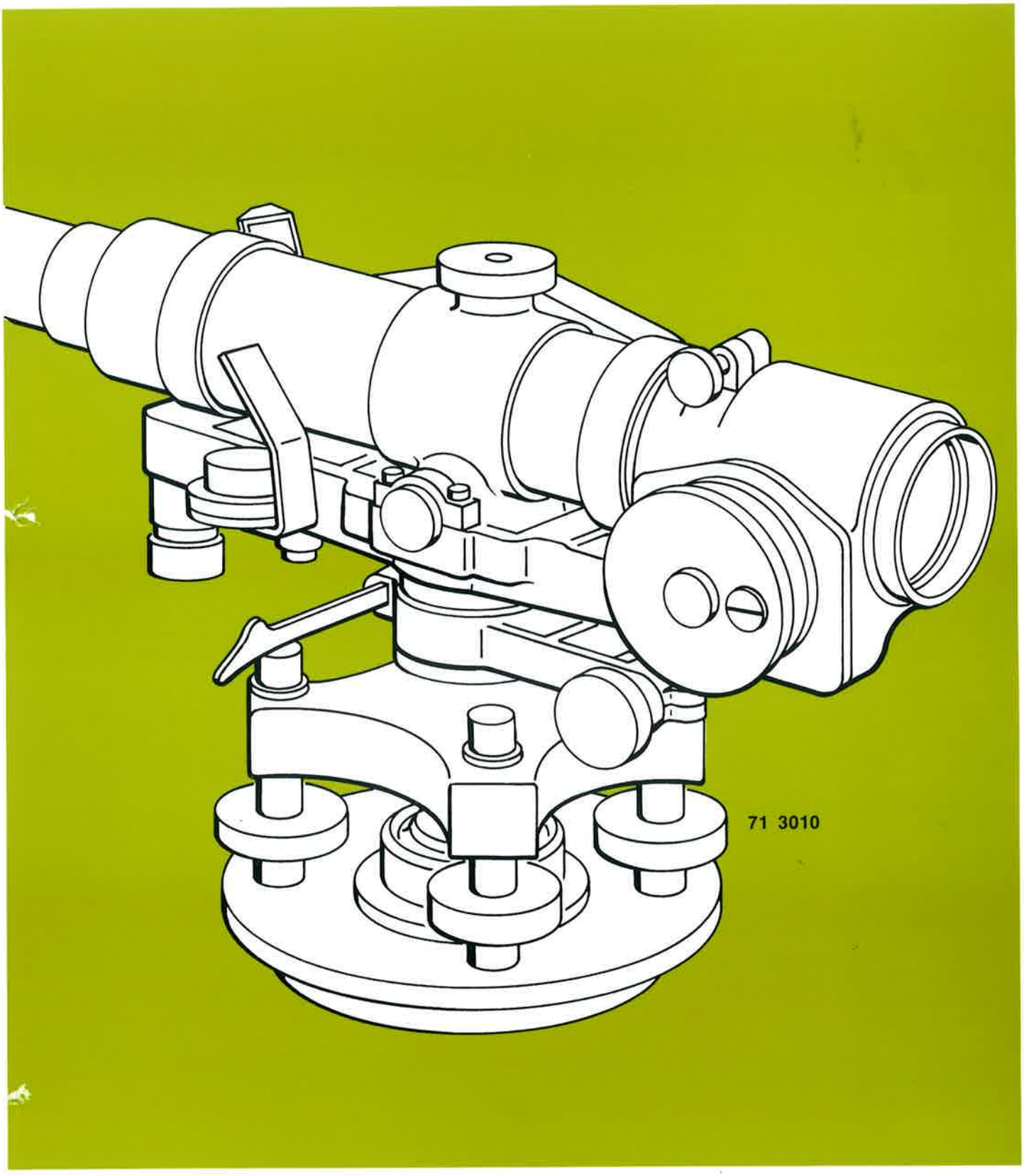
PARAGON® Tilting Level
PARAGON® Leveling Kit
Operating Manual

Manual No. 71 1000-2



METROLOGY SOLUTIONS INCORPORATED DBA
CUBIC PRECISION

Additional manuals covering Optical Alignment Equipment are available from Cubic Precision. For a complete set of manuals plus binder, contact Cubic Precision, 27 Central Ave., Teterboro, NJ 07608.

Product Number
71 1001 Optical Alignment Equipment Operating Manuals

Set of four operating manuals with illustrations and complete instructions for the use, care and adjustment of Optical Alignment Equipment. Also includes a comprehensive glossary of Optical Alignment Terms for easy and convenient referral.

The set includes the following manuals:

1. Alignment Telescope, Bright Line Alignment Telescope, Line of Sight Telescope and Alignment Collimator, Straightness of Line of Sight Collimator Operating Manual.
2. PARAGON® Tilting level, PARAGON Leveling Kit Operating Manual.
3. PARAGON® Jig Transit, PARAGON Jig Transit Telescope Square Operating Manual.
4. Alignment/Auto-Collimating Laser System Operating Manual.
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SECTION 1 — INTRODUCTION

1-1. PURPOSE OF EQUIPMENT

The tilting level is a precision instrument designed for optical tooling and alignment applications. It can be used to establish a place in space that is level (horizontal) to within 1 second of arc. When the instrument is used with an optional optical micrometer and optical tooling scale, displacements from the horizontal plane can be determined at distances up to 100 feet to an accuracy of thousandths of an inch. All types of machinery and equipment, such as machine tools, turbine foundations, and paper machine bed plates, can be leveled with ease to accuracies difficult if not impossible to achieve with conventional mechanical methods. Cubic offers both the basic 71 3010 PARAGON® Tilting Level (Figure 1-1) and the 71 3015 PARAGON® Leveling Kit (Figure 1-2).

1-2. DESCRIPTION

1-3. 71 3010 PARAGON® Tilting Level

The 71 3010 PARAGON® Tilting Level consists basically of a telescope and a precision, coincidence-type level. The telescope incorporates a new optical design which provides a minimum focus of 4 inches and variable magnification. The coincidence-type level has 2½X times magnification. Four-screw leveling, with the tilt (elevation) axis intersecting the azimuth axis, is used. With this leveling system, the height of the instrument remains constant during leveling, thereby eliminating errors that frequently occur with three-screw leveling instruments and those with a tilt axis not intersecting the azimuth axis.

1-4. 71 3015 PARAGON® Leveling Kit

The 71 3015 PARAGON® Leveling Kit, in a compact carrying case, provides the basic equipment required for precision optical leveling and alignment. It contains the following items:

- 71 3010 PARAGON® Tilting Level
- 71 1111 Optical Micrometer
- 71 6010 WYTEFACE® 10-Inch Optical Alignment Scale
- 71 3270 Scale Level
- 71 6065 Scale Holding Magnet
- 71 1260 Prismatic Eyepiece

NOTE: Space is provided in the carrying case for an extra 71 6010 WYTEFACE® Optical Alignment Scale and 71 6065 Scale Housing Magnet.

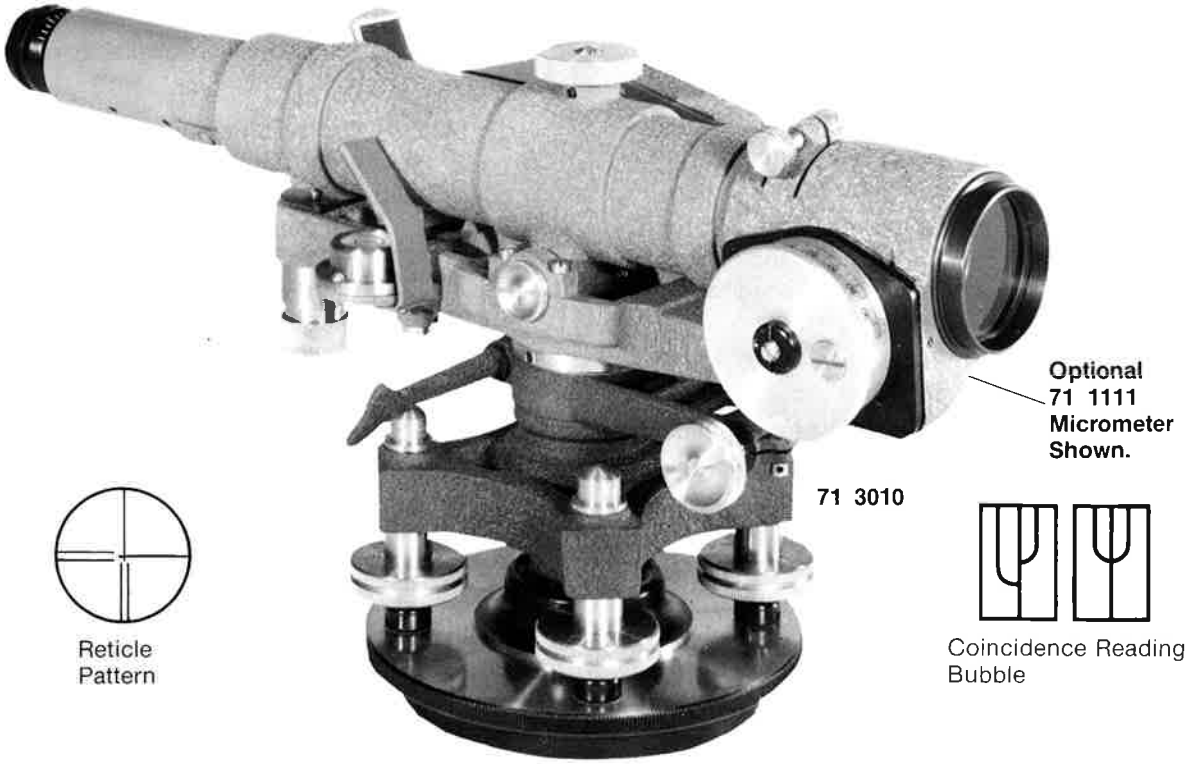


Figure 1-1. 71 3010 PARAGON® Tilting Level

1-5. SPECIFICATIONS

Characteristic	Specifications
Telescope:	
Length	11¼ inches
Optical System	Fully erecting, achromatic
Magnification	Varies automatically from 20x at near distance to 30x at infinity
Focusing Range	4 inches to infinity
Resolving Power	4 seconds of arc (per Bureau of Standards test procedure)
Field of View	55 minutes at infinity, 5.2 mm at near distance
Effective Aperture	30 mm
Optics	Fully coated throughout
Reticle	All purpose, double glass, dustproof; cross-pattern with single lines top and right, paired lines bottom and left
Eyepiece	Erecting, achromatic; removable blank provided for Auto-Collimation Conversion Unit.
Levels:	
Circular Vial	Sensitivity 10 minutes per 2 mm movement
Level Vial	Coincidence-reading type, 2½x magnification, sensitivity 20 seconds per 2 mm movement
Tripod Plate	Threaded, 3½ x 8, U.S. Standard
Weight	11 pounds (approximately)
Carrying Case	Formica with foam rubber inserts and four large rubber supports; adjusting pin, center key, webbed strap

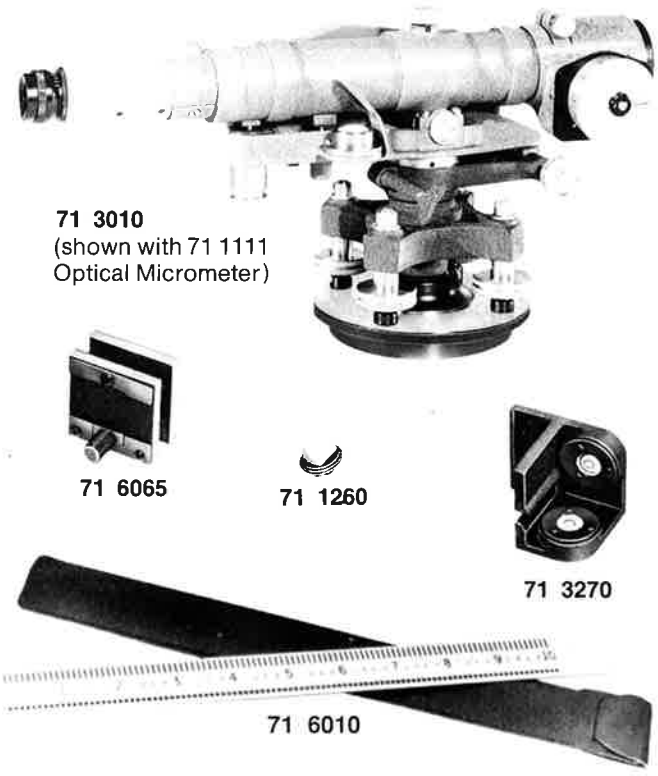


Figure 1-2. 71 3015 PARAGON® Leveling Kit

1-6. ACCESSORIES

The following accessories are available for use with the Tilting Level:

- 71 1111 Optical Micrometer
- 71 1113 Metric Optical Micrometer
- 71 1115 Optical Micrometer with Auto-Reflection Target
- 71 1211 Auto-Collimation Conversion Unit
- 71 1231 Right-Angle Eyepiece
- 71 1241 Combination Auto-Collimation, Projection, Right-Angle Eyepiece
- 71 1260 Prismatic Eyepiece*
- 71 5511 Replacement Auto-Collimation Illumination Unit
- 71 3280 Coincidence Level*

For description, installation, and use of these accessories, refer to the APPENDIX to this manual.

*To order only

SECTION 2 — OPERATION

2-1. UNPACKING AND INSPECTION

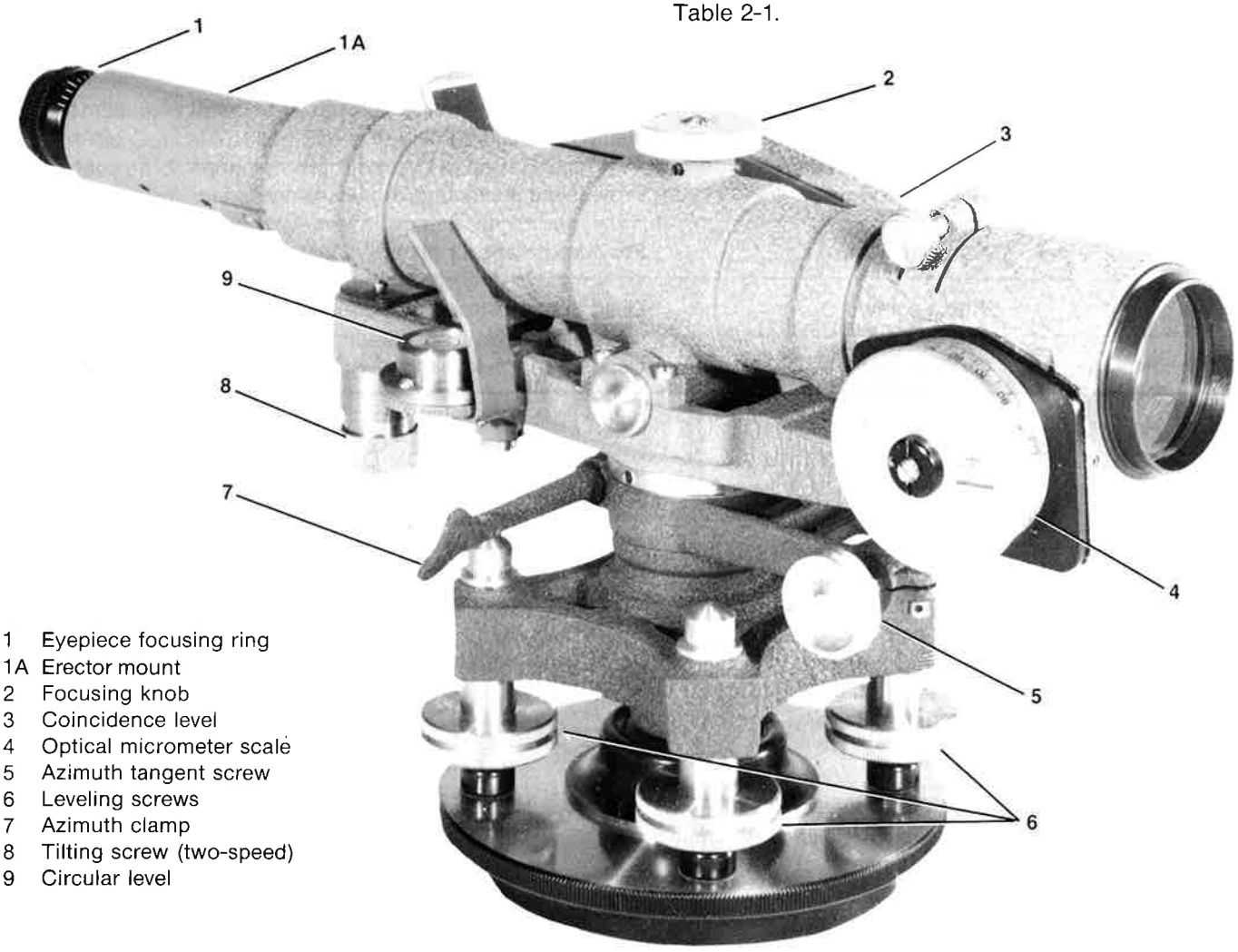
Upon receipt of the instrument, a complete mechanical inspection should be performed. Unpack the instrument carefully from the shipping container. Open the carrying case and check to see that all ordered items have been included in the shipment. Remove the instrument carefully from the carrying case and inspect it for signs of damage that may have occurred in shipment. Inspect glass parts especially for cracks and breakage.

2-2. INSTALLATION AND ADJUSTMENT OF ACCESSORY ITEMS

Select the accessories to be used for the particular application and install and adjust the accessories in accordance with the applicable instructions in the APPENDIX to this manual.

2-3. OPERATING CONTROLS

The main operating controls of the Tilting Level are shown in Figure 2-1, and their functions are listed in Table 2-1.



1 Eyepiece focusing ring
1A Erector mount
2 Focusing knob
3 Coincidence level
4 Optical micrometer scale
5 Azimuth tangent screw
6 Leveling screws
7 Azimuth clamp
8 Tilting screw (two-speed)
9 Circular level

NOTE: Tilting Level shown with *optional* 71 1111 Optical Micrometer.

Figure 2-1. Operating Controls

TABLE 2-1. OPERATING CONTROLS

Fig. 2-1 Index No.	Nomenclature	Function
1	Eyepiece focusing ring	Provides means for focusing reticle image in eyepiece.
1A	Erector mount	Holds optics which changes the normally inverted image into an erect image.
2	Focusing knob	Used to focus target image.
3	Coincidence level	Used for precision leveling of instrument.
4	Optical micrometer scale	Accessory item: used to measure vertical displacements from telescope line of sight.
5	Azimuth tangent screw	Provides means for fine azimuth adjustment after azimuth clamp has been tightened.
6	Leveling screws	Provide means for leveling instrument.
7	Azimuth clamp	Provides means for clamping instrument in azimuth plane.
8	Tilting screw	Used to level telescope precisely.
9	Circular level	Used for rough leveling of instrument.

2-4. SPECIAL OPERATING FEATURES

2-5. Two-Speed Tilting Screw. Tilting screw (8, Figure 2-1) is a two-speed screw which incorporates two stops, one third of a turn apart, within its knurled head. Between stops the tilting screw operates at low speed (8:1 ratio); beyond the stops it operates at high speed (1:1 ratio). To use the tilting screw, turn it in either direction until just past the desired point. Then, reverse the direction. Low-speed operation starts automatically, and continues until the final setting is made.

2-6. Coincidence Level. The Tilting Level uses a coincidence-reading level for precision leveling. A small window in the end of the coincidence level enables the operator to view both ends of the level bubble simultaneously through a mirror arrangement. The mirror arrangement causes the two ends of the bubble to appear side by side. When the tilting screw is adjusted, the ends of the bubble move with respect to each other. Leveling is achieved when the two ends of the bubble are made to coincide. With this arrangement, a tilt of one second of arc (equivalent to approximately 0.0015 inch at 25 feet) is easily discernible. (See Figure 1-1).

2-7. OPERATION OF TILTING LEVEL

2-8. To Take a Sight (See Figure 2-1).

1. Screw the base of the instrument onto a support having a 3½ inch by 8 thread.

2. Center the bubble of circular level (9) using four leveling screws (6). This aligns the azimuth axis of the instrument very nearly in the direction of gravity.

3. Free azimuth clamp (7) and sight the telescope at a white or light colored object.

4. Look through the telescope and turn eyepiece focusing ring (1) until the reticle pattern is sharp. Note the setting of the diopter scale engraved on the eyepiece focusing ring for future use.

NOTE: The diopter scale setting may be different for different observers and sometimes for different instruments, but it is the same for the same observer for sights of different lengths.

5. Position a Cubic Optical Tooling Scale vertically with the zero end on a fixed object.

6. Look over the top of the telescope and direct the telescope toward the Optical Tooling Scale.

7. Sight through the telescope and bring the Optical Tooling Scale into the field of view. Focus on the Optical Tooling Scale with focusing knob (2).

8. Lock azimuth clamp (7) and bring the vertical line of the reticle on the Optical Tooling Scale with azimuth tangent screw (5).

9. Set Optical Micrometer scale (4) to zero.

10. Adjust tilting screw (8) so that the two ends of the bubble in coincidence level (9) coincide.

11. Observe where the horizontal cross line falls on the Optical Tooling Scale. If it is not exactly at a tenth inch mark on the Optical Tooling Scale, turn the Optical Micrometer drum so that the cross line moves to the nearest *lower* tenth of an inch mark. For example: if the cross line falls between 9.3 and 9.4 on the Optical Tooling Scale, move it to least tenth position on the scale. Add the Optical Micrometer Scale reading to the current Optical Tooling Scale reading.

NOTE: For complete description, installation and adjustment of 71 1111 Optical Micrometer and 71 1113 Metric Optical Micrometer see Appendix A-1 or A-2.

12. Recheck bubble coincidence.

For greater accuracy, or to save time when many readings are to be taken from one setup, it is best to refine instrument leveling using the coincidence level. This is done as follows:

1. Turn the telescope parallel to an opposite pair of leveling screws (6).

2. Using tilting screw (8), adjust the ends of the bubble in coincidence level (3) so that they coincide.

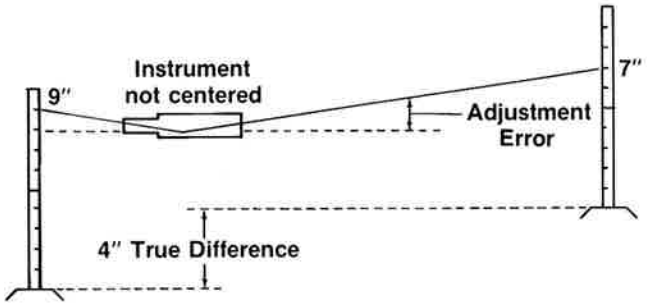
3. Turn the telescope 180 degrees and check the coincidence level bubble. If any leveling error is noted, eliminate half the error using leveling screws (6), and eliminate the remaining half using tilting screw (8).

4. Rotate the telescope 90 degrees. Using only the other pair of leveling screws (6), adjust the two ends of the coincidence level bubble so that they coincide.

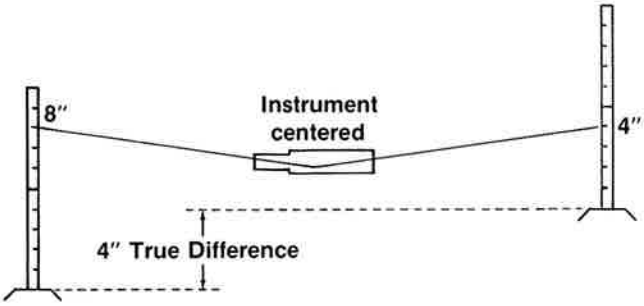
5. Repeat steps 1 through 4 until the ends of the coincidence level bubble coincide in at least three of the four instrument positions (for example, 0 degrees, 90 degrees, and 180 degrees). The fourth position will usually show a slight error.

2-9. To Determine Differences in Height. It is best to establish one point from which the differences in height to all other points are measured. Make measurements upward from top surfaces, and downward from bottom surfaces. Read Optical Tooling Scales positioned with the zero end on the points whose height difference is to be determined, and subtract the readings to obtain the differences in height.

NOTE: When high accuracy is required, position the instrument so that the horizontal lengths of the sights from the instrument to the two points are approximately equal. This eliminates the effect of slight errors in instrument adjustment, as shown in Figure 2-2.



Computed Diff. — 9" - 7" = 2"



Computed Diff. — 8" - 4" =4"

Figure 2-2. Minimizing Difference-in-Elevation Errors Through Proper Instrument Positioning

SECTION 3 — MAINTENANCE

3-1. CARE OF INSTRUMENT

The Tilting Level must be given reasonable care. Jarring and vibration may loosen screws and destroy all adjustments that depend on adjusting screws. The following rules for care of the instrument are suggested:

1. Always support the instrument in its normal position during storage, use, and adjustment.

2. Never transport an instrument unless it is fully supported on resilient material.

3. Allow the instrument to adjust to surrounding temperature before operating the instrument.

4. Install all accessories that are to be used with the instrument before making instrument adjustments.

5. When using the instrument, remember that a column of hot or cold air along the line of sight will destroy the accuracy of the reading.

6. Avoid even partial obstructions along the line of sight when using the instrument. Partial obstructions may make the line of sight unreliable.

7. Protect the instrument from dust as much as possible. Never rub dirt or dust off a lens. Blow or brush dust and dirt off lightly. If the view through the instrument lens becomes dim, take the instrument to a competent instrument repairman for cleaning.

8. Lubrication of the instrument is normally a shop operation; however, if necessary, the threads of the leveling screws may be lubricated with a small amount of instrument lubricant. Work the lubricant in by turning the leveling screws up and down throughout their range. Then, wipe off excess lubricant with a clean, lint-free cloth.

3-2. TEST AND ADJUSTMENT

The Tilting Level should be tested frequently, but adjusted only if three successive tests show the same error. Many adjustments affect other adjustments. Minimum interference occurs if the adjustments are made in the order given in the following paragraphs. If an adjustment does affect another, it is stated in the adjustment procedure.

Object 1: To Make the Bubble of the Circular Level Center When the Azimuth Axis Is Vertical

1. Test 1.

(a) Center the circular bubble with the leveling screws.

(b) Turn the telescope 180 degrees in azimuth. The bubble should then be centered.

2. Adjustment 1.

(a) With the telescope in the final test position, eliminate half the error in bubble position using the leveling screws.

(b) Adjust the circular level adjusting screws so that the bubble is centered. There are three adjusting screws around the vial that pull the circular level down against a spherical base. These screws can be adjusted with a jeweler's screwdriver. Loosen slightly the adjusting screw toward which the bubble should move, and tighten the adjusting screw that lies in the opposite direction an equal amount. Continue alternately so that tension is not lost. It is usually necessary to use only two adjusting screws.

(c) Repeat Test 1.

Object 2: To Make the Horizontal Cross Line Lie in a Place That is Perpendicular to the Azimuth Axis

This adjustment destroys adjustment 3.

1. Test 2. Aim at a well-defined point. Using the horizontal tangent screw, turn the telescope left and right. The horizontal cross line should remain on the point.

2. Adjustment 2.

(a) Unscrew the reticle cover just in front of the eyepiece.

(b) Four reticle adjusting screws are now exposed. Loosen two adjacent reticle adjusting screws. Tap the reticle adjusting screws gently to make them slide around the telescope until the cross line remains on the point.

(c) Tighten the two reticle adjusting screws that were loosened.

(d) Repeat Test 2.

Object 3: To Make the Split-Bubble Ends Coincide When the Line of Sight Is Level

NOTE: Two alternate peg test procedures are provided. Test 3A is a general peg test procedure that is standard for instruments used for accurate leveling. Because the K&E Tilting Level has a short minimum focus, the simpler Test 3B peg test procedure may be used instead.

1. Test 3A.

(a) Set Cubic Optical Tooling Scales at points 1 and 2 (Figure 3-1) that are at least 40 feet apart. The Optical Tooling Scales must be vertical (use the 71 3270 Scale Level) and must be on a firm base that is not subject to vibration or settlement. Provide good illumination for the Optical Tooling Scales.

(b) Set up the Tilting Level, equipped with an Optical Micrometer, at point M, which is exactly midway between points 1 and 2. Determine the mid-point by measurement, not by approximation.

(c) Level the Tilting Level so that the ends of the coincidence bubble coincide. Take five readings at A and B, and record the average of the A readings and the average of the B readings.

(d) Move the Tilting Level to position P. Position P should divide the distance between the two Optical Tooling Scales in a ratio of 1:4. For example: if the distance between the two Optical Tooling Scales is 40 feet, point P should be 8 feet from point 1 and 32 feet from point 2.

(e) Level the Tilting Level so that the ends of the coincidence level bubble coincide. Take five readings at C and D, and record the average of the C readings and the average of the D readings. If the Tilting Level is correctly adjusted, A minus B will equal C minus D. If this is not the case, calculate reading D^1 required to make the line of sight level, using the following formula:

$$D^1 = 4/3\ [(B + C) - (A + D)] + D$$

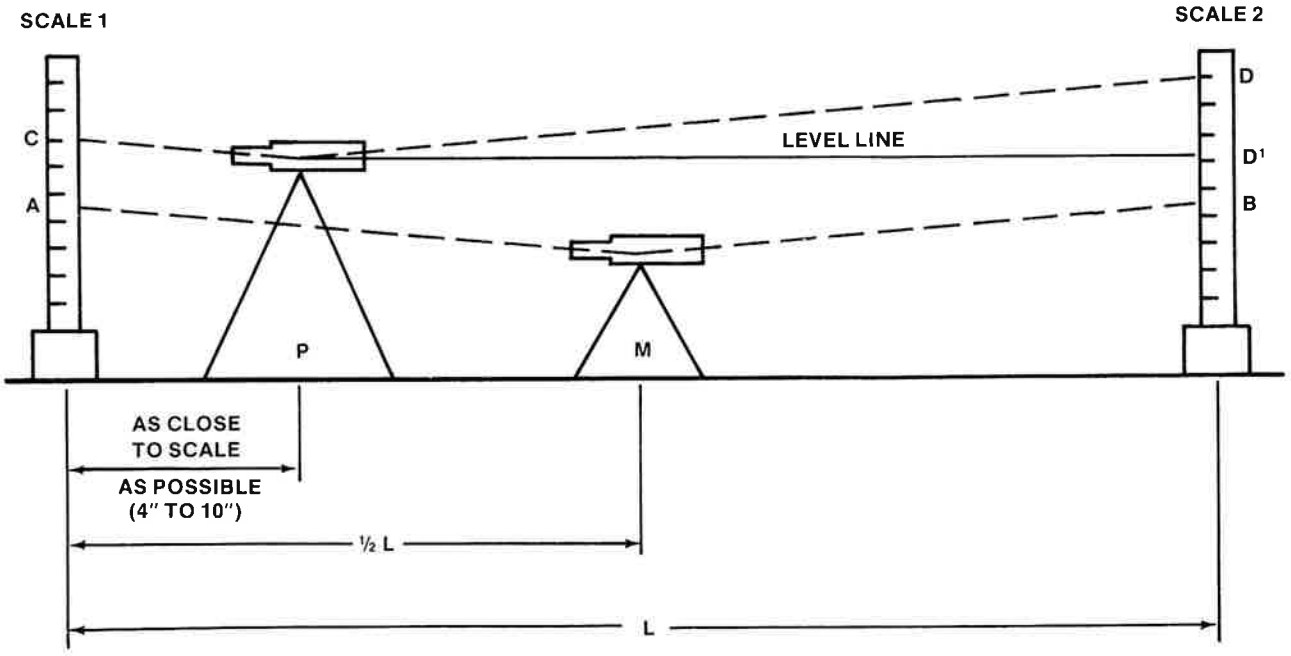


Figure 3-1. Peg Test Diagram

2. Test 3B. (Optional Peg Test for Instruments With Short Minimum Focus)

(a) Set Optical Tooling Scales at points 1 and 2 (Figure 3-1) that are at least 40 feet apart. The Optical Tooling Scales must be vertical (use the 71 3270 Scale Level), and must be on a firm base that is not subject to vibration or settlement. Provide good illumination for the Optical Tooling Scales.

(b) Set up the Tilting Level, equipped with an Optical Micrometer, at point M exactly midway between points 1 and 2. Determine the midpoint by measurement, not by approximation.

(c) Level the Tilting Level so that the ends of the coincidence level bubble coincide. Take five readings at A and B, determine the difference in elevation for each set of A and B readings, and average the five difference-in-elevation values.

(d) Move the Tilting Level to position P. Position P should be as close to one of the Optical Tooling Scales as possible; however, it must be at least 4 inches from the Optical Tooling Scale in order to be within the minimum focusing range of the Tilting Level, and may have to be even farther to provide enough clearance to sight through the Tilting Level to the other Optical Tooling Scale.

(e) Level the Tilting Level so that the ends of the coincidence level bubble coincide. Take five readings at C and D, and determine the difference in elevation for each set of C and D readings. Average the five difference-in-elevation values. This average should be the same as that obtained in step (c). If it is not, compute the D^1 reading required to make the line of sight level; D^1 is the average D reading obtained in this step minus the difference in the difference-in-elevation values computed in step (c) and this step.

NOTE: The principle of the peg test is to set up a true difference in elevation by first setting up the instrument in the exact center, and then at an out-of-balance position as at point P. If there is an error in the level of the instrument, the difference-in-elevation reading obtained at the exact center will differ from that obtained at point P. With an instrument having a long minimum focus, it is necessary to compute the actual error through similar triangles, as in Test 3A; with Cubic instruments having a very short minimum focus, similar triangles can be ignored and the total correction can be made in the long direction since point P is established as close to one of the Optical Tooling Scales as possible. The base of a short similar triangle is so small as to be considered negligible. A greatly simplified peg test is the result of this approach.

3. Adjustment 3.

(a) With the Tilting Level set up and leveled at point P, loosen the outer two of the three capstan screws located at the back of the Coincidence Level bubble housing.

(b) Using the tilting screw, set the Tilting Level cross line to the computed D^1 reading on Optical Tooling Scale 2. The computed D^1 reading probably cannot be read directly off the Optical Tooling Scale; use the Optical Micrometer for precise readings. For example: if the computed D^1 value is 4.671, set plus 0.071 on the Optical Micrometer, and adjust the cross line to read 4.600 on Optical Tooling Scale 2.

(c) With the adjusting pin, turn the center capstan screw at the back of the coincidence level bubble housing until the bubble ends are in coincidence. Lock the bubble adjustment by tightening the two outer capstan screws.

(d) If the center capstan screw has insufficient range to make the adjustment in step (c), set the center capstan screw to the center of its range, repeat Test 3A or 3B as applicable, and proceed to step (e).

(e) Remove the dust cap screws at the top and bottom of the eyepiece end of the coincidence bubble housing to expose the coarse bubble adjusting screws.

(f) With the Tilting Level set for the required D^1 reading on Optical Tooling Scale 2, turn the coarse adjusting screws with the two hexagon keys provided to bring the bubble ends into approximate coincidence; then, lock the coarse adjusting screws firmly. Replace the dust cap screws.

(g) Make the final fine adjustment with the center capstan screw as described in step (c).

(h) Repeat Test 3A or 3B, as applicable.

APPENDIX — ACCESSORIES

71 1111
Optical Micrometer

71 1113
Metric Optical Micrometer

71 1115
Optical Micrometer

71 1211
Auto-Collimation Conversion Unit

71 1231
Right-Angle Eyepiece

71 1241
Combination Auto-Collimation, Projection, Right-Angle Eyepiece

71 1260
Prismatic Eyepiece

71 3270
Scale Level

71 5511
Auto-Collimation Illumination Unit

71 6065
Scale Holding Magnet

Figure A-1. Tilting Level Accessories

A-1. 71 1111 OPTICAL MICROMETER

Description

The 71 1111 Optical Micrometer can be installed on the objective end of the Tilting Level telescope to enable measurement of vertical displacements from the instrument line of sight. Its range is + 0.100 inch. Vertical displacements can be read directly to 0.001 inch on a uniformly graduated scale; readings to 0.0001 inch can be made using a vernier scale. The Optical Micrometer operates by displacing the line of sight parallel to itself as shown in Figure A-2.

The Optical Micrometer has a dustproof glass cover and a split-ring clamp for mounting. It can be adjusted without removal from the Tilting Level telescope.

Installation and Adjustment

1. Free the split-ring clamp screw of the Optical Micrometer.

2. Slide the Optical Micrometer onto the front end of the Tilting Level telescope with the Optical Micrometer drum positioned at the side.

3. Tighten the split-ring clamp screw just enough so that the Optical Micrometer can be turned, but has no play.

4. Aim at a target.

5. Rotate the Optical Micrometer so that the vertical cross line remains on the target as the Optical Micrometer drum is rotated over its full range. Tighten the split-ring clamp screw.

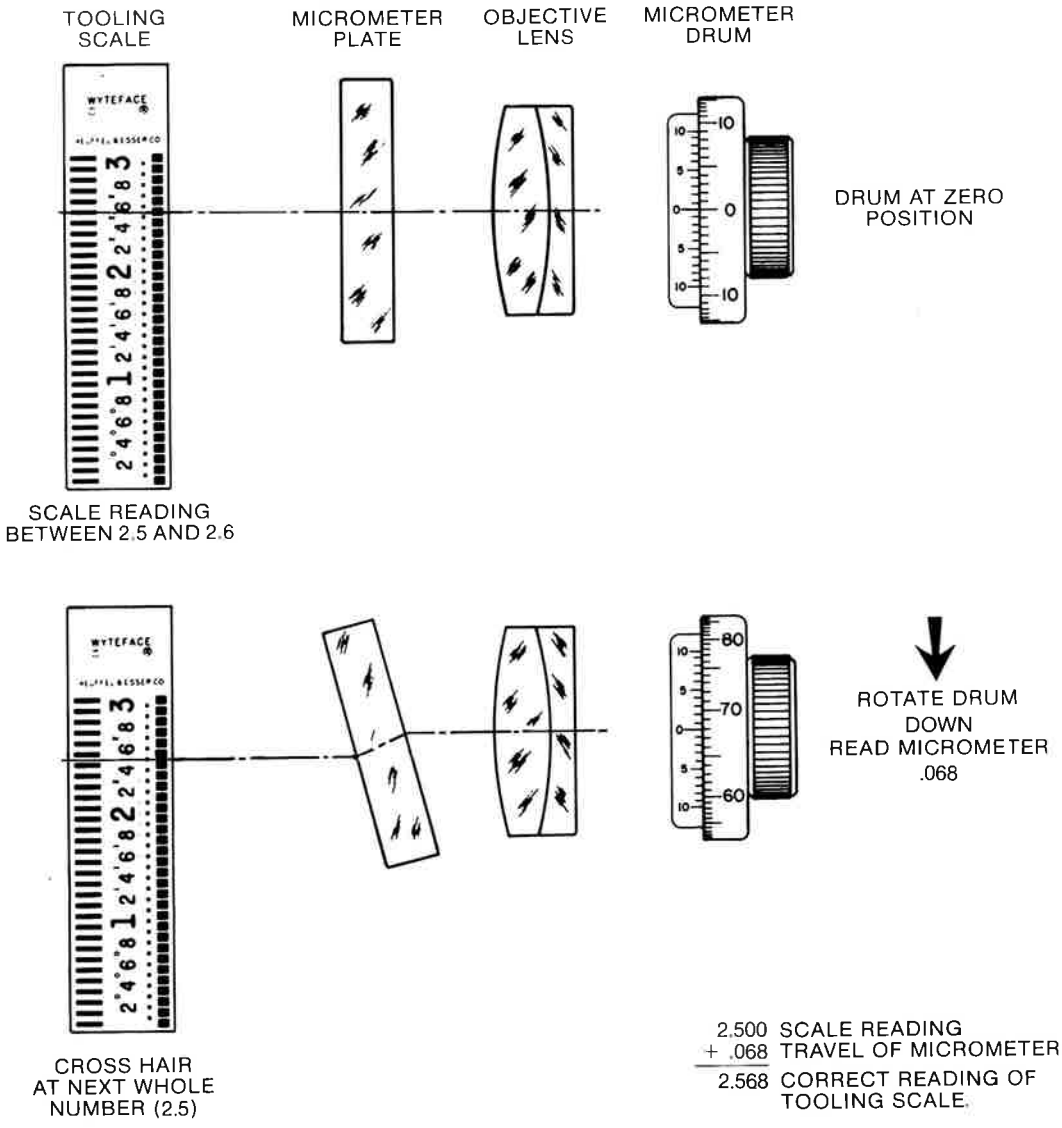


Figure A-2. Operating Principle of Optical Micrometer

Use

To use the Optical Micrometer, the Tilting Level is first leveled precisely; then, the Optical Micrometer is used to make precise vertical measurements using the procedures illustrated in Figure A-3.

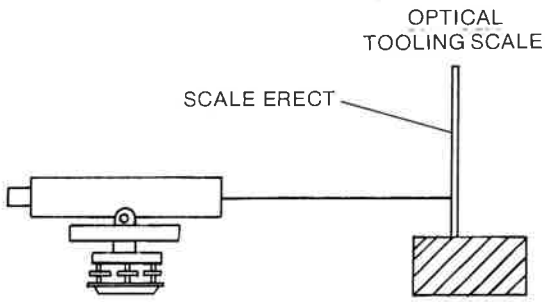
A-2. 71 1113 METRIC OPTICAL MICROMETER

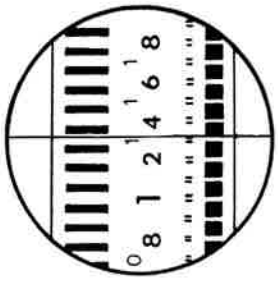
Description

The 71 1113 Metric Optical Micrometer is similar to the 71 1111 Optical Micrometer, except that it is calibrated in metric units. Its range is +2.0 mm, the main scale reads directly to 0.02 mm, and the vernier scale reads to 0.002 mm.

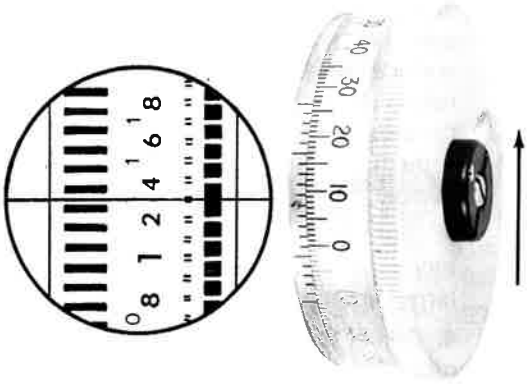
Installation and Adjustment

The installation and adjustment procedure is the same as that for the 71 1111 Optical Micrometer.

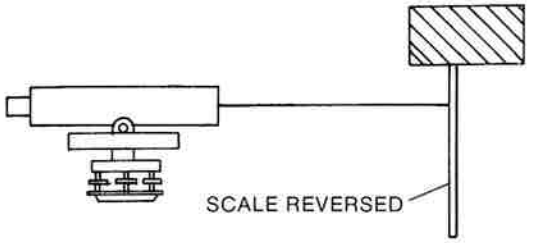


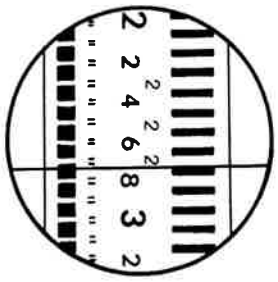


Step 1. Set micrometer scale at zero, and read optical tooling scale at crossline. Reading shown is between 1.3 and 1.4.

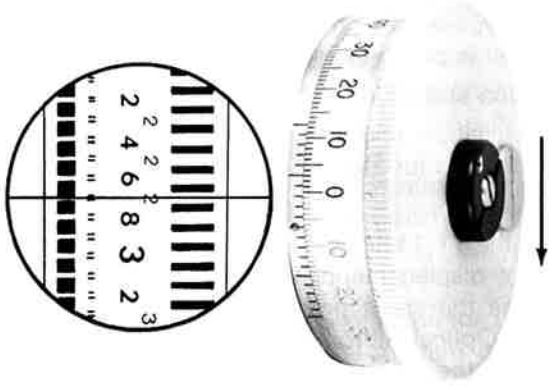


Step 2. Move crossline to least tenth, add micrometer reading (black numbers). Final reading shown is 1.3075 inches.





Step 1. Set micrometer scale at zero, and read optical tooling scale at crossline. Reading shown is between 2.7 and 2.8.



Step 2. Move crossline to least tenth, add micrometer reading (red numbers). Final reading shown is 2.7065 inches.

Figure A-3. Procedure for Reading Optical Micrometer Scale

Use

The 71 1113 Metric Optical Micrometer must be used with a metric optical alignment scale, such as the 71 6041 Metric WYTEFACE® Optical Alignment Scale. This scale has a uniformly graduated length of 25 cm. The graduations are numbered at each centimeter, and each centimeter is further subdivided into 2 millimeter segments. To take a reading using the Metric Optical Micrometer, proceed as follows:

1. Set up and level the tilting level.

2. Set the Optical Micrometer scale to zero, and read the optical alignment scale at the target point.

3. If the reading in step 2 does not fall exactly at one of the graduations on the Optical Alignment Scale, adjust the Optical Micrometer as necessary to bring the cross line of the instrument onto the nearest *lower* mm mark on the Optical Alignment Scale. The correct reading is then the Optical Alignment Scale reading plus the Optical Micrometer scale reading.

Example:

Assume that, in step 2, the cross line falls between the 19.2 and 19.4 cm marks on the Optical Alignment Scale. In step 3, the Optical Micrometer would be adjusted to bring the cross line to the 19.2 cm mark. If the Optical Micrometer scale reads 1.036 mm after this adjustment, the final reading is 19.2 cm (the Optical Alignment Scale reading) plus 0.1036 cm (the Optical Micrometer scale reading converted to cm), or 19.3036 cm.

A-3. 71 1115 OPTICAL MICROMETER

Description

The 71 1115 Optical Micrometer is the same as the 71 1111 Optical Micrometer, except that an auto-reflection target is photo-etched on its cover glass.

Installation and Adjustment

The installation and adjustment procedures are the same as those for the 71 1111 Optical Micrometer.

Use

To use the 71 1115 Optical Micrometer for measurements of displacements from the instrument line of sight, use the same procedures as specified for the 71 1111 Optical Micrometer. The auto-reflection target facilitates the auto-reflection process, whereby a surface can be set perpendicular to the instrument line of sight or, conversely, the instrument line of sight can be set perpendicular to a surface. For auto-reflection, proceed as follows:

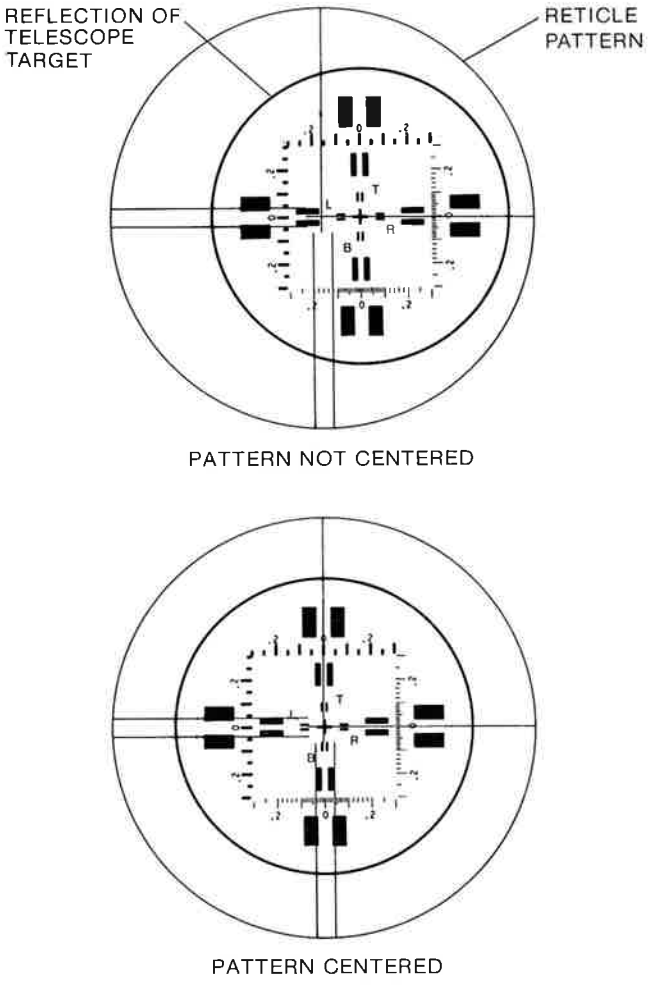


Figure A-4. Auto-Reflection

1. With the Optical Micrometer installed on the objective end of the Tilting Level telescope, set up and level the Tilting Level.

2. Mount an optically flat target mirror on the part that is to be positioned, with the reflective surface of the mirror parallel to the proper reference plane of the part. Position the part at its proper location with the instrument line of sight approximately centered in the target mirror.

3. Sight through the Tilting Level telescope and focus on the reflection of the auto-reflection target in the target mirror. (See Figure A-4.)

4. Adjust the part on which the target mirror is mounted until the reflection of the auto-reflection target coincides with the cross lines of the instrument reticle. The surface to which the target mirror is attached is then perpendicular to the instrument line of sight.

NOTE: If it is desired to set the instrument line of sight perpendicular to the part, adjust the instrument in step 4 instead of adjusting the part.

A-4. 71 1231 RIGHT-ANGLE EYEPIECE

Description

The 71 1231 Right-Angle Eyepiece can be used in place of the standard eyepiece for very low setups or when leveling close to walls, columns, or other obstructions. The right-angle eyepiece maintains a fully erect image and can be rotated through 360 degrees for sighting from any perpendicular angle.

Installation and Adjustment

Unscrew the standard eyepiece from the Tilting Level telescope and screw the Right-Angle Eyepiece onto the telescope tube in its place. Observe the reticle; if the reticle cannot be brought into sharp focus using the Eyepiece focusing ring, the following adjustment is required:

1. Set the Eyepiece at the middle of its total movement.
2. Remove the eyepiece and adapter from the Eyepiece assembly. (See Figure A-5.) Loosen setscrew "A" with a 0.023 inch socket wrench.
3. Move the lens mount in or out in small increments until the reticle can be focused sharply with the eyepiece focusing ring.
4. Tighten setscrew "A".
5. Recheck reticle focusing. If necessary, repeat steps 1 through 4.

Use

Except for the fact that the eyepiece is displayed 90 degrees relative to the instrument line of sight, the Right-Angle Eyepiece is focused and used in the same manner as the standard eyepiece. Merely position the Right-Angle Eyepiece for most convenient sighting.

A-5. 71 1260 PRISMATIC EYEPIECE

Description

The 71 1260 Prismatic Eyepiece is used as an attachment on the standard eyepiece of the Tilting Level for very low setups, or when working close to walls, columns, or other obstructions. It may be rotated through 360 degrees and gives an erect but *reversed* image.

Installation

To install the 71 1260 Prismatic Eyepiece, unscrew the end ring of the standard eyepiece, and screw on the Prismatic Eyepiece in its place. No adjustments are required.

Use

To use the Prismatic Eyepiece, merely rotate it to the position that provides the most convenient viewing, and sight through it. Note that the Prismatic Eyepiece will give a *reversed* image.

Figure A-5. 71 1231 Right-Angle Eyepiece

A-6. 71 1211 AUTO-COLLIMATION CONVERSION UNIT

Description

The 71 1211 Auto-Collimation Conversion Unit can be used to convert the Tilting Level telescope into an auto-collimating telescope. It is supplied complete with a light plug assembly, power cord, switch, and fixed 6-volt transformer.

Installation

The 71 1211 Auto-Collimation Conversion Unit consists of two major parts: the beam splitter with its mount, and the illumination unit. In case of loss or damage, the illumination unit may be ordered separately as the 71 5511 Auto-Collimation Illumination Unit. To install the 71 1211 Auto-Collimation Conversion Unit on the telescope of the Tilting Level, proceed as follows:

1. Locate the dust cover plate on the underside of the telescope tube just forward of the eyepiece. (See Figure A-6.)
2. Remove the two dust cover plate attaching screws, then remove the dust cover plate. The same screws are used to mount the Auto-Collimation Conversion Unit.

3. Insert the Auto-Collimation Conversion Unit into the opening in the telescope tube. Note that the mounting holes are off-center so that the Unit can be mounted only in its proper orientation. The Unit should be mounted with the wide edge forward of the holes. When the Unit has been properly positioned, insert the mounting screws and snug the screws up tight.

4. The 71 5511 Auto-Collimation Illumination Unit is provided with an on-line 6-volt transformer with a 3-prong, twist-lock male connector. (This is in accordance with AIA requirements.) Plug the male connector into a suitable 110 volt AC outlet or extension cord. If a 3-prong, twist-lock outlet or extension cord is not available, the unmounted female connector supplied with the Auto-Collimation Conversion Unit can be used to fabricate an extension cord or short pig-tail to adapt to the available AC outlet or extension cord.

5. Turn on the switch and check the light in the Auto-Collimation Illumination Unit. It is used to illuminate the cross lines of the telescope.

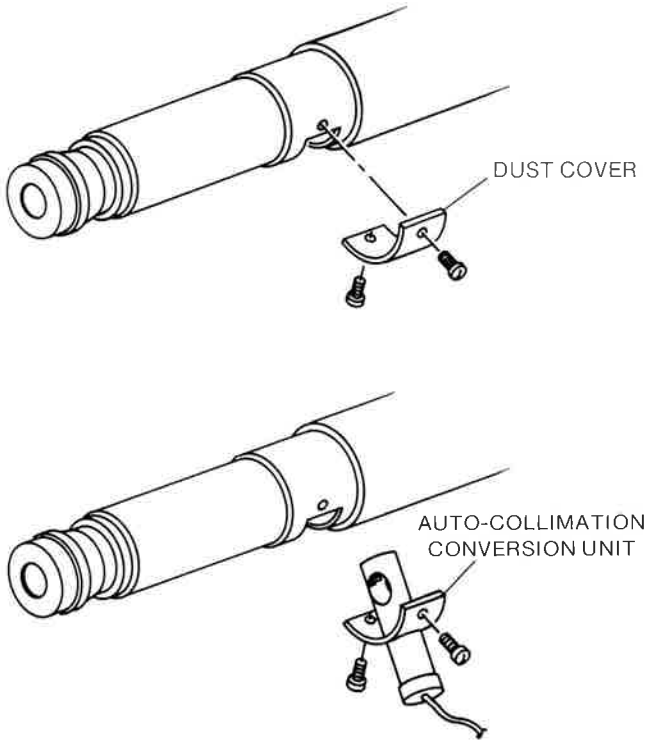


Figure A-6. Installation Location for 71 1211 Auto-Collimation Conversion Unit

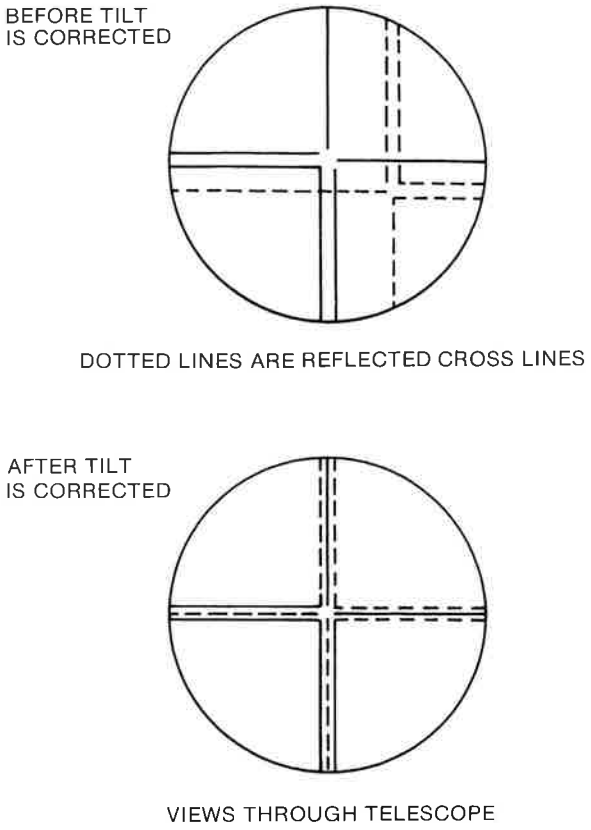


Figure A-7. Auto-Collimation

Use

The auto-collimation process can be used to position a part perpendicular to the line of sight of the telescope. With the Auto-Collimation Conversion Unit installed on the Tilting Level telescope, proceed as follows:

1. Set up and level the tilting level.

2. Mount an optically flat target mirror on the part that is to be positioned, with the reflective surface of the target mirror parallel to the reference plane of the part. Position the part so that the target mirror is centered approximately with the tilting level line of sight.

3. Switch on the Auto-Collimation Conversion Unit to illuminate the cross lines of the tilting level reticle.

4. Sight on the *reflection* of the instrument cross lines in the mirror and focus the instrument. Adjust the part so that the reflection of the cross lines falls on the cross lines themselves. (See Figure A-7.) The part is then perpendicular to the line of sight of the Tilting Level.

A-7. 71 1241 COMBINATION AUTO-COLLIMATION, PROJECTION, RIGHT-ANGLE EYEPIECE

Description

The 71 1241 Combination Auto-Collimation, Projection, Right-Angle Eyepiece is interchangeable with the standard eyepiece of the Tilting Level Telescope. It can be converted in the field as required to form a straight-through vision system or a right-angle vision system. The unit includes a variable output transformer for use with 110 volts AC, 50-60 Hz.

Installation and Adjustment

Unscrew the standard eyepiece and Erector mount from the Tilting Level telescope, and screw on the Combination Auto-Collimation, Projection, Right-Angle Eyepiece in its place. Observe the reticle through the eyepiece; if the reticle cannot be brought into sharp focus using the eyepiece focusing ring, adjust the Eyepiece as follows:

1. Set the Eyepiece at the approximate center of its movement. Then, unscrew the entire unit.

2. Loosen setscrew "A" (Figure A-8) with a 0.035 inch hexagon key.

3. Move the lens mount in or out in small increments. Check the reticle focusing after each incremental adjustment.

4. When the reticle can be focused sharply with the eyepiece focusing ring, tighten setscrew "A".

5. Focus the telescope at infinity.

6. Hold a piece of white paper approximately 2 feet from the end of the telescope.

7. Connect the projection unit to the transformer, switch on AC power, and observe the projected filament on the white paper. If the filament does not appear sharp, loosen the four projection unit adjusting screws and move the lamp forward or backward until the filament appears sharp.

8. Adjust the lamp with the four projection unit adjusting screws until the filament appears centered in the projected circle of the field.

9. Refocus the telescope until the reticle appears sharp on the white paper. The projected circle should be bright and evenly illuminated. If a shadow appears in the field, the lamp (filament) is not centered properly; repeat step 8.

Figure A-8. 71 1241 Combination Auto-Collimation, Projection, Right-Angle Eyepiece

Use

1. To use the Combination Auto-Collimation, Projection, Right-Angle Eyepiece for right-angle viewing, merely position the Eyepiece for most convenient viewing, and focus and use the Eyepiece in the same manner as the standard eyepiece.

2. To use the Combination Auto-Collimation, Projection, Right-Angle Eyepiece for straight-through viewing, interchange the projection unit and the eyepiece/eyepiece mount assembly. Then, focus and use the Eyepiece in the same manner as the standard eyepiece.

3. To use the Combination Auto-Collimation, Projection, Right-Angle Eyepiece, for auto-collimation, connect the projection unit to its transformer, switch on AC power, and push the prism slide assembly to the right. The auto-collimation process is the same as that described for the 71 1211 Auto-Collimation Conversion Unit.

4. To use the Combination Auto-Collimation, Projection, Right-Angle Eyepiece as a projection eyepiece, connect the projection unit to its transformer, switch on AC power and push the prism slide assembly to the left.

A-8. 71 3270 SCALE LEVEL

Description

The 71 3270 Scale Level can be used to set optical alignment scales such as WYTEFACE® Optical Alignment Scales, vertically or horizontally. It can be attached to any steel optical alignment scale up to 1/8 inch in thickness and between 1 and 1 1/2 inches in width. The horizontal and vertical vials each have a sensitivity of 15 minutes of arc per 2 mm movement.

Installation

To install the Scale Level, merely slide it onto the optical alignment scale.

Use

Adjust the position of the optical alignment scale until the bubble in the appropriate vial is centered.

A-9. 71 5511 REPLACEMENT AUTO-COLLIMATION ILLUMINATION UNIT

Description

The 71 5511 Auto-Collimation Illumination Unit is part of the 71 1211 Auto-Collimation Conversion Unit, although it may be ordered separately for replacement purposes. It consists of a 6-volt transformer, cord, switch, and light plug assembly. It is designed for operation from 110 volts AC, 50-60 Hz, and may be used with all auto-collimation illumination attachments. Installation and use are described in connection with the 71 1211 Auto-Collimation Conversion Unit.

A-10. 71 6065 SCALE HOLDING MAGNET

Description

The 71 6065 Scale Holding Magnet can be used to hold 3 inch, 10 inch, 20 inch, and 25 centimeter optical alignment scales such as WYTEFACE® Optical Alignment Scales, at right angles to the finished surface of any magnetic metal. Its overall size is 2 by 2 by 1 inch. In use, one side of the Scale Holding Magnet is attached to the finished surface of the metal, and the optical alignment scale is attached to the perpendicular side of the Scale Holding Magnet with the zero end of the optical alignment scale against the finished surface of the metal. Distances from the finished surface can then be read off the optical alignment scale.