65	64.026	65.329
68	67.026	68.329
70	69.026	70.329
72	71.026	72.329
75	74.026	75.329
76	75.026	76.329
78	77.026	78.329
80	79.026	80.329

4) Threads marked with 4) can only be measured by way of difference measuring. They require the instrument to be set according to thread gauge rings.

Metric ISO thread according to TGL 7907
(fine pitch thread with pitch P = 1 mm)

Ball diameter d_K = 0.8 mm

nominal diameter D mm	D_2 mm	x mm
12.5	11.850	12.727 4)
13	12.350	13.227 4)
13.5	12.850	13.726 4)
14	13.350	14.226 4)
14.5	13.850	14.725 4)
15	14.350	15.225 4)
16	15.350	16.225
17	16.350	17.224
18	17.350	18.224
19	18.350	19.223
20	19.350	20.223
20.5	19.850	20.723
21	20.350	21.223
22	21.350	22.222
23	22.350	23.222
24	23.350	24.222
25	24.350	25.221
26	25.350	26.221
27	26.350	27.221
28	27.350	28.221
30	29.350	30.220
32	31.350	32.220
33	32.350	33.220
34	33.350	34.220
35	34.350	35.220
36	35.350	36.220
38	37.350	38.219
39	38.350	39.219
40	39.350	40.219
42	41.350	42.219
44	43.350	44.219
45	44.350	45.219
46	45.350	46.219

nominal diameter D mm	D_2 mm	x mm
48	47.350	48.219
50	49.350	50.219
51	50.350	51.219
52	51.350	52.218
53	52.350	53.218
54	53.350	54.218
55	54.350	55.218
56	55.350	56.218
57	56.350	57.218
58	57.350	58.218
59	58.350	59.218
60	59.350	60.218
61	60.350	61.218
62	61.350	62.218
63	62.350	63.218
64	63.350	64.218
65	64.350	65.218
66	65.350	66.218
67	66.350	67.218
68	67.350	68.218
69	68.350	69.218
70	69.350	70.218
71	70.350	71.218
72	71.350	72.218
73	72.350	73.218
74	73.350	74.218
75	74.350	75.218
76	75.350	76.218
77	76.350	77.218
78	77.350	78.218
79	78.350	79.218
80	79.350	80.218

4) Threads marked with 4) can only be measured by way of difference measuring. They require the instrument to be set according to thread gauge rings.

Whitworth thread according to TGL 0-11

nominal diameter in	P mm	d_K mm	D_2 mm	x mm
5/8	2.309	1.35	14.397	16.664
3/4	2.540	1.35	17.424	19.913
7/8	2.822	1.8	20.419	23.182
1	3.175	1.8	23.368	26.474
1 1/8	3.629	2.30	26.253	29.806
1 1/4	3.629	2.30	29.428	32.973
1 3/8	4.233	2.30	32.215	36.356
1 1/2	4.233	2.30	35.391	39.525
1 5/8	5.080	3.75	38.024	42.994
1 3/4	5.080	3.75	41.199	46.161
1 7/8	5.645	3.75	44.012	49.529
2	5.645	3.75	47.187	52.699
2 1/4	6.350	3.75	53.086	59.284
2 1/2	6.350	3.75	59.436	65.623
2 3/4	7.257	3.75	65.205	72.281
3	7.257	3.75	71.556	78.622
3 1/4	7.816	3.75	77.548	85.156
3 1/2	7.816	3.75	83.899	91.499

Whitworth thread 2 according to TGL 0-240

nominal diameter mm	P mm	d_K mm	D_2 mm	x mm
20	2.540	1.35	18.373	20.858
22	2.540	1.35	20.373	22.854
24	2.540	1.35	22.373	24.851
27	2.540	1.35	25.373	27.845
30	2.540	1.35	28.373	30.842
33	2.540	1.35	31.373	33.839
36	3.175	1.8	33.967	37.055
39	3.175	1.8	36.967	40.052
42	3.175	1.8	39.967	43.049
45	3.175	1.8	42.967	46.047
48	3.175	1.8	45.967	49.045
52	3.175	1.8	49.967	53.043
56	4.233	2.30	53.290	57.402
60	4.233	2.30	57.290	61.399
64	4.233	2.30	61.290	65.396
68	4.233	2.30	65.290	69.394
72	4.233	2.30	69.290	73.392
76	4.233	2.30	73.290	77.390
80	4.233	2.30	77.290	81.388

15. List of illustrations

16. List of reference numbers

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2	left-hand contact faces	1
3	adjustable object table	1 3 23 24
4	box level	1
5	right-hand sliding faces	1 12
6	right-hand contact faces	1
7	handwheel for compensating unit	1 23 27
8	footscrews	1
9	baseplates	1
10	clampscrew handle for lower limitation of table height	1
11	survey graduation for table height adjustment	1 3 27
12	handwheel for table height adjustment	1 3 23 25 27 30
13	clampscrew handle for table height adjustment	1 3 30
14	clampscrew handle for upper limitation of table height	1
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18	slots for table attachments	2
19	socket for lighting equipment (36)	2
20	socket for measuring equipment with magic eye (115)	2
21	socket for mains connection	2
22	fuse for lighting equipment (36)	2
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reference number	designation	Figures
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27	clamping lever for table tilt	3 24 30 35
28	lever for table tilt	3 24 30 35
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30	index mark	3 24 25 29
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40	glass scale	5
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44	clampscrew for stop pin (46)	5
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210	fastening screw	19
211	securing screw	19
212	securing screw	19
213	fastening screw	19
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216	knurled knob	19
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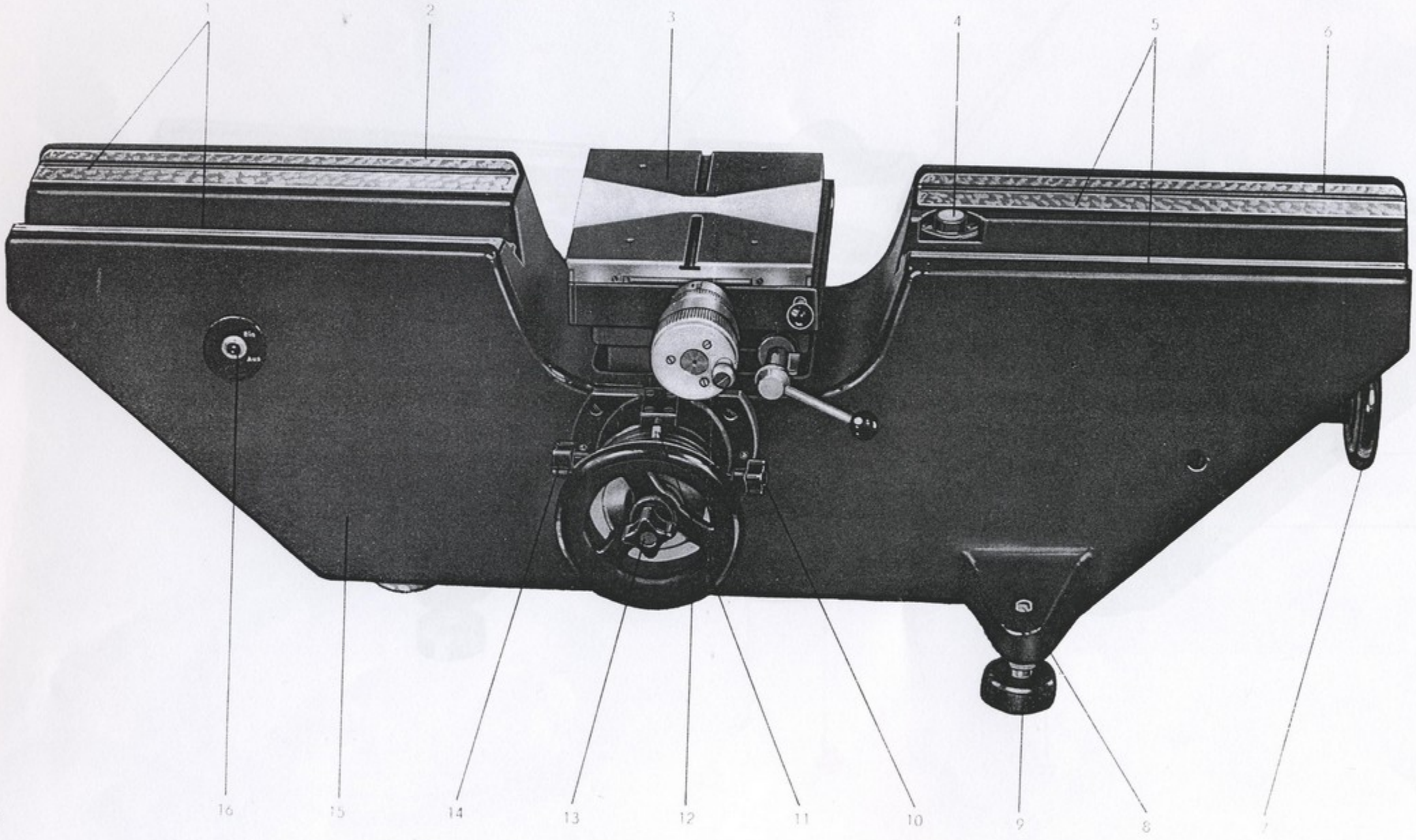
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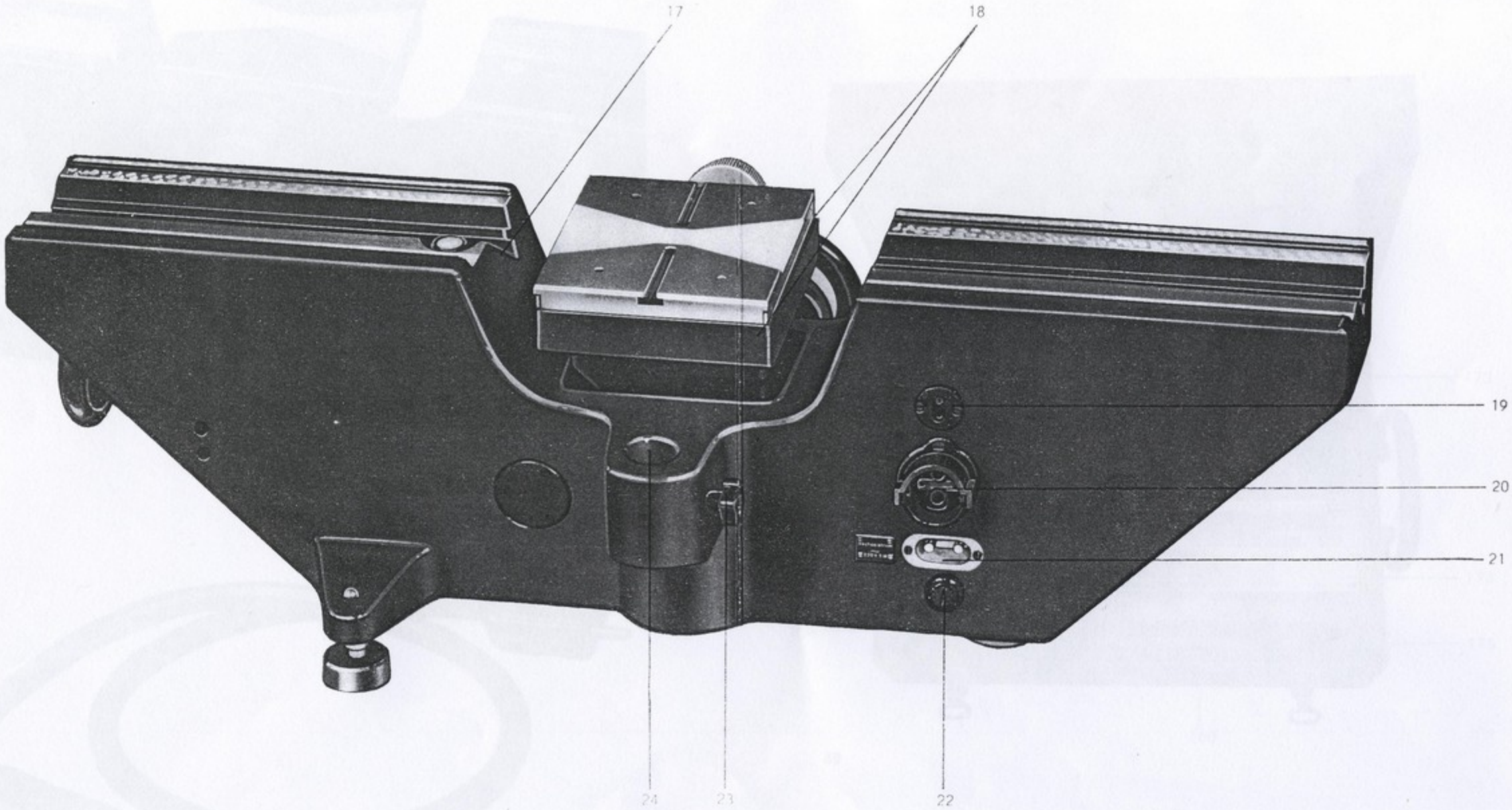
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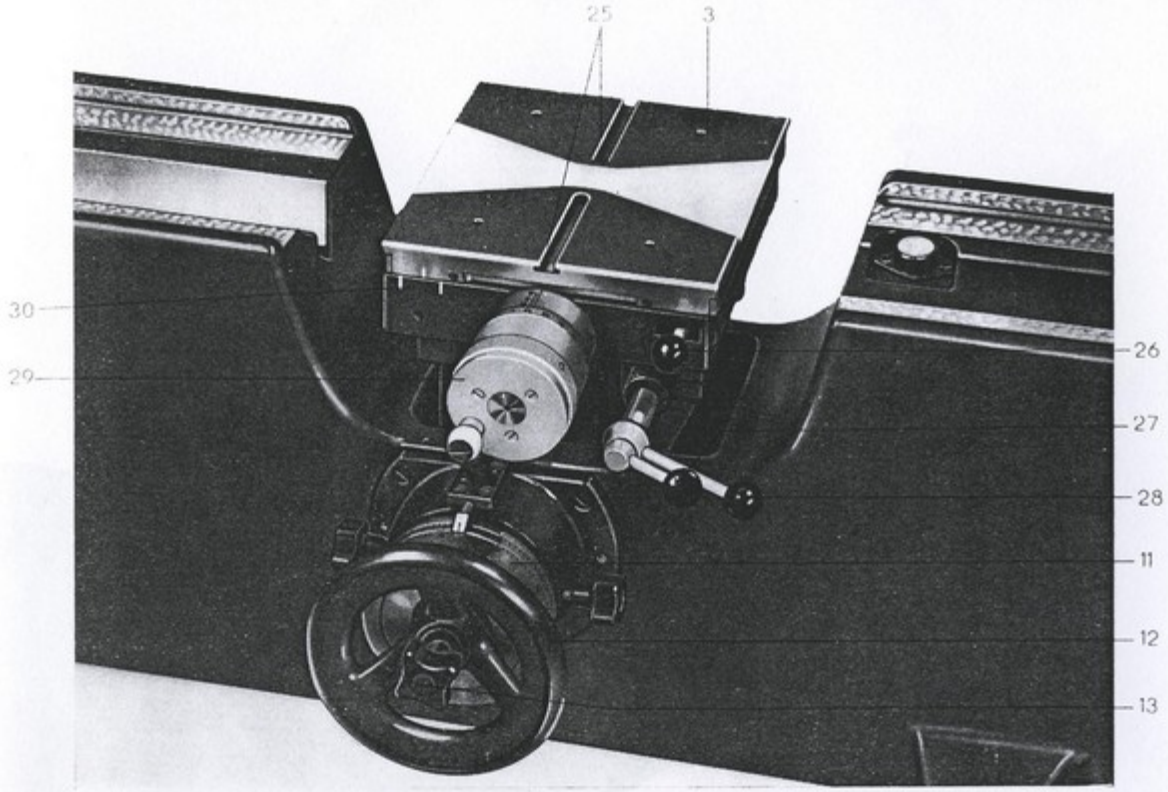

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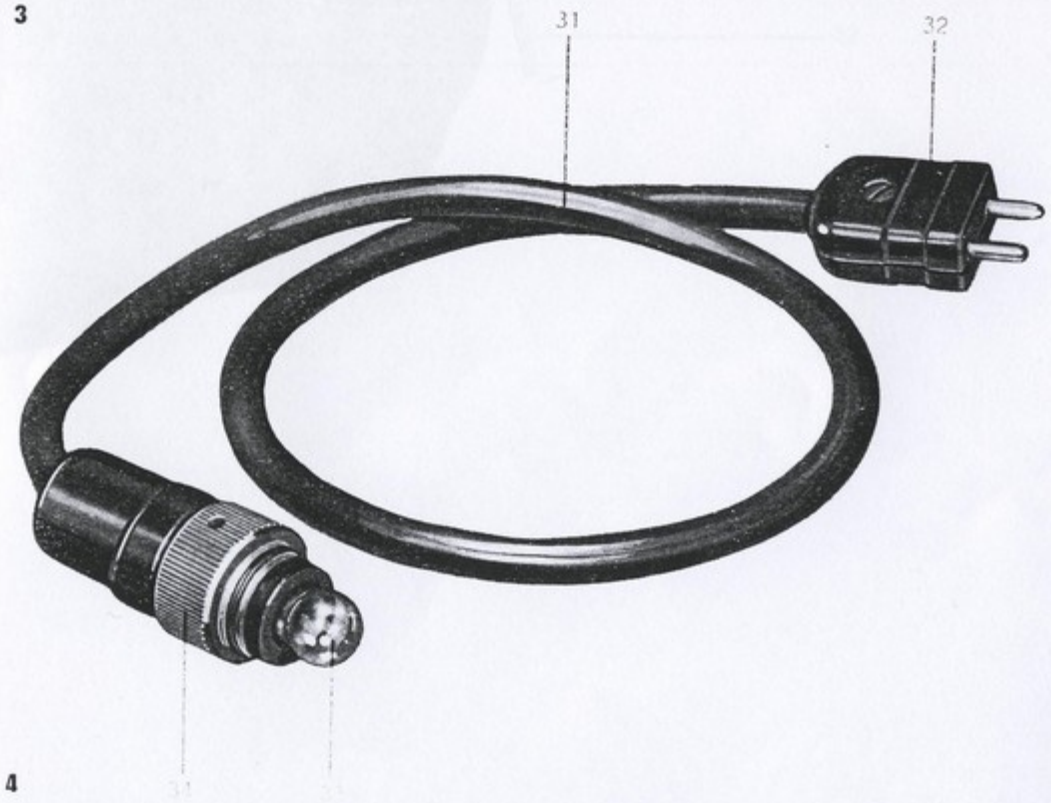

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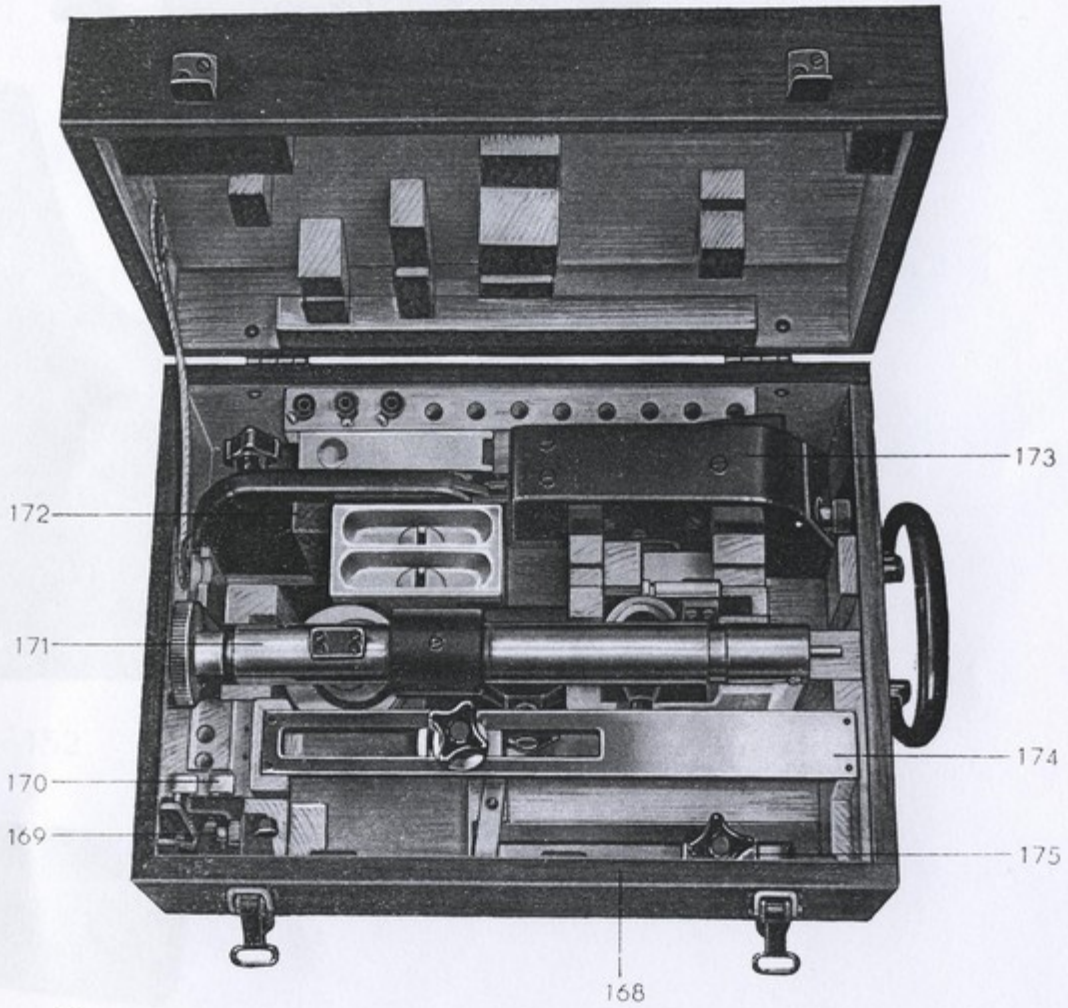

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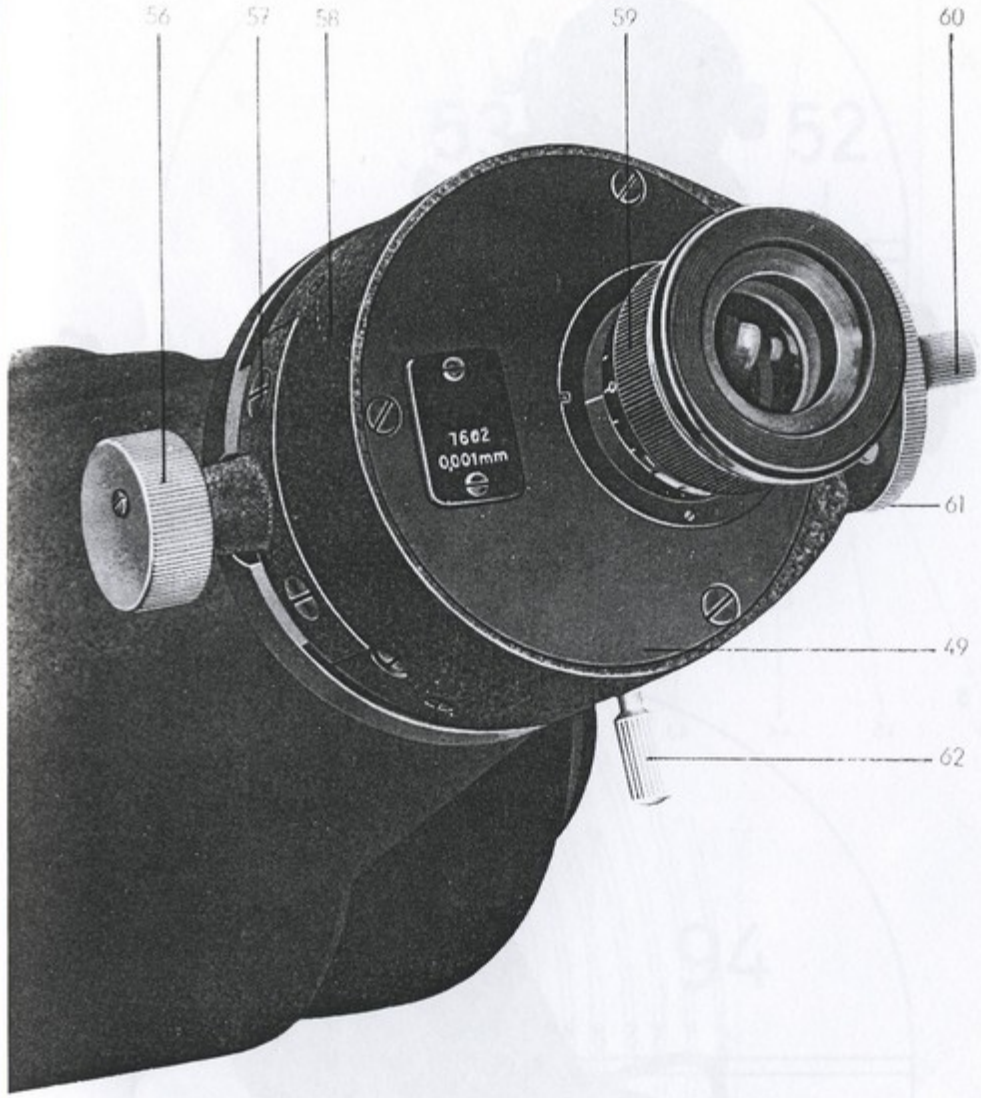
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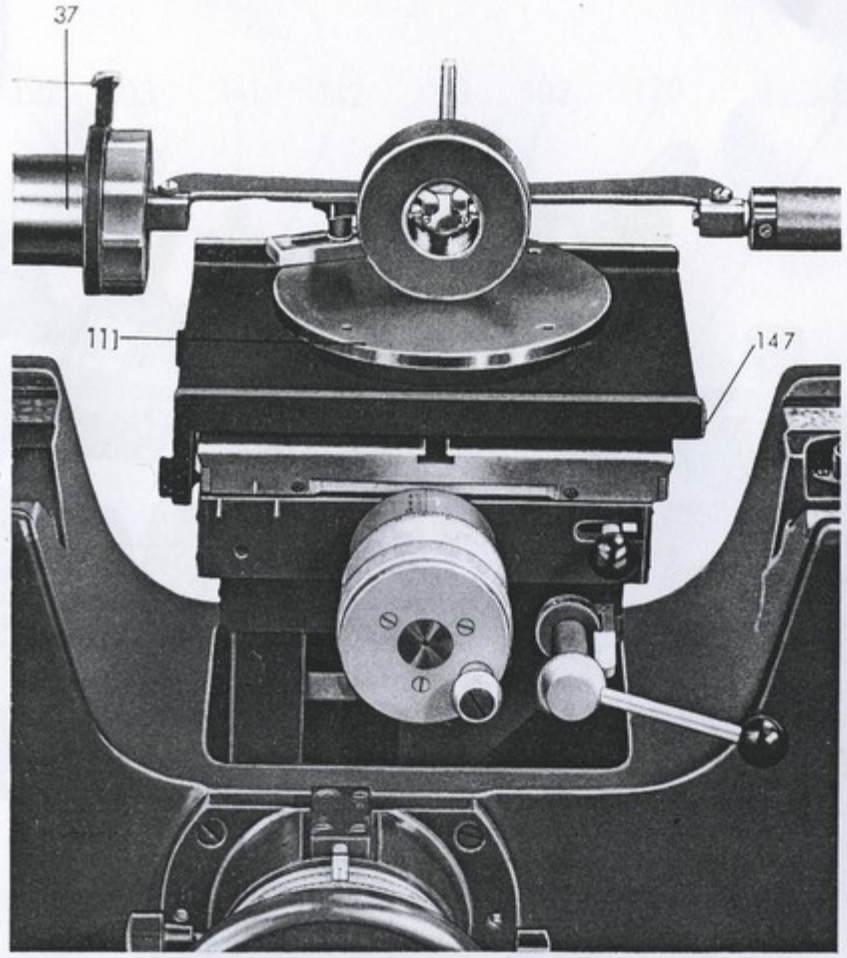
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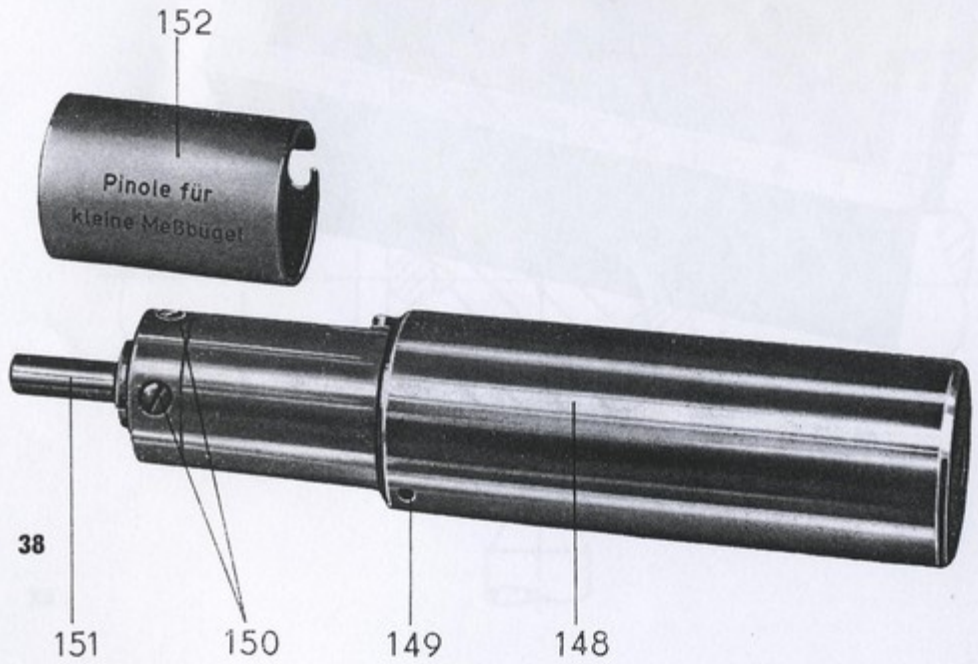
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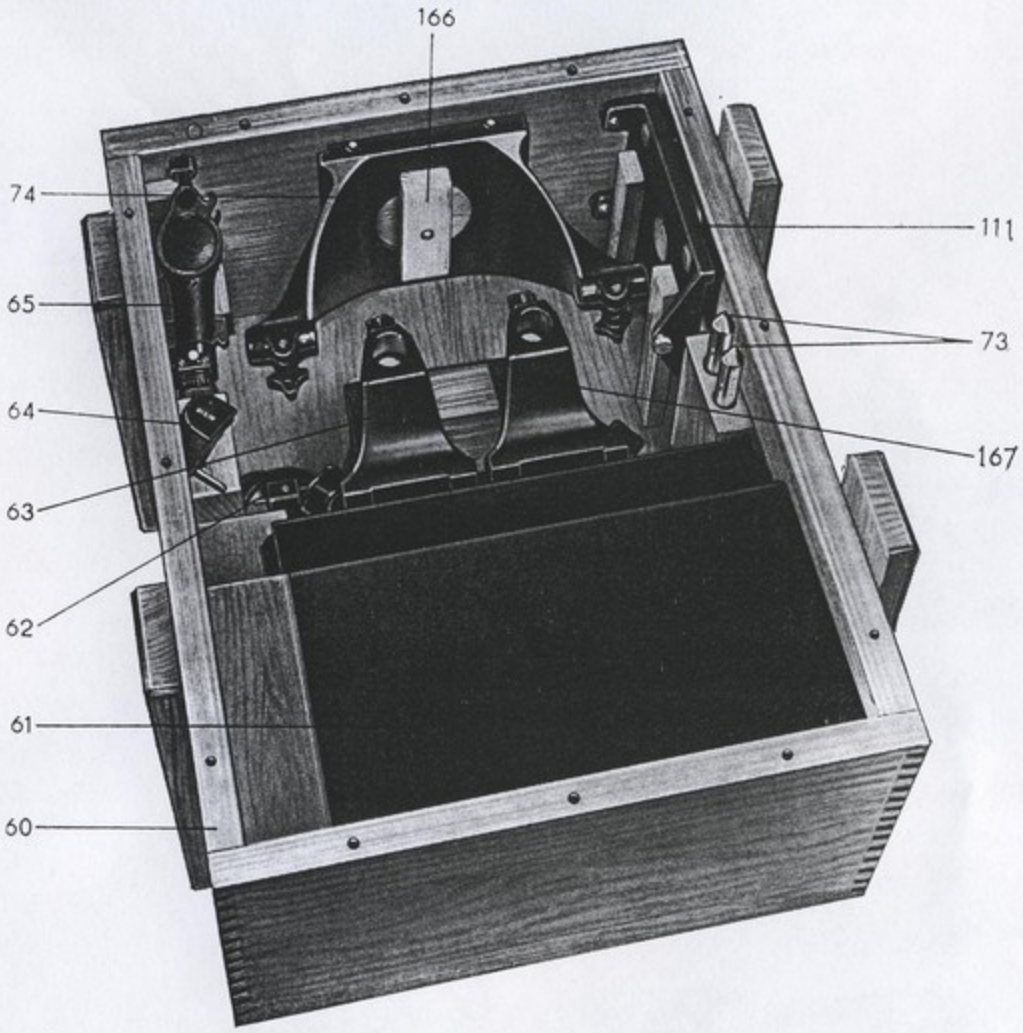
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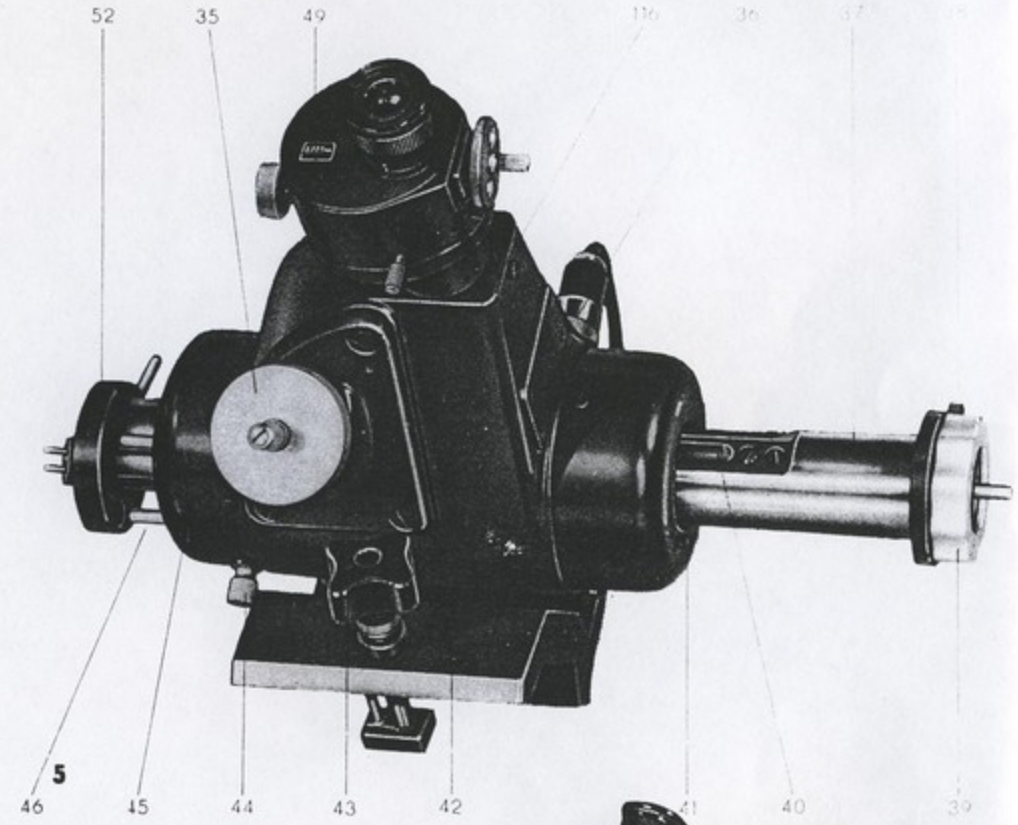
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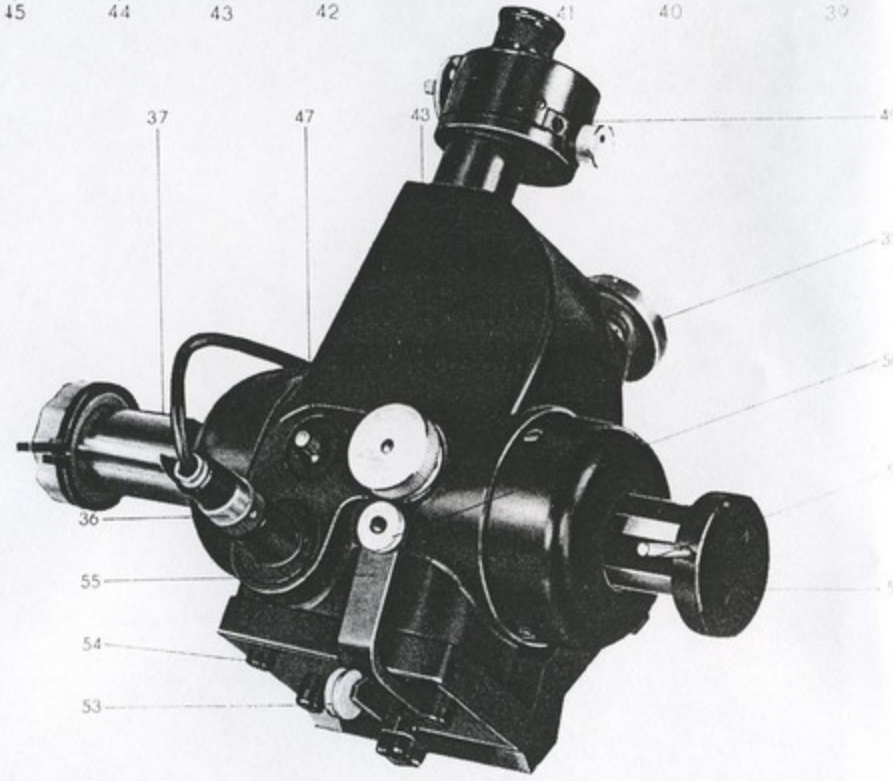
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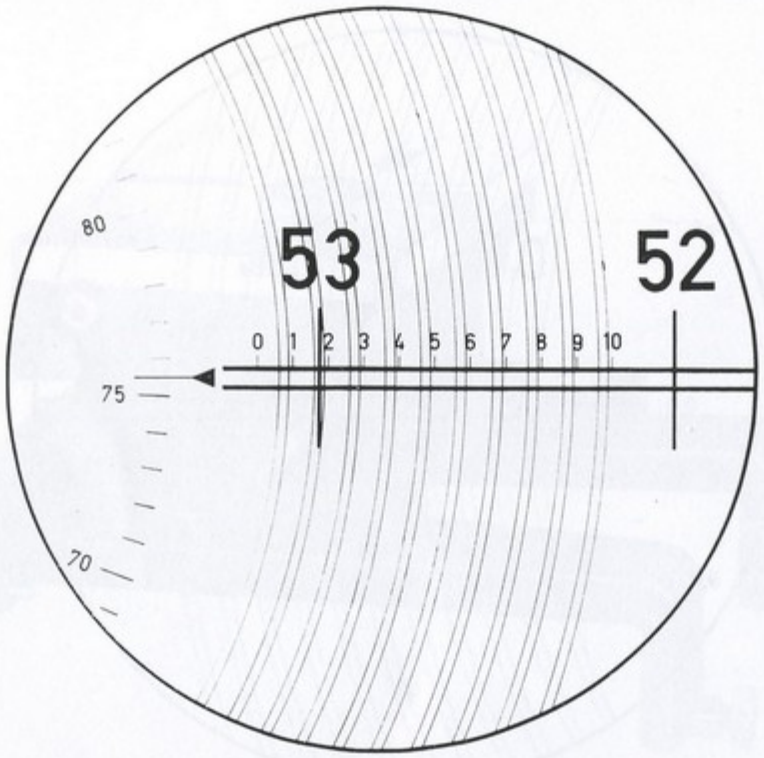
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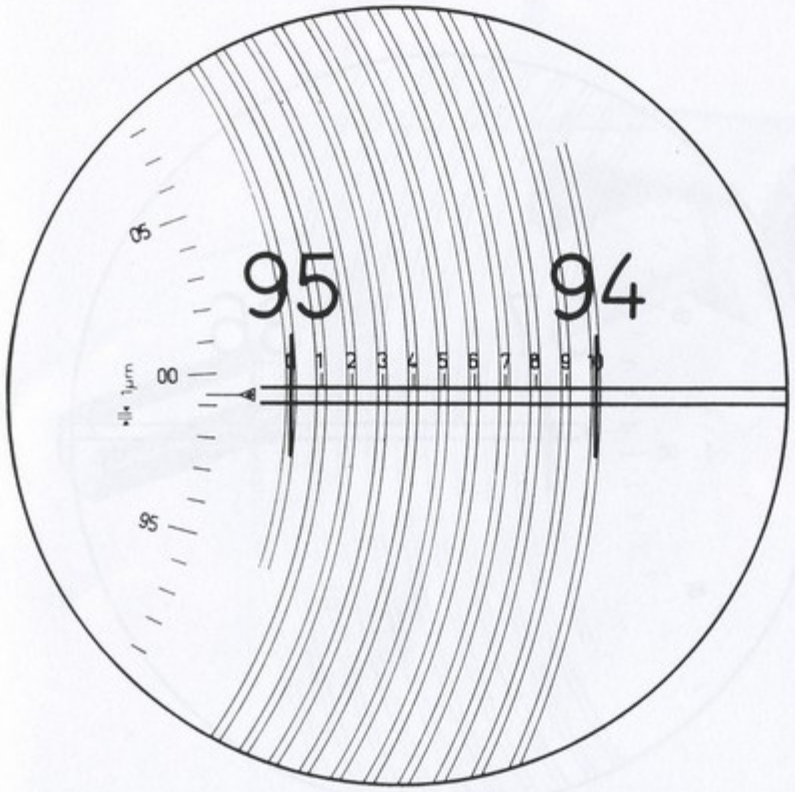
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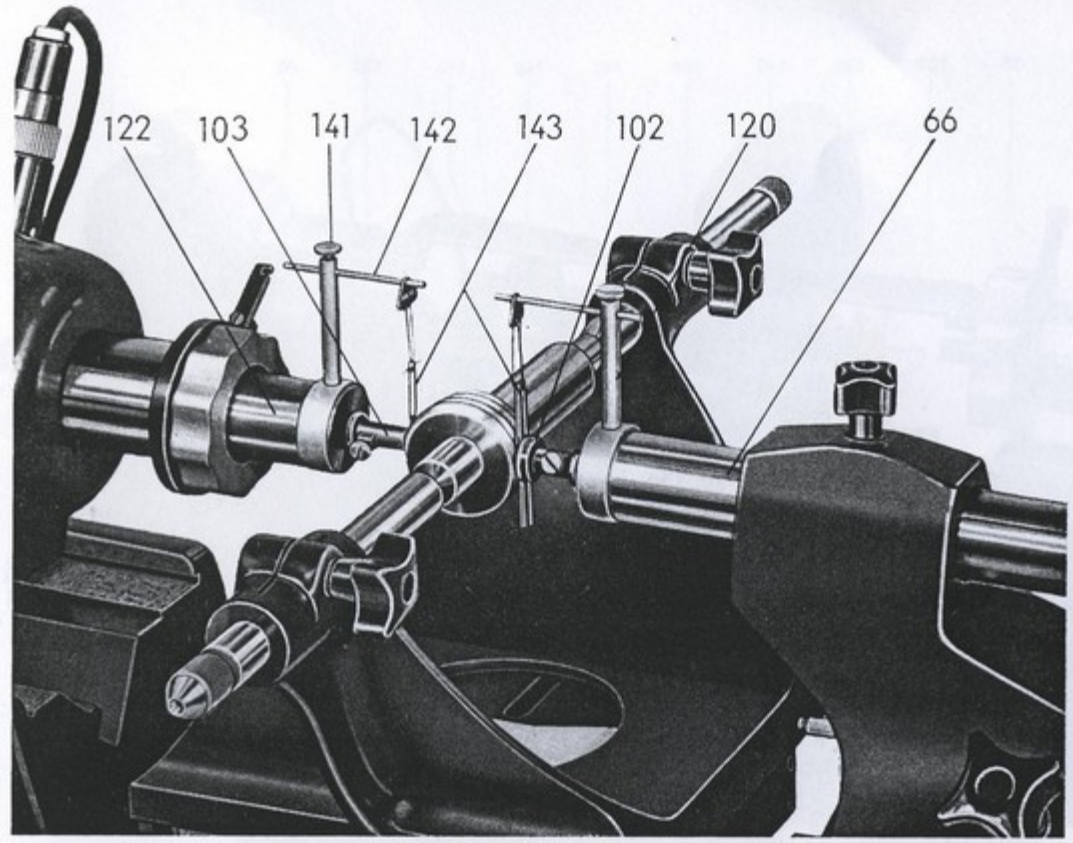
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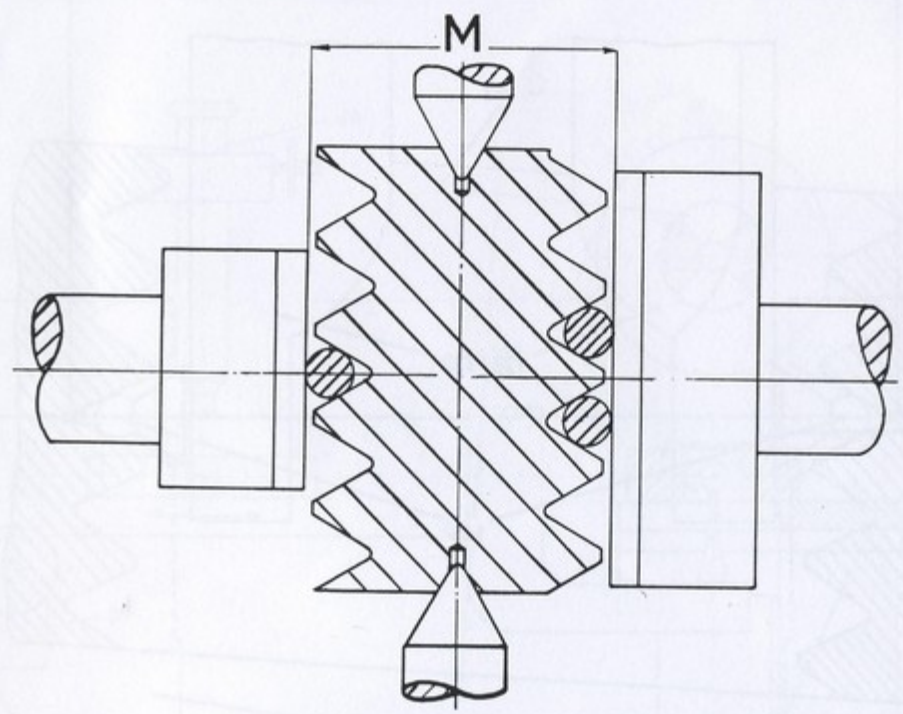
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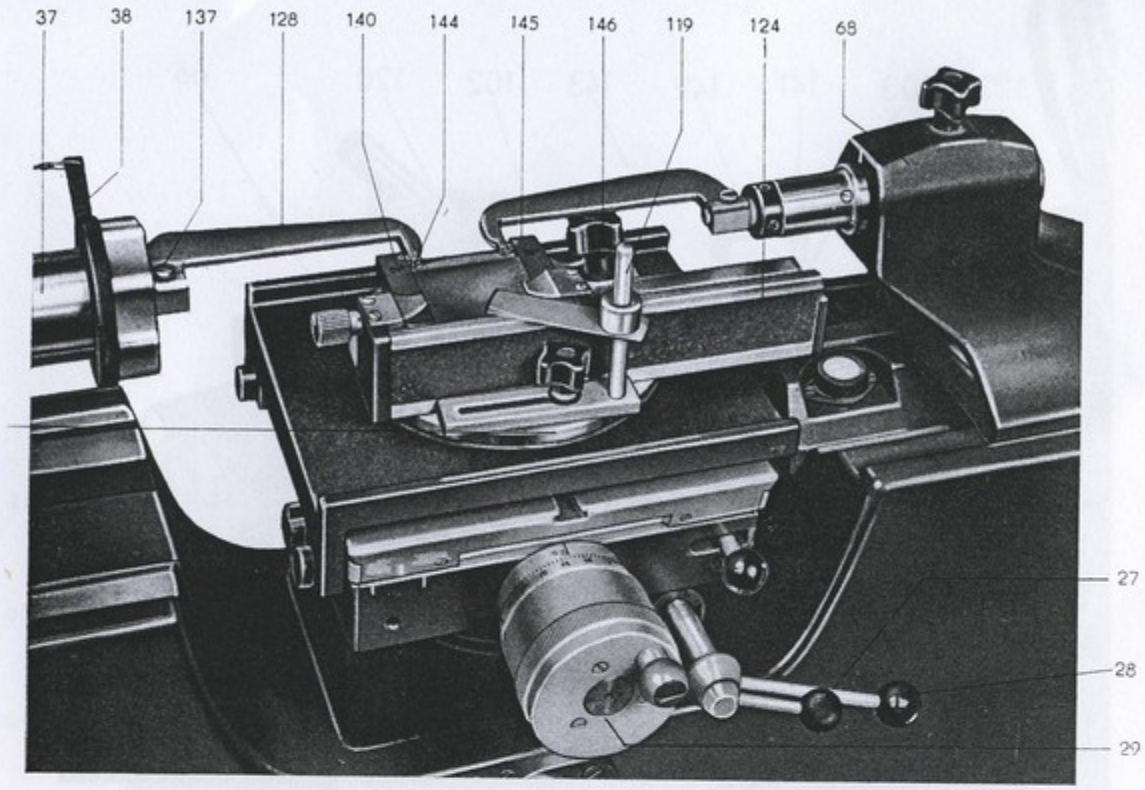
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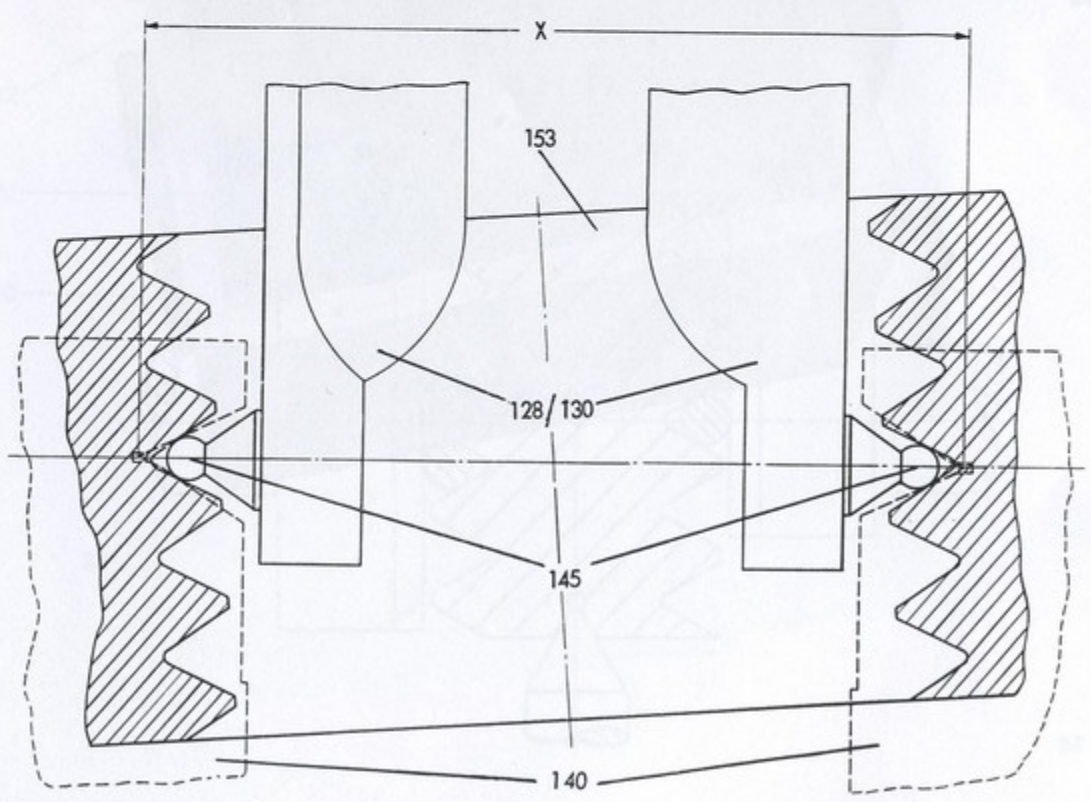
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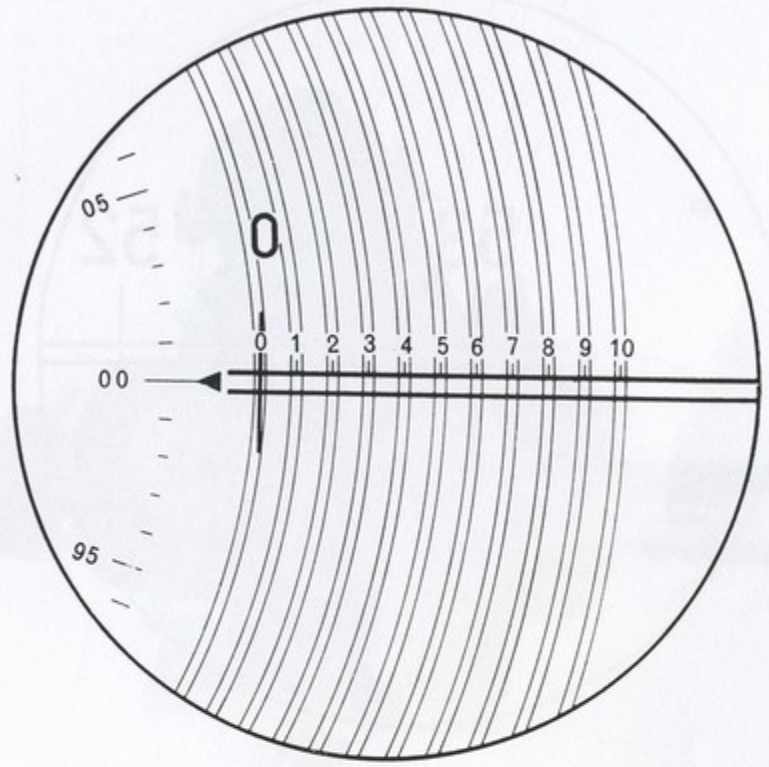
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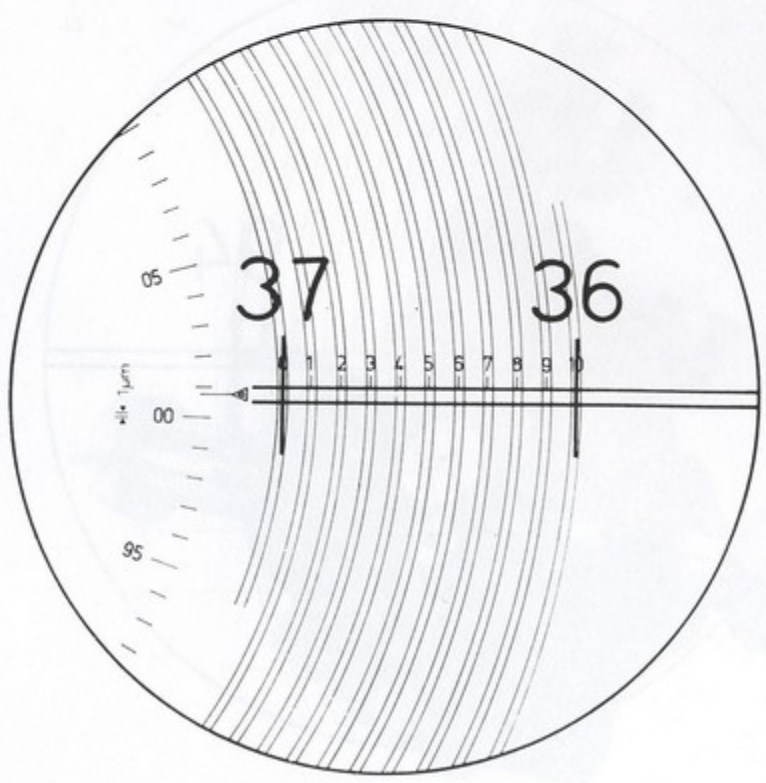
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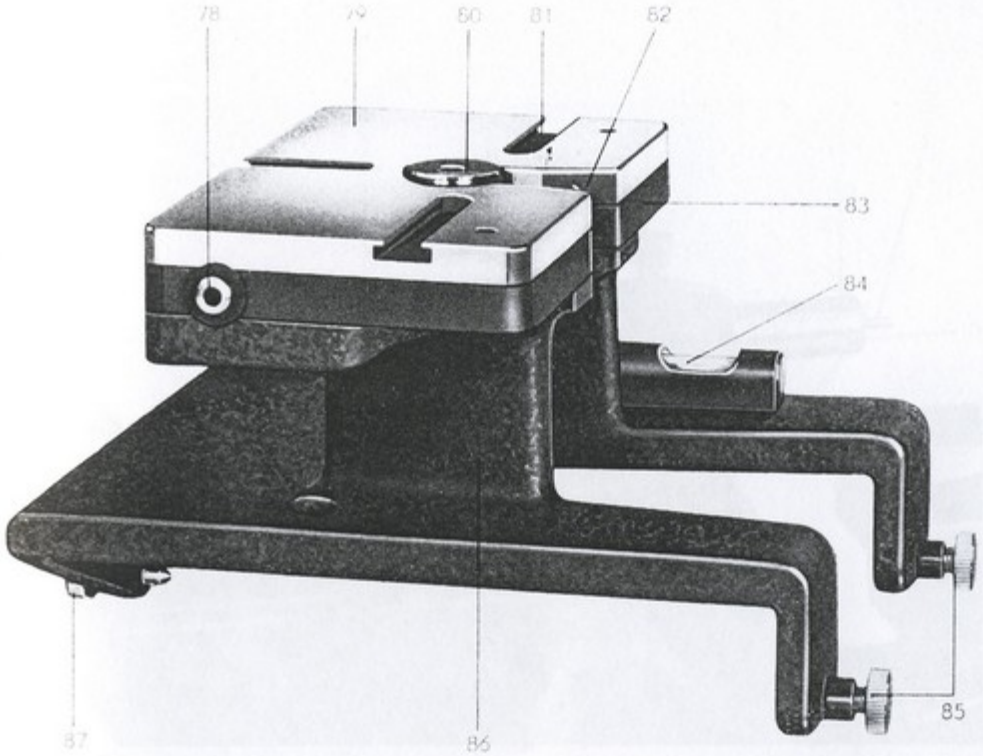
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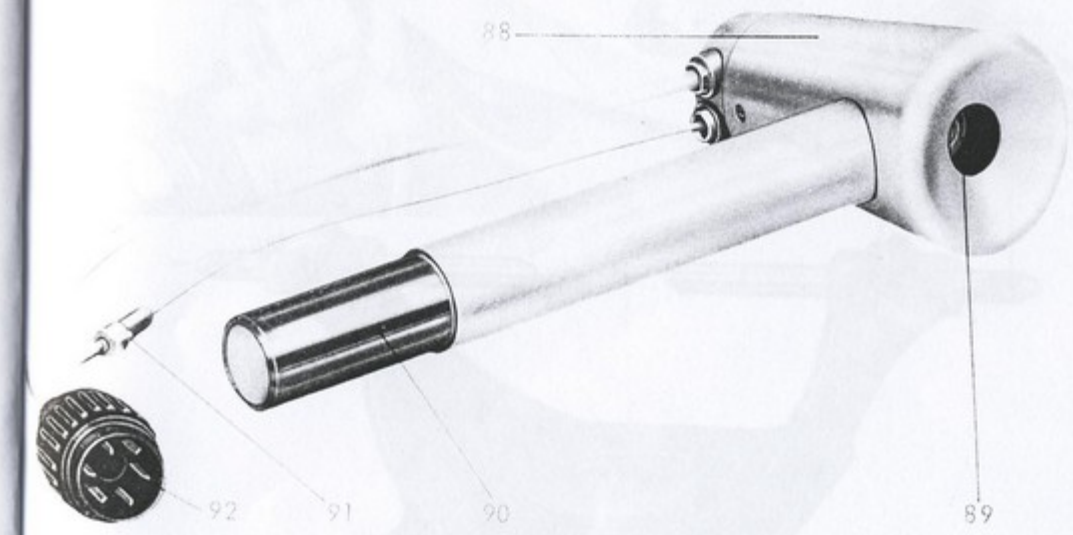
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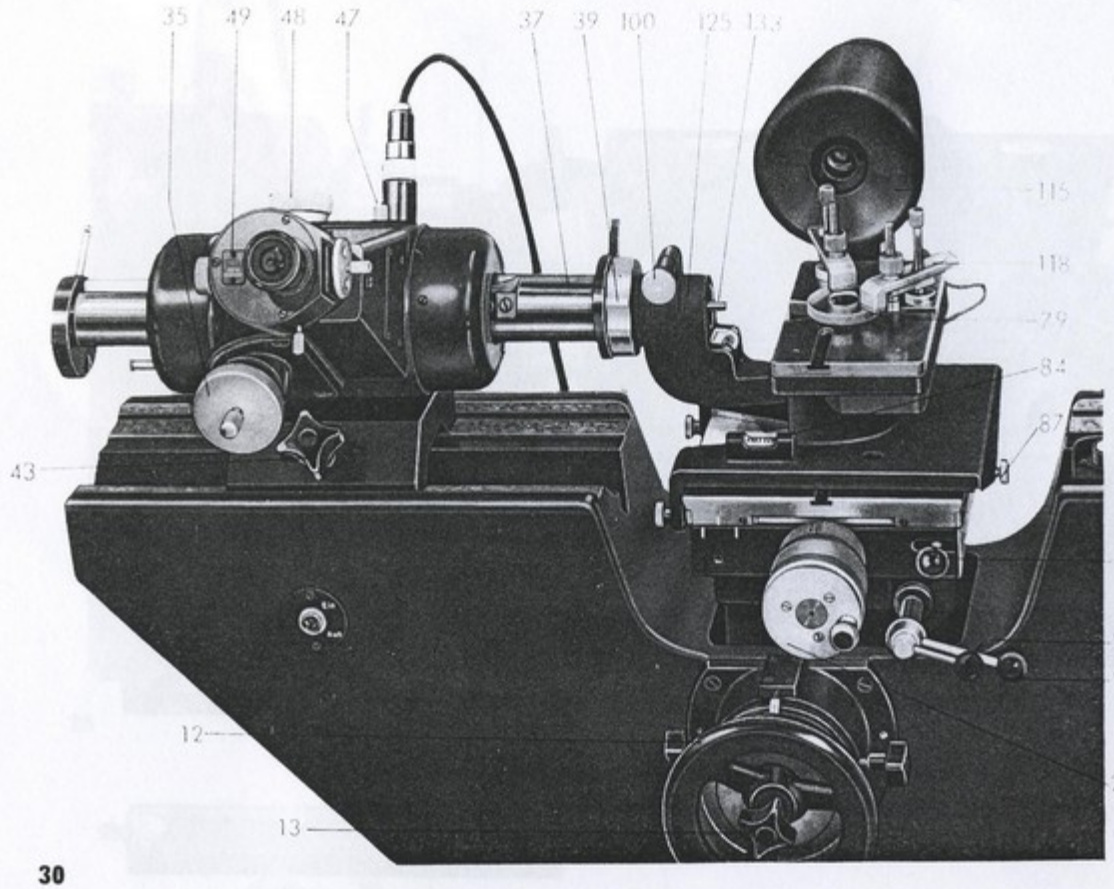
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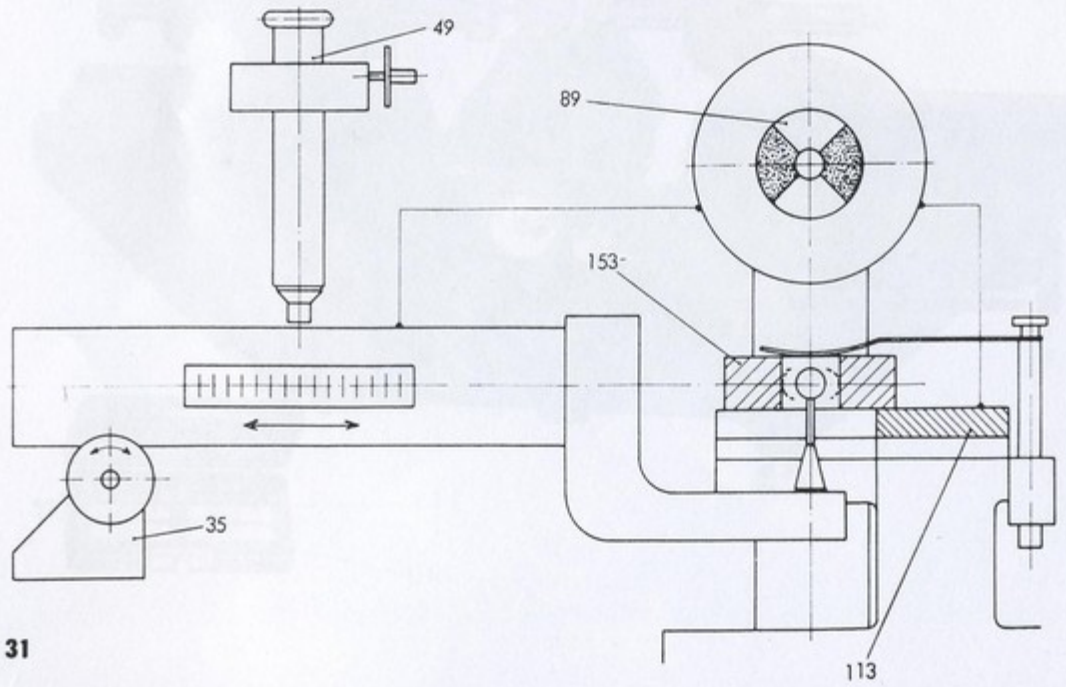
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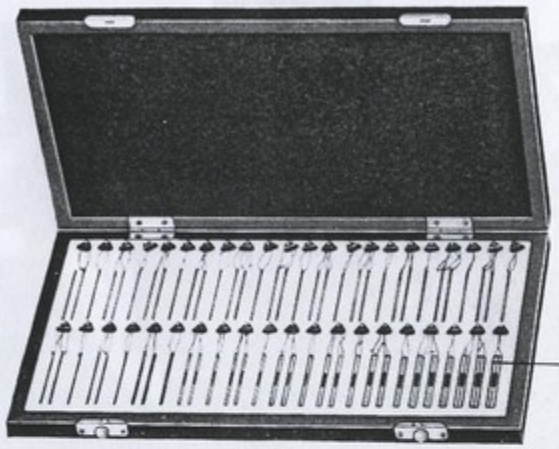
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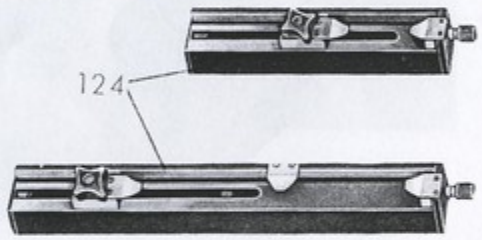
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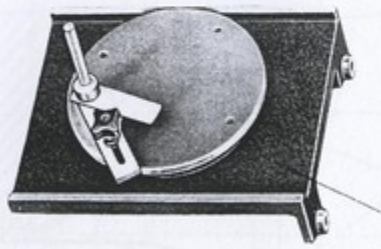


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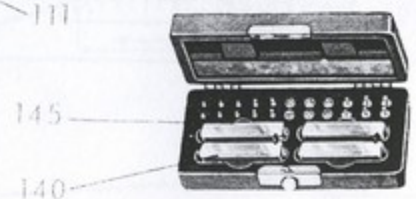
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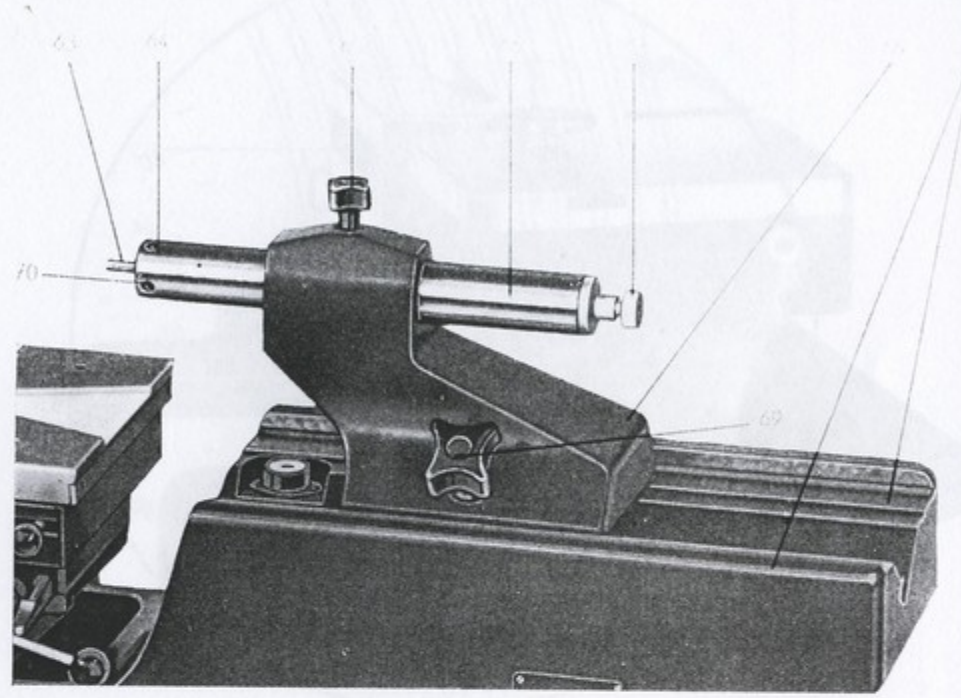
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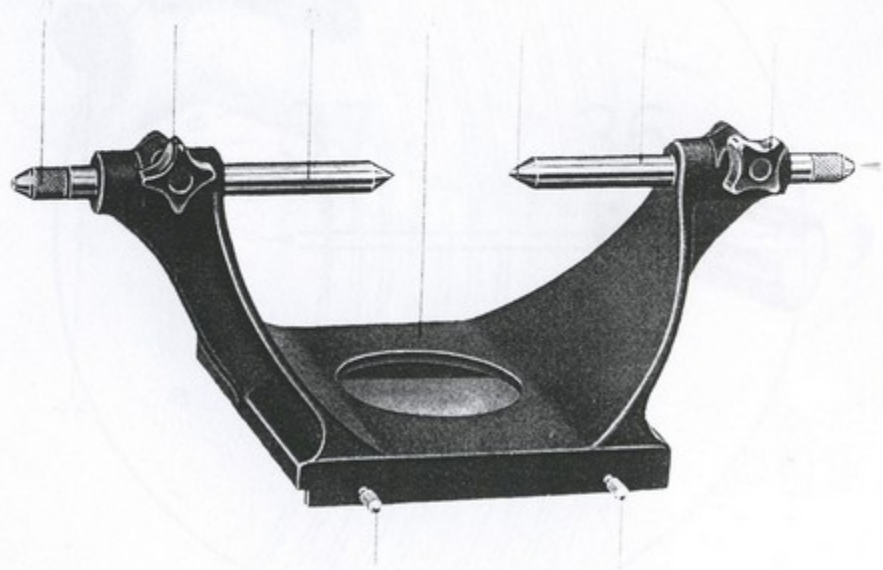

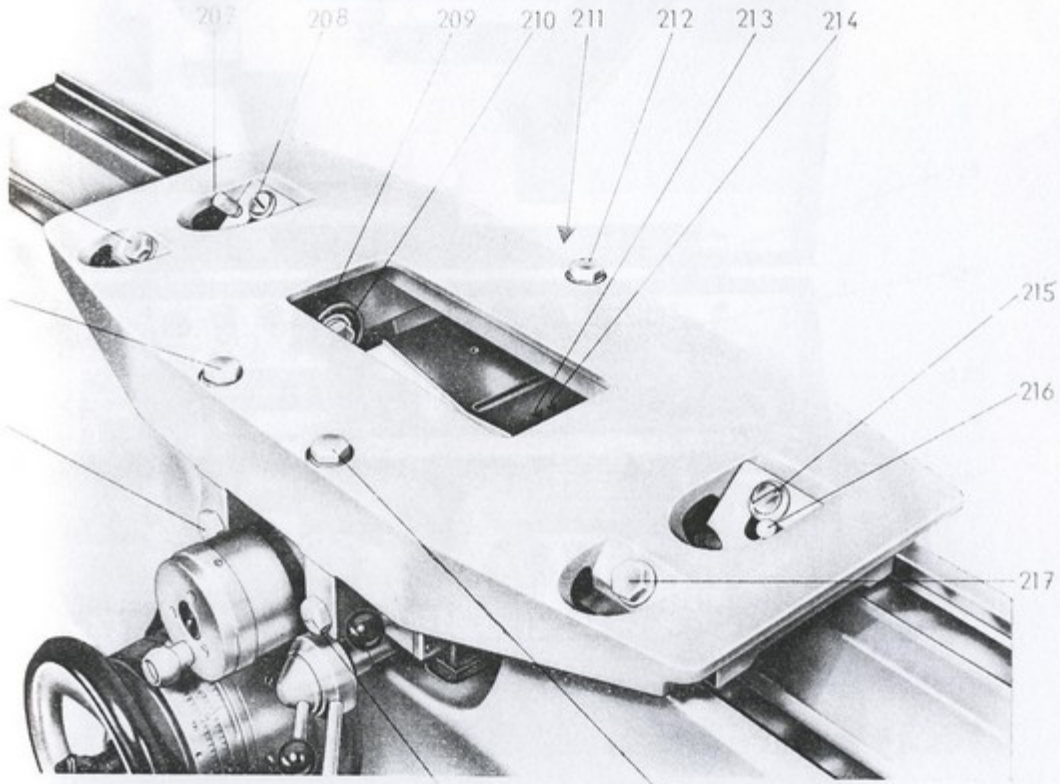
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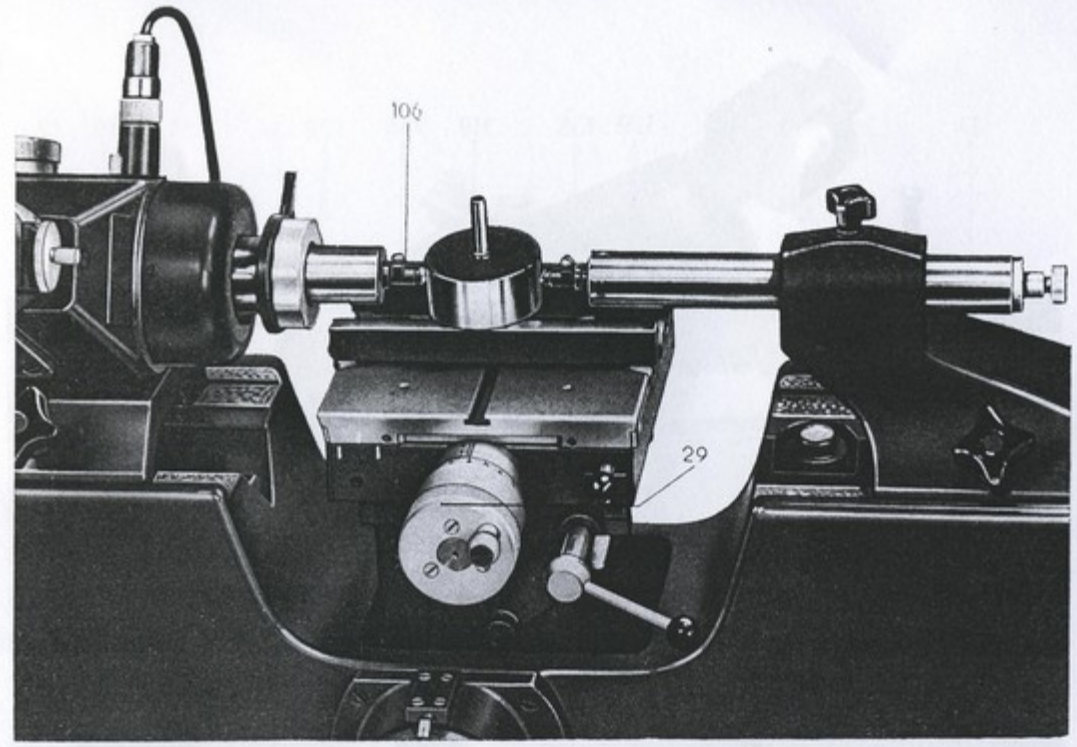
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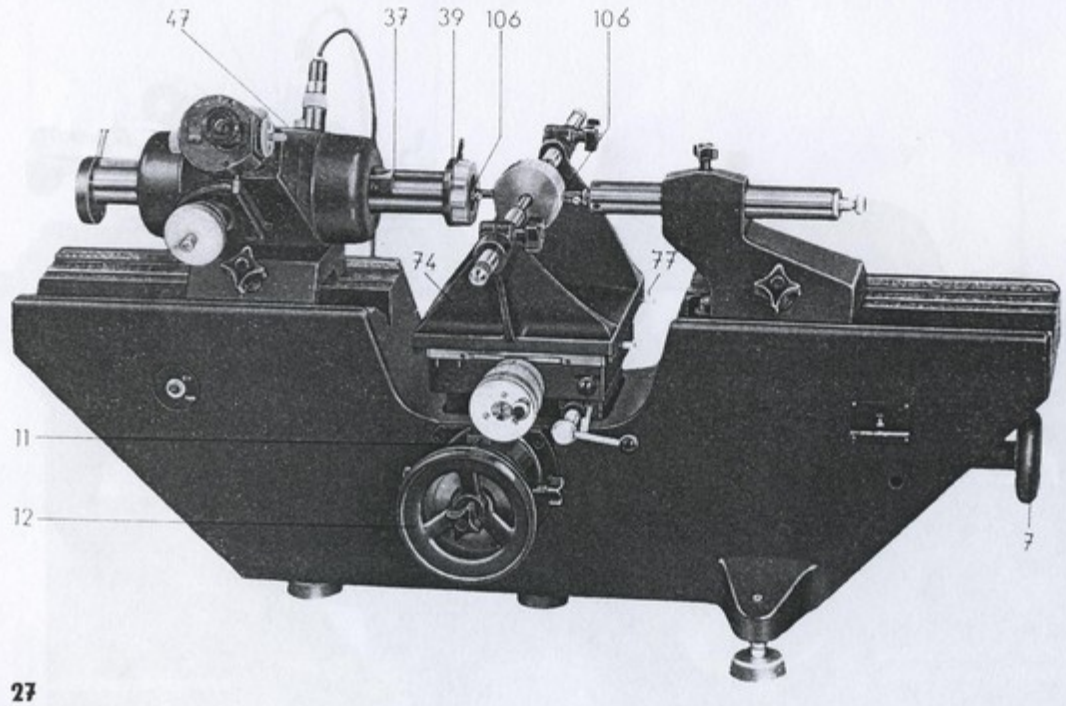
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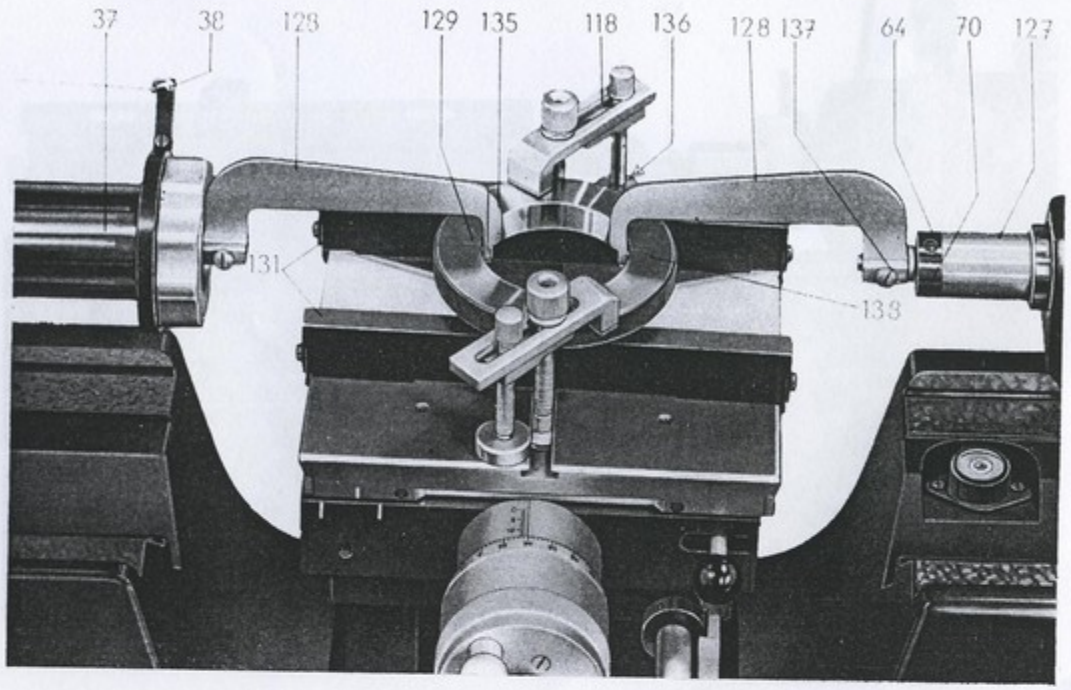
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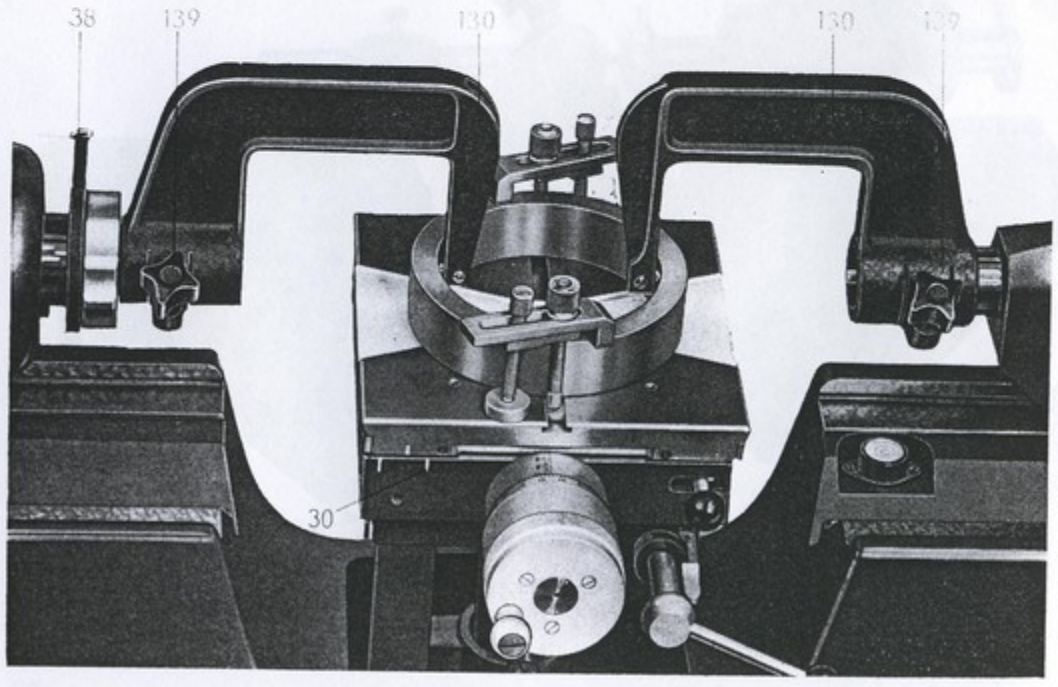
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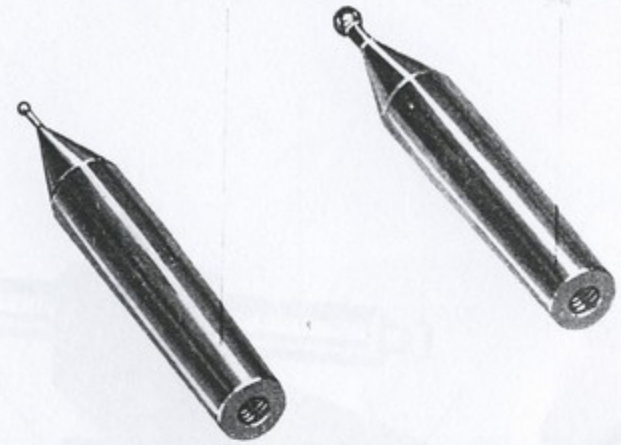

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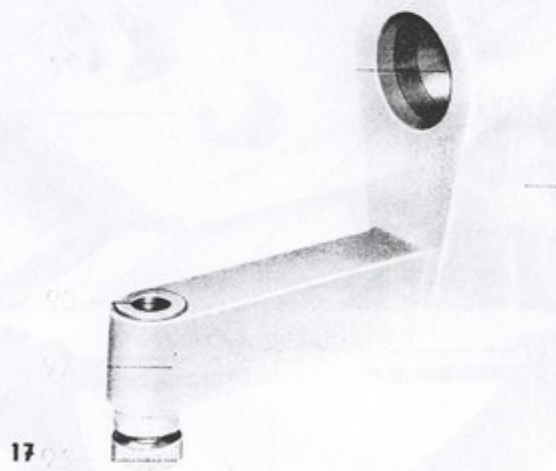

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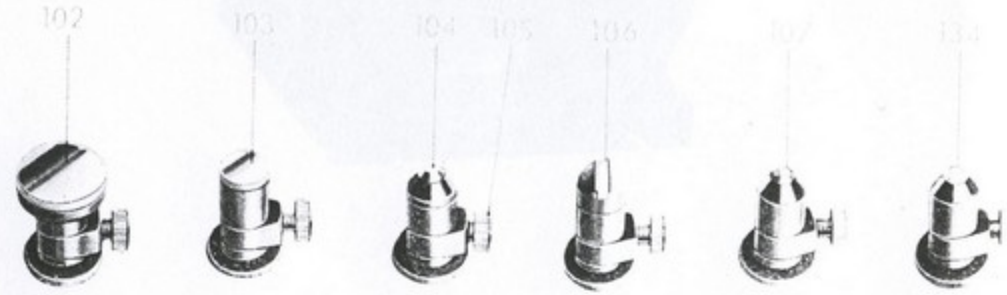
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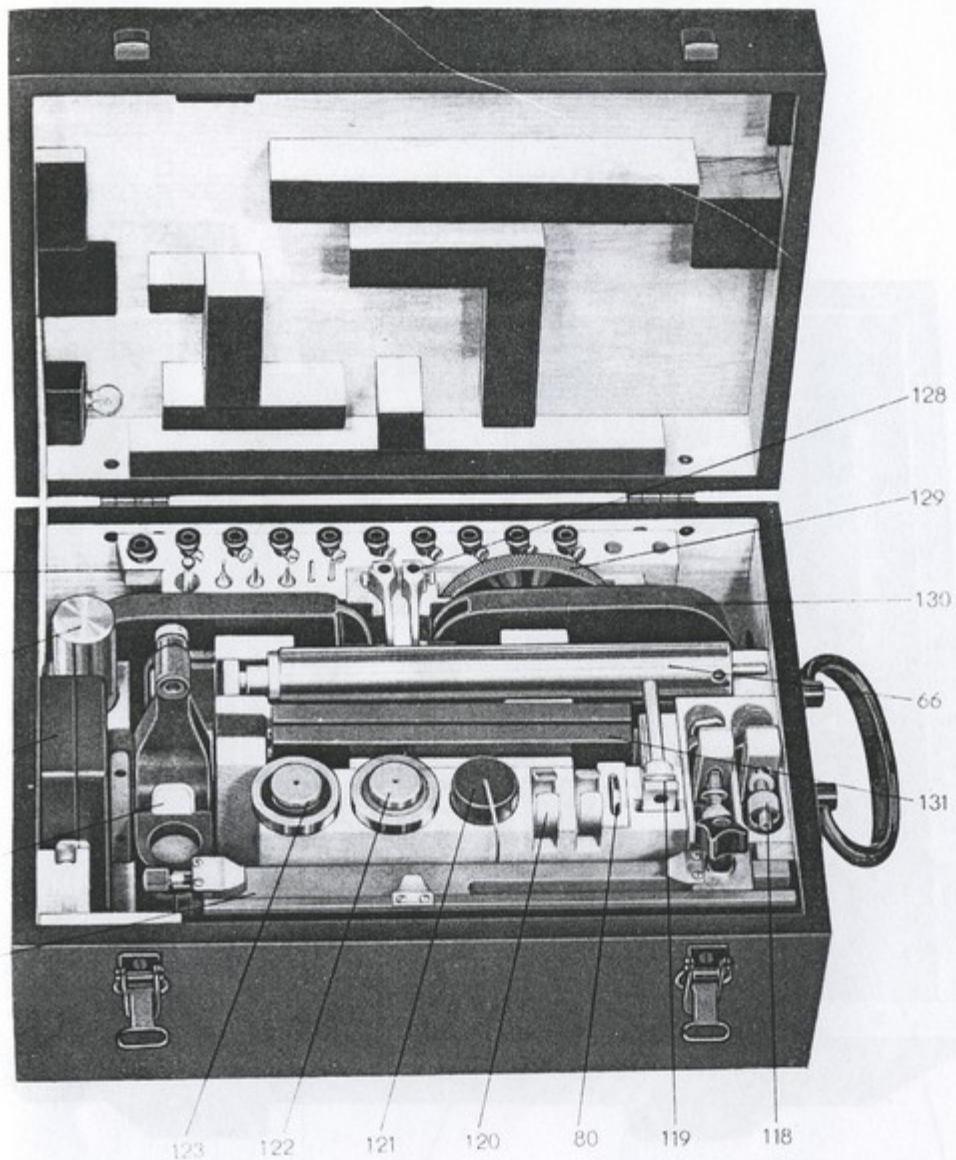
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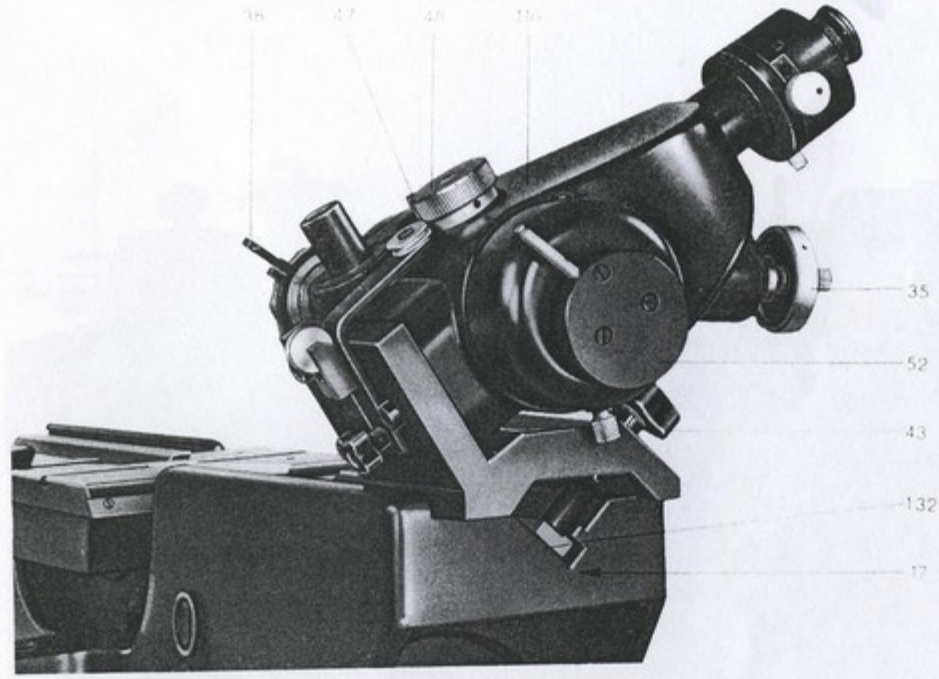
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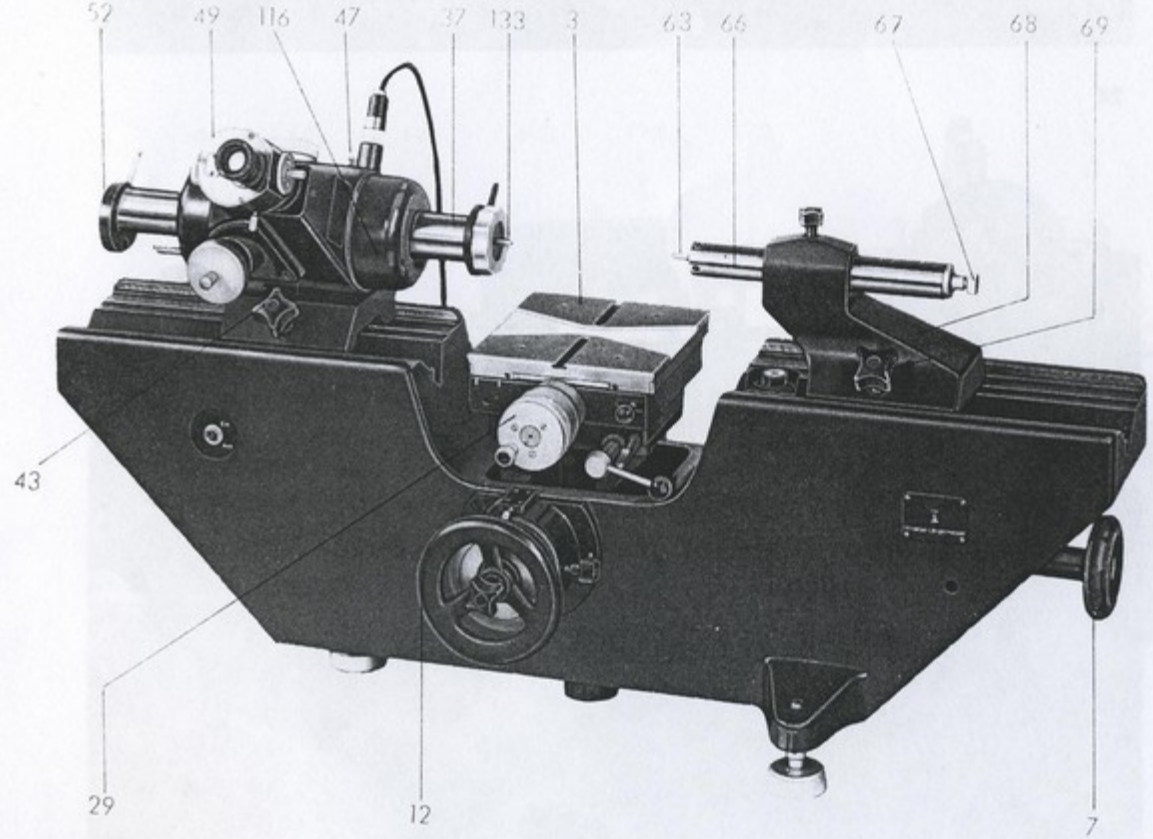
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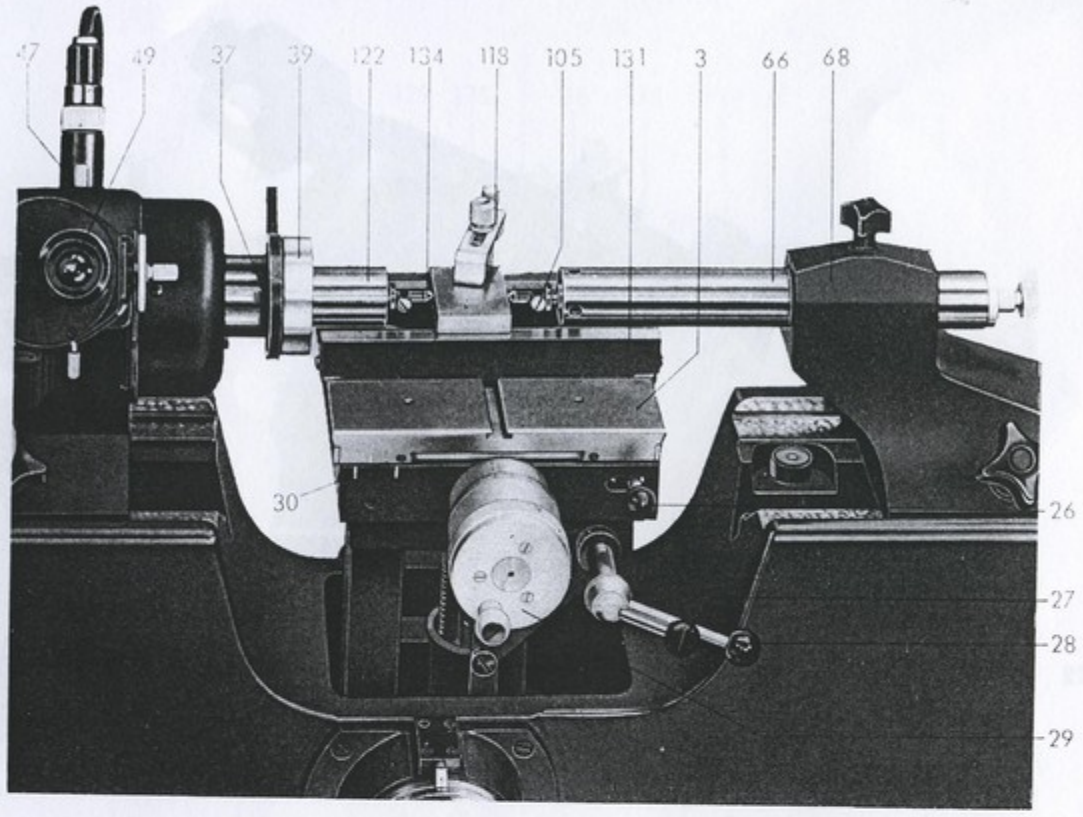
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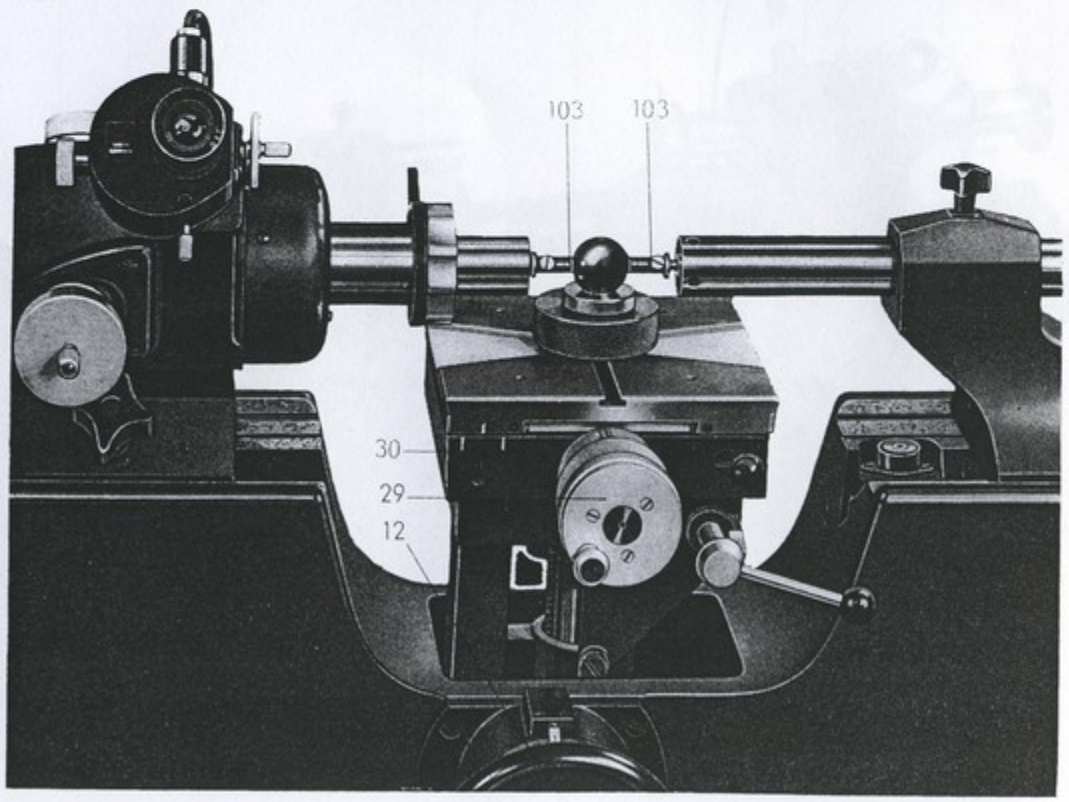
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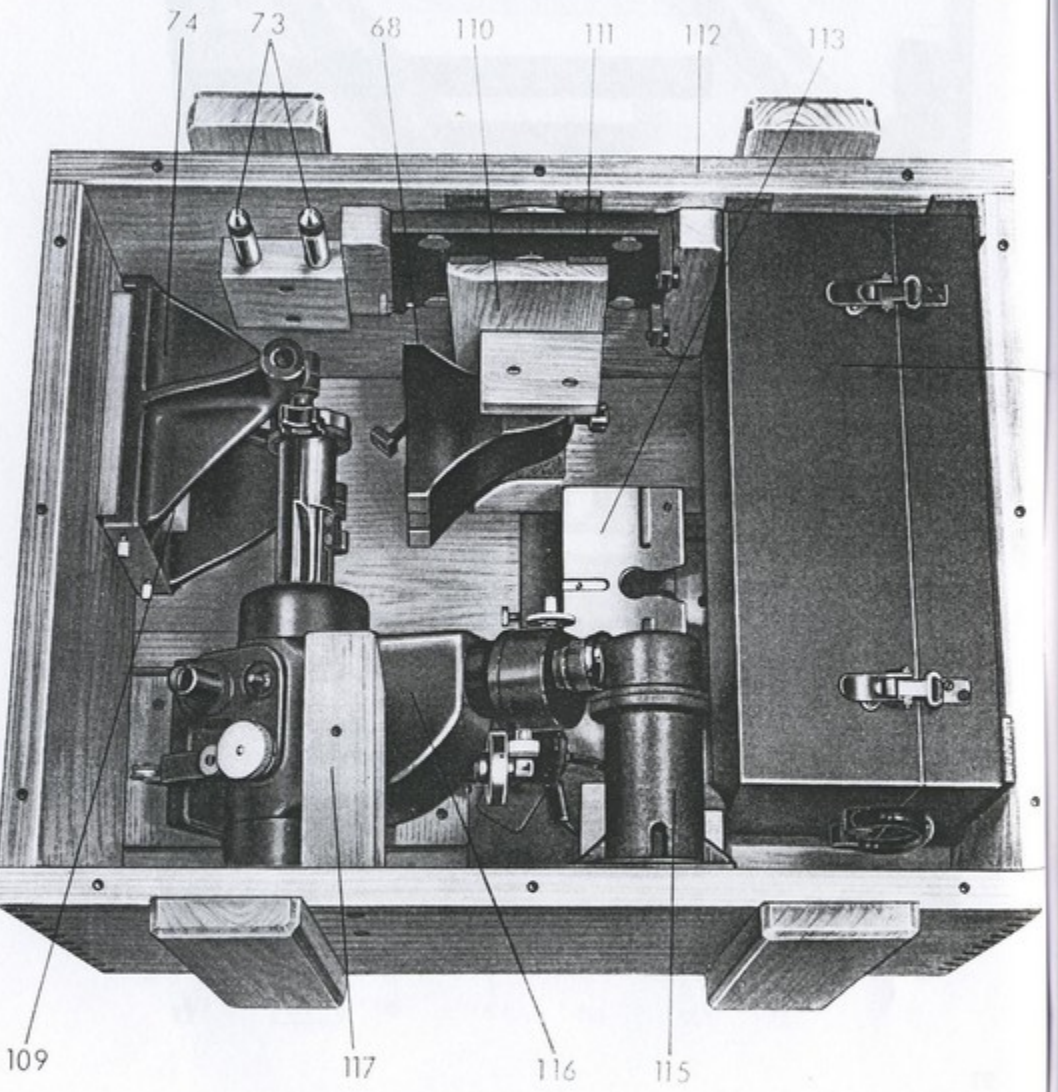
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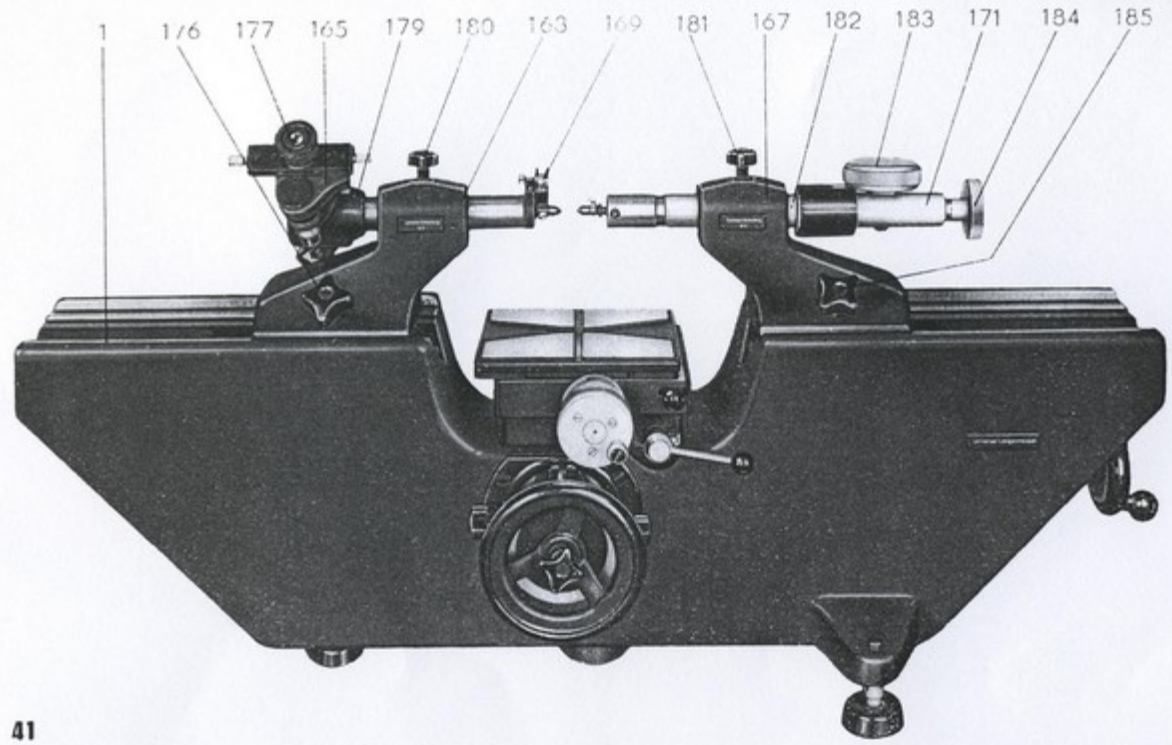
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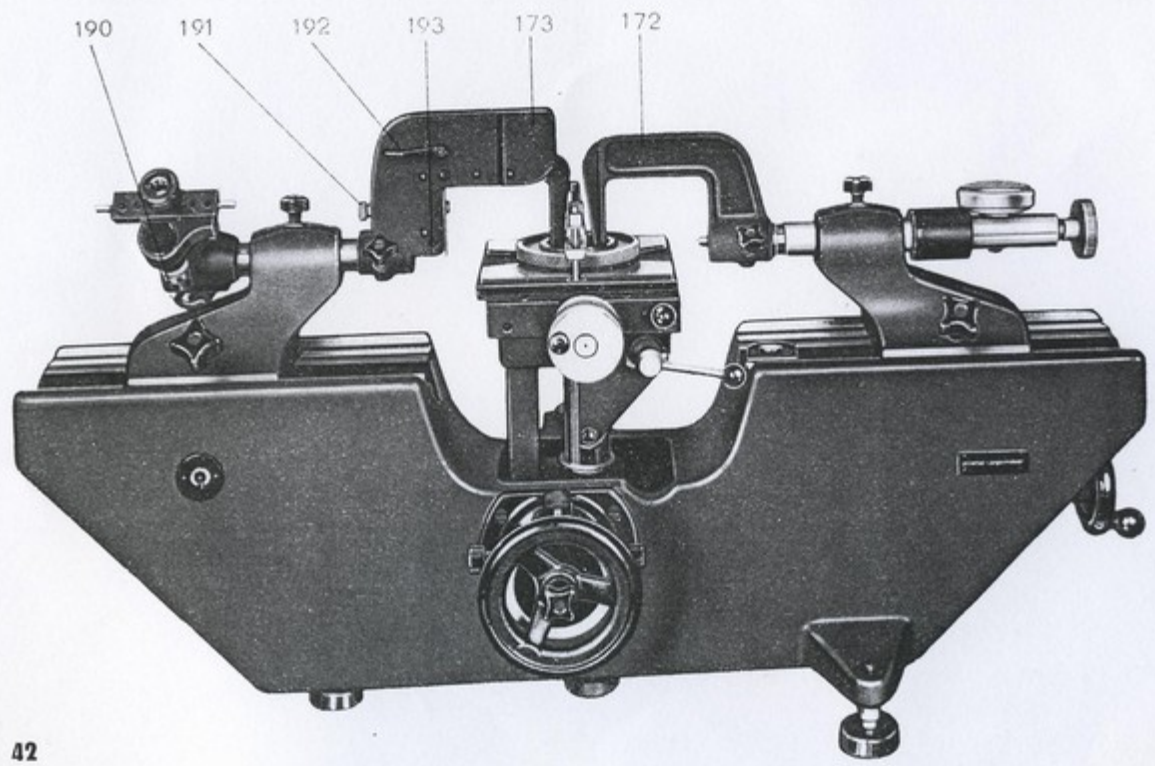
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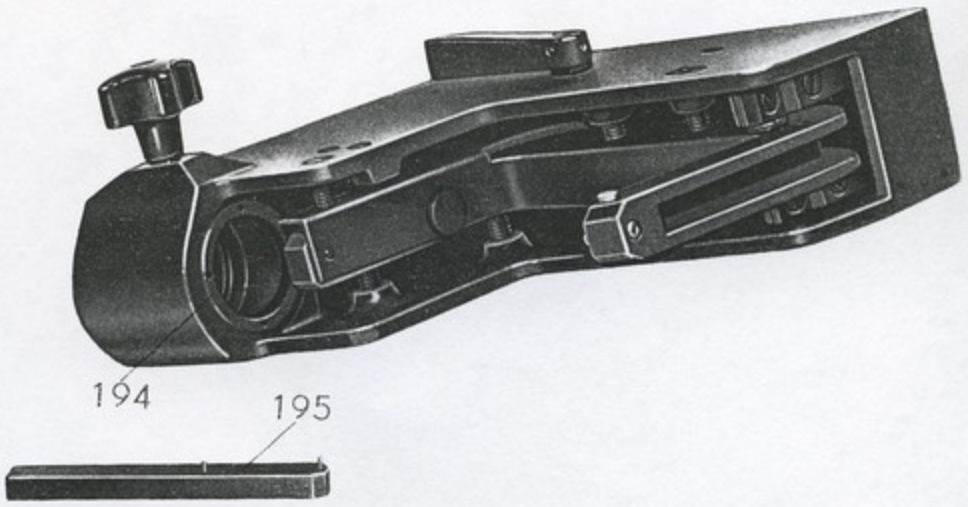
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