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MN-ISQ-ELM670-E

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ISQ-ELM670

LENGTH MEASURING INSTRUMENT

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CONTENTS

1. Illustration

Before unpacking and installing the instrument, read the following directions carefully and do by steps in order to guarantee the accuracy of the instrument.

2. The sequence of unpacking and installation

2.1 Take down the four screws12# which fasten the box, move out the Able measuring unit 13# completely. (Fig. B)

2.2 Open the front cover 8# of the Able measuring unit and remove the screws 2# and 3# , then close the front cover 8#. (Fig. A, B)

2.3 Release two screws 4# in right and left a little, then two screws 7#; firstly remove two screws 4# f and then two screws 7#.

Attention: When removing the screws 4# and 7#, it should be done in the meantime.

2.4 Locking screw 1#, support the Able unit 13# with two hands. Take out four screws 10#, take out 5#, 6# and 11# in a whole.

2.5 Take out the bed of the instrument form the box, and mount three foot-screws under it.

2.6 Take off three screws 16# (Fig. C)

2.7 Take off three screws 17# (Fig. C)

2.8 Loosen two screws 14# and 15#, take out 18# in a whole. (Fig. C)

2.9 Place the Able unit and the tailstock on the bed respectively. So the complete the unpacking and installing of the instrument.

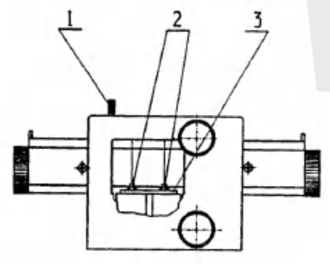

Fig A

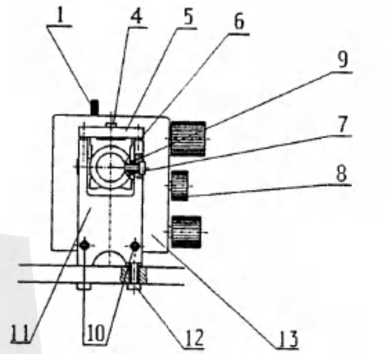

Fig B

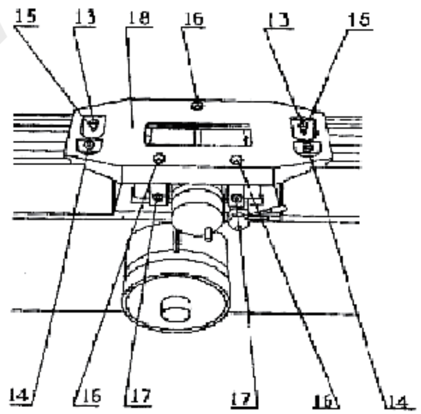

Fig C

Operation Manual

For ISQ-ELM670 Data Processing Universal Metroscope

1. Uses

The universal metroscope is a metrological instrument for direct and differential measurements. It has high accuracy because it exactly adopts the Able comparator principle and uses a high-precision measuring system. This instrument is mainly used in metal-working industry, especially the inspecting departments of machine building, tool making, in the manufacture of gauges and measuring instruments

The difference of the **ISQ-ELM670** metroscope and the conventional universal metroscope is: the **ISQ-ELM670** adopts the grating displaying technology and is the high-technology product of the integration of the optics, mechanic and electricity. This has greatly improved the accuracy and efficiency. At the same time, adding many accessories have improves the universal performance.

Its measuring parts is as follows:

a. Smooth cylindrical workpieces such as axis, hole, gauge and ring gauge.

b. The pitch diameter of internal and external thread, thread gauge and thread ring gauge.

c. Workpiece with parallel plane surface, such as measuring rod and lower grades gauge.

The **ISQ-ELM670** metroscope has a one-dimensional data processing system, which includes signle coordinate grating signal commutator, computer and data processing software.Printer outputs their results.

2. Specifications

Code		ISQ-HLM700	ISQ-HLM1000
Absolute measuring range		external size: 0~700mm	external size: 0~700mm
		inernal size: 12~580mm	inernal size: 12~580mm
Resolution		0.05μm	
Accuracy		±(0.2+L/1000)um, (L is measuring length in mm)	
Repeatability		external size: 0.2μm, internal size: 0.5μm	
Measuring force		(0.5~2.5)N, adjustable	
Measurement of external thread		0~100mm	
Abel axis travel range		0~16mm	
Maximum clamping diameter of the ejector pin holder		when the length is 0~170mm: Ø100mm	
		when the length is 170~205mm: Ø90mm	
Universal working table	range of height adjustment	0~70mm	
	transverse travel	0~40mm	
	horizontal float	10mm	
	Y axis gradient	±3°	
	rotation of the working table	±3°	
	permissible load	30kg	
Working environment requirement		temperature: 20±0.4°C, temperature change: ≤0.3°C/h	
Calibration environment requirement		temperature: 20±0.2°C, temperature change: ≤0.2°C/h	
Power		220V±10%, 50Hz	
Dimension (L×W×H)		1462×260×220mm	1780×260×220mm
Weight		250kg	350kg

3. Measuring Principles

3.1 The instrument is a contact mode length metrological instrument with a 100 mm grating scale as its measuring datum. The grating scale is placed in the centerline of the Able measuring axis, which is following the Able measuring principle. The worktable can move freely in five directions, with the special accessories like internal contact tip, electric measuring equipment. The instrument can fulfill all kinds of internal and external measurements of parts. And these are accordance with the conventional metroscope.

3.2 Grating digital display system

The grating digital display system includes two parts: the grating measuring system and digital display system.

3.2.1 The grating measuring system is composed of a grating scale and a reading head. (Fig.1)

a. Illuminating system

An infrared light diode is used as a light source in the grating reading head. Through a condenser, a parallel light casts on the surface of grating scale. The infrared light diode has high radiation efficiency and works in lower voltage and current, and has the advantages of small bulk, long life and high reliability.

b. Photoelectricity changing-over

The grating scale is white and black grating and each 1 mm has 100 pieces reticles. The indicating grating is four split phase mode. When the two reticles are parallel each other, it forms the moire fringe because of the transmission and blocking light effect. The silicon optical battery, which lies in the back of the indicating grating, will receive the periodic variety luminous flux, which convert into electric signal of 0 degree, 90 degree, 180 degree and 270 degree in sequence and send to the digital display system.

3.2.2 The digital display system is composed of signle coordinate grating signal commutator and computer system. Certainly, it also needs the corresponding software CD102 to support.

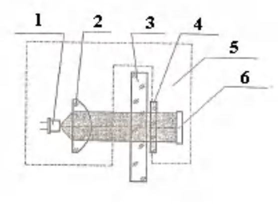

Fig.1 Diagrammatic drawing of grating measurement

1. Light diode 2. Condenser 3. Grating scale 4. Indicating grating 5. Grating reading head 6. Silicon optical battery

4. Structure

4.1 Bed

The bed is used to support the main body of the instrument and all kind of accessories and is composed of the base 5 and universal worktable 3.

4.1.1 Base (Fig.2, 3)

In the inside right of the base has balance equipment, which can easily raise or lower movements even in case of heavy parts. Adjust the balance equipment by the handwheel 4 in the right side of the base. The bed is supported by three foot screws 7, which rest in the plates. By means of these screws and a level 10 the bed can be leveled.

4.1.2 Universal worktable (Fig.2)

The front of the universal worktable is provided a handwheel for adjusting the height. The dial 14 of 0.5mm value is on the handwheel. Screws 13 and 21 limit the range of the worktable height adjustment, screw 21 controls the upper limit, the 13 does the lower limit. The worktable can be secured against vertical displacement by rotating the knob 11.

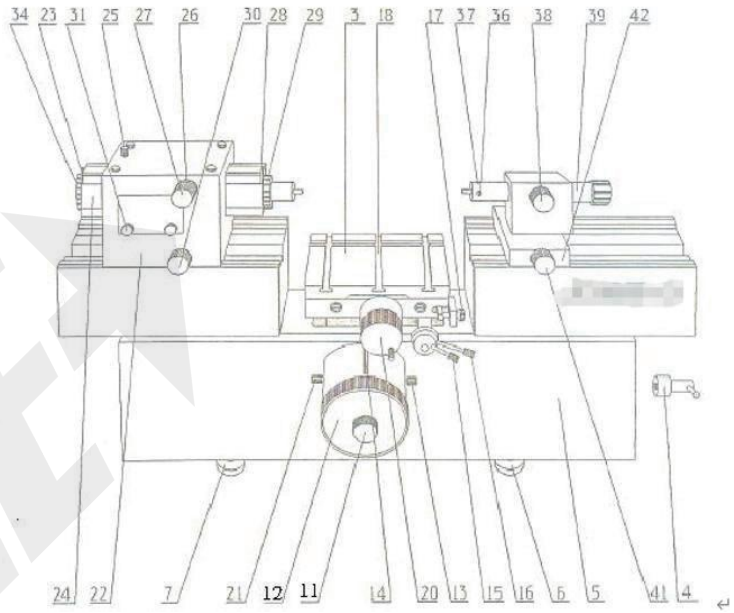

Fig.2 Outline of the digital universal metroscope

3. Universal worktable 4. Adjusting wrench for worktable balance 5. Base 6,7 Foot screws 11. Locking handwheel for raising or lowering worktable 12.

Handwheel for raising or lowering worktable 13. Screw for setting lower limit

14. Dial for raising or lowering worktable 15. Locking handle for swinging

worktable 16. Adjusting handle for swinging worktable 17. Adjusting handle for

rotating worktable 18. "T" slot 20. Micro-drum 21. Screw for setting

upper limit 22. Able measuring head 23. Holder for tension in external

measuring 24. Measuring main axis 25. Locking screw for measuring main axis 26. Knob for engaging fine position system 27. Fine knob for measuring axis 28. Holder for tension in internal measuring 29. Locking nut of front side of measuring axis 30. Locking screw for Able head 31. Switch of weight hammer 34. Locking nut of back side of measuring axis 36,37 Adjusting screw for tailstock tip axis 38. Locking screw of tailstock 39. Tailstock main axis

41. Locking screw of slide base 42. Slide base

The universal worktable 3 is a basic worktable and various accessories can add on it. By means of the two bevel surfaces, the electrically insulated worktable, the center cradle, bevel surface worktable and circular floating worktable are fastened on it. The worktable 3 also has two "T" slots, which is used to impact the presser, single V cradle, and double V cradle and cross cradle. The worktable can do the following movements for operation's need.

a. The worktable can be vertical adjusted within 100mm by handwheel 12 and dial 14. And can be set to a defined position by tightening the locking knob 11

b. The worktable can move within 25mm in the Y direction by turning handwheel 20. The scale value of its drum is 0.01mm.

c. The worktable can tilt ± 3°around the Y-axis by adjusting operation level 15. And can be set to a defined position using the locking lever 16.

d. The worktable surface can rotate ± 4° around vertical axis by turning screw 17.

e. The X direction of the worktable moves on the rolling slide, its travel is 18mm. Thus the testpiece can freely positioned without any constraint.

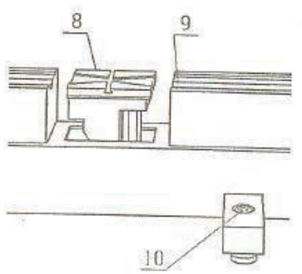

Fig.3 Rear view of the bed

4.2 Able measuring head (Fig.2)

The Able measuring head contains the measuring main axis 24 and the grating measuring system. The grating system operates in the case of transmission illumination with a 100mm grating scale as it measuring datum. The reticle space of the grating scale is 0.01mm, which has zero mark as absolute starting point for measurement.

The Able measuring head can move on the left side of the bed and be fixed in any position by locking handwheel 30. If required, the measuring head can also be mounted on the right side of the bed to adapt the operator with left hand.

The measuring main axis on the antifriction bearings can move in the Able head. The locking screw 25 can lock the measuring main axis in a position. The measuring main axis moves in the range of 100mm. The grating reading head is connected with measuring axis and performs the axis movements along the main axis. The grating scale is fixed on the unmovable framework.

Screw caps 29 and 34 are used to fasten the contact tip connector. Holding the screw cap 34 with hands can push or pull the main axis. In internal measurement, the end of the cord of the tension has to be attached to holder 28, in external measurement to holder 23. Inside of the measuring head rolls are provided by which the cords of the tension are suspended. Rubber pads prevent a hard impact of the measuring axis at the end of the measuring range.

For a little displacement the main axis in the axial direction, fine-position knob 27 is used. It can turn only, if the red mark on switching knob 26 points upwards. The high transmission ratio of the fine knob causes a slow motion of the main axis. The circular movement of the handwheel is converted into the axial movement of the main axis by frictions gears. The fine-position system is used for measuring holes by means of the electric measuring device. When using the system, the internal and external tension cords should be come away, and the locking screw of the main axis should be loosened.

4.3 Tailstock (Fig.2)

The tailstock main axis serves as a fixed datum (locating surface). Its slide 42 runs on the right side of the bed and can be locked in any position by knob 41. The tailstock main axis can be axially displaced in its bushing and locked in any position by locking knob 38. The measuring lever mounted the contact tip can be arbitrarily adjusted by screws 36 and 37 so as to make the plane contact tip and measuring surface are parallel to or concentric with each other.

4.4 Electric measuring equipment (Fig.4, 5, 13)

The equipment includes an electrically insulated worktable with a LED (Fig.4), measuring yoke (Fig.5) and spherical-end contact rod. It mainly serves for measuring holes of 1 mm to 60 mm diameter. And with universal measuring yoke of 14mm to 112 mm without measuring force. The maximum measured diameter can be get as the following formula:

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$D_{max} < 60 + K - W$ (mm)

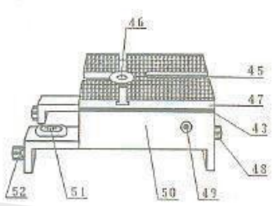
Where : W is the wall thickness for hole

D is the diameter of measuring ball

Dmax is the maximum diameter of measured hole

The electrically insulating worktable (Fig.5) provided with a table surface 47, which is electrically insulated from the table base by the insulating plate 43. There is a concave gap on the worktable surface. The spherical end contact tips can be inserted into the hole of the measured parts that is directly placed on the insulating worktable. Small parts are held via an intermediate ring 46 that is inserted into the hole.

The electrically worktable is attached on the universal worktable and fastened the groove on the universal worktable by clamp screws 48 and 52.The long level 50 on the base 50 is used for finely leveling the worktable. The insulating worktable is connected with a 6V transformer. Slots accommodate clamps for fastening the testpiece. The LED indicates when the contact tip contacts with the testpiece. The measuring yoke is mounted on the measuring main axis (Fig.13) and locked by the knob 55. The spherical end lord is fixed in the hole 57 of the measuring yoke and locked by screw 58. The measuring rod and electrically device are used measuring holes, and the value on the rod is the effective ball diameter. The electric circuit is closed which causes the LED to light up when in contact mode.



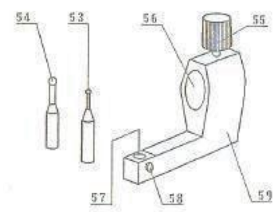


Fig.4 **Electrically insulating worktable** **Fig.5 Yokes and tips of electrically method**

4.5 Equipment for internal measurement (Fig.6, 9, 10)

It has a pair of small and large measuring yokes. The small are used for center axis and composed of two standard ring gauges.

The two kinds of yokes permit measure different internal diameter and depth of penetration. Try to use the large yokes. The small yokes are intended for measuring holes of 10 mm to 400mm and maximum depth of penetration of 12mm. They are holding on the measuring axis and center axis by means of knob. The large yokes are intended for measuring holes of 30 mm to 370mm and maximum depth of penetration of 50 mm. They are fixed on the main axis and tailstock axis. The ring gauge is used for the datum of internal measurements and has two kinds of diameter of 14mm and 50mm. The actual sizes and marks of effective measuring direction exist on it.

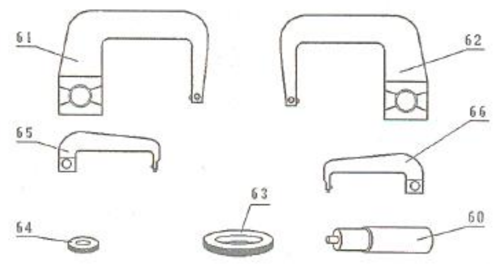


Fig.6 Accessories of internal measurement

4.6 Universal yokes (Fig.7, 11)

It is used for measuring external diameter micrometer and consists of yoke

68; two spherical tip with 4mm ball diameter 70 (5mm of depth of penetration) and with 12mm diameter 72 (80mm of depth of penetration), and a contact tip with a needle of 100mm 71, these contact tips is fixed on yokes with a gap 25mm within 200mm. The maximum gap of yokes is 230mm (along the main axis direction). For the large ring parts, the universal yoke can be used with electrically measuring device when requiring large depth of penetration.

5. Method of operation

5.1 Key points of use

5.1.1 Selecting and adjusting for contact tip

As the contact measurement method is used in the universal metroscope, it will avoid bigger error by reasonable selecting the adjusting the contact tips.

The principle of selecting contact tip is to try to reduce the contacting area between the contact tip and the testpiece.

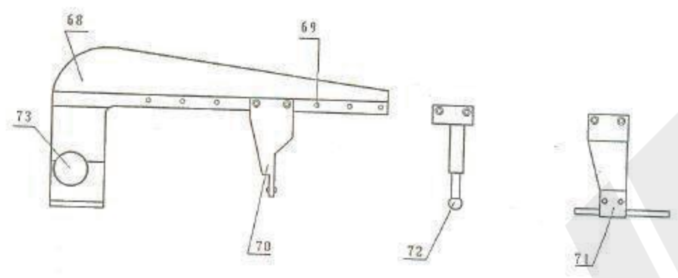


Fig.7 Universal yokes

The bigger contacting area has the following disadvantages:

a. Bringing the adjusting error, for example, the fine unparallel of the two surface of the tips makes the result error of different parts of the knives when the using 1.5×8 knife tips to measure diameter of cylinder.

b. Causing the measuring value easily changed, the dirty thing and oil of the contact surface bring the value changed when in contact mode. If it use the spherical contact tip, the dirty and oil can be removed only slight moving the contact tip and the testpiece.

For different parts, the following selecting of contact tips is for your reference.

Type of the testpiece	Contact tip selected
The distance of the measuring plane	Spherical contact tip
Cylindrical parts	Spherical contact tip
Spherical parts	Φ2 or Φ8 plane contact tip
Measuring thread pitch diameter with three-pin	Φ8 plane contact

Adjusting the contact tip:

a. Adjustment of spherical contact tip

The purpose of adjusting the spherical contact tip is to let the centers of a pair of contact tip pass the measuring axis. Mount one pair of contact tip on the tailstock and measuring axis respectively and let them contact with each other. Adjusting the screws 36 and 37 using screwdriver, meanwhile, observe the indicating value of the instrument and stop the position of the screws just in the maximum value, that is the "turning point". Pulling the measuring axis makes the contacts slight striking so that the instrument tends to steady after completed the adjustment.

b. Adjustment of contact tip with plane surface or knife-edge

The purpose is to make the measuring surfaces parallel to each other. Firstly do the coarse adjusting with above the method of finding "turning point"to obtain the minimum value. Then place the testpiece, and observe whether the indicating value in different position of the tips is the same. Finely adjust the reading difference by screw until the reading value in each position is the same. For measuring the thread pitch diameter with three-pin, place a three-pin in the up, down, right and left positions of the tip to test the parallelism after have done the coarse adjusting. Then be on the fine adjusting with purpose.

5.1.2 Selecting the measuring force

As the instrument adopts the contact method, the measuring force must be put both on the contact tips and the testpiece to assure the good contact. However, the function of the force will lead the elastic deformation of the tip and the testpiece, then the measuring errors are brought into. The elastic deformation will disappear when the measuring force is canceled.

Selecting the measuring force according to the tolerance and the extent of deformation, for the parts with small tolerance and easy distortion, the measuring force is as possible as small. The weight causes measuring force of 2.5N and 1.5N of the universal metroscope. Turning knob 31 to open the small door and removing the weight can change the measuring force. For large testpiece or yoke, 2.5N measuring force is used. Otherwise, 1.5N measuring force is used.

5.1.3 Selecting attached worktable

Except of the basic worktable, The **ISQ-ELM670** has many kinds of attached worktables to meet various different parts' requirements. The using range is listed in the following table:

Type of worktable	Range of suitable parts	Fig. No
Basic worktable	Gauges, square parts, short and thick cylindrical parts	Fig.10
Center cradle	Gauge, center axis with center hole	Fig.17
Single V cradle	Gauge and short with short axis	Fig.12
Double V cradle	Thin long gauge rod, inside micrometer	Fig.8
Circular floating worktable	Spherical and thread ring gauge	Fig.19
Electrically insulating worktable	Measuring hole with ?Magic eye?	Fig.13
Inclining fixed cradle	Outside micrometer	Fig.11
Cross fixed cradle	Caliper	Fig.9
A pair of backing strip	Diameter of thin disc and ring, internal and external dimension of plate	Fig.10

5.1.4 Basic operation to find "turning point"

When a workpiece is put on worktable, the measured line does not coincide usually with the measuring axial line of the instrument. So it is necessary to rectify the workpiece, which is come true through finding the"turning point". Therefore, finding "turning point" is a kind of basic frequent operation for the metroscope.

The indicating value will be altered when we operate the handle to move or turn the workpiece. Back point of the value is called "turning point" or "inflection point". Rectification is come true when the workpiece stops at the "turning point".

It requires finding "turning point" two times for most parts. For example, see Fig.14:

For measuring a cylinder, firstly make the worktable swinging right and left by adjusting handle, then find the minimum value, called "the first turning point", and keep the state. (Fig.14a)

Secondly, move the transverse handle of the worktable in order that the

measuring axis passes the diameter of the cylinder, and then find the maximum value, called "the second turning point".

Operating handle slowly and many times, the "turning point" can be obtained through comparing indicating value.

5.1.5 Impact and correction of temperature

The ideal temperature of the measuring length is at 20℃. The temperature of the workpiece should be identified with the instrument's. In the course of measurement, the alteration of the temperature should be as possible as small. The environment temperature deviates the 20℃ and the temperature of the instrument and the parts is not the same, which will bring measuring error.

The error of length measurement is:

$$\triangle L=[\alpha 1\times(t1-20)-\alpha 2\times(t2-20)]\times L$$

α1 : expansion coefficient of workpiece

α2 : expansion coefficient of the material of grating scale

t1 , t2 are the actual temperature of a workpiece and an instrument respectively.

L nominal length of workpiece

△L measuring error because of the temperature

Expansion coefficient of the material of grating scale of the instrument is :

10×10-6 1/℃

When measuring precise or large workpiece, it is necessary to measure the temperature of workpiece and instrument and to find out expansion coefficient of material of workpiece. Then calculate △L to modify the value. The temperature of workpiece and instrument can be measured with attached thermometer. For ISQ-ELM670 universal metroscope, the measuring value can be rectified with software.

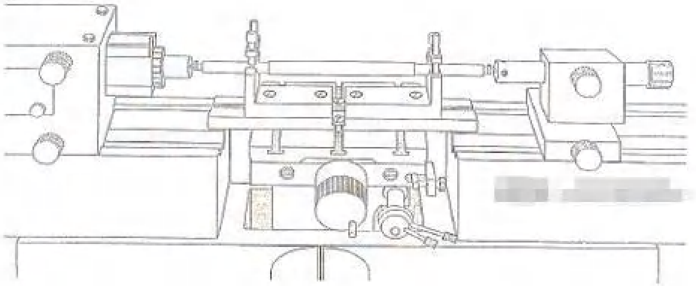


Fig.8 Measuring long gauge rod with double V-type cradles

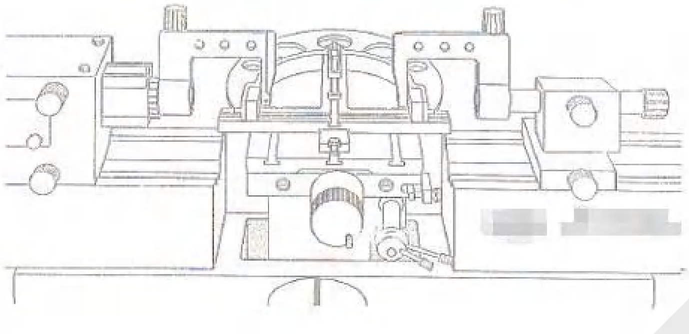


Fig.9 Measuring caliper with cross cradles

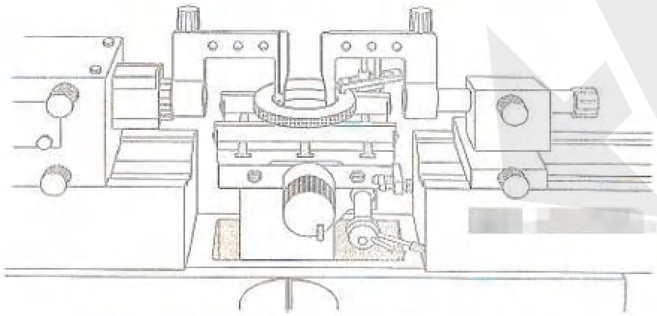


Fig.10 Blocking up thin workpiece with backing strip

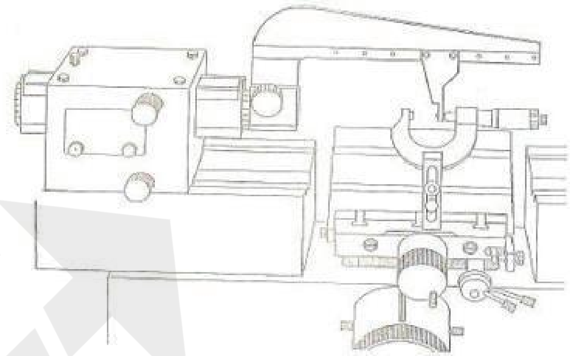


Fig.11 Applications of universal yokes and inclined cradles

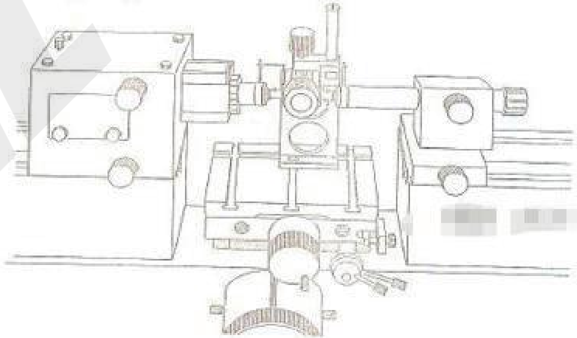


Fig.12 The applications of single V cradles

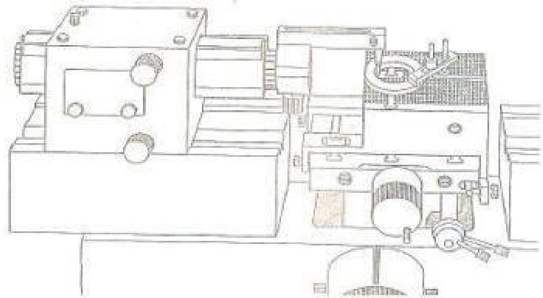


Fig.13 Measuring holes with "Magic eye"

5.2 Measurement of a typical workpiece

5.2.1 External measurement of a smooth workpiece

The external measurement has absolute and relative measurement.

Adjust the contact tip and measuring force and observe the temperature according to

5.1. Then select and mount the worktable, and place the workpiece on it.

The steps of absolute measurement:

a. To contact two contact tips each other, write down the value L0 or zero by pressing the key.

b. To put a workpiece measured between two contact tips and to contact, to find out"turning point" and write down the value L1.

c. The actual length measured L=L1-L0.

The steps of relative measurement:

a. To put a workpiece measured between two contact tips and to contact, to find out "turning point” and write down the value L0 or zero by pressing the key.

b. To put a workpiece measured between two contact tips and to contact, to find out “turning point” and write down the value L1.

c. The actual length measured L=L1-L0＋Ls.

Lsis the actual length of a standard workpiece.

For the sake of precision, to repeat a after b. The measuring value is effective if L0 is not altered. Shape error can be found out through repeating b. The measuring position of a workpiece being measured can be altered through moving worktable, thus can get the L2, L3, L4.......

If the size is smaller than 100mm, you can use either absolute measurement or relative measurement. If bigger than 100mm, only relative measurement, and the difference between a workpiece and a standard workpiece is less than 100mm.

5.2.2 Measuring a cone

Center cradles in level can hold a measured cone; its taper K and cone angle α can be calculated as follows: $tg\alpha/2=K/2=(D-d)/2L$

D: Diameter of big end d: Diameter of small end

L: Axial length between D and d

α/2: The angle between the cone line and centerline.

A certain distance exists between D, d and the surface. The measuring method is same as 5.2.1. The value L can be read out in wokrktable transverse micrometer drum (Fig.2). L had better be an integer.

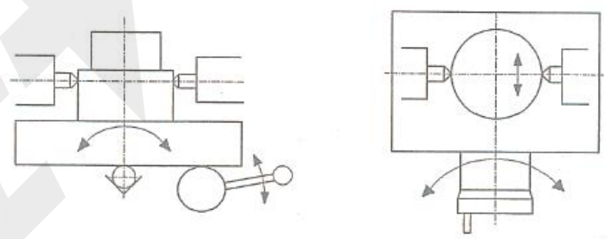


Fig.14a Finding mini value Fig.14b Let axis passing cylindrical diameter

5.2.3 Internal measurement with double measuring yokes

Internal yokes have big and small ones. The big one is used in measuring hole with more than 30mm

(Fig.9, 10), and small one is used in measuring hole with less than 30mm. For smaller hole, measure hole with"Magic eye" (See 5.2.4)

The method of double measuring yokes is in relative. The standard workpiece is a ring gauge attached to instrument. (No63, 64 in Fig.6). There are a big one and a small one. The actual size is on the surface respectively. The position is marked on it with line.

Big yokes are fixed on the measuring axis and on the Φ28mm diameter of tailstock. When using small yokes, tailstock have to be changed into a special tailstock, in the meantime, its mark has to be aimed at mark of tailstock. Yoke is fixed on the measuring axis. Open the cover in front of the tailstock and adjust the four screws to correct the axis. (It has been rectified before leave the factory, do not adjust at random). Lock the four screws after adjusting.

The steps of internal measurement with double yokes:

a. Mounting yoke, outside weights separate from the measuring axis and then hang up internal weights.

b. Place the standard ring gauge on the worktable; the mark is parallel to the measuring axis. Raising the worktable, two yokes are inserted into a hole and contacted with a surface. Find out "turning point" and write down a value L0 or zero by pressing key.

c. Take down the ring gauge and mount the testpiece. Raising the worktable, two yokes are inserted into a hole and contacted with a surface. Find out "turning point" and write down a value L1.

d. The actual value L=L1－L0＋Ls (Ls is the actual size of a ring gauge).

e. Repeating b, the value is effective if L0 is not altered.

Shape error can be obtained through repeating c step operation. The measuring position of a workpiece can be altered through moving worktable; we can get L2, L3, L4.....

5.2.4 Measuring a hole with "Magic eye" device

The method of "Magic eye" is internal measurement without measuring force through spherical contact tip; the "Magic eye" (a LED on the insulating worktable) indicates the state of contact. Its characteristic is without measuring force, so has high precision and can measure small hole.

Before measuring, the instrument should be adjusted as follows:

a. Check whether the base bubble is in the center (No 10 in Fig.3)

b. Mount the electrically measuring worktable (Fig.4) and adjust the handle (No15 in Fig.2) to make the bubble in center.

c. Take out the weight and loosen locking screw (No 25 in Fig.2) to tooth the giggle device (No 26 in Fig.2)

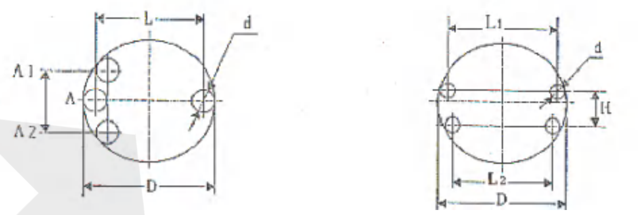
d. Mount an electric contact tip. For small hole, beam of yokes lies under the measuring axis for convenience observation.

e. Mount the measured testpiece and press it. A medium ring should be used when the diameter of a workpiece is less than Φ 20mm (No 26 in Fig.4).

f. Turn on the circuit and check “Magic eye” to make sure whether twinkle is sensitive.

Before measuring, rectify the position of a workpiece to make that the center

of a hole on the workpiece should coincide with a measuring axis. The method as follows (Fig.15a):



Measuring hole with two points Measuring hole with double string

Fig.15 Principle for mesauring hole with "magic eye"

Turning the transverse fine handwheel, the center of a hole is deflected from the measuring axis purposefully. Moving measuring axis slightly make a contact tip approaching a workpiece until "Magic eye" twinkling. And write down the reading A1. Again turning the transverse fine handwheel makes the contact tip away the testpiece until tip is close to the inside surface. Write down the reading A2 when the “Magic eye” twinkling. We get a average value:

A=(A1＋A2)/2. Turn the handwheel to the value A, at this moment; the center

of the hole coincides exactly with the measuring axis.

The measuring steps:

Slightly moving the measuring main axis makes tip approaching the inside surface until the"Magic eye"

twinkling. Record the reading value L1 of main axis. And turning measuring axis in reverse direction makes the contact tip away the testpiece until tip is close to the inside surface. Write down the reading L2 when the"Magic eye" twinkling. Then back to the state L1 and check whether L1 is altered. If no, the end value is the average of two times.

The result of hole:

D=L＋d=| L2-L1|＋d ; d is the actual value of tip spherical diameter

Above method is called “two points”. See the Fig.15b, it is the “double string” method. Measure two strings L1 and L2 at random near the diameter; the distance H of the two strings can be read by transverse handwheel.

The step is:

a. Take a1 and a2 at two ends of string 1 according to the indication of "Magic eye"

b. Move the handwheel for a distance H.

c. Take a3 and a4 at two ends of string 2 according to the indication of "Magic eye"

d. Calculating: L1=|a2 – a1|; L2=|a4 – a3|

e. Calculate the measuring result according to the following formula.

D= d + {L22 + [(L1/2)2 – (L2/2)2 + H2]2/H2}1/2

d is the actual value of tip spherical diameter

Note: measuring accuracy is the best high when the H is 1/20 to 1/40 of the diameter of a measured hole.

5.2.5 Internal measurement with a single yoke

"A single yoke", that is the "universal yoke"(No 68 in Fig.7), is used for bigger internal measurement. It can be used together with a electric worktable. The method is similar to that of 5.2.4. And also can be used together with an inclinable cradle (Fig.11). Now, weight should be hung up on the measuring axis when the tip contacts with the sides of the parts. Measuring force had better be 1.5N.

5.2.6 Measuring external thread pitch diameter with “three-pin” method (Fig.18)

The measuring principle is shown in Fig.16.

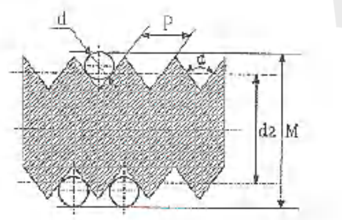


Fig.16 Principle for "three-pin"

In Fig.16, d2 is the actual pitch diameter; P is pitch screw; α/2 is half angle of tooth

shape; d is diameter of three-pin; M is the distance of two external surfaces of three-pin when measuring.

The selection of "three-pin"s diameter:

Try to make the contact points of three-pin and thread close to the pitch diameter so as to reduce the measuring error. The optimum diameter of three-pin should be selected according to the below table:

Metric thread		Metric thread		Metric thread	
Pitch of screw	Three-pin dia	Pitch of screw	Three-pin dia	Pitch of screw	Three-pin dia
0.2	0.118	0.75	0.433	3.0	1.732
0.3	0.142	0.8	0.461	3.5	2.020
0.35	0.201	1.0	0.572	4.0	2.311
0.4	0.232	1.25	0.724	4.5	2.595
0.45	0.260	1.5	0.866	5.0	2.866
0.5	0.291	1.75	1.008	5.5	3.177
0.6	0.343	2.0	1.157	6.0	3.468
0.7	0.402	2.5	1.441		

Inch thread		Inch thread		Inch thread	
The number of	Three-pin dia	The number of	Three-pin dia	The number of	Three-pin dia
24	0.572	11	1.302	5	2.866
20	0.724	10	1.441	4.5	3.177
18	0.796	9	1.591	4	3.580
16	0.866	8	1.732	3.5	4.091
14	1.008	7	2.020	3.25	4.400
12	1.157	6	2.311	3	4.773

Trapezia thread		Trapezia thread		Trapezia thread	
Pitch of screw	Three-pin dia	Pitch of screw	Three-pin dia	Pitch of screw	Three-pin dia
2	1.047	5	2.595	10	5.176
2	1.302*	5	2.866	12	6.212
3	1.553	6	3.106	16	8.282
3	1.732*	6	3.287	20	10.353
4	2.071	8	4.141	24	12.423
4	2.217	8	4.211	32	16.565

Note: one which has "*" is used in open-end gauge.

Adjusting the instrument

Selecting a plane contact tip, rectify its parallelism roughly with the method of "turning point". And then check its parallelism with three-pin. Mounting center cradle, hold a workpiece. To make sure the position of tailstock so that floating worktable is located in the middle of worktable when the measuring tip of tailstock contacts with a workpiece. Take out workpiece and contact the two tips each other. Return the measuring axis after zeroing. Through moving the worktable up and down, the axis of needle is in the same surface with measuring axis. Mounting three-pin holder to contact a measuring tip with the measuring axis and insert three-pin into a thread according to Fig.16. Adjust the worktable and turn it to find out a turning point of a minimum and get a value M. Take out the workpiece and check the instrument to make sure whether the zero-point is altered.

In term of the thread's length, pitch diameter should be measured many of longitudinal sections. Two directions of a gap 90°of measured sections should be measured to find out the shape error of a pitch diameter.

The measurement result is get by following:

d2=M－d[1＋1/Sin(α/2)]＋P/2×Ctg(α/2)

5.2.7 Measurement for internal thread pitch diameter (Fig.19)

For universal metroscope, measuring internal thread is belong to relative measurement. Its standard testpiece is composed of a pair of side block and gauge block that have standard thread.

Its principle is shown in Fig.17. and the mathematic model is below:

d2=E－P/2×Ctg(α/2)＋(a＋b)－P2/{8×[d2＋P/2×Ctg(α/2)－d/Sin(α/2)]}

E : the size of gauge block d2 : nominal pitch diameter of thread

P: the pitch of measured workpiece α/2: semi-angle of thread

a＋b the size of a side block d : tip diameter can be select in the following

table. (For inch thread,first convert the pitch diameter into metric thread, and then select it according to the table.)

The table for contact tip is not suitable forthe no go gauge withdock-toothed mode. If need contact tip that the diameter is out of the table, contact our

company for special order.

Recommending table for tip diameter

Metric thread Pitch diameter p (mm)	Tip diameter d (mm)
≤ 2	0.8
2～2.5	1.35
3～3.5	1.8
4～4.5	2.3
4.5～5	3.1
＞5	3.75

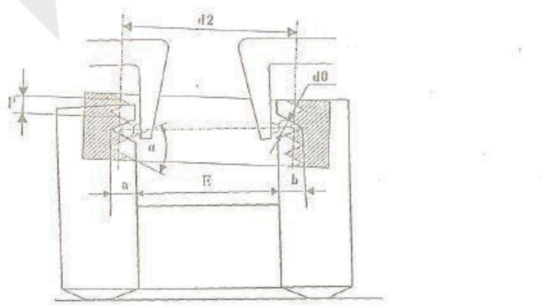


Fig.17 Principle for internal thread measurement

Before measuring, calculate the E:

E = d2＋P/2×Ctg(α/2)＋(a＋b)－P2/{8×[d2＋P/2×Ctg(α/2)－d/Sin(α/2)]}

Measuring steps of internal thread pitch diameter:

a. Component gauge

Calculating the E according to nominal pitch diameter of a thread measured. E is not usually an integer. In fact, the accuracy of component gauge needs only 0.1mm. The other difference can be rectified by ΔE.

For example, to measure the pitch diameter of M52×1f “T” thread ring gauge,

the size of a side block : a＋b=6.17mm: tip diameter : Φ 0.8mm. Look up

M52×1f

"T" in a manual and get its nominal pitch diameter : 51.329 + 0.014 .

Therefore:

E = 51.329 + 0.5×1.732 + 1/[8×(51.329 – 0.8/0.5 + 0.5×1.732)] – 6.171

= 46.026mm

According to the value E, in fact, select two gauge blocks of 40 and 6; in the qualification of gauge, the rectification is –0.5um, -0.3um for 6mm gauge. So the total rectification is:

Δ = -0.026 – 0.0005 – 0.0003= -0.0268mm

To improve the measury accuracy, it should try to make the E(actual value of gauuge) approach the E0(gauge value for calculating by software).

Hold the gauge block and side block tightly, and note that ought to rest the down-end of a side block against position of gauge clamp tightly. Put the compound gauge and a workpiece on a flat plate to equalize their temperature each other.

b. Adjusting the instrument:

Mount a circular worktable, an internal yoke and a thread tip according to the Fig.19. Mount a workpiece and clamp it with an elastic clamp. Move a contact tip to a hole nearby, at this time, the worktable ought to have enough floating room. Position headstock and tailstock and lock them.

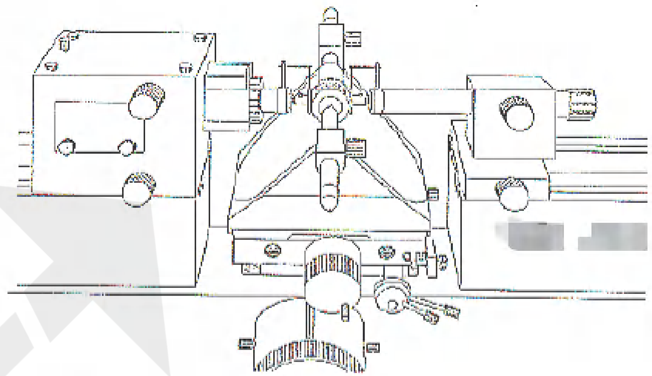


Fig.18 Measuring external thread pitch diameter with "three-pin"

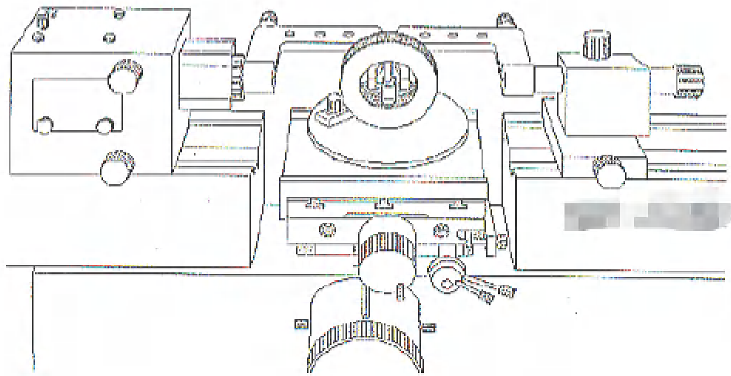


Fig.19 Measuring internal thread pitch diameter

c. Rectifying the gauge:

Take out the workpiece and put a gauge on the worktable. Hook the V-type slot of the standard gauge through a yoke. Now the worktable ought to have enough floating room. If no, have to adjust the position of gauge. Turn the fine handle of worktable and read the indication. After finding out a minimum "turning point", lock the handle and write down the value L1.

d. Measurement:

Taking out gauge, mount the measured workpiece and clamp it with an elastic clamp. When mounting, let the worktable be floating enough. Operate the worktable and measuring axis to make two yokes inserted a thread measured and separated half a pitch each other. To raise up and down, observe the indicating value. After finding out a maximum "turning point", lock the handle and write down the value L2. For the sake of finding the shape error of thread, we can measure its different position.

e. Zeroing:

Take down the workpiece and put a gauge, then repeat operation c to see if L1 is altered. If no, taking the average value of two times' is the end value of L1.

f. Data processing:

The deflection of measured pitch diameter: Δd2=L2－L1＋ΔE

For example: as above illustration, L2－L1=0.060mm

So Δd2 = 0.060－0.0268=0.0332mm

Actual pitch diameter: d2=51.329＋0.332=51.3622mm

6. Maintenance

6.1 The room for installing the universal metroscope should be kept as far as possible from dust, vibration, and corrosive atmosphere and moisture. A thermostat should be installed in the room so as to keep the room temperature at about (20±0.5)℃. The relative humidity should not exceed 60%, otherwise the optical parts would get moldy. The instrument should not be placed near the thermal sources.

INSIZE

6.2 After each measurement is completed, the surfaces of worktable, contact tips and other accessories should first be cleaned with gasoline and then coated with a thin film of non-acid Vaseline.

6.3 When it is necessary to clean the surface of the optical parts, the dust should be removed first with a soft, clean and degreased brush, then mop slightly the unclean parts with a soft fine cloth (already degreased or cleaned), or with degreased cotton soaked with a mixture of a alcohol (30%) and ether (70%).

6.4 When the instrument is not in use, its accessories should be placed in their containers or dry tanks. The instrument proper should be covered with a plastic hood.