Federal State Unitary Enterprise
Production Amalgamation
"Novosibirsk Instrument-Making Plant"

UNIFIED AUTOCOLLIMATORS AKU

CERTIFICATE

2.766.789 PS

Since efforts are continually made to improve the reliability and performance of the autocollimator, minor changes may be introduced into its design without special notice.

CONTENTS

1 APPLICATION

The unified autocollimators AKU-0,2; AKU-0,5 and AKU-1 (with second-scale factor of 0.2, 0.5 and 1", respectively) are designed for visual measurement of angles and non-linearity of guides as well as for determining mutual angular dispositions of axes and planes in space and double also as zero-indicators (hereafter referred to as the autocollimators).

The autocollimators are provided with a two-coordinate eyepiece head which makes it possible to take measurements simultaneously in two planes without additional adjustment.

In combination with a polygonal prism the autocollimators may be used for checking angle-measuring instruments such as optical dividing heads, optical quadrants, etc.

The autocollimators may also stand duty as usual telescopes.

The AKU-0,2 and AKU-0,5 autocollimators are meant for taking measurements in the laboratories of precision-production shops, while the AKU-1 autocollimator may be used for taking measurements at the worker's places in the shops of machine-building plants.

The instruments must operate in closed premises at an ambient temperature of 20±3 °C and relative humidity of up to 80%, with the objectives protected against rays from extraneous light sources.

2 SPECIFICATIONS

Table 1

Name of main parameters and dimensions	Normal values		
	AKU-0,2	AKU-0,5	AKU-1
All-Union Product	4431564030	4431563020	4431562020
Classifier Second scale factor in visual field, ... "	0,2	0,5	1
Minute scale factor, ..."	10	30	60
Maximum working space from objective to mirror, m	30	25	20
Full-scale range, ... ' minimum when space from objective to mirror is:			
up to 0,7 m	10	20	40
up to 0,2 m	10	20	22
when working space is maximum	2,0	1,8	1,0
Limit of permissible error over whole measurement range, ...":			
with one-coordinate measurements taken	1,5	3,0	5,0
with two-coordinate measurements taken	3,0	6,0	10,0
Visual magnification, x	58	29	14,5
Angular field of view, ...°	1±0,1	2±0,2	4±0,4
Entrance pupil diameter, mm	56	50	30
Sight axis adjustment range:			
in horizontal plane, ...°, minimum	±1	±1	Unlimited
in vertical plane, ...', minimum	±20	±20	Unlimited
Visible,length of divisions, mm, minimum:			
second scale	0,8	0,8	0,8
minute scale	1,4	2,0	2,0
Space from base to objective axis, mm	100	100	–
Power supply-single-phase a.c. mains:			
voltage, V	220^{+22}_{-33}	220^{+22}_{-33}	220^{+22}_{-33}
freguency, Hz	50±1	50±1	50±1

Table 1, continued

Name of main parameters and dimensions	Normal values		
	AKU-0,2	AKU-0,5	AKU-1
Overall dimensions, mm maximum:			
length	535	430	300
width	130	130	130
height	145	145	145
Mass, kg, maximum	4.6	3.8	2.2

3 COMPLETE SET

Table 2

Designation			Name	Qnty per type
AKU-0,2	AKU-0,5	AKU-1		
5.176.501-01	5.176.501	5.176.501-02	Autocollimator	1
5.087.038-02	5.087.038-02	5.087.038-02	Power unit	1
5.950.106-04	5.950.106-04	5.950.106-04	Mirror	1
		Spare parts		
			Lamp OP4-4-1	6
			Fuse link VP 1-0.25A-250V	3
		Tools and Accessories		
5.927.008-02	AL5.927.008-02	5.950.823	Attachment with diagonal mirror	1
5.817.020-02	AL5.817.020-02	5.817.020-02	Level	1
5.935.810	AL5.935.810	5.935.810	Prism Yu	1
6.120.602	AL6.120.602	6.120.598	Base	1
8.890.001-01	AL8.890.001-01	8.890.001-01	Napkin	1
6.890.030-08	AL6.890.030-08	6.890.030-08	Screwdriver	1
–	–	8.122.674	Support	3
8.367.104	AL8.367.104	–	Stop	1
–	–	8.902.162	Screw	3
		Service Documents		
2.766.789 PS	2.766.789 PS	2.766.789 PS	Certificate	1
		Packing Means		
4.161.646-01	4.161.646	4.161.642	Case	1

The accessories for the autocoilimators, delivered at the customer's request, are shown in Table 3.

Table 3

Designation			Name of set components	Qnty per type
AKU-0,2	AKU-0,5	AKU-1		
5.950.901-01	5.950.901	5.950.901	Mirror	1
5.935.098-04	5.935.098-05	5.935.098-05	Prism	1
5.935.126-05	5.935.126-06	5.935.126-06	Polyhedron	1
5.950.089-02	5.950.089-02	5.950.089-02	Mirror	1
6.120.603	6.120.603	–	Base	1
4.161.651	4.161.651	4.161.651	Case	1

4 DESIGN AND OPERATION PRINCIPLES

4.1 Design

The autocollimator AKU-0,5 is shown in Fig. 1, while AKU-0,2 — in Figs. 2, 3 and AKU-1 – in Figs. 4, 5 and 6.

The design and principle of operation of the said autocollimators are similar. They differ from each other only in objective design as well as in graduation of minute and second scales.

Additionally, AKU-1 differs from AKU-0,2 and AKU-0,5 in the design of base it is mounted on.

The autocollimator consists of barrel 6 (Fig. 1), objective 5, eyepiece head 7 and base 11.

Barrel 6 is a pipe with objective lens 5 screwed in from one side, and eyepiece head 7 and compensator screwed in from the other side. The barrel is mounted on base 11 and fixed thereon by screws 3 (Fig. 2).

Base 11 is provided with mechanims for setting the autocollimator sight axis perpendicularly to the reflecting surface. Knobs 10 (Fig. 1) and 5 (Fig. 2) serve to set the axis in the vertical and horizontal planes, respectively.

The autocollimator is secured in the working place with the aid of two permanent magnets which are switched on by knob 4 (Fig. 2).

Eyepiece head 7 (Fig. 1) has a minute and second scales as well as positive and negative lenses of the compensator.

The compensator's second scale connected rigidly with the positive lens can be moved in two directions relative to the minute scale with the help of knob 2 (Fig. 2) and knob 1 when measuring deflection of the mirror angles in the vertical and horizontal planes, respectively. When using knots 1 and 2 (Fig. 2) handles 6 must be placed in the Grip position. The dioptric eyepiece can toe moved according to the operator's eyesight within the range of ±5 diopters. The autocollimator is switched on via power unit 9 (Fig. 1) by toggle switch 8.

The instrument's complete set includes mirror 1 in a mount with magnetic base 15. The magnet is switched on by handle 14 and the mirror is fixed on the metal surface. To avoid demagnetization of the instrument and mirror, when in the inoperative condition, one should switch off the magnets. Cap 13 is meant to protect the mirror surface from damage. There is prism 3 in the instrument complete set to set plane mirror 1 perpendicular to the autocollimator optical axis. The prism is prism Ю assembly 2 (Fig. 20) fixed in housing 1.

The prism is to be placed between the autocollimator and mirror, with one of its faces pressed to the end face of the objective lens mount according to the diagram (see Fig. 19). Turn the mirror or autocollimator to make two images of the autocollimation mark be visible and matched in the viewfield of the prism. Next, while looking through the autocollimator eyepiece, bring the autocollimation mark image into coincidence with (the sight reticle by making use of knobs 10 (Fig. 1) and 5 (Fig. 2).

Besides mirror 1 – on the magnet base, the complete set includes diagonal mirror 4 fastened on the objective lens mount by a screw and striding level 12.

The diagonal mirror serves for changing the direction of sight axis and operates in conjunction with mirror 1.

The complete set of AKU-1 autocollimator incorporates a special stand.

The stand comprises adjustable table 4 (Fig. 4) to place details to be checked and adjustable post 1 with movable slide 2. The autocollimator Is fixed by yoke 3 having the ability of turning.

The spatial position of the table surface may be changed by means of adjusting screws 5 (Fig. 4) to ensure accurate adjustment of the detail being checked relative to the autocollimator. The post design affords movements of the autocollimator in the vertical plane and gyration to set the instrument in a required working position. It is possible to detach the adjustable post and set it in the horizontal position with the help of three adjusting screws 1 (Fig. 5).

4.2 Principle of autocollimator operation

Flat mirror 1 (Fig. 7) is mounted at a distance of up to 30 m from the autocollimator and perpendicularly to its sight axis.

The rays of light which come out of objective lens 2 in a form of parallel beams reflect from mirror 1 and enter again the objective lens, thus giving an image of the autocollimation mark on minute scale 3.

If the mirror is moved parallel to its initial position, no displacement of the autocollimation mark occurs. In turning the mirror by the angle α, the rays reflected from it turn through the double angle 2 α and the image of the autocollimation mark in the scale plane changes its position by the value a. The value of autocollimation image displacement is measured by means of compensator 16 (Fig. 8), one of its lenses is immovable, while the other one is rigidly connected with second scale 17 and can move perpendicularly to the autocollimator's optical axis in two interperpendicular directions.

4.3 Optical train

The autocollimator optical train with illumination system is shown in Fig. 8.

The beam of rays from light source 3 passes condenser 4 and light filter 5, illuminates mark 6 and, having reflected from two turning mirrors 7 and 8, enters prism-cube 9 cemented of two rectangular prism elements. Then the beam of rays falls on objective lens 2. Each autocollimator type has its own objective lens type: AKU-0,5; AKU-0,2 and AKU-1 (Fig. 8: reference number 2, 2a and 2b, respectively).

Autocollimation mark 6 is located in the focal plane of objective lens 2, therefore the rays leave the objective lens in the form of parallel beam. Having reflected from the mirror surface (the plane of mirror 1) and passed again through the objective lens and prism-cube, the rays enter an optical eyepiece-micrometer.

The eyepiece-micrometer is composed of compensator lenses 16, second scale 17 and minute scale 18. The plane of the minute-scale divisions is located in the objective's focal plane. Prism 15 is meant for changing the path of rays by 45 °.

The system comprising accessory light filters 12, 13 arid 14, turning mirror 11 and lens 10 serves for uniform illuminating of the second and minute scales.

The autocollimator field of view is illustrated in Figs. 9, 10 and 11.

5 SAFETY PRECAUTIONS

When using the autocollimator one should adhere to the safety regulations.

CAUTION. Prior to operation it is necessary to earth the power unit.

When the instrument is switched on, it is prohibited:

to replace the fuse link;

to replace the lamp in the illuminator.

Only the persons briefed on the safety precautions are allowed to use the autocollimator.

6 PREPARATION OF AUTOCOLLIMATOR FOR USE

6.1 Unpacking

On receiving the autocollimator it is necessary to keep it packed for six nouns at a temperature of 20±3 °C.

Then unpack the instrument, remove the lead-seals and open the cover of the market container,

Carefully take out the autocollimator, and accessories, thoroughly wipe the lubricated metal parts with a clean napkin. If need be, wipe the outer optical parts with a degreased clean cotton wool wad moistened in rectified alcohol or remove dust with a brush. Never wipe the optical surfaces with a dry wad.

The mirrors should be cleaned with a particular care, because a reflecting layer is applied to the outer surfaces.

It is forbidden to touch the reflecting mirror surtaces with hands or dry cleaning material.

Operation is over, put down special cap 13 on mirror 1 (Fig. 1).

6.2 Setting and adjustment

The base of the AKU-1 autocollimator (Fig. 4) is packed in a disassembled state (three separate parts).

Yoke 3 is attached to post 1 along cone, with screw 2 slackened. Then post 1 with yoke 3 secured thereon is fastened to base 4 by three fastening screws 1 (Fig. 6).

The autocollimator must be placed on a vibration-proof ferromagnetic plate and kept for six hours without being connected to an a.c. mains.

The autocollimator should be protected against the influence of heating plants and falling of rays from extraneous sources on the objective lens.

Connect the power unit to the autocollimator and energize the former.

Switch on the autocollimator lamp by means of toggle switch 8 (Fig. 1).

Set mirror 1 in front of the objective lens as described in item 4.3.

Check the knobs of the eyepiece and mechanisms of setting the autocollimator in vertical and horizontal planes for smooth rotation as well as the magnets for proper functioning. Make sure that all mechanisms are in good repair and get down to work.

7 OPERATION ORDER

7.1 General

It is good practice to use the autocollimator in a dark room or screen the objective lens to avoid penetration of direct or diffused light in the system, thus causing appearance of light glares.

When taking measurements, turn the compensator knobs easily and smoothly, without applying force in the axial and radial directions.

To ensure minimum errors when measuring simultaneously in two planes one should make the coordinate planes of measurement be parallel to the actual planes in which the mirror inclinations to be measured take place. The coordinate planes of the autocollimators are oriented relative to the lower bearing plane so that one plane of measuring will be horizontal while the other one – vertical, provided that the autocollimator is placed on a well-levelled surface.

Proceeding from this, when taking simultaneous two-coordinate measurements, is it advisable to set the autocollimator always on a levelled surface, simultaneously checking as far as possible the correct orientation of the measuring mechanism in the cross plane with the aid of applied level 12 and mirror 1 (Fig. 1).

For proper orientation of the autocollimator's measuring mechanism proceed as follows.

Place level 1 on seat 2 (Fig. 3) so that the marks on the level vial are symmetric about the guides of seat 1. Should the level bubble deflection be beyond one division, turn autocollimator 3 (Fig. 21) around base 4. For this purpose, give screws 5 a half of a turn, then undo the screws locking screws 1 and 2, and bring the level bubble to the central position by turning slowly screws 1 and 2.

Set mirror 1 (Fig. 1) in front of the autocollimator objective lens and find the image of autocollimation mark in the field of view. Turn the mirror so, that the mark moves horizontally and keep watch on the mark displacement at the end of the visual field. The displacement should not exceed two divisions of the second scale. If more, turn the autocollimator around in the base as described above, set the mark properly and tighten screws 5 (Fig. 21)as far as they will go.

The AKU-1 autocollimator should be turned around in yoke 3 (Fig. 4), with screw 6 slackened preliminarily by hand and then tightened home.

Prior to taking measurements, check the autocollimation mark for being properly illuminated.

The illuminator action will be most effective if the lamp filament is (located in the optical axis of the system. In this case, the mark is illuminated uniformly and brightly. This is particularly important when the objective lens is far from the mirror.

The lamp-holder design provides for centring of the lamp. To do so, slightly loosen nut 1 (Fig. 12) fastening the lamp-holder set the mirror at a required maximum distance and, while eyeing the autocallimation mark image and positioning the lamp, achieve the most uniform and bright lighting.

If the intensity of the viewfield illumination is inadequate and the contrast of autocollimation mark image is poor, adjust them with the aid of a rheostat found on the power unit and by using accessory light filters. Next screw the nut into place.

To replace the lamp, undo screw 2 (Fig. 1 2), take out the holder and replace the burnt lamp with a new one.

7.2 Checking non-linearity of horizontal guides

Set the mirror with magnetic base directly on the guide (Fig. 13) or on the device which affords adjustment in the vertical and horizontal planes. The device is required only if it is impossible to set the mirror on the guide due to a structural feature of the latter.

Setting of the mirror's reflecting surface perpendicularly to the guide is performed by means of adjusting screws of the device.

The indicator tip is set at the edge of upper trueing seat 2 (Fig. 1). When moving the mirror mount along the full length of the seat (15 mm), variation of the indicator readings must not exceed 0,005 mm.

Having set the mirror on the upper trueing seat, accomplish the same setting by the lateral one and fix the mirror by switching on the magnet.

The longer is the guide, the more accurate must be setting of the flat mirror. Using a bevel scale, divide the guide to its entire length info uniform sections (pitch of measurement) equal to the interval between the bearing protrusions of the mirror (or of the device it is mounted on). The points of divisions are marked with figures 0, 1, 2 and so on.

Place the autocollimator in front of the mirror so that its sight axis is aligned for height with the axis of the flat mirror. By making use of screws 10 (Fig. 1) and 5 (Fig. 2) set the autocollimator axis perpendicularly to the mirror's reflecting surface.

The autocollimation mark image formed by the mirror must be approximately matched to the middle division of the minute scale (Table 4).

Table 4

Instrument type	Middle division of minute scale, angular minutes
AKU-0,2	5
AKU-0,5	10
AKU-1	20

In moving the mirror along the guide between the points of divisions (1-2) view a displacement of the autocollimation mark image in the visual field. This displacement, measured by means of the compensator, characterizes the angular value of non-linearity in the given section.

Measurements should be taken in the direct (towards the objective lens) and reverse runs of the mirror and the obtained results – averaged. The example of measuring non-linearity of the guides by means of the AKU-0,5 autocollimator and processing the data of measurements are given below. The results of measurement are summarized in Table 5 which is formed in the following way. Shown in the first and second columns are the points to be checked and intervals on the guide taken in the sections equal to the pitch of measurement.

The values of autocollimator readings in the direct and reverse runs of measuring and their means are put down respectively in the third, fourth and fifth columns.

The sixth column presents deviations of readings of the fifth column α^i from the first reading α_1.

The obtained differences $\alpha^i - \alpha_1$ give angles β^i of inclination of the sections being checked with respect to the first section 0-1.

The seventh column gives the calculated values h^1 which show by what value each subsequent point to be checked is higher or lower than the previous one.

$$h^i = 5 \cdot 10^{-6} \times L \cdot \beta^i \cdot j,$$

where L is the pitch of measurement.

With L = 100mm, $h^i = 0.5 \cdot \beta^i$ (μm).

The calculated values are algebraically summarized and the A (the eighth column) is obtained, which indicates by what value each point to be checked

Table 5

Nos. of points to be checked	Interval to be checked, mm	Reading by autocollimator		Mean value of readings	$\beta i = \alpha i - \alpha_1$ angular second	$hi = 0{,}5 \cdot \beta$ μm	$Ai = hi + h^2 + \ldots + hi$ μm	$Bi = i\frac{A_{13}}{13}$ μm	Hi=Ai—Bi μm
		direct motion of mirror	reverse motion of mirror						
0	0	–	–	–	–	–	–	0	0
1	100	10 15,0"	10 13,0"	10 14,00"	0	0	0	+0,97	-0,97
2	200	10 15,5"	10 13,5"	10 14,50"	+0,50	+0,25	+0,25	+1,94	-1,69
3	300	10 14,5"	10 13,5"	10 14,00"	+0,00	+0,00	+0,25	+2,92	-2,67
4	400	10 14,5"	10 14,0"	10 14,25"	+0,25	+0,13	+0,38	+3,89	-3,51
5	500	10 14,0"	10 14,5"	10 14,25"	+0,25	+0,13	+0,51	+4,85	-4,34
6	600	10 13,5"	10 15,0"	10 14,25"	+0,25	+0,13	+0,64	+5,84	-5,20
7	700	10 15,0"	10 15,0"	10 15,00"	+1,00	+0,50	+1,14	+6,79	-5,65
8	800	10 17,0"	10 16,0"	10 16,50"	+2,50	+1,25	+2,39	+7,76	-5,57
9	900	10 16,5"	10 16,5"	10 16,50"	+2,50	+1,25	+3,64	+8,76	-5,12
10	1000	10 16,5"	10 16,5"	10 17,50"	+3,50	+1,75	+5,39	+9,70	-4,31
11	1100	10 17,5"	10 19,0"	10 18,25"	+4,25	+2,13	+7,52	+10,67	-3,15
12	1200	10 18,5"	10 19,0"	10 18,75"	+4,75	+2,38	+9,90	+11,68	-1,78
13	1300	10 19,5"	10 19,5"	10 19,50"	+5,50	+2,75	+12,65	+12,65	0

is higher or lower than the first point. Now we can plot a graph by the data of the eighth column. The sections to be checked on a definite scale are plotted on the X-axis, while the summarized deviations for height A corresponding to each of the said sections – on the Y-axis.

Having connected the separate points one can obtain a curve which corresponds approximately to a profile of the guide being checked.

Having connected the end points of the curve one obtains a straight line with distances from the straight line to the curve on the Y-axis being deviations H from linearity of the guide in units of length.

$$H^i = A^i - B^i,$$

where B^i is the ordinates of the straight line at the points being checked.

To determine the B^i value (the ninth column) you should divide excess An of the last point by its number and multiply by numbers *i* of the respective points, i.e. $B^i = i \cdot \frac{An}{n}$ (n=13 as exemplified in Table 5).

The differences $A^i - B^i = H^i$ are recorded in the tenth column of Table 5.

The results of measurement can be expressed in diagram form. By plotting values of the intervals to be checked on the X-axis and the respective values A on the Y-axis one may construct a curve of a profile of the surface being checked (on cross-section paper). The distance from any point of the curve to the straight line connecting its ends is determined on the Y-axis.

7.3 Checking non-linearity of vertical guides

To measure non-linearity of the vertical guides (Fig. 14) put diagonal mirror 4 (Fig. 1), changing the direction of ray path by 90 °, on the autocollimator's objective lens.

For convenience, position the autocollimator either higher or lower than the guides being measured.

When setting the flat mirror on the vertical guide, the former must be provided with an additional support from below to avoid its sliding down.

The results of measurements are calculated as described in item 7.2.

7.4 Determination of deviation from planeness

Determination of deviation from planeness of plates and other plane surfaces is based on the principle of measuring their non-linearity in various directions. Checking should preferably be carried out in two diagonal directions as well as in the longitudinal and transverse directions at definite intervals from the previous setting. The shorter these intervals, the more precise the data on planeness of the surface being measured.

In moving the mirror to every new position it is necessary to check for presence of the autocollimation mark image in the visual field of the autocollimator. If no image is seen one should turn the mirror around the vertical axis to bring the autocollimation image to the required position and take the next measurement of deviation from non-linearity by the scales of the eyepiece-micrometer using the above described method.

7.5 Checking parallelism of two surfaces

There are two possible variants of checking parallelism of two surfaces.

1. The surfaces to be measured are matched 1 (or in contact) with each other, but displaced in depth. In this case their mutual non-parallelism can be measured with the aid of two plane-parallel mirrors (Fig. 15). If there are no such mirrors available, you can use two usual gauge blocks of small length (0.5-1.5 mm), though their use is somewhat difficult due to small area of the reflecting surface.

The best accuracy of measurements may be achieved in checking surfaces which makes it possible to wring a plane-parallel mirror or gauge block to them.

In the given case apply the plane-parallel mirrors to both surfaces being measured, each of the mirrors reflecting a portion of rays which leave the autocollimation objectivie lens and, hence, forming a new image of the autocollimation mark. The space between the two mark images as measured by the eyepiece-micrometer is the of parallelism of the surfaces being measured in angular units.

2. To be checked is parallelism of two surfaces displaced in depth and positioned at some distance from each other which makes their checking by the above methods impossible.

In this case checking may be done with the help of a pentaprism in a mount with a magnet base and by means of a plate with levels* placed on the mount and located in two interper-pendicular planes (Fig. 16). The pentaprism in the mount is set on a support provided with three adjusting screws.

Carry out the checking as advised below.

Apply a plane-parallel mirror or a plane-parallel gauge block to one of the surfaces being checked. Set the pentaprism on the support so that one of its inlet holes is parallel to the mirror, while the other one is perpendicular to the autocolli-mator axis. Place the plate with levels on the adjusting seats of the pentaprism mount and bring the levels bubbles to the central (zero) position by making use of the adjusting screws.

Set the autocollimator so that the autocollimation mark formed by the mirror is seen in the visual field. Cut off the beam of rays by placing a sheet of paper between the mirror and pentaprism to make certain that the image is obtained from the mirror but not from the pentaprism. With this done, the autocollimation mark image must disappear.

The setting procedure has been finished, read the instrument and write down the readings.

Next, without touching the autocollimator, apply the mirror to the second surface and set the pentaprism so that it directs the rays from the mirror to the autocollimator. See to it that the axes of both levels are set to the zero position as accurate as possible.

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* The pentaprism complete set in a mount on a magnet base and the plate with levels are supplied at the customer's request (Re. table 3).

The difference of the instrument readings of the initial and subsequent settings characterizes the deviation parallelism of the surfaces being checked in the direction of measurement.

7.6 Setting two surfaces at given angle

To set two surfaces at a given angle it is required to use a special angle standard with sufficiently wide reflecting surface (Fig. 17) or usual angle standard if the AKU-1 autocollimator is in use.

Perform setting in the following order.

Fix the angle standard on one of the surfaces to be set. Place the pentaprism and autocollimator opposite, to the surface and carry out the operations described above. Shift the autocollimation mark image formed in the autocollimator's field of view to the middle line of the reticle (Table 4). Fasten a plane-parallel mirror on the second surface.

By turning the part, set the mirror in parallel to the reflecting surface of the angle standard, without touching the autocollimator.

Put the pentaprism opposite to the mirror and, having brought the levels to the central zero position, keep turning the part till the autocollimation mark occupies the position corresponding to the Initial setting of the angle standard.

7.7 Using autocollimator as telescope

The autocollimator can be used as a usual telescope for making all possible measurements, adjustments and checkings. The eyepiece-micrometer may stand duty for taking angle measurements.

The division value of the minute and second scales must correspond to the data given in Table 6.

Table 6

Instrument cipher	Second-scale division	Value of minute-scale division
AKU-0,2	0,4"	1/3'
AKU-0,5	1"	1'
AKU-1	2"	2'

7.8 Checking linearity of holes axes

For checking linearity of hole axes in long parts (pipes) make use of a mirror set in a cylindrical mount. Insert the mirror into the hole to be checked. Set the autocollimator in front of the mirror so that its axis is at the same height with the mirror axis. The further setting is described in section 7.1.

While moving the mirror inside the hole being checked, watch the position of the autocollimation mark image in the visual field of the autocollimator.

A displacement of the autoeollimation mark image measured with the help of the autocollimator compensator gives the angular value of non-linearity of the hole axis in the part being checked.

7.9 Using AKU-1 autocollimator with stand

The possible variants of using the AKU-1 autocollimator with a special stand are shown in Fig. 18.

8 MAINTENANCE

For maintaining the autocollimator in working order, ensuring trouble-free operation, extending the overhaul period as well as for timely revealing and removing the causes of premature wear and damage of the autocollimator components one should regularly carry out the functional check and maintenance including the following kinds:

Routine Maintenance (RM);

Maintenance No. 1 (M-l);

Maintenance No. 2 (M-2).

8.1 Routine Maintenance (RM) is carried out before and after operation, but at least once a fortnight and according to Table 7.

Table 7

Content of works	Technical requirements	Tool to be used
Wipe away dust and dirt from autocollimator and set of components	Autocollimator and set of components must be kept clean	Napkin from STA set
Wipe unpainted metal surfaces	Unpainted metal surfaces must have no traces of corrosion	Ditto
Clean surfaces optical parts	Surfaces of outer optical parts must be clean	–"–

Notes: 1. A napkin, which has been previously used for cleaning the metal parts, should never be made use of for wiping the optical surfaces.

2. Mind you take maximum care when cleaning the optical surfaces.

8.2 Maintenance No. 1 (M-l) is to be performed at least once a year according to Table 8 and also when the autocollimator comes to the User and being placed in short-term storage.

8.3 Maintenance No. 2 (M-2) is to be performed at least once in two years and also on the basis of M-l results and when placing the autocollimator in long-term storage.

Table 8

Content of works	Technical requirements	Tool to be used
Paint metal surfaces with damaged paint coat	Autocollimator must be free from corrosion and damaged outer coats	Light-grey Enamel Black enamel
Clean outer surfaces of optical parts with alcohol-ether mixture (10% of alcohol and 90% of ether) or alcohol	Outer surfaces of optical parts must be kept clean	Cotton wool for optical industry, industrial rectified ethyl alcohol of high grade, ethyl ether
Check contacts in auto-collimator remove deposit from contacts if need be	No oxidation and salt deposit must be on contacts	High-grade industrial rectified ethyl alcohol,cotton wool for optical industry

Maintenance No. 2 (M-2) must be performed in specialized repair shops where faulty components of the autocollimator are replaced with serviceable ones.

When using the autocollimator for a long period of time be sure to Lubricate its friction surfaces with optical lubricant.

When out of use, the objective lens and accessories being as parts of the autocollimator complete set must be kept in the packing cases.

9 CHECKING

The instrument should be checked in conformity with the methodical directions "Autocollimators. Methods and Means of Checking".

10 TROUBLE SHOOTING

Table 9

Trouble, its symptoms	Probable cause	Remedy	Note
1. With autocollimator energized, visual field is not	Burnt fuse link in power unit illuminator lamps blown	Replace burnt fuse link Undo screw 2 (Fig. 12), take out holder 1 and replace lamp	
2. Autocollimator fails to be fixed on plate, or mirror or pentaprism – on magnet base	Magnets demagnetized	Use special device for magnetizing magnets. Clearance between magnet poles equal to 245 mm is adjus table. Magnetic intensity in clearance is 8500 oersteds, maximum current is 80 A, supply voltage is 380 V, frequency is 50 Hz	If possible, magnetizing is performed by User or, if impossible, in repair shops

Note. The said troubles are not a cause for sending in a UER.

11 STORAGE RULES

The autocollimator should be stored in its packaging.

The storage conditions of autocollimators in the stock of the manufacturer (customer) must be in accordance to the requirements of group 1 (L) GOST 15150-69.

Devices must be stored in the heated and ventilated stocks. The temperature in the stock must be from +5 to +40 °C and relative humidity not more than 80% at +25 °C.

The daily temperature fluctuations must not be a cause of moisture condensation on the metal details of the package. The room must be free from acid vapors, alkali and other matters, which can damage autocollimators.

12 TRANSPORTATION

The transportation of autocollimators must be carried out with the railway, automobile, sea or river transport in covered transportation. All handling operations must be carried out according to transportation marking GOST 14192-96.

The transportation of autocollimators must be in accordance with requirements 5 ZH GOST 15150-69.

13 TECHNICAL EXAMINATIONS

The check of autocollimator is carried out in the accordance with technical maintenance.

The certificate of prescribed form is provided, when autocollimator AKU – is considered operational feasible.

The autocollimator should pass initial and periodical check.

The check is carried out according to methodical instructions "Autocollimators. Methods and means of checking."

The initial check is carried out at the manufacturing enterprise, the results are indicated in the passport, and manufacturer approves positive results of the check with a stamp.

The periodical check is carried out in accordance with a year plan-graph of the enterprise-customer.

The interval between checks – two years.

The data about the checking of the device on the enterprise-customer of checking organs are recorded in the table 11.

14 ACCEPTANCE CERTIFICATE AND DATA ABOUT THE INITIAL CHECK

Autocollimator AKU – , serial No , and mirror, serial No , are manufactured meet the specifications and state standards and are accepted for service.

Initial check is implemented.

Date of issue_____

Signatures _____

15 PRESERVATION

The preservation of the autocollimator and the mirror is carried out in the accordance with GOST 9.014-78 for the group of devices III-1, protection variant V3-4. Preservation term – 3 years.

Preservation date _____

Preservation term – 3 years.

Preservation is carried out by _____ Stamp
Signature

Quadrant after preservation is accepted by

_____ Stamp
Signature

16 PACKAGING

Autocollimator AKU – , serial No , and mirror, serial No , are packed in the FSUE "PA "Novosibirsk Instrument-making Plant" in the accordance with requirements of technical documentation.

Repair facility address

Federation State Unitary Enterprise
Production Amalgamation "Novosibirsk Instrument-Making Plant"
179/2, D.Kovalchuk,
Novosibirsk, 630049
Russian
Tel. (383) 226-29-08, Tel./Fax: (383) 226-17-82,
e-mail: npz@ngs.ru,
www.npzoptics.ru

Appendix A
(recommended)

List of figures

FIGURES

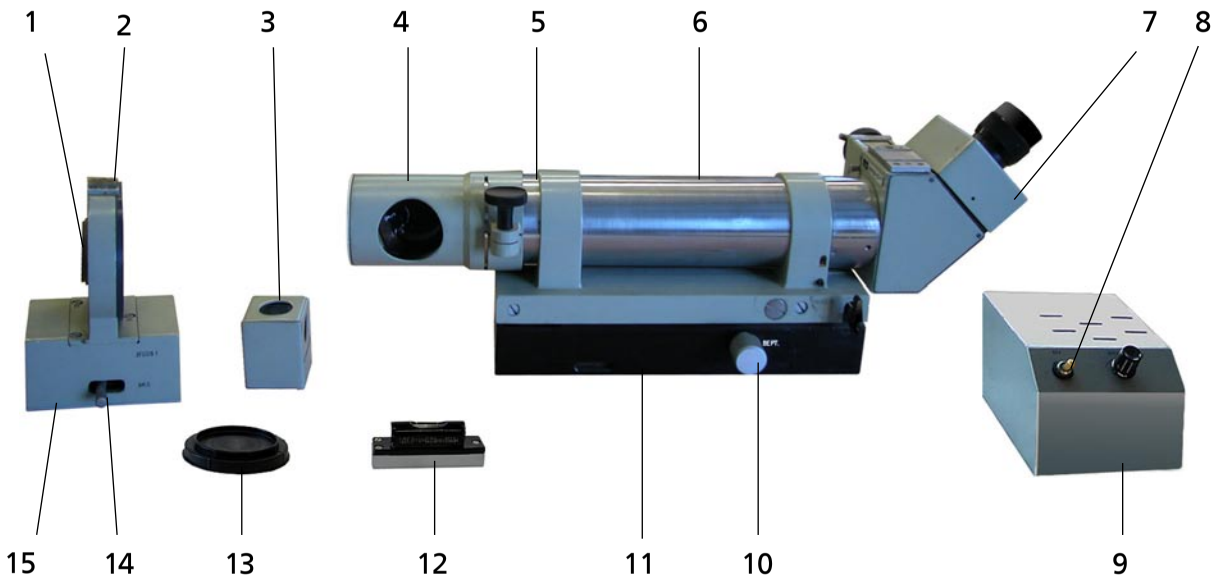

Fig. 1 – **Autocollimator AKU-0,5**

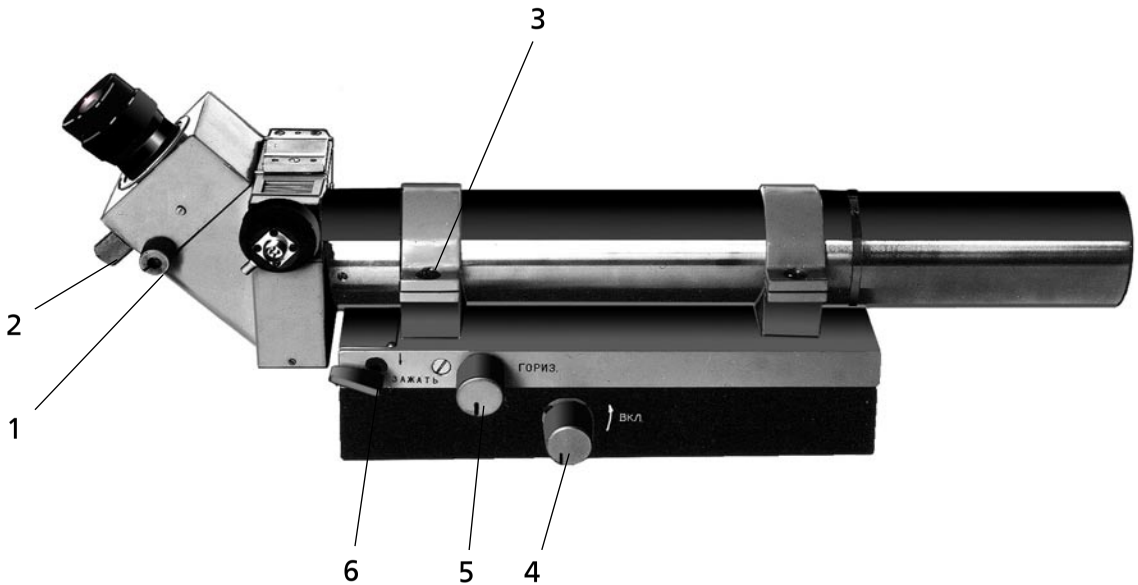

Fig. 2 – **Autocollimator AKU-0,2**

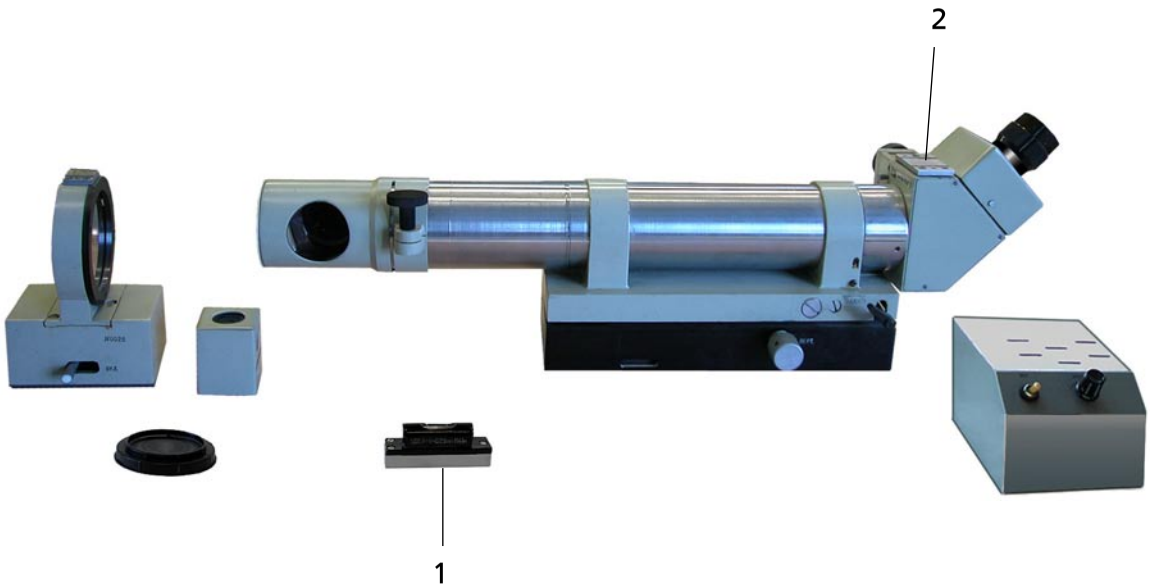

Fig. 3 – **Autocollimator AKU-0,2**

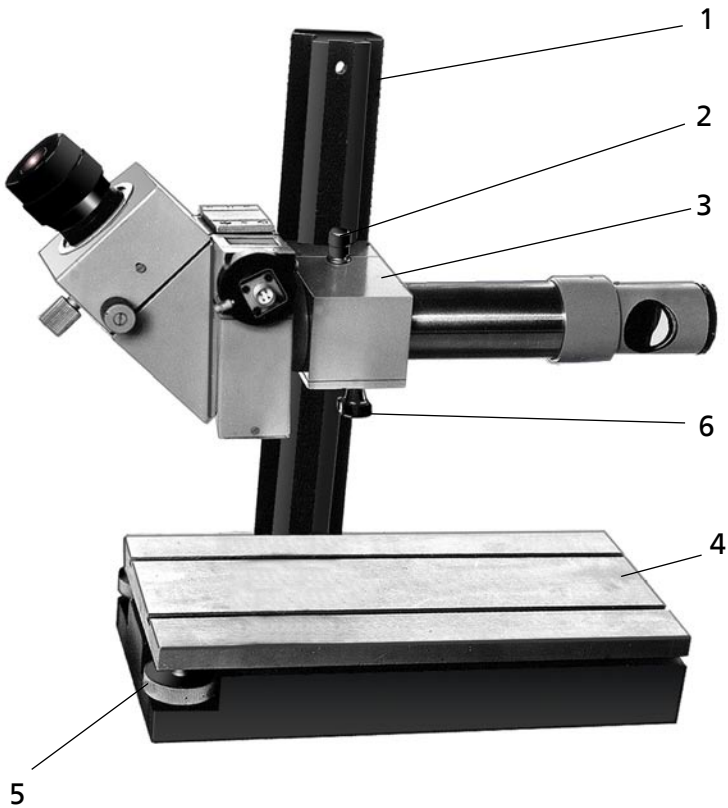

Fig. 4 – **Autocollimator AKU-1**

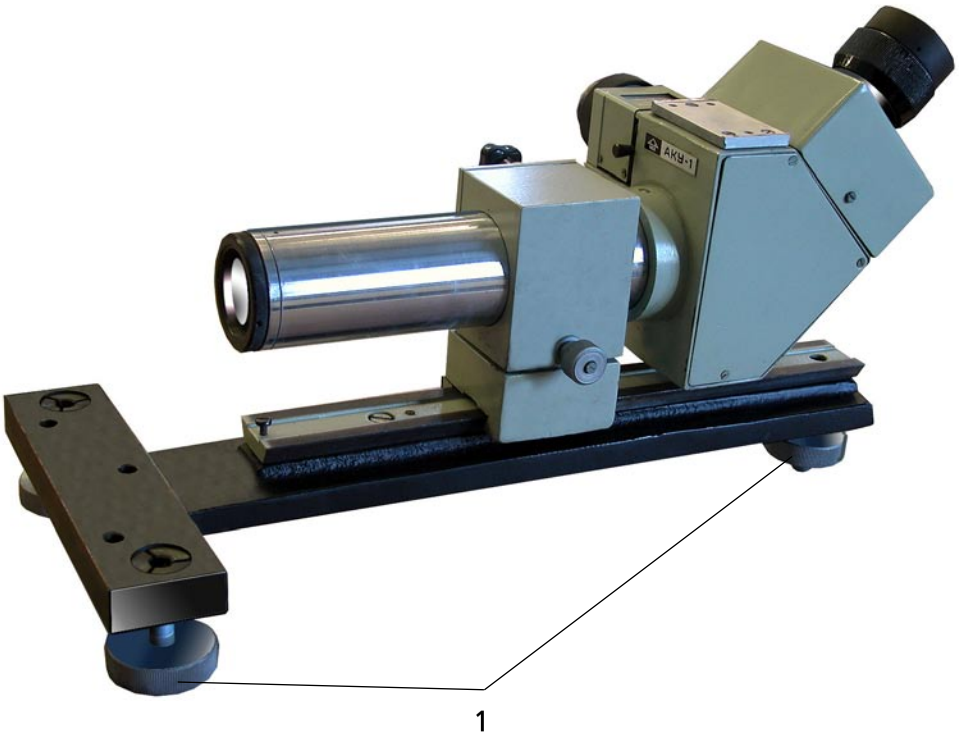

Fig. 5 – **Autocollimator AKU-1**

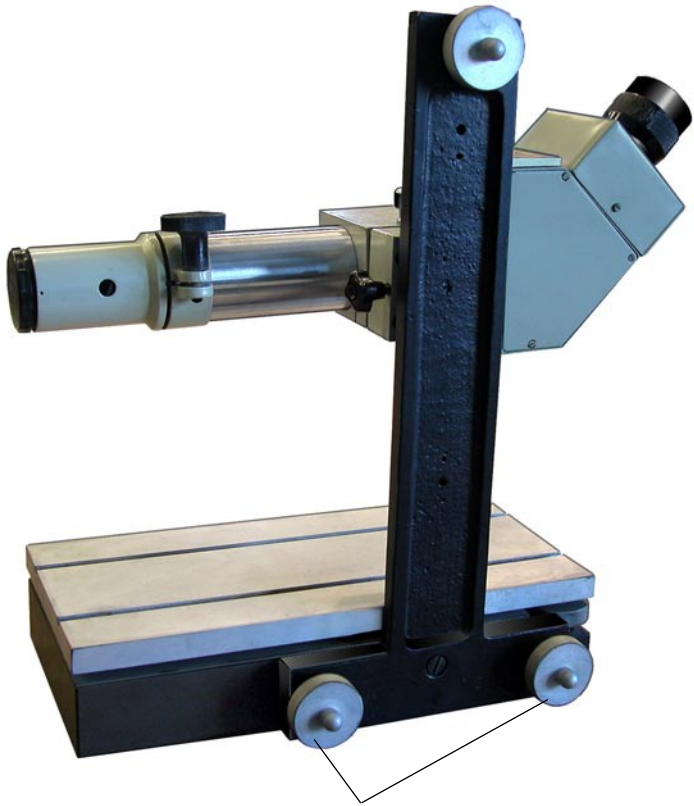

Fig. 6 – **Autocollimator AKU-1**

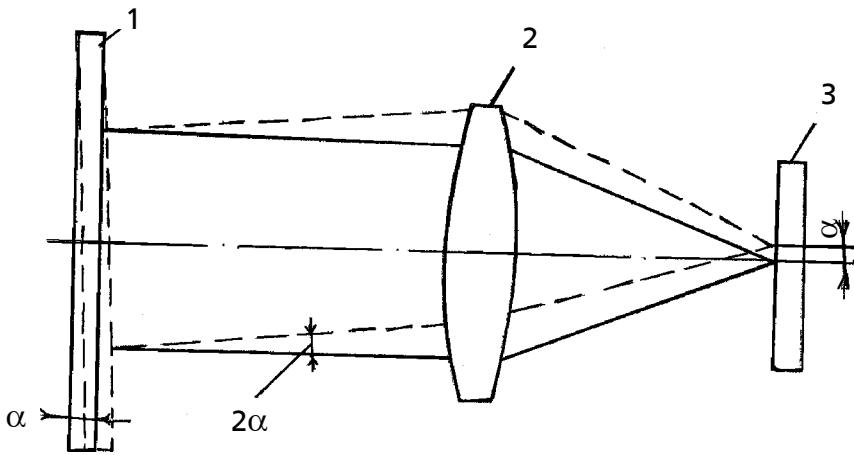

Fig. 7 – **Autocollimator Operation Principle**

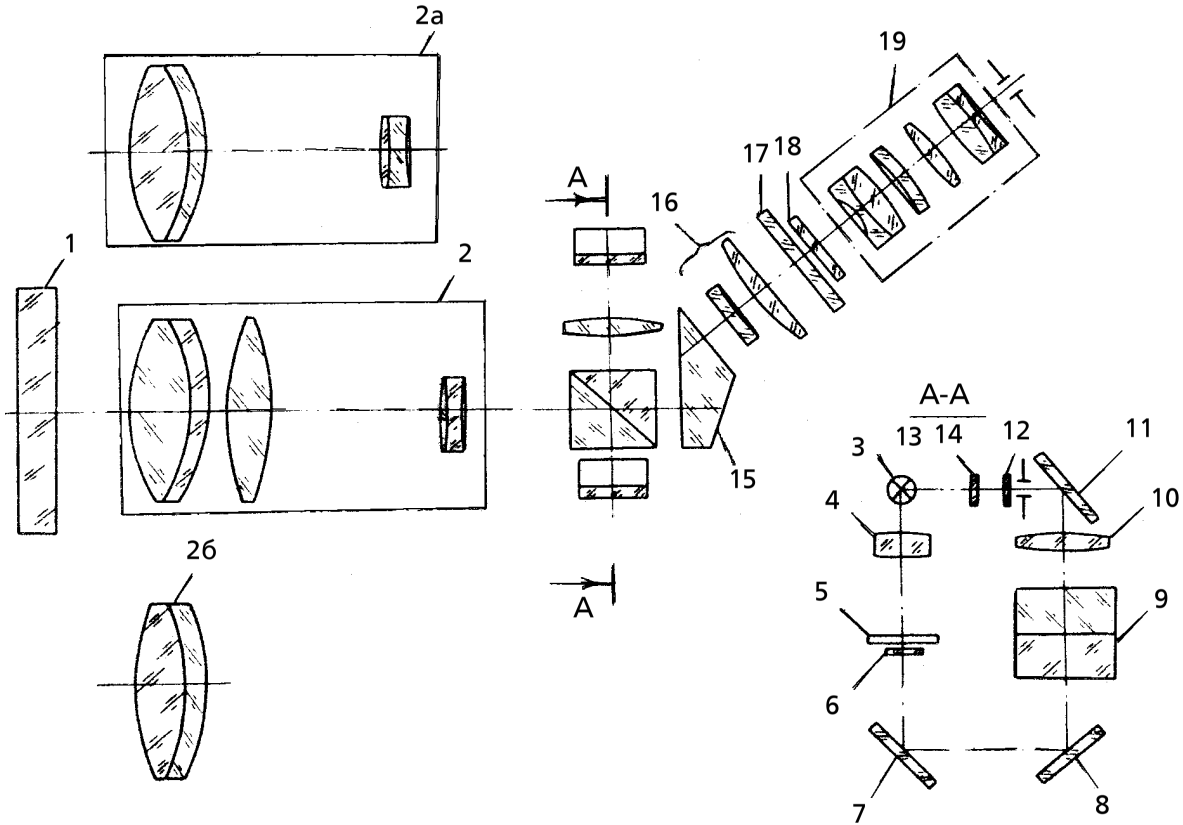

Fig. 8 – **Optikal train Autocollimator**

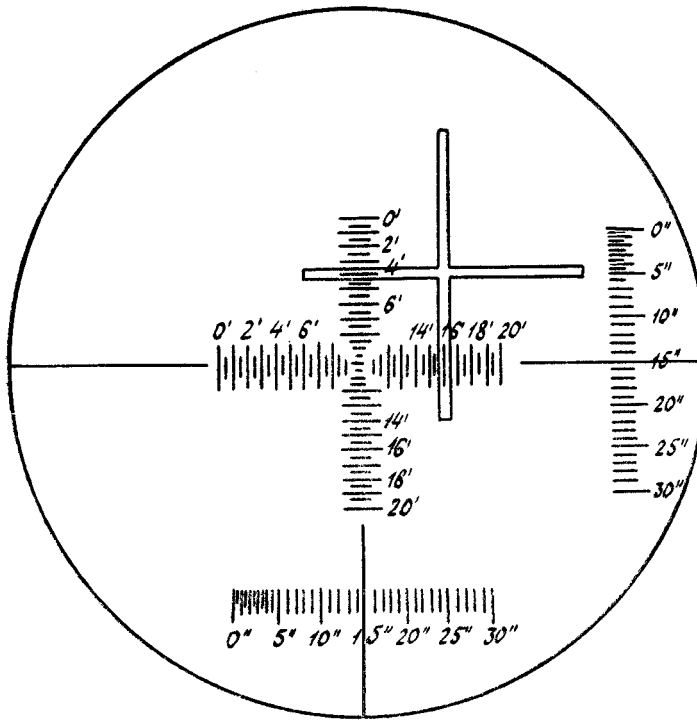

Fig. 9 – **Visual Field of AKU-0,5 Autocollimator**

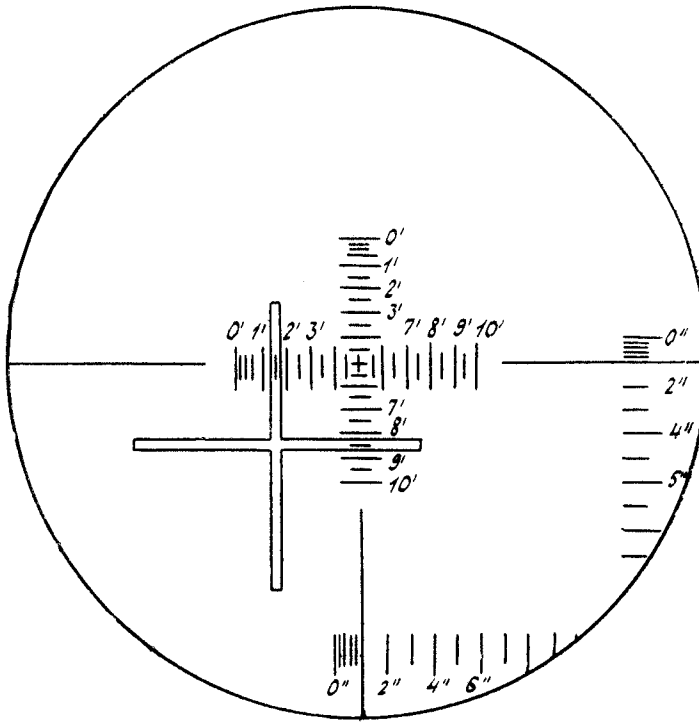

Fig. 10 – **Visual Field of AKU-0,2 Autocollimator**

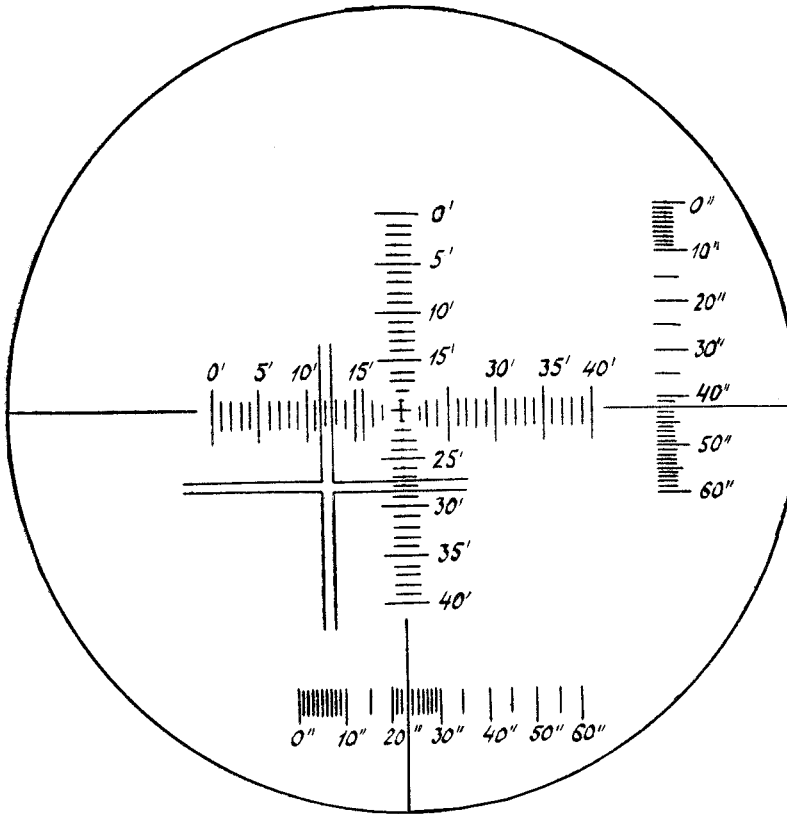

Fig. 11 – **Visual Field of AKU-1 Autocollimator**

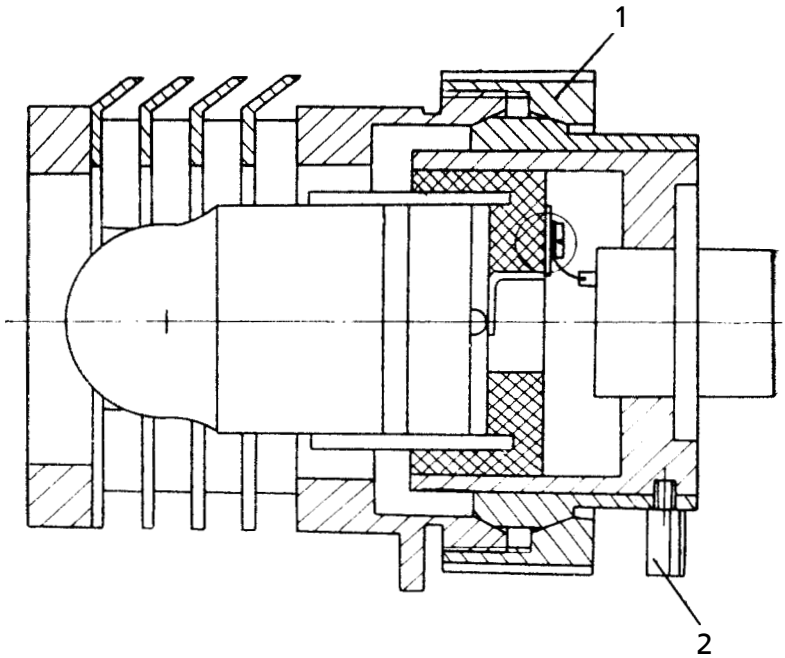

Fig. 12 – **Lamp Holder**

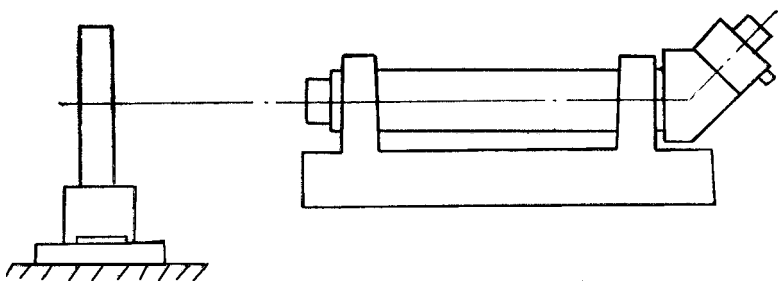

Fig. 13 – **Diagram of Measuring Non-linearity of Horizontal Guides**

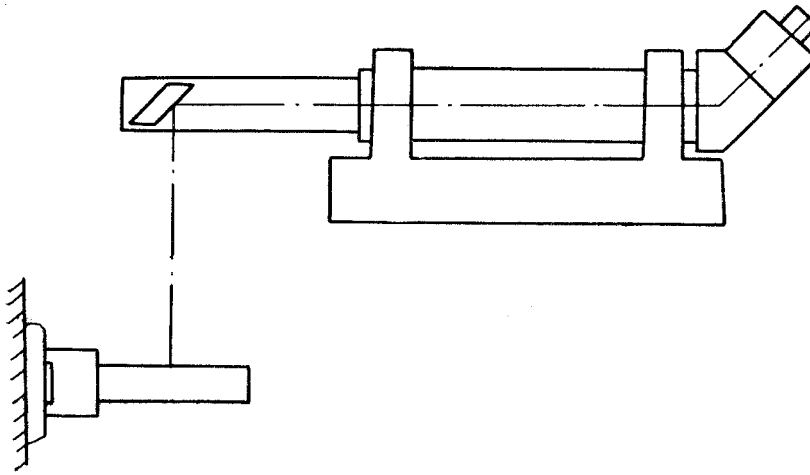

Fig. 14 – **Diagram of Measuring Non-linearity of Vertikal Guides**

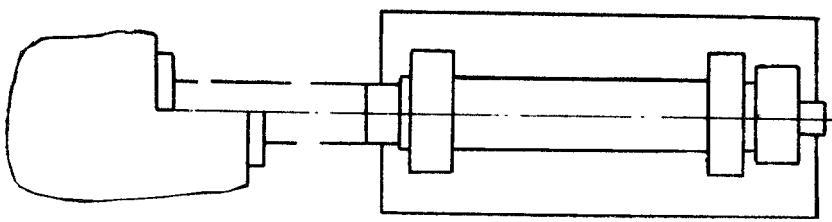

Fig. 15 – **Diagram of Checking Non-parallelism of Two Surfaces**

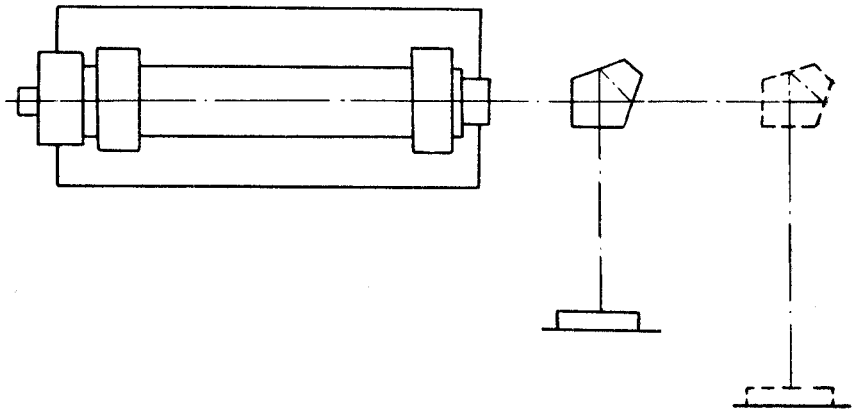

Fig. 16 – **Diagram of Checking Non-parallelism of Two Surfaces**

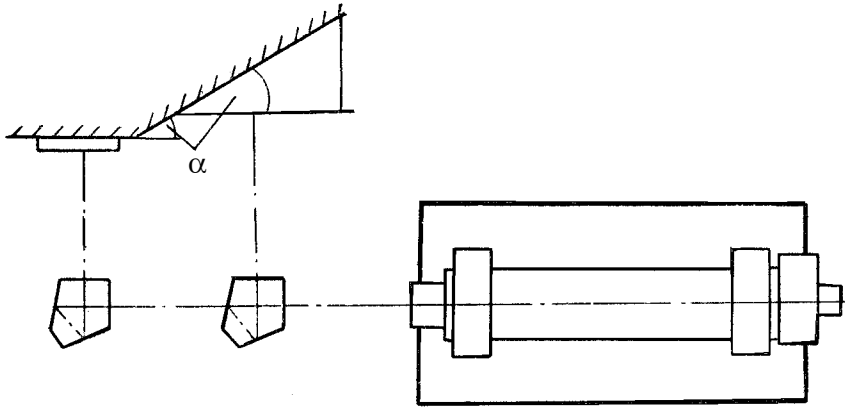

Fig. 17 – **Diagram of Setting Two Surfaces at Given Angle**

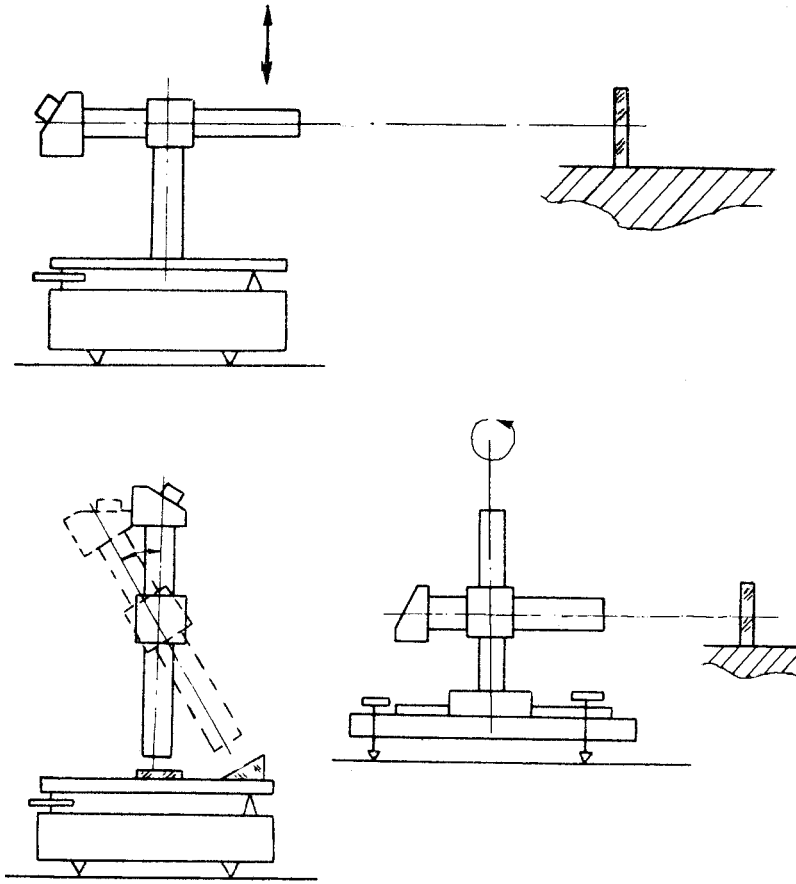

Fig. 18 – **Variants of Using AKU-1 Autocollimator**

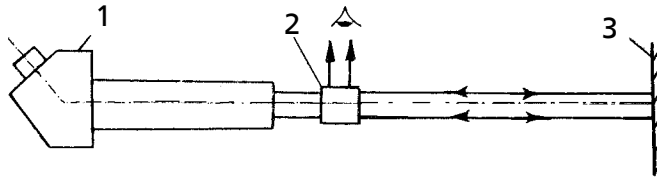

Fig. 19 – **Diagram of Setting Autocollimator and Mirror with Help of Prism**

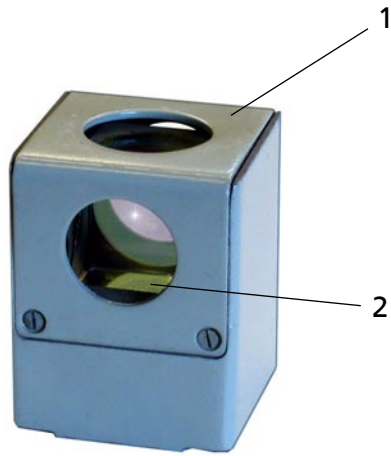

Fig. 20 – **Prism Yu**

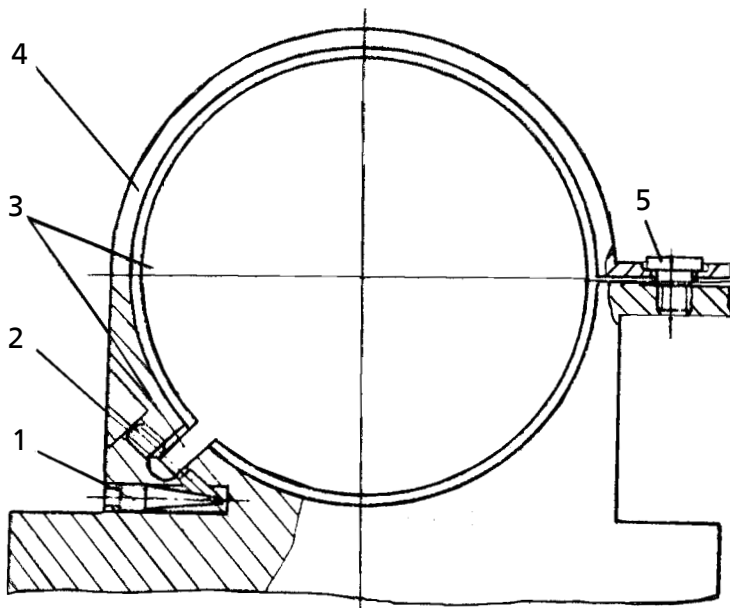

Fig. 21 – **Mechanism of Autocollimator Adjustment by Striding Level**

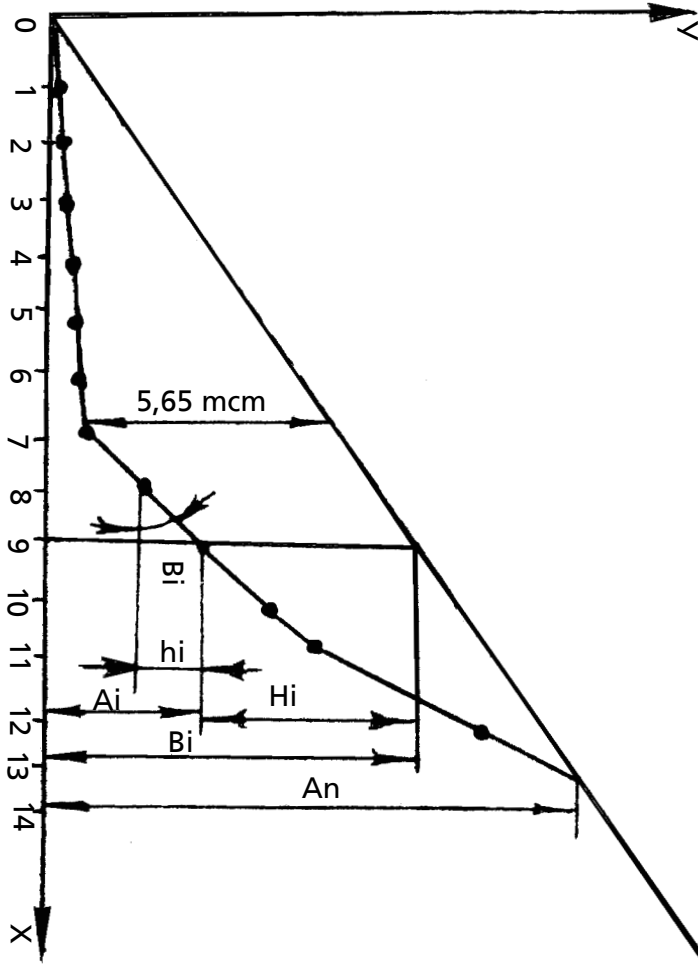

Fig. 22 – **Graph of analysis of measuring the straightforwardness of horizontal guides**