No.99MBA051A
SERIES No.172

PH-A14

Profile Projector

User's Manual

Read this User's Manual thoroughly
before operating the instrument. After reading,
retain it close at hand for future reference.

Mitutoyo

Conventions Used in this User's Manual

This section describes the symbols (safety alert symbols) used in this manual.

Safety Precautions

This manual uses various symbols to help you use this instrument correctly, and prevent danger to personnel or equipment damage.

- The following symbols indicate general dangers, warnings and cautions.

 DANGER	Indicates an imminently hazardous situation which, if not avoided, will result in serious injury or death.
 WARNING	Indicates a potentially hazardous situation which, if not avoided, will result in serious injury or death.
 CAUTION	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury or property damege.

- The following symbols indicate specific warnings or prohibited actions.

	Alerts the user to a specific hazardous situation. The given example means "Caution, risk of electric shock".
	Prohibits a specific action. The given example means "Do not disassemble".

Conventions Used in this User's Manual

On Various Types of Notes

The following types of notes are used in this manual to help the user operate this instrument correctly and obtain precise images.

Important

- An *important note* is a type of note that provides information essential to the completion of a task. You cannot disregard this note to complete of a task.
- Information that, if disregarded, could result in a loss in performance, or make it difficult to maintain performance.

Note

A *note* emphasizes or supplements important points in the main text. A note supplies information that may only apply in special cases.

Tip

A *tip* is a type of note helps the user apply the techniques and procedures described in the text to their specific needs. It also provides reference information associated with the topic being discussed.

Handling precautions

1. **Operation manual**

   To obtain the best possible performance and long service life from your Mitutoyo Profile Projector PH-A14, please read this User's Manual carefully prior to setup and operation.

2. Handling

   Since the PH-A14 Profile Projector incorporates high precision components of large weight, take special care so that no part of the projector is subjected to impact or excessive force when it is being installed, set up or operated.

   Use the carrying handles on both sides of the projector to lift or carry the Profile Projector during unpacking and setting up. Never apply pressure to the control panel, microstage or other important parts.

3. Installation site

   Select a location where the Profile Projector is not exposed to extreme temperatures, sudden temperature changes, high humidity, oil, direct sunlight, or vibration.

   In addition, the machine should be placed on a rigid stand. Although a dark setup location is not required, take care to shield the projection screen from direct light.

4. Power source/grounding

   A single-phase power supply must be used with the Profile Projector. Only allow the power outlet at the installation site to be used for the PH-A14 Profile Projector. Do not share the outlet with other electric equipment.

5. Replacement parts

   Use only the specified fuse and lamp, and follow the procedures described in this manual. Never attempt to remove the cover/panel or disassemble components except for those parts associated with consumable item replacement. This could cause machine failure or produce low-quality images.

6. **Dust and dirt protection for the lens**

   Never touch the lens, mirror, or bulb in order to avoid fingerprints, dust or oil.

   Ensure that these optical parts are always kept clean. Refer to "4.1 Maintenance of Optical Components for proper lens maintenance".

Warranty

This instrument has been manufactured under Mitutoyo's rigorous quality control system. In the event that it proves defective in workmanship or materials within one year from the date of purchase under normal usage, Mitutoyo will repair the instrument free of charge. Contact your dealer or nearest Mitutoyo Service Center.

This warranty does not apply to the following cases:

- **Equipment failure or damage due to incorrect usage or unauthorized modification or repair.**
- **Equipment failure or damage resulting from moving, transporting, or dropping the instrument.**
- **Equipment failure or damage due to fires, salt damage, gas damage, abnormal voltages, or natural disasters.**

Contents

SERVICE NETWORK

1 Overview

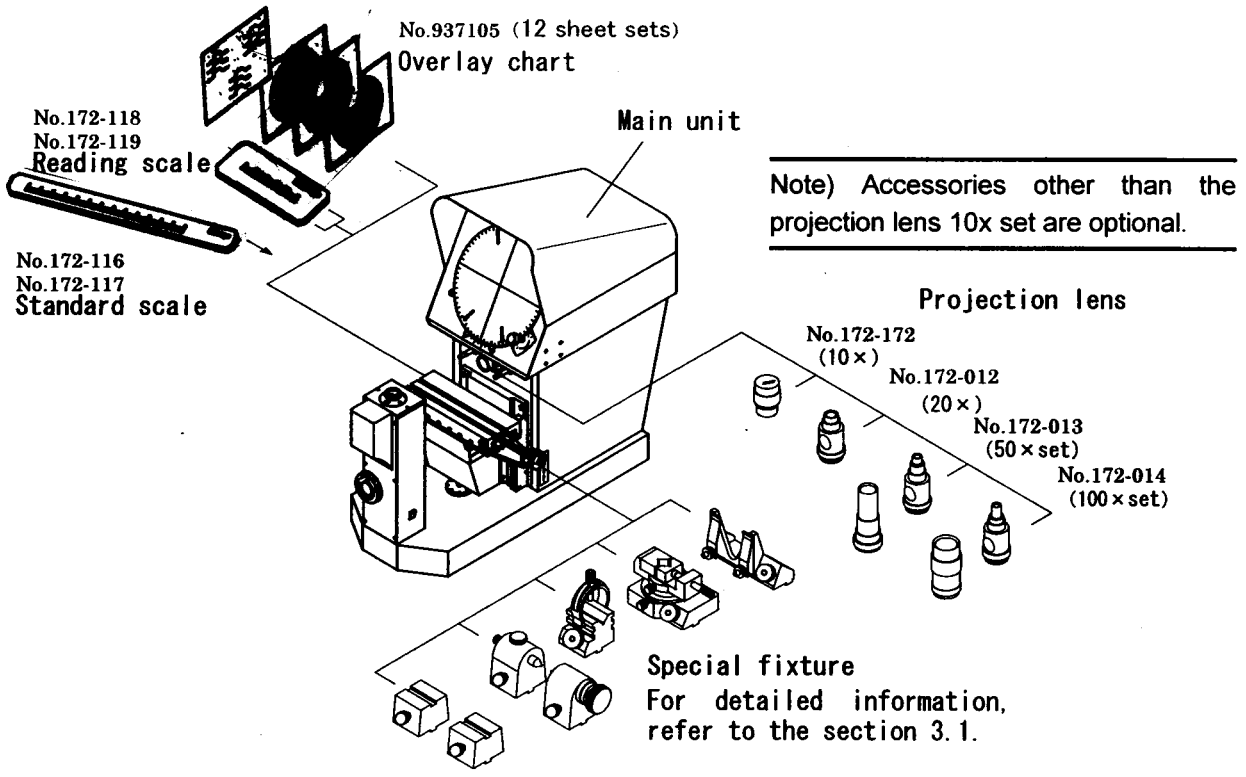
This chapter describes the configuration of the Profile Projector PH-A14. The name and function of each part are also given here.

1.1 Outline

The Mitutoyo Profile Projector PH-A14 is an advanced piece of instrumentation used to project a workpiece surface or contour on a screen for dimensional measurements and observation.
This instrument provides the following features:

- The PH-A14 is a bench-type profile projector which has a protractor screen with an effective diameter of 356mm and a horizontal light axis.
- Four types of high-performance projection lenses are available at 10x (standard accessory), 20x, 50x, and 100x magnifications (magnifications over 10x are optional).
- The microstage has a large loading capacity that enables a heavy workpiece, such as a formed cutter, hob-gear, large screw threads, and cutters, to be measured.
- A long list of accessories facilitates easy workpiece set-up and enhances measurement efficiency.
- The twin fiber illumination unit is provided as standard. It is suitable for spotlighting.

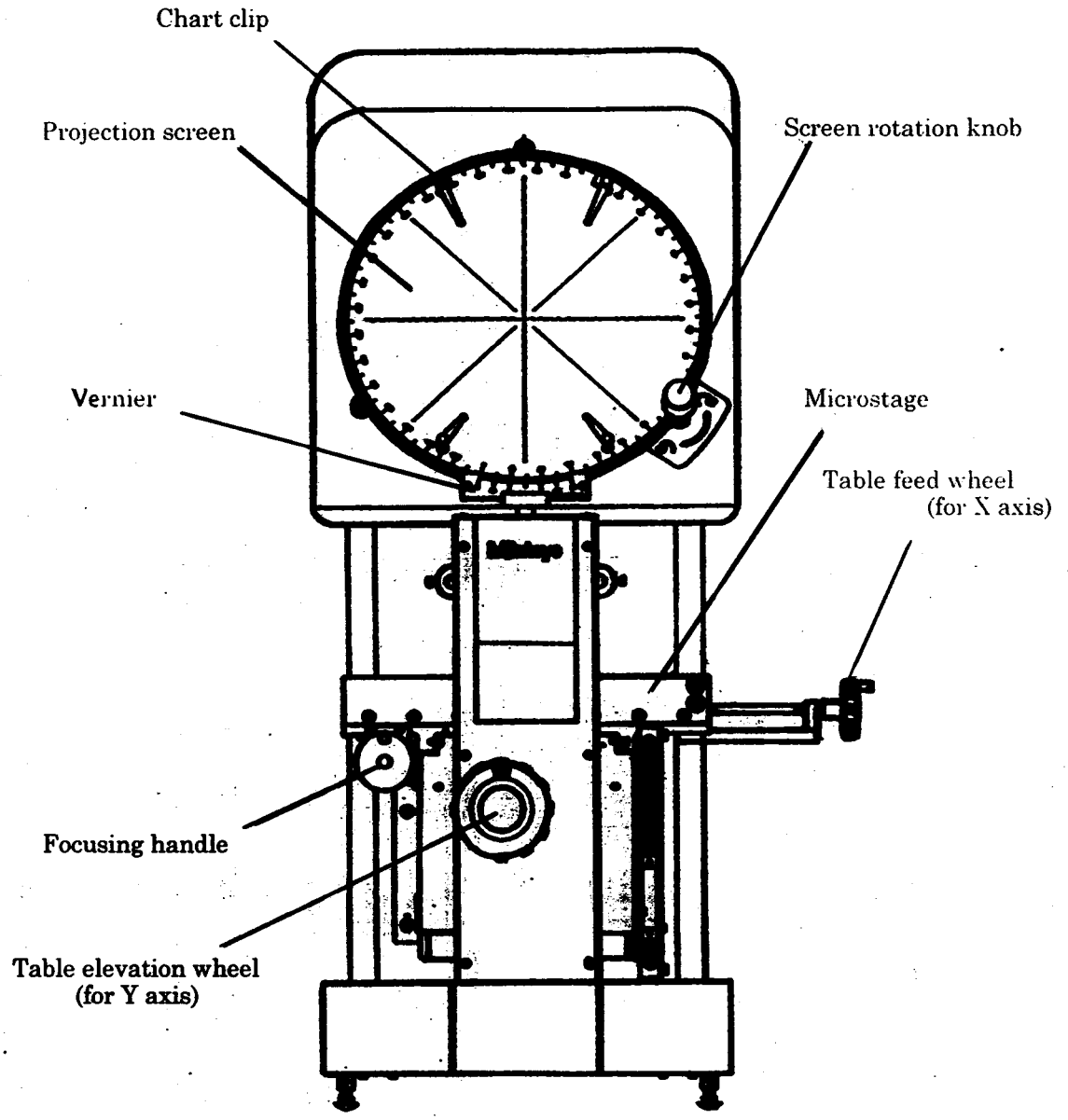
1.2 System Configuration

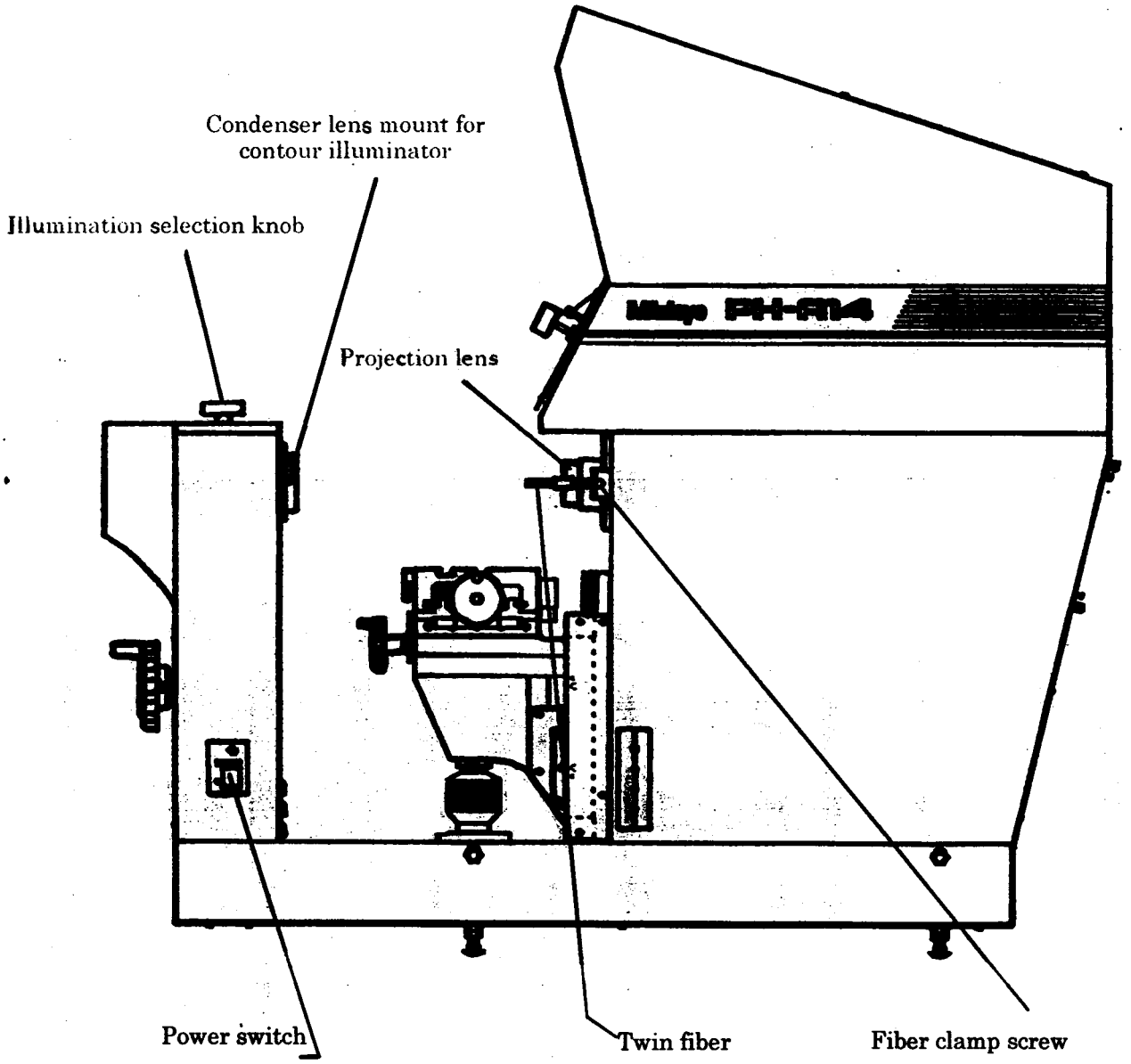


Note) Accessories other than the projection lens 10x set are optional.

1.3 Name of Each Part

1.3.1 System appearance




Condenser lens mount for contour illuminator
Illumination selection knob
Projection lens
Power switch
Twin fiber
Fiber clamp screw

2 Setup

This chapter describes the environment of the installation site, installation method including the part attachment, and magnification accuracy check.

2.1 Unpacking

The following describes how to unpack the PH-A14.

Note To unpack, a nail puller, scissors, cutter, and Allen key are required. Prepare these tools beforehand.

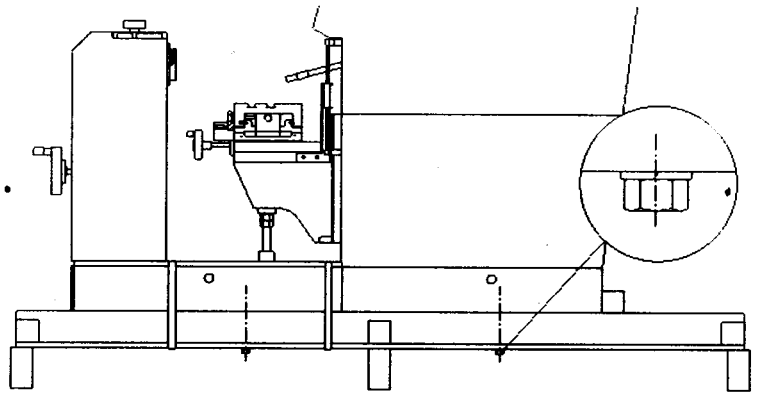
●Procedure

①Remove the wrapping material using the scissors and cutter.

Note Confirm that the main unit does not have a significant fault or distortion.

②Separate the standard accessory box from the main package.

③Take off the 4 pieces of screw bolt on the bottom of the table by wrench.



④Remove the cushion protecting the protractor screen.

⑤Open the standard accessory box and check the supplied accessories.

Item		Part No.	Quantity	Note	Check
Lens set 10X		172-172	1		
Halogen lamp 24V 150W		515530	1		
Fuse	6A (For 100 to 120V)	358191	2	A fuse is pre-installed in the fuse holder.	
	2.5A (For 220 to 240V)	384208			
Allen wrench (nominal 2.5)		538615	1		
Wrench		12BAC245	1		
Operation Manual		99MBA051A	1		
Warranty Card			1		

2.2 Installation

Set-up the profile projector while observing the following points.

2.2.1 Environmental condition

- Vibration

  The precision components of the projector will go out of adjustment if they are subjected to prolonged vibration, resulting in deterioration of measurement accuracy. If vibration is present at the setup site, take the necessary vibration-reduction measures, such as laying a vibration damping rubber pad under the projector.

- Dust

  Airborne dust will adversely affect the optical parts such as lenses and mirrors and the precision mechanical parts of the microstage, causing wear and damage. The projector environment should therefore be as dust-free as possible.

- Light

  Glare on the screen makes it difficult to view projection images. Direct sunlight can cause deformation of the projector due to thermal expansion, which will adversely affect measuring accuracy.

  Therefore, the projector should be positioned so it does not face windows or room lights. It should be shaded with curtains, etc., if placed near a window.

- Ambient temperature

  Temperature and humidity requirements for operating this projector are 0□ to 40□ and 20% to 80%, respectively. However, avoid installing this projector where steep temperature change or high humidity may be present. This will be detrimental to the measurement accuracy.

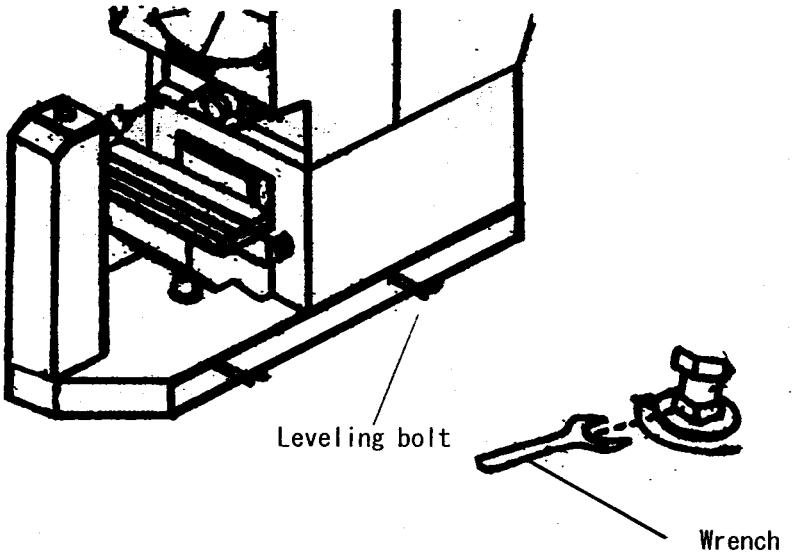
2.2.2 Transportation and installation

Be sure to use the supplied carrying handles when handling, shifting or installing the main unit and due to its heavy weight (140kg) four people will be required to carry it. The PH-A14 has been fully adjusted at the factory, therefore take special care when handling and setting up the projector so that no part of the projector is subjected to impact or vibration.

(1) Installation of the main unit

This profile projector is heavy and should be placed on a sturdy steel desk, or equivalent. Refer to subsection "2.2.1".

If the main unit is shaky or not level, use the leveling bolts located on the bottom of the main unit to level it.

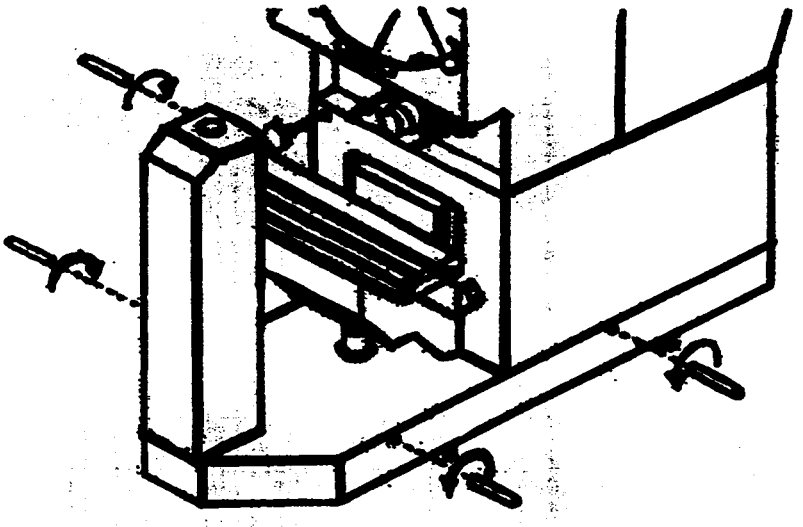


① Loosen the leveling volts using the wrench.

② Adjust the main unit level with the leveling bolts.

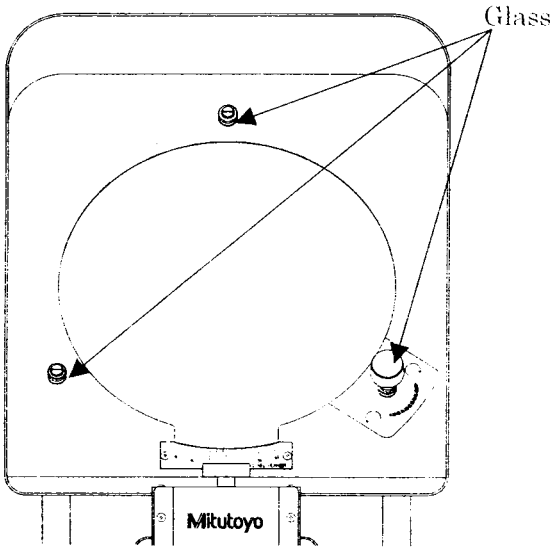
(2) Removing the carrying handles

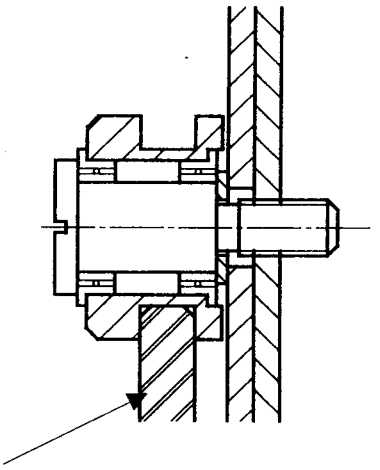
After setup, remove the carrying handles.



2.3 Attach the screen glass

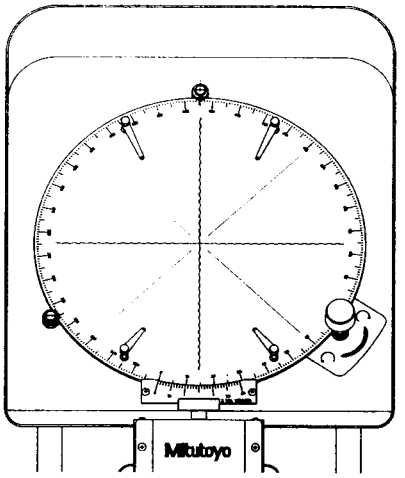
① The glass receptacle of the upper end of a screen frame is removed with a slot screw-driver.
② Insert screen glass between two glass receptacles at the bottom.
③ Thrust the glass receptacle of the upper end into the screen glass, and thrust the glass receptacle into the position of insertion origin.





screen glass

The state before The glass

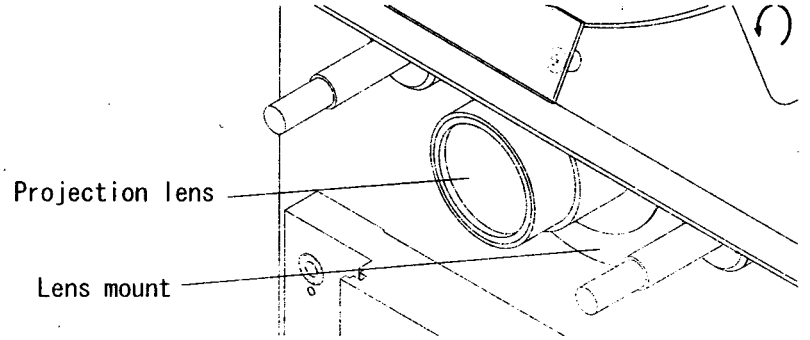


Attachment completion

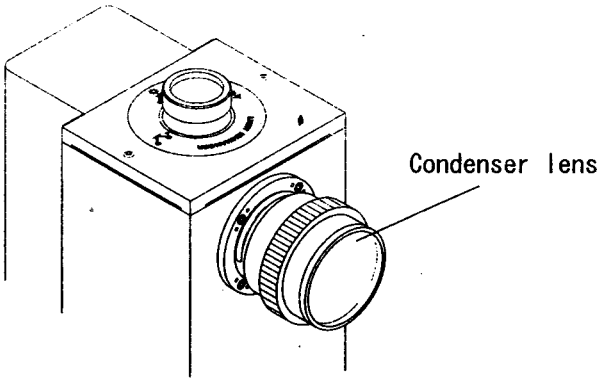
2.4 Mounting the Lens

In mounting the projection lens, move the microstage down as required.

①Screw-in the projection lens into the lens mount as far as it can go.



②When using a projection lens of 50X and 100X, select a condenser lens for contour illumination, which matches the magnification of the projection lens, and insert it firmly into the lens mount located at the front of the contour illuminator unit.



Note The condenser lens 10x and 20x are incorporated in the main unit.

2.5 Setting-up the Power Supply

The power supply specification is any voltage of 100V, 120V, 220V, or 240VAC±10% and either 50Hz or 60Hz. Provide the power supply according to the specification. A two-pole outlet with a ground terminal is required as the AC power outlet. Make allowance for the power output capacity in consideration of the total consumption of the system.

TIP

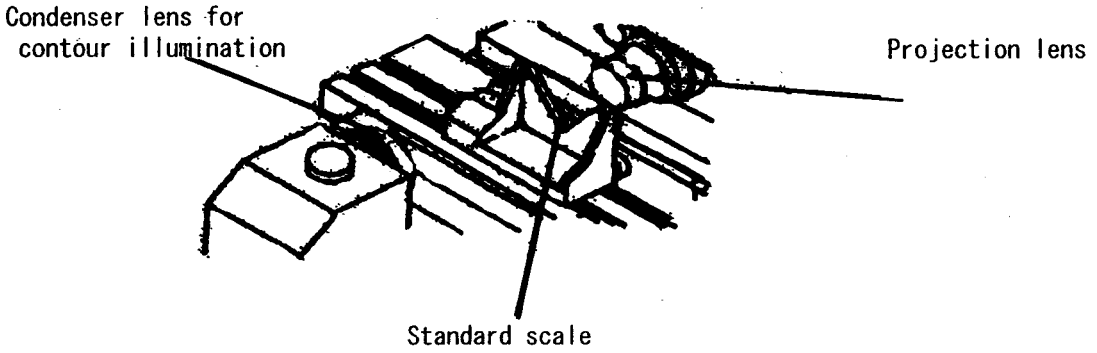
The system may require a power regulator if power fluctuation is not within ±10% of the specified voltage. An uninterruptible power system is required if there is any potential for power failure.

For more information, contact your dealer or the nearest Mitutoyo sales office.

Note Only allow the power outlet at the installation site to be used for the machinery including the Power Focus Unit. Do not share the outlet with other electric equipment.

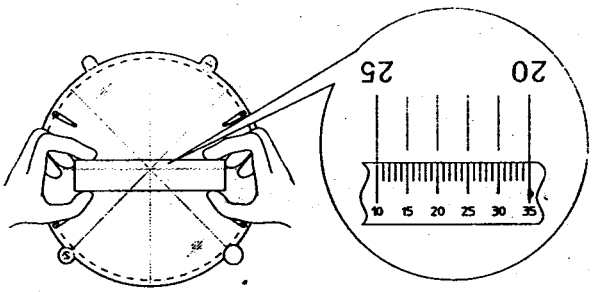
2.6 Checking the Magnification Accuracy

①Mount the projection lens and corresponding condenser lens for contour illumination.



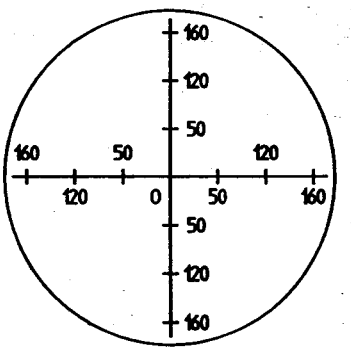
②Using a vertical workpiece holder (option), etc., place a standard scale (optional accessory, No. 172-116) on the microstage.

③Project the image of this standard scale onto the screen and measure it using a reading scale (option) as follows.



Tip **Inverted image is projected on the screen.**

④Measure the projected image of the standard scale on the screen using a reading scale. Take measurements at three reference points (50mm, 120mm, 160mm) in four or more radial directions along the cross-hair lines on the screen.



⑤Calculate the magnification error using the following formula:

$$\Delta M = \frac{L - lM}{lM} \times 100\%$$

ΔM	:	Magnification error
L	:	Measured length of the standard scale.
l	:	Length of the standard scale
M	:	Magnification of the projection lens.

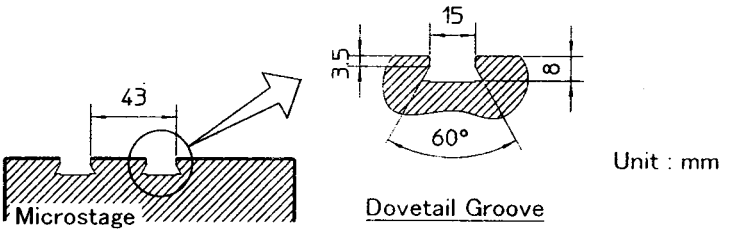
The magnification error is specified as ±0.05% or less for contour illumination (within ø100mm of the central area on the screen). (If the magnification error for contour illumination falls within the tolerance, that for surface illumination will also fall within the specified tolerance of ±0.1% (within ø100mm of central area on the screen)).

3 Operation

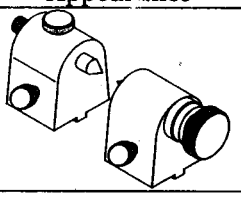
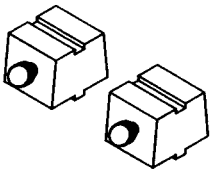
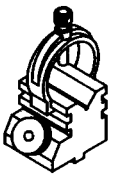
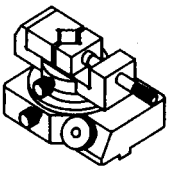
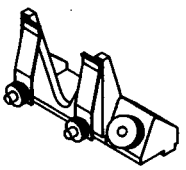
This chapter describes the operations of the Profile Projector PH-A14 corresponding to various applications.

3.1 Positioning the Workpiece

Two parallel dovetail grooves are provided on the microstage surface at intervals of 43mm. With these dovetail grooves, position a workpiece on the microstage using a special fixture that conforms to the workpiece feature or your jig.



There are various types of dedicated fixtures provided for this profile projector, as follows.

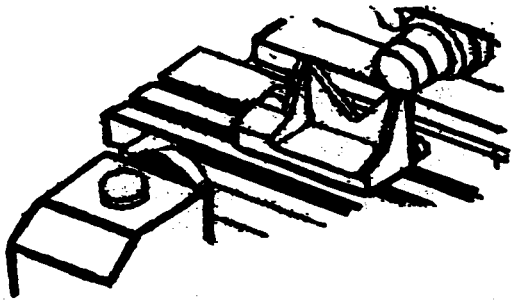
Model name	Appearance	Purpose
Center support (No.172-142)		Used to position a cylindrical workpiece which has two punched holes on both sides.
Riser (No.172-143)		Used to offset the center support.
V-block (No.172-234)		Used to position a general cylindrical workpiece.
Rotary vise (No.172-144)		Used to position a general cylindrical workpiece.
Vertical workpiece holder (No.172-132)		Used to hold a thin workpiece.

3.2 Projecting Methods

When turning on the power switch, the pilot lamp on the switch lights up.
The illumination lamp is lit simultaneously.

3.2.1 Projection by contour illumination

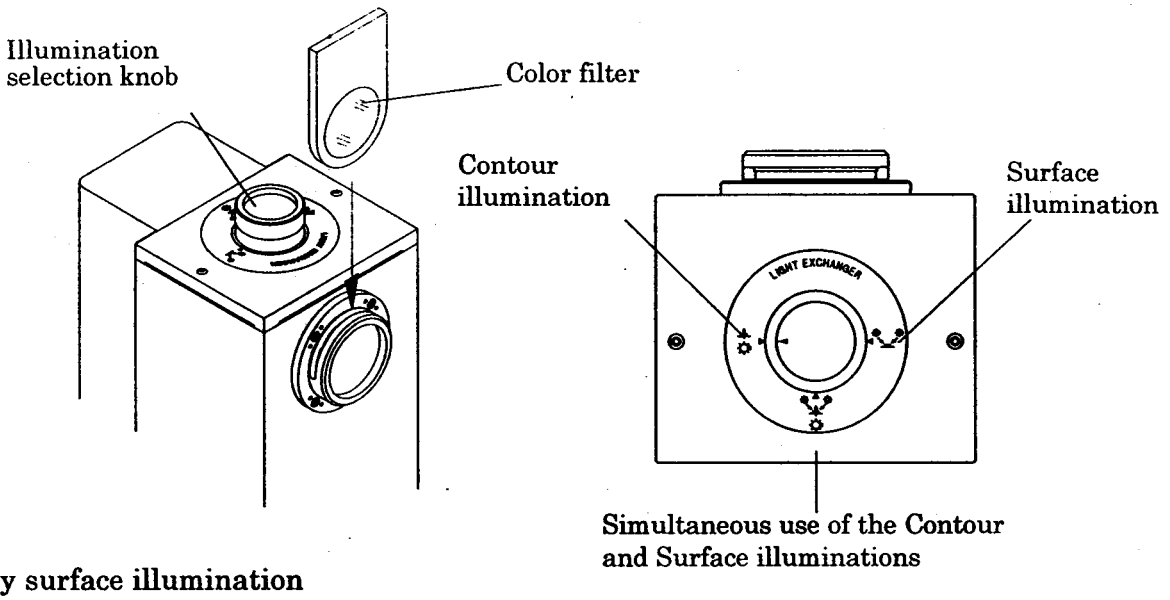
- The contour image of the workpiece is projected onto the screen.
- The contour illumination can be selected with the illumination selection knob.
- Be sure to use the condenser lens which corresponds to the magnification (50x, 100x) of the projection lens to be used.



Position the workpiece so it intersects the optical axis of the projection lens (which is collinear with the axis of the contour illumination).

- If using a color filter

  Insert an optional color filter (No. 172-286) into the slot behind the condenser lens mount.



3.2.2 Projection by surface illumination

- The twin-fibers light beam is reflected on the workpiece surface, then its surface condition is projected on the screen.
- The twin-fibers surface illumination can be selected with the illumination selection knob.

3.2.3 Projection by contour and surface illumination

- The contour image and surface texture of the workpiece is projected onto the screen.
- The illumination can be switched with the illumination selection knob.

3.3 General Measurement and Inspection

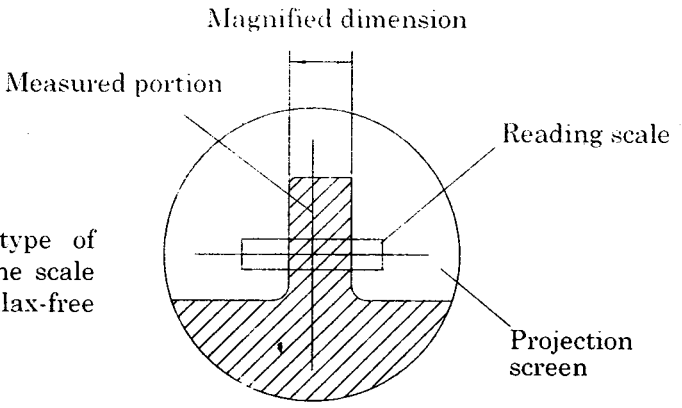
This profile projector has a wide range of measuring applications. Select a measuring method that suits the shape, size, quantity of the workpiece, and the measuring purpose and requirements. How to measure/inspect a workpiece is explained below

3.3.1 Dimensional measurement using a scale

After completing the procedure as shown in 3.2, place the scale on the screen and measure the enlarged image. Divide the measurements by the magnification of the projection lens to determine the actual dimensions.

(Example)

Measured value on the screen : 150mm
Projection lens magnification : 10X
Actual dimension of the workpiece : 15mm



- The optional reading scale is ideal for this type of measurement because the graduated surface of the scale fits on the screen glass, providing parallax-free measurement.

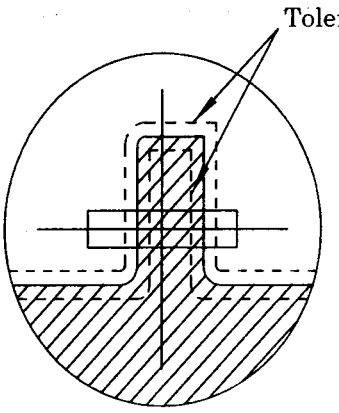
3.3.2 Comparison with an overlay chart

After completing the procedure as shown in 3.2, perform measurement and inspection by comparing the workpiece image with the standard overlay chart which is custom-made for the selected magnification. Use this method for measurement of shapes, multiple point and dimensions.

This method of measurement is suitable for checking a complex part feature which cannot be inspected in a simple one-dimensional measurement.

Adding tolerance lines to the standard overlay chart will improve inspection efficiency, since workpieces can be inspected with reference to these lines.

Standard charts can be made from the workpiece blueprint, or the master workpiece image projected on the screen. Use transparent or semi-transparent tracing sheets (or film) to make them. For close inspection or for long-term storage, plastic tracing sheets are recommended because of their greater dimensional stability.



3.3.3 Measurement using an external counter/2D data processing unit

This projector can easily perform high-accuracy measurement with the linear scales built in the microstage/stage base, which are connected to an external counter (KS counter or Opt-eye A2 counter) or 2D data processing unit (QM-Data200).

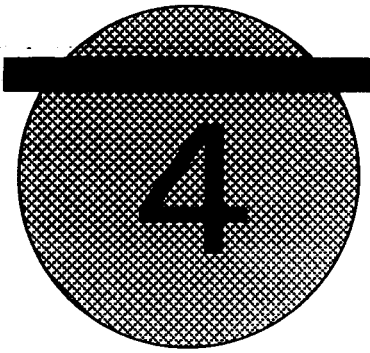
(1) Connection to an external counter/2D data processing unit

The linear scales incorporated in this projector are described below. Connect the connectors from two axes of linear scales to the following specified portions on the external counter or 2D data processing unit.

* X axis: Linear scale AT115-200 with a minimum reading of 1μm
* Y axis: Linear scale AT115-100 with a minimum reading of 1μm

(2) Operating procedure with the external counter/2D data processing unit

For detailed information, refer to the user's manuals of KS Counter, Opt-eye A2 Counter, and 2D Data Processing Unit.



Maintenance

This section describes the daily maintenance PH-A14 Profile Projector, including cleaning, and replacing consumable parts.

4.1 Maintenance of Optical Components

The maintenance method for the optical components of the profile projector is explained below.

4.1.1 Projection lens and condenser lens

Compared with ordinary hard glass, the optical glass of the projection lens or condenser lens used for this projector is soft and subject to scratches. In order to remove dust, do not use a cloth to wipe the lens. Use a blower brush instead.

To remove oil or fingerprints, dampen a piece of clean gauze with high-grade alcohol and wipe gently using a circular motion.

For lens storage, replace the lens cap and store it in its case.

Replace the lens cap when the projector is not in use. The lens does not have to be removed from the projector.

4.1.2 Mirror (surface reflection mirror)

The mirrors inside the machine are called surface reflection mirrors and the reflection surfaces are easily scratched. Exercise care so as not to allow dust or oil mist inside the machine.

Should the mirror have to be cleaned, dust must be blown away with a blower, rather than be wiped off.

Important **Do not wipe off the stains on the mirror surface with gauze or tissue paper.**

4.1.3 Screen glass

Use a soft cloth with high-grade alcohol and wipe the glass when removing oil and finger prints.

Important **In cleaning, be careful not to allow alcohol drops inside the machine.**

4.2 Maintenance of Mechanical Components

The maintenance method for the mechanical components of the profile projector is explained below.

4.2.1 Projector main unit

Periodically apply a thin coat of grease on the feed screws and gears of the microstage vertical travel using a brush.

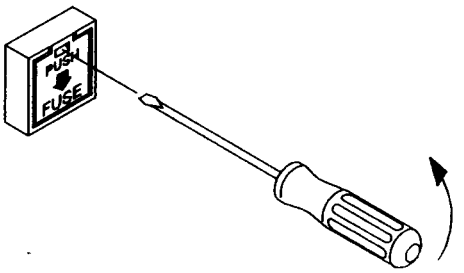
4.2.2 Microstage

Apply a small amount of spindle oil to the V-groove guide rail.

4.3 Replacing Consumable Parts

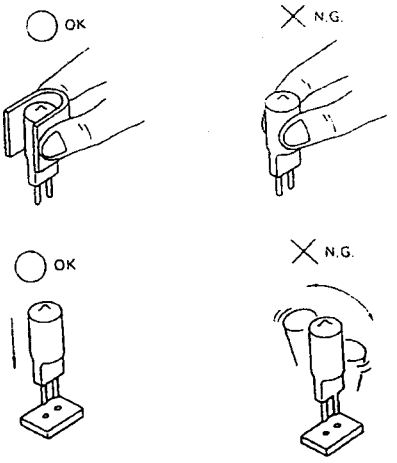
The replacement method for the consumable parts of the profile projector is explained in the following.

4.3.1 Fuse



①Turn the power switch to off.
②Pull the power plug from the power outlet.
③Insert a screwdriver in the slot on the upper side of the fuse holder case located on the rear side of the main unit. Then press it down and the fuse holder will come out of the case.
④Replace the cut fuse. then insert the fuse holder in the case.

4.3.2 Bulbs for contour and surface illuminators



①Turn the power switch off.
②Remove the illumination selection panel with an Allen wrench (nominal 3). At this time, pull the panel straight up, confirming the incorporated cylinder-shaped selection unit in the panel does not hit the lamp or lamp housing.
③Remove the bulb by pulling it straight up after the lamp and lamp housing have cooled down.
④Insert a new lamp straight into the socket. When inserting a new one, do not hold it by your bare hands. Use a clean piece of paper, etc., as shown on the right, and insert it as far as it can go.
⑤Reattach the illumination selection panel. At this time, slowly lower it so that the incorporated cylinder-shaped selection unit in the panel does not hit the lamp or lamp housing.

Caution

1. To prevent personal injury, do not touch the hot bulb during use or immediately after turning it off.
2. To prevent the bulb from being soiled by oil or finger-prints, do not touch the bulb with your bare hands.
3. Do not apply force to the bulb pin in the horizontal direction, or the bulb could be damaged.

4.3.3 Periodic inspection

In order to obtain a long service life from the PH-3500 Profile Projector, periodically perform inspection, cleaning, and necessary lubrication.

4.3.4 List of parts for maintenance

Item		Part No.	Note
Halogen lamp		515530	24V 150W (For Contour and Surface illuminations)
Fuse	6 A	358191	For 100~120V
	2.5 A	384208	For 220~240V

5 Troubleshooting

When the Profile Projector PH-A14 malfunctions, diagnose the problem and remedy the situation with the aid of the following tables. If the problem cannot be resolved with the procedures presented here, contact your dealer or nearest Mitutoyo Service Center.

5.1 Problems on the Power Supply

Symptom	Possible cause/Check point	Inspection/Remedy
The power switch is On, but the pilot lamp is not lit	① Is the power cord properly connected?	Connect the cord properly.
	② Is the fuse OK?	Replace the fuse. (Refer to 1.3.1)
	③ Does the power switch operate normally?	Contact Mitutoyo if the system does not work correctly even after the checks and remedies described in the left hand column.
	④ Is the input voltage to the power switch or fan motor okay?	
The illuminator lamp does not light when the power switch is ON.	① Does the pilot lamp in the power switch light?	Contact Mitutoyo if normal operation is not achieved after the checks and remedies were carried out according to the instructions on the previous symptom "The power switch is On, but the pilot lamp is not lit".
	② Is the fan motor working properly?	
	③ Is the lamp filament OK?	Replace the lamp. (Refer to 4.3.2)
	④ Turn the power switch to OFF and wait for more than 5 seconds. Then turn it again to ON.	If the lamp does not light after two or three tries, contact Mitutoyo.

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5.2 Problems on the Operation

Symptom	Possible cause/Check point	Inspection/Remedy
Focusing is not performed smoothly.	Is the operation of the focusing wheel smooth?	If there is play, excessive tight or uneven movement, or abnormal noise in the wheel, contact Mitutoyo. Do not disassemble the unit or do not rotate the focusing wheel forcibly.
Error is observed in glass scale or overlay chart measurement.	This may be a magnification error. Check the magnification accuracy by referring to 2.5.	Contact Mitutoyo if normal operation is not achieved after the checks and remedies were performed according to the instructions in the left hand column.
Abnormal protractor screen operation.	Does the screen rotation knob rotate smoothly?	If the screen rotation, fine adjustment, or clamp does not work normally, contact Mitutoyo. Do not rotate the knob forcibly.
Partially obscured image	① Is the projection lens properly mounted?	Mount the projection lens correctly. (Refer to 2.3)
	② Is focusing correct?	Perform focusing correctly.
	③ Is there any stain or damage on the projection lens?	Clean the projection lens. (Refer to 4.1.1)
	④ Is there any stain or damage on the surface reflecting mirror?	Clean the reflecting mirror. (Refer to 4.1.2)
	⑤ Is there any stain on the projection screen?	Clean the projection screen. (Refer to 4.1.3)

* Contact Mitutoyo if normal operation is not achieved even after the checks and remedies as described above are carried out.

6 Specifications

6.1 Main Unit

Model		PH-A14
Projected image		Inverted image
Protractor screen	Effective measurement diameter	356mm (14")
	Angle reading	Vernier reading, Resolution: 2'
Projection lens		10x(standard accessory), 20x, 50x, 100x (option)
Magnification accuracy	Contour illumination	Central area on the screen (area enclosed by an imaginary central circle ø100 (4")) : ±0.05% or less The rest of the area on the screen (area outside an imaginary central circle ø100 or less) : ±0.1 % or less
	Surface illumination	Central area on the screen (area enclosed by an imaginary central circle ø100 or less)
Micro-stage (X-axis)	Measuring range	203mm (8")
	Reading unit	Linear Scale
	Minimum reading	※1 0.001mm (.00005")
	Displacement accuracy : When no load is applied.	(6+L/15)μm L = Measuring length(mm)
	Table size	407mm (16") × 153mm (6")
Vertical travel unit (Y-axis)	Measuring range	102mm (4")
	Reading unit	Linear Scale
	Minimum reading	※1 0.001mm (.00005")
	Displacement accuracy : When no load is applied.	(6+3L/15)μm L = Measuring length (mm)
Possible traveling amount for focusing		50.8mm (2")
Maximum loading capacity		45kg (100lb)
Contour illumination unit		24V, 150W halogen lamp Telecentric illumination · Built-in heat absorbing filter and cooling fan · Color filter (options) is available
Surface illumination unit		24V, 150W halogen lamp (Common to the contour illumination) Twin fiber-optic illuminator
Power source		AC100V/120V/130V/230V/240V 50/60Hz
Power cable length		2.5m(98")
Main unit dimension		W × D × H:612 × 1240 × 1158mm (24.1" × 48.8" × 45.6")
Main unit mass		Approx. 140kg (308lb)

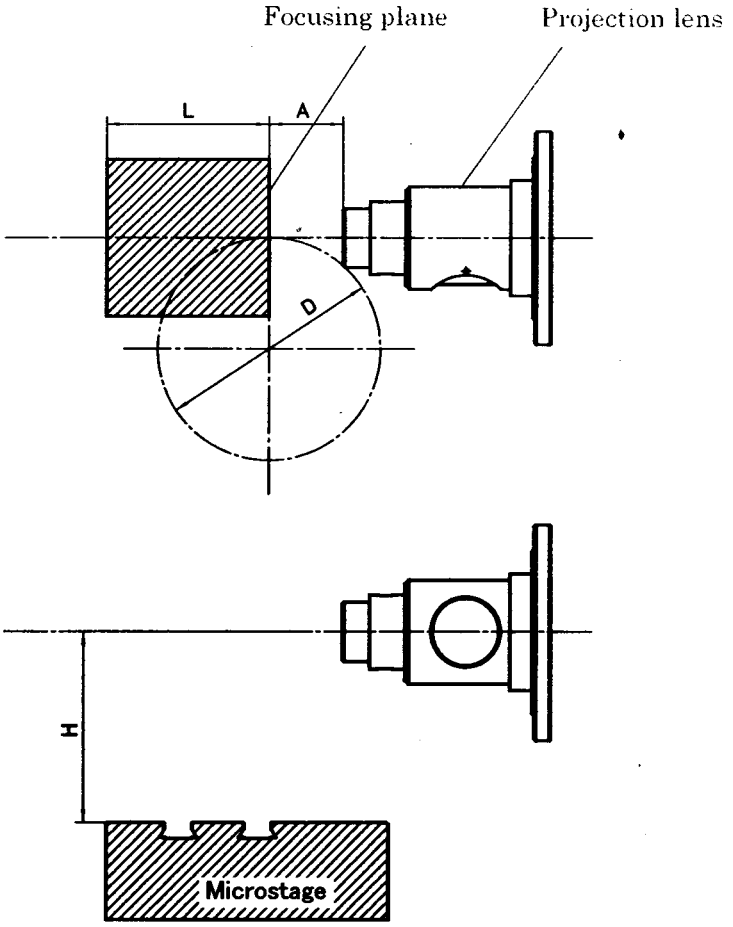
※1 Resolution shows the value for the case KS counter or QM-Data200 is used.

6.2 Projection Specifications

The following projection lenses are available for this profile projector, either as a standard or as an option.

Unit: mm

Magnification			10×	20×	50×	100×
Mounting method			Screw mount			
Projection capability	Field of view		35.6	17.8	7.12	3.56
	working distance	A	93	40	14.6	9.5
	Maximum workpiece height	L	235	235	109	109
	Maximum projecting diameter	D	102	102	31.3	19.2
	Maximum distance between the optical axis and microstage top face	H	102			



6.3 Accessories

6.3.1 Standard accessories

Refer to "2.1".

6.3.2 Optional accessories

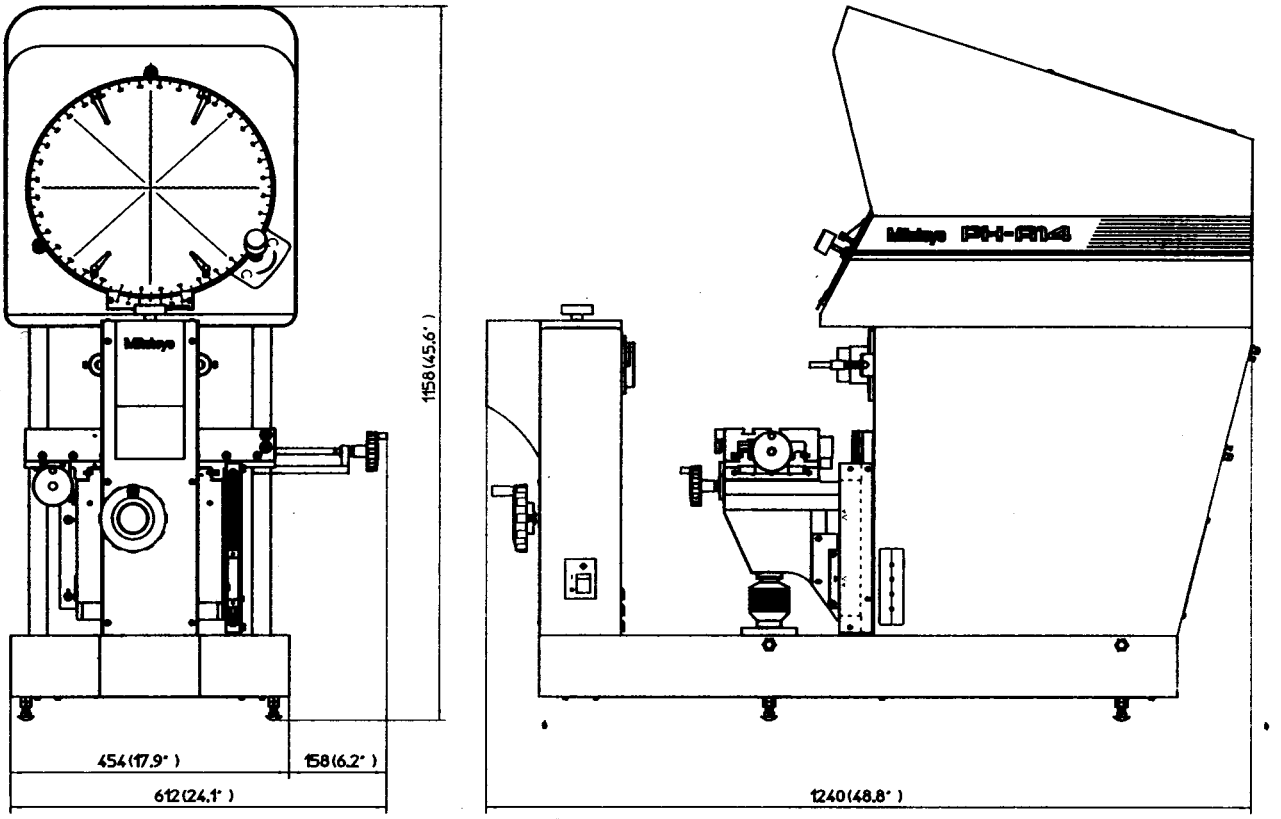
Order No.	Name
172-012	Projection lens 20 X
172-013	Projection lens 50 X
172-014	Projection lens 100 X
172-117	Standard scale 2″
172-119	Reading scale 8″
172-162	Reading scale 12″
172-116	Standard scale 50mm
172-118	Reading scale 200mm
172-161	Reading scale 300mm
172-286	Color filter
12AAB817	Condenser lens for the fiber-optic illumination (2 pcs/ set)
172-142	Center support
172-143	Riser
172-144	Rotary vise
172-132	Vertical workpiece holder
172-234	V-block
172-001	Tip-saw support stand ※1
172-002	Cutter support stand ※1
174-103-1 ※2	KS counter (Recommended counter)
332-115-1 ※2	Optoeye A2 counter
270032	Detector attachment plate (For Optoeye image edge sensor attachment)
264-141 ※2	2D data processing unit QM-DATA-200 (Arm type)
264-140 ※2	2D data processing unit QM-DATA-200 (Stand type)

※1 : Fixture for chip saws or cutters is corresponding to the center hole of ϕ25.4mm of the cutter tools.

※2 : Order No. differs depending on the power supply voltage used.

Order No.	Name
932105	Overlay chart : 12 sheet set
512066	Overlay chart : Top portion: 1 -grad. radical index Bottom potion: 1mm-radious increment concentric semicircles
512067	Overlay chart : 5mm-radious increment concentric circles, 1mm-reading cross hair
512068	Overlay chart : 1mm-radious increment concentric circle with cross hair
512069	Overlay chart : 50mm pitch horizontal parallel lines, 20mm pitch vertical parallel lines
512070	Overlay chart : 10 x 10mm sections
512071	Overlay chart : 5mm-reading cross hair
512072	Overlay chart : 1 x 1mm sections1mm
512073	Overlay chart : 1 -grad. radical index
512074	Overlay chart : 1mm pitch parallel lines
512075	Overlay chart : 1mm-radious increment concentric circles, 1 -grad. radical index
512076	Overlay chart : Metric thread (20x) : P=0.2~2mm Unified thread (20x) : 28~12 threads Whitworth screw thread (20x) : 20~10 threads
512077	Overlay chart : Metric thread (100x) : P=0.075~0.225mm Involute gear tooth (20x) Pressure angle20° , m=0.2~1 Pressure angle14.5° , m=0.2~1

6.4 External Dimensions



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