Manual of Field Adjustments

BERGER

American Made — American Style

ENGINEERING AND SURVEYING INSTRUMENTS

berger instruments

DIVISION OF HIGH VOLTAGE ENGINEERING CORP.

4 RIVER STREET
BOSTON, MASSACHUSETTS 02126

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MADE IN USA

Price $2.95

WHEN YOU OWN A BERGER. . .
You Own A Great Instrument!

Favorites on surveying and construction sites for more than a century, Berger instruments are built better to last longer — to help you achieve lower costs and speedier completions.

Designed and fabricated to meet the job challenges of the future, **every Berger model offers maximum performance and value** for your instrument dollar. And, there's a full range of Berger models to choose from and a model that's precisely right for your needs and for your budget.

So whether you're grading, leveling, aligning, turning angles — building single-family units, apartments, or large commercial projects — there's a Berger available to help you to reduce costly measuring errors and expensive rework.

Berger instruments are better in many important ways. Get behind one. Take a look. You'll welcome the exceptionally clear optics — cross hairs that are sharp and distinct, smooth dependable controls and a host of other features that make Berger instruments the finest in their class.

For example, vernier and circle graduations are clear, permanent and accurately registered on metal so it takes just seconds to line up for precise readings.

Finishes are tough, hard-baked, extra durable for stronger impact abrasion resistance. Materials (only the best have been used); special aircraft aluminum alloys; brass, bronze and steel, sterling silver, to make sure that a Berger keeps working day in and day out.

Above all, **Berger instruments are engineered to be easy to use and simple to maintain.**

Leveling screws are large — so you can work even with gloves on, and circles and verniers are sized to speed readings and prevent errors.

But, **there's even more to a Berger**. . .

Level vial mountings are of the most up-to-date design to make sure that your instrument holds its adjustment in the field.

Tripods are of proven standard and wide frame designs for greatest stability and strength.

And, **to help you keep your Berger in good order and free from damage, every Berger instrument is packaged in a unique, specially designed and custom-tooled, highly protective, maximum visibility, yellow ABS case with full polyethylene foam insert or a custom crafted mahogany case with fitted retainers.**

Finally, **there's the company and the people behind the product** . . . experienced, caring craftsmen who constantly strive to produce the better instrument . . . the instrument that's made to last and to be the favorite on your job. **Try a Berger today!**

All instruments and accessories shown and/or described in this manual are designed and manufactured to exacting standards by American Craftsmen in Boston, MA, U.S.A.
The manufacturer reserves the right to change specifications and prices without notice.

Table of Contents

Berger Instruments

FOR ENGINEERS AND SURVEYORS

SPECIFICATIONS FOR BERGER ENGINEERS TRANSITS

Model	Bronze	Astron		Polara	Project
Horizontal Circle Diameter	6¼ inches	6¼ inches	6¼ inches	5½ inches	5½ inches
Horizontal Vernier Reading	See Next Page	See Next Page	See Next Page	See Next Page	See Next Page
Telescope Length	11½ inches	11½ inches	10½ inches	10½ inches	10½ inches
Telescope Power	26x	25x	22x	22x	22x
Effective Aperture	1.430" (36.3 mm)	1.4" (35.6 mm)	1.3" (33 mm)	1.3" (33 mm)	1.3" (33 mm)
Exit Pupil	.055" (1.4 mm)	.055" (1.44 mm)	.062" (1.5 mm)	.062" (1.5 mm)	.062" (1.5 mm)
Resolving Power	3½ seconds	4 seconds	4½ seconds	4½ seconds	4½ Seconds
Minimum Focus	4 ft.	4 ft.	3 ft.	3 ft.	3 ft.
Field of View	1° 6'	1° 6'	1° 24'	1° 24'	1° 24'
Vertical Circle Diameter	5 inches	5 inches	5 inches	5 inches	5 inches
Vertical Circle Graduations	30 minutes	30 minutes	30 minutes	30 minutes	30 minutes
Vertical Vernier Reading	1 minute	1 minute	1 minute	1 minute	1 minute
Telescope Level Vial -					
Sensitivity	25 secs./2 mm div.	40 secs./2 mm div.	40 secs./2 mm div.	40 secs./2 mm div.	60 secs./2 mm div.
Length	4-29/32"	4-29/32"	4-29/32"	4-1/16"	4-1/16"
Plate Vials (2) Sensitivity	65 secs./2 mm. div.	80 secs./2 mm div.	80 secs./2 mm div.	80 secs./2 mm div.	120 secs./2 mm div.
Length - Front	2-1/16"	2-1/32"	2-1/32"	2-1/32"	2-1/32"
Side	2-11/16"	2-11/16"	2-11/16"	2-1/32"	2-1/32"
Compass Needle Length	3½ inches	3½ inches	3½ inches	3-1/16 inches	3-1/16 inches
Compass Graduations	20 minutes	30 minutes	30 minutes	30 minutes	1 degree
Power Zoom Range*	20x to 36x	20x to 36x	20x to 36x	18x to 34x	18x to 34x
Approximate Shipping Weight	36 lbs.	42 lbs.	41 lbs.	33 lbs.	33 lbs.
*Power Zoom optional, extra.					

INSTRUMENT TYPES, GRADUATIONS AND MODEL NUMBERS

	Horizontal Circle Grad. To	Verniers Read To	With 11½" Telescope Model No.	With 10½" Telescope Model No.
Bronze Transit with Compass	30 minutes 20 minutes 15 minutes	1 minute 30 seconds 20 seconds	65-816 65-813 65-812	
Bronze Transit with Compass and Beaman Stadia Circle	30 minutes 20 minutes 15 minutes	1 minute 30 seconds 20 seconds	65-836 65-833 65-832	
Astron Transit with Compass	30 minutes 20 minutes 15 minutes	1 minute 30 seconds 20 seconds	67-816 67-813 67-812	62-816 62-813 62-812
Astron Transit with Compass and Beaman Stadia Circle	30 minutes 20 minutes 15 minutes	1 minute 30 seconds 20 seconds	67-836 67-833 67-832	62-836 62-833 62-832
Polara Transit with Compass	30 minutes	1 minute		57-216
Polara Transit without Compass	30 minutes	1 minute		57-916
Project Transit with Compass and 1 Double Vernier	30 minutes	1 minute		100
Project Transit with Compass and Double Opposite Verniers	30 minutes	1 minute		102

Other types of graduations to suit individual preference or requirements are available. Many of these can be furnished without extra cost. Specify type desired and request quotation.

SPECIFICATIONS FOR BERGER ENGINEERS DUMPY LEVELS

Model	05-700	05-700-10
Telescope Length	18 inches	18 inches
Objective Lens Diameter	2 inches (50.8 mm)	2 inches (50.8 mm)
Effective Objective Aperture	1.921 inches (48.8 mm)	1.921 inches (48.8 mm)
Exit Pupil Diameter	.055 inches (1.37 mm)	.055 inch (1.37 mm)
Telescope Magnifying Power	36X	36X
Field of View	1 degree, 4 minutes	1 degree, 4 minutes
Resolving Power	2.6 seconds	2.6 seconds
Eye Relief	.400 inch (10.2 mm)	.400 inch (10.2 mm)
Minimum Focus	9 feet	9 feet
Telescope Level Vial Length	7¾ inches	7¾ inches
Telescope Level Vial Sensitivity	20 seconds per 2 mm div.	10 seconds per 2 mm div.
Objective Lens	Achromat	Achromat
Eye Lens	Achromat	Achromat
Approximate Shipping Weight	25 lbs.	25 lbs.

Specifications subject to change without notice.

BERGER ENGINEERS' TRANSITS AND LEVELS

The engineers and constructors who are changing the face of America have one thing in common. They rely on Berger engineers' instruments to get the big job off to a fast accurate start.

Why a Berger? Get behind one and you'll see: the clear, sharp image, free of any chromatic or spherical aberration . . . the unvarying true line of collimation . . . the smooth-focusing action of the telescope with easy meshing rack and pinion — no binding or side-play . . . no backlash. And note how freely a Berger rotates on its centers without fretting or binding, whatever the variation in climatic conditions . . . and how perfectly positioned and positive are the controls.

These are features you'll find in all Berger engineers' instruments . . . features that make Berger such a favorite with the men and with the companies that have guided some of the major construction projects of the century.

When there's no margin for error . . . they rely on a Berger. After you've used one . . . you'll know why.

BERGER OPTICAL PLUMMET TRANSITS
65 and 67 Series

All the features of the standard models plus the advantages of optical centering.

Berger Optical Plummet Transits provide the ultimate in speed and accuracy when setting up over a specific point. The use of an optical line of sight through the instrument center and a tripod which enables a shifting of the instrument offers maximum efficiency in cases where multiple set ups must be made or when wind conditions are a factor.

Berger Optical Plummet Transits are especially designed for durability and ease of use. The plummet telescope is set at a 45° angle to the horizontal plate so that the user need only bend his head to view the cross hairs and point. Centering accuracy is readily determinable by rotating the upper portion of the transit about its axis. The Optical Plummet is approximately 4 power and focuses from 18″ to

infinity. The reticle supplied is of a cross lines and circle type. Individual focus for reticle and ground.

The Berger Lateral Adjuster Shifting Head Tripod (used in conjunction with OP transits) allows the user to shift his instrument approximately 2″ in any direction. The shifting head is meticulously manufactured to assure that there will be no significant change in the level condition of the instrument while centering over the point. Any sight through the plummet will therefore be perpendicular to the level of the instrument. The shifting head surfaces are coated with a special hard abrasion resistant Teflon* material providing a smooth sliding action during use.

* Reg. Trademark of DuPont

BERGER BRONZE TRANSIT
65 Series

As fine an engineering instrument as expert design, skilled craftsmanship and superb materials can achieve.

All of its features are skillfully combined to produce an instrument which is world-famous for its ability to provide a lifetime of accurate trouble-free service. Achromatic optical system; fully enclosed 3/8″ x 32 thread, nickel silver leveling screws, hand fitted into replaceable bronze bushings; reversion type telescope vial; sterling silver circles and verniers with hinged shade frames. Horizontal circles have two rows of figures in opposite directions 0°-360° and 360°-0°. Figures inclined in the direction they should be read; double opposite verniers. Vertical circle has one double vernier, protected with removable guard.

Bronze tapered repeating centers are hand lapped to precise fit. Hand fitted nickel silver tangent screws have 1/4″ x 40 thread. Forged brass foot plate with 3½″ x 8 thread. Choice of spiderweb or glass reticle with cross and stadia wires at 1:100.

Carrying case, sunshade, 12 oz. Berger Retracta-Bob™*, magnifier, adjusting wrenches, screwdriver and Field Adjustment Manual. Instrument finished in baked, non-reflecting, black wrinkle enamel. Use with tripod Models 841, 842, 843 or 844.

*™ — Patent Pending

BERGER ASTRON TRANSIT
67 Series

A mid-priced, top performing instrument of advanced design, high quality and rugged construction, Bronze ''U'' type yoke frame with wye bearings. Precision turned and hand lapped repeating centers of long wearing bronze alloy. Fully enclosed 3/8″ x 32 thread nickel silver leveling screws in hand fitted replaceable bronze bushings. Nickel silver ¼″ x 40 thread tangent screws with wear takeup adjustment. One piece erecting achromatic telescope with internal rack and pinion focusing. Spider web or glass reticle with stadia wires at ratio of 1:100. Horizontal circle has two rows of figures in opposite directions, 0°-360° and 360°-0°, inclined in direction they should be read; double opposite verniers with hinged shade frames. Vertical circle with one double vernier, protected with removable guard. Graduations on corrosion resistant aluminum alloy. Forged brass foot plate with U.S. Standard 3½″ x 8 thread.

Carrying case, sunshade, 12 oz. Berger Retracta-Bob™, magnifier, adjusting wrenches, screwdriver and Field Adjustment Manual. Instrument finished in baked black wrinkle enamel. Use with tripod Models 841, 842, 843 or 844.

BERGER POLARA TRANSIT
57 Series

An all-around utility transit at a budget price. Exceeds government specifications for a 5½″ transit reading to one minute. One piece erecting,

achromatic telescope with interior rack and pinion focusing. Spiral focusing eyepiece. Spider web reticle with stadia wires at ratio of 1:100 (glass reticle extra). Horizontal circle with two rows of figures in opposite directions, 0°-360° and 360°-0°. Double opposite verniers. Vertical circle with one double vernier, removable guard. Graduations on corrosion resistant aluminum alloy. Tapered, repeating centers of bronze alloy — hand lapped and precisely fitted. Nickel silver tangent screws with ¼" x 40 thread. Fully enclosed nickel silver leveling screws with ⅜'' x 32 thread, hand fitted into replaceable bronze bushings. Forged brass foot plate with U.S. Standard 3½" x 8 thread.

Carrying case, sunshade, 12 oz. Retracta-Bob™, magnifier, screwdriver, adjusting wrenches, and Field Adjustment Manual. Instrument finished in baked black wrinkle enamel. Use with tripod Models 841, 842, 843 and 844.

THE BERGER PROJECT TRANSIT
Series 100 and 102

A quality American Made 5½'' Transit for the cost conscious constructor. Accurate and versatile — rugged and dependable.

Will perform all the functions of horizontal angle setting and measuring as well as leveling operations ordinarily required of a one-minute transit. Model 100 with one double vernier reading to one minute; Model 102 with two double opposite verniers to 1 min. Vertical Circle is 5 inches in diameter with one double vernier reading to one minute.

Features reinforced bronze standards, special corrosion resistant aircraft aluminum alloy circles and verniers, Asarcon inner center, coated, color corrected lenses. Telescope is 22 power with stadia lines at 1:100 ratio. Power Zoom 18X-34X available at extra charge. Supplied with carrying case, sunshade, 12 oz. Berger Plumb Bob, magnifier, adjusting wrenches, screwdriver. Use with tripod Models 821, 822, 841, 842, 843 or 844.

BERGER MOUNTAIN/MINE TRANSIT
45 Series

Berger developed this instrument to overcome the many problems encountered in underground surveying. 8½" erecting, internal focusing, 18 power optical system with short focus of 2-1/3 feet. Stadia lines at ratio of 1:100.

One piece bronze "U" type yoke frame. 4½" diameter horizontal circle (sterling silver) with two rows of figures 0°-360° in opposite directions. Double opposite verniers read directly to one minute. Shade frames with reflectors.

4" diameter vertical circle with one double vernier (sterling silver) reads directly to one minute.

4-1/8" long reversion type level vial of 45 seconds sensitivity per 2 mm division.

2 plate levels of 75 seconds sensitivity per 2 mm div. Nickel silver leveling screws.

Nickel silver tangent screws. Bronze, tapered, repeating centers are hand lapped and fitted.

Finished in baked black wrinkle enamel.

Forged brass foot plate with 2¼" x 10 threads.

Compass reads directly to 30 minutes with 2-5/8" needle.

Furnished complete with carrying case, sunshade, 12 oz. brass plumb bob, magnifier, spanner wrench, screwdriver and Instruction Manual.

Choice of special full length tripods or 1/2 length versions.

BERGER ENGINEERS DUMPY LEVEL
Models 05-700 and 05-700-10

Outstanding accuracy and performance under all conditions of use including extremes of heat, cold and dusty locations.

Erecting, interior focusing optical system, two-inch achromat objective lens (one of the largest available) and achromat eye lens provide exceptional brilliance of image, wide field of view, large exit pupil diameter and unusually high resolution. Coated lenses for maximum light transmission and minimum reflectance.

Eye relief of almost one-half inch aids in comfortable viewing. Carefully fitted bronze focusing slide maintains true line of sight throughout entire focusing range. Spiral focusing eyepiece with reset scale, permits instant return to the proper setting for your eye.

36 power magnification. Plain cross wires in a choice of spider-web or glass reticle. Stadia wires available at slight extra cost.

The conical spindle is a special bronze alloy noted for its stability and long wearing qualities. It is machined to an accuracy of .000050" (fifty millionths of an inch), then carefully hand lapped and fitted to its bronze leveling head. Integral telescope and flexure-proof level bar of high strength, heat treated aircraft aluminum alloy.

Precision ground level vial (20 seconds per 2 mm div. on Model 05-700 and 10 seconds per 2 mm div. on Model 05-700-10) is nested inside the bar for protection. Assembly, spring loaded at one end is adjustable by a single capstan nut. Drain and ventilation ports in the level bar allow air circulation around the level vial and dissipation of rain water.

Nickel silver leveling screws with 3/8" x 32 threads hand lapped and fitted to replaceable bronze bushings. Precisely fitted nickel silver tangent screw with ¼" x 40 threads with take-up adjustment for wear, has bronze helical spring with counter-motion. Forged brass foot plate with U.S. Government standard 3½" x 8 threads. Finished in baked black wrinkle enamel.

Fitted carrying case with sunshade, screwdriver, adjusting wrenches and Field Adjustment Manual. Use with tripod Models 841, 842, 843 or 844.

II USE AND CARE OF INSTRUMENTS

To obtain the greatest possible service from your finely constructed engineering instrument, take good care of it, follow the instructions in this manual and should repairs be necessary, entrust it only to the factory or to a qualified service center. Your instrument has been precision built to provide good and lengthy service provided you follow these basic rules setting up and leveling.

A. Use Of The Tripod

Your Berger tripod is designed to provide a solid, steady support for your instrument. Extension leg models are adjustable for leg length and are recommended for convenient transport and for use on rough, highly irregular terrain.

When setting up the tripod, it is advisable to place the tripod legs about 30 inches apart and initially set the tripod so that the top of the tripod is nearly level. Be sure that the tripod leg clamps are firmly tightened and that provision is made to prevent slippage by pressing the tripod points firmly into the ground. On hard surfaces, such as concrete, small pockets should be chiseled into the concrete to secure the points. Another (and safer) method is to use the chain restraint assembly available as an option.

B. Fastening The Instrument To The Tripod

The instruments in this manual are fastened to the tripod by threading the leveling screw foot plate on to the top of the tripod head. The mounting should be done carefully to avoid crossing threads and the footplate must be firmly screwed onto the flange of the tripod head. Be sure that the plumb bob chain and hook hang freely through the tripod head. (Fig. 1).

Fig. 1

C. Leveling The Instrument

1. **Transits.** To level a transit with a four screw leveling head follow this procedure: Set the tripod in such a position that the tripod head is about level. This will make leveling the instrument easier.

Leveling The Instrument Using The Plate Vial

Loosen any two **adjacent** leveling screws until they are free but without play. Rough level with the instrument in line with one pair of opposing leveling screws. Learn and remember the rule: "Thumbs in, thumbs out, the bubble always follows the left thumb." And always turn the screws in opposite directions remembering that, the direction of movement of the bubble is the same as the direction of movement of the left thumb. Maintain a slight friction between the screws as they are turned. Repeat with the second pair and then continue by alternating the adjustment with each pair of screws until the bubble is centered in line with both. Make the final setting by tightening just one screw of each pair so that the screws bear firmly (but not tightly) on the footplate.

Leveling The Instrument Using The Telescope Vial

Once the transit has been leveled using the plate vials, turn the instrument to position the telescope level vial in line with two opposite leveling screws, and center the bubble using the vertical clamp and tangent screws. Then, turn the instrument (telescope) 180° and if the bubble does not center.

eliminate half the error with the vertical motion and the other half with the leveling screws. Next, turn the instrument 90°, and center the bubble using the leveling screws. The instrument should now be level.

Continue the procedure, alternating over each pair of opposite leveling screws until the bubble stays centered in whatever direction the telescope (and upper portion of instrument) are turned.

2. **Dumpy Levels.**

NOTE: In bright sun or on a hot day, allow the instrument to come to temperature before attempting to "level up."

Level up by first releasing the tangent clamp and placing the telescope in line with a pair of opposite leveling screws (as A-B) and rotating them while keeping them firm against the foot plate. (Fig. 2)

Only two motions can be used. Either both thumbs go toward each other or both thumbs go away from each other. The bubble will move in the same direction as the left thumb. When the bubble is brought to the center, check that screws A and B are still firm against the foot plate.

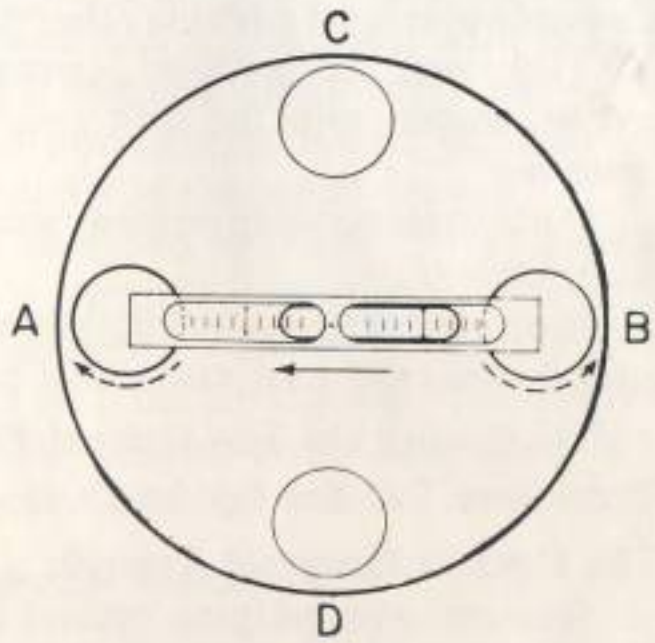


Fig. 2

Watch that the level vial is on line over the screws being used. The bubble will always move in the direction that the left thumb is moved. Keep turning the pair of leveling screws until the bubble is approximately centered in the level vial. Judge the position by noting the ends of the bubble. A centered bubble will be between the two main graduations (longest lines) of the level and will have each end equidistant from the main graduations. Note, a bubble will change its length with changes in temperature, getting longer when cold and shorter when warm. Consequently the reading of one end against its adjacent graduations is not a satisfactory indication of center. Get both ends of the bubble equidistant from the main graduations. And, it is **improper procedure** to center the bubble exactly over one pair of leveling screws without first bringing it nearly to center over the other pair of leveling screws.

Now, rotate the telescope clockwise 90° so it is over screws C—D and following the same procedure as for screws A—B, bring bubble to the center making sure that the screws are still firm against the foot plate. Now turn the telescope counterclockwise 90° back to the first position, check the bubble and recenter it if necessary. Finally, turn 90° clockwise to the second position again and check the bubble, centering it again if necessary.

Your instrument is now leveled up, but one more check is necessary and that is the adjustment of the bubble itself. Rotate the telescope end for end

(180°). The bubble should remain centered. If it doesn't, recheck the leveling procedure. Then, if the problem persists, follow this adjustment procedure:

Note the amount of error in the bubble centering. With the pin wrench supplied, turn the capstan screw at the right hand end of the bubble counterclockwise if bubble is off-center to the left or clockwise if off-center to the right. Turn this screw only enough to remove one-half of the error. Remove the other half of the error with the leveling screws. Turn the unit end for end (180°) and check whether the bubble remains centered. If there is still some error remaining, again remove one-half of remaining error with the adjusting screw and the remaining error with the leveling screws. At this point, it is advisable to relevel with the other two leveling screws, so turn the unit only 90° (1/4 turn) and level up, centering the bubble only with the leveling screws. Again turn the unit end for end (180°) and check for bubble centering.

If adjustments were properly made, the bubble should remain centered in all positions.

In any event, the adjusting procedure described above must be repeated until the reversal test proves that the bubble will remain centered.

D. **Setting Up The Optical Plummet Transit**

Procedure For Set Up And Use

The Optical Plummet Transit:

a. features a magnifying optical system which can be focused from 18 inches to infinity;
b. employs an easy-to-view reticle with cross lines and target circle (bull's eye) and
c. allows focusing on the ground point quickly by a simple motion of the plummet eyepiece.

The Lateral Adjuster:

a. is affixed to the Shifting-Head tripod, is recommended for effective use of the Optical Plummet;
b. allows almost 2 inches of travel in any direction and
c. affords the easiest and most accurate method of setting up over a point regardless of wind conditions or type of terrain.

To Center Instrument Over A Point:

a. Set the instrument on the tripod and position it by eye as nearly as possible over the ground point.
b. Level the instrument using the plate level vials.
c. If greater centering accuracy is desired, or if the instrument is more than 5 ft. (tripod height) from the ground point, also level the instrument with the telescope level vial.
d. Focus the optical plummet reticle by grasping the smaller (uppermost) knurled tube and slide in or out until bull's eye is in sharp focus.

To focus on ground point, grasp lower knurled tube and slide in or out until ground point is in sharp focus.

Additional Suggestions:

If the ground point cannot be seen in the plummet field of view, loosen lateral adjuster knob (located underneath the tripod head) one-half turn and shift the instrument in the necessary direction.

If the tripod is offset to such a degree that the ground point cannot be seen in the Optical Plummet, (1) reset the tripod as required, (2) relevel the instrument, (3) shift the instrument while looking through the Optical Plummet until centered over the point.

Until you get the feel of the Optical Plummet, or in case of peculiarities of terrain, (1) attach plumb bob to hanger located under the lateral adjuster clamping knob. (2) Adjust the instrument and tripod setup with the bob suspended near the point until the bob is within approximately 3/4" of the point. (3) Remove the plumb bob and push hanger out of the way. (4) Proceed to center with the Optical Plummet as described above.

Although the Optical Plummet is designed to remain in adjustment indefinitely under normal conditions, it should be checked occasionally. Simply rotate the instrument (after leveling-up) while observing the point through the Optical Plummet. If it stays on point the Optical Plummet is in adjustment. If not, it should be adjusted by an instrument repair shop or by the factory. Do not attempt to adjust it in the field.

E. Use Of The Transit With Beaman Stadia Arc

Berger Beaman Stadia Arc

When the stadia method of measuring distances is to be used to any considerable extent, we recommend that Transits be equipped with the special Berger type of Beaman Stadia Arc (See Fig. 3) This special auxiliary graduation mounted on the Vertical Circle will be found to be a great convenience in determining the vertical and horizontal components of inclined stadia readings. Instead of measuring the vertical angle in degrees and referring to and converting the reading by means of the stadia tables, the Beaman Stadia Arc makes it possible to dispense with these tables and to obtain a similar result by a very simple calculation.

Assume an up-hill sight being taken at an angle of approximately 10½ degrees. By looking at the index "V" on the right side of the Vertical Circle, it is noted that the corresponding graduation on the circle is close to 18. With the Telescope Tangent Screw the inclination is changed until the Index is exactly opposite the mark 18. It is noted that in this position the central cross wire intersects the rod at, say 7.8 feet and that the stadia interval on the rod is 6.4 feet. To obtain the

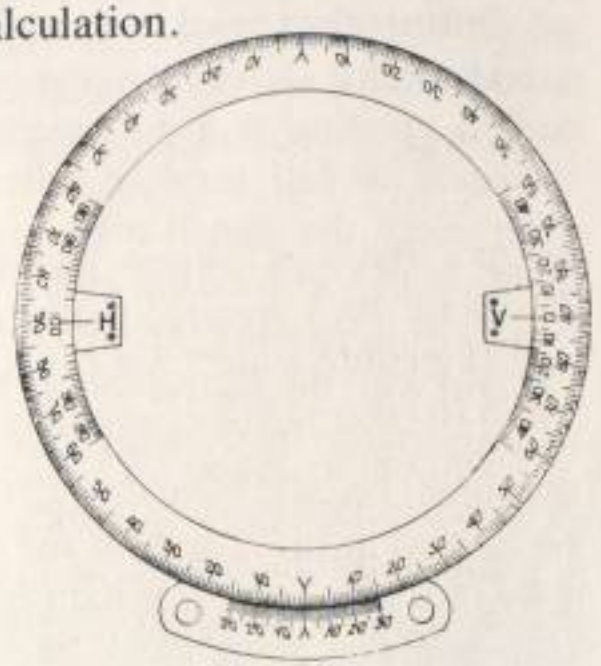


Fig. 3

difference of elevation between the center of the instrument and the point on the rod which is intersected by the central cross wire it is only necessary to multiply the number opposite the Index "V" (18) by the stadia interval (6.4 feet) which in this case equals 115.2 feet. To obtain the elevation of the base of the rod above the base of the instrument we need only add the height of the instrument (say 4.2 feet) and subtract the reading of the central cross wire on the rod (7.8 feet); thus: — 115.2 plus 4.2 minus 7.8 equals 111.6 feet for base to base elevation.

To obtain the horizontal component, the reading on the graduation opposite "H" is taken and used as a number by which the stadia interval is to be multiplied. In the case above the reading would be 96.9, which, when multiplied by the stadia interval 6.4, indicates a horizontal distance of 96.9 times 6.4 or 620.2 feet. If the conditions are such that only one of the stadia wires in addition to the center cross wire can be read on the rod at one time, the method can still be used by measuring the half interval and multiplying the results by two.

F. **Use Of The Stadia Reticle**

In our transit telescopes the instrument constant need not ordinarily be considered, since all stadia measurements give directly the distance from the center of the instrument without having to apply the instrument constant (**f** + **c**), in other words, the stadia wire interval on the rod when multiplied by 100 will give the distance from the center of the instrument to the rod. Strictly speaking, the constant multiplier (100) varies according to the distance. But the error involved in neglecting this small variation is much less than the error of reading the stadia rod interval. Hence we are justified in using the formula.

$$\textbf{Distance} = 100\ \mathbf{s}$$

s being the intercepted space on the rod between the stadia hairs.

G. **Carrying Instruments**

During field work ordinary transits and levels may be carried on their tripods on the shoulder of the instrument-man. The tripod should be held in such a position that the instrument is nearly balanced, but with a slight tendency to fall forward when the tripod is held with one hand. In an emergency the transit-man can bring his instrument quickly to a vertical position and set it on the ground. When carrying an instrument through thick woods or in passing through doorways it is advisable to put the tripod under the arm with the instrument in front, so that the one carrying it is better able to protect the instrument. For transportation in vehicles or whenever the instrument would be in danger of injury if carried on its tripod it should either be carried in its case or in the arms with one hand under the leveling base. Obviously, there is less danger of damage and change to adjustments if the instrument is in its case, because of its erect position and the protective construction of the container.

When carrying the instrument on the shoulder it is best to clamp the principal motions slightly to prevent wear on the centers. Clamp the transit when the telescope is in line with the centers; the level when hanging down. If this is not done and the instrument is allowed to swing, the centers will gradually be worn oval and the instrument rendered unfit for good work. Do not, however, clamp them so tightly that if the instrument receives an accidental blow the clamps will not give, for this might result in a serious injury which could be avoided by setting the clamps lightly. The leveling screws should be brought to bear firmly on the footplate before the instrument is lifted onto the shoulder.

H. **Specific Parts of Transits And Levels, Use And Care**

1. **Telescope** — Every surface of the lenses comprising the eyepiece and the object glass should be free from grit and film to insure a clear image in a telescope of high power. If the image appears to be foggy the lenses need cleaning.

Dust may be removed with a fine camel's-hair brush. To remove dirt film from a lens, rinse it off in clean water and wash it with a liquid detergent. Rinse the lens off and dry it as soon as possible. Do not allow the glass to air dry. An old lint-free linen cloth should be used so that the lens will not be scratched.

When the telescope is being used the sunshade should be in place, to prevent reflections. Furthermore the instrument is not perfectly balanced without the sunshade. When the telescope is not in use the sunshade should be replaced by the objective cap. In rain, place telescope vertical, object end up, and no water can enter.

2. **Cross-Hairs** — If dust is allowed to settle on the cross-hairs they will present a rough, irregular appearance.

To remove dust, unscrew both the objective lens and the eyepiece and gently blow through the telescope tube. Before putting the lenses back into place cover both ends of the tube with a cloth and wait a few minutes for the moisture to evaporate. The objective lens should be screwed well against its shoulder. Since the cross-hair adjustment may have been disturbed by the removal of the objective lens this should be tested after the lenses are put back into place. Do not unscrew the object glass unnecessarily for this is likely to alter the collimation adjustment.

3. **Transit Compass** — The compass needle rests on a finely sharpened pivot and the accuracy of the results obtained with the needle depends more upon keeping the pivot point sharp than upon any other condition. The needle should be let down as gently as possible onto its pivot. When not in actual use it should always be raised by means of the lifter. If, when lowering the needle, it is found that it swings violently to reach its North-and-South direction, check the movement with the lifter to prevent undue wear on the pivot. When the instrument is being carried the needle should, of course, be lifted against the glass cover.

The preservation of the magnetism is also an important factor in the proper action of the needle. Magnets or iron or steel objects should not be brought close to the needle on account of possible permanent injury. When taking readings of the needle care should be taken that no ferrous substances carried on the person are brought near enough to affect the direction of the needle.

A silk, rayon, nylon or other synthetic cloth should not be used to clean the glass cover of the compass box because of the likelihood of electrifying the glass. After cleaning the glass breathing upon it tends to draw off the electric charge. If the needle is attracted to the glass when a reading is being taken, the cover may be touched with a moistened finger to draw off the charge.

When storing the instrument lower the needle and allow it to assume the direction of the magnetic meridian; then raise the needle against the glass cover by means of its lifter. When the instrument is sent from the factory the needle is balanced for our latitude by means of a fine wire. When used in a different latitude the position of the wire may have to be changed. If the needle is only a little out of balance it is better not to disturb it. However, if adjustment is necessary, raise the cover glass by first prying up (with a knife blade) the circular split ring which holds it (applying the blade where the ends of the ring meet), then lifting the glass by means of a piece of softened beeswax. When the construction of the compass box is different from the one just outlined, unscrew the knurled threaded bezel ring which holds the cover glass of the compass. The needle should then be raised by means of the lifter and removed with a pair of tweezers. Move the wire counterpoise in the direction required to balance it, replace it on the lifter, lower the glass and then test the balance by letting the needle down gently onto the pivot.

Polara Transit Compass — The precautions noted previously apply also to the Polara Transit Compass. However, to operate the compass on the Polara Transit, the operating instructions enumerated below should be followed carefully:

1) To Release Compass Needle: Turn knurled pinion knob counterclockwise (this releases locking thread). If needle should not fully release after the knob snaps up, then again turn the knob slightly until the pinion can be felt to engage the teeth in the variation ring.

2) To Dampen Free Swinging Needle: Push lightly downward on knurled pinion knob.

3) To Lock Compass Needle: Push knurled pinion knob firmly downward until it stops, then turn knob clockwise to engage locking thread.

4) To Set Declination: With needle in the released position — insert adjusting pin in hole in knurled pinion knob and turn required number of degrees from north index.

5) To Adjust Needle for Dip: Remove snap ring which holds cover glass. Lift cover. (To do this easily, stick piece of cellophane tape on to glass and

pull up.) With housing in level position, rest needle on pivot. Both tips of needle should stand at same height. If needle is dipped, slide coiled wire counter-balance on needle toward high end. To re-assemble, lower cover carefully into housing. Replace snap ring.

ALWAYS TRANSPORT COMPASS IN LOCKED POSITION

4. **Graduations** — Cleaning of the circles and verniers should be kept to a minimum. When cleaning becomes absolutely necessary, extreme care should be exercised to prevent damage to the edges and graduations. Dust should be removed with a fine camel's hair brush. Rub the faces cautiously as wear on the edges will make it difficult to obtain accurate readings.

To clean the graduations apply some fine watch oil and let it remain for some time. Wrap a piece of old linen around a small, flat block of wood; hold the block flat against the face and wipe gently. If this precaution is followed the danger of breaking down the edge will be minimized.

The inner edges of the circles and verniers should be free from dirt and grease before replacing the inner center. The verniers must not be removed from the upper plate nor the centering of the circle altered, as their adjustment is too delicate for anyone but a qualified instrument repair man.

Both the glass vernier covers and the compass cover should be carefully brushed and cleaned. If the shades become dirty they should be taken from their frames and washed in soap and water.

5. **Centers** — The centers should revolve freely but without the slightest looseness. If they do not turn easily they should be cleaned as soon as possible. To do this unscrew the knurled nuts on both the plate and lower clamp tangent housings. This will release the spring pressure on the pistons and will facilitate the disassembly and reassembly of the instrument. Then remove the cylindrical cup which carries the plumb line chain and hook. Now unscrew the retainer nut attached to the inner center using wrench supplied with the instrument, and gently raise the vernier plate from the lower part of the instrument. Then remove the horizontal circle and the outer center assembly.

To clean the centers, use a turned stick which has approximately the same taper as the centers. Cover the stick with a lint free cloth or a piece of chamois on which a small amount of watch oil has been applied and clean the sockets carefully. Replace the cloth or chamois with a fresh piece without oil and repeat this procedure. Apply a small amount of watch oil to the surfaces and reassemble the instrument.

After the cleaning has been completed it is advisable to check the performance of the centers. Level the instrument. While holding the vernier plate stationary slowly revolve the horizontal circle about 30° at each turn until approximately six positions have been checked. Be sure to examine the telescope bubble after each turn to see if it has maintained its level position.

If it does not, the condition of the centers must be checked as they may require refitting.

6. **Level Vials** — The level vials used on Berger Engineering instruments are carefully ground on the inner surface to a curvature suitable for the particular purpose for which the level is intended. The glass tube is filled with a fluid which responds quickly to any change in inclination.

Level vials are very susceptible to the least change in temperature, as will be noticed by the changes in length in varying termperatures during field work. One of the greatest sources of error in the use of level vials is that due to unequal heating of the level tube. This is particularly noticeable with higher precision/lower sensitivity vials. Whenever there is unequal heating, the bubble tends to move toward the warmer end. This is due more to a change in the condition of the liquid itself than to any change in the form of the glass tube. Therefore it is very important to protect the level as well as possible from all sources of heat, not only from the direct heat of the sun but from the heat from the hands or the breath. In using very sensitive levels it is important that no part of the body should remain near the level long enough to affect it. If a level has been improperly exposed and is therefore liable to error it should be covered with a cloth for a few minutes until the termperature has become uniform.

7. **Leveling Screws** — The screw threads of leveling or tangent screws should be kept clean to avoid sticking. For this purpose use a stiff tooth brush dipped in a solvent such as gasoline. Then apply a thin film of lubricant.

8. **Tripod** — The tripod legs should not be allowed to become loose. The wing nuts and bolts at the head of the tripod should be well tightened up. If one of the tripod legs is raised and allowed to fall of its own weight it should sink slowly to the ground. If it drops quickly it is too loose; if it does not fall it is too tight. The shoes should be examined to see if they are loose. The screws should be set up tightly. The points of the shoes should be sharpened whenever necessary. Wooden tripods should be kept well varnished to preserve the wood from the effect of moisture, and should be wiped off, if wet. Metal tripods should be wiped with a cloth to prevent damage from moisture and sprayed with a rust corrosion preventative.

9. **Carrying Case** — The safety of the instrument often depends upon the way it is packed in its case. With a wooden carrying case, if any of the wooden blocks should become loose they should be repaired at once; the rubber cushions underneath the box, the leather straps, buckles, hinges and locks should be examined frequently and kept in good condition. The case should be varnished whenever necessary. If it becomes wet, it should be wiped dry. If a plastic case is provided, wipe dry and keep clean.

III ADJUSTMENTS OF INSTRUMENTS

A. Repair Shop Adjustments

The following adjustments **should not be attempted in the field** and must be made only by a qualified repair service center or by the factory:

1. The fitting of centers.
2. The centering of the graduated circles and the verniers.
3. The fitting of focusing slides.
4. Straightening and re-magnetizing needle, and straightening and sharpening pivot.

B. Adjustments Of The Transit Which Can Be Made In The Field And With Which The User Of The Instrument Should Be Familiar

1. Adjustment of the two plate levels.
2. Adjustment of the cross-hairs:
   (a) Adjusting the vertical cross-hair.
   (b) Adjusting the cross-hairs into the line of collimation.
3. Adjusting the horizontal axis.
4. Adjusting the telescope level.
5. Adjusting the vernier of the vertical arc.

1. **Plate Levels** — To adjust the two small plate levels so that their axes are in planes at right angles to the vertical axis of the transit, turn the plate until each level is parallel to the line through a pair of opposite leveling screws, center each bubble carefully with the leveling screws and then turn the upper plate 180° in azimuth, that is, until each bubble has been turned end for end. Any displacement of the bubble represents twice the actual error of adjustment. To correct this error move the capstan-head screws on the level cases so as to bring each bubble **halfway** back to the center. Then re-level by means of the leveling screws and test the adjustment again. Several repetitions of the adjustment may be required. When the levels are in perfect adjustment they should remain in the center in all azimuths. (See Fig. 4 — Fig. 7).

The function of these levels is to place the vertical axis in a true vertical line. Whenever this must be done with great accuracy it is always possible to use, for this purpose, the long level attached to the telescope. This level is more sensitive than the plate levels and gives a better control over the vertical axis. By centering the bubble over one pair of leveling screws, turning 180° in azimuth, and correcting half the displacement with the tangent screw on the standard, and the other half with the leveling screws, the level axis and the vertical axis are placed at right angles to each other. This test should be repeated several times over each pair of leveling screws. When the bubble will remain central in all azimuths the axis is vertical.

Plate Bubbles on some Astron and Polara transits employ the same principle of adjustment as described in the preceding under "Plate Bubbles." However, these transits have plate bubble mountings, spring loaded on one end.

To adjust bubble, insert adjusting pin in capstan screw located under bubble housing and rotate in direction required to bring bubble toward center. A clockwise rotation lowers this end of the bubble — counterclockwise rotation raises it.

Caution — Do not rotate this screw in counterclockwise direction beyond that necessary to center bubble. If it is forced too far the spring loaded mounting will be distorted and the spring action will cease to be effective. This will result in unstable bubble action.

2. **Cross-Hairs** — In a perfectly adjusted instrument the intersection of the cross-hairs should lie in the optical axis of the telescope, the vertical hair should lie in a plane perpendicular to the horizontal axis of the transit, and the line of sight as defined by the vertical hair should be perpendicular to the horizontal axis. (See Fig. 8).

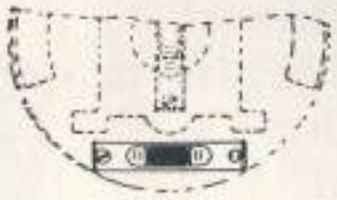
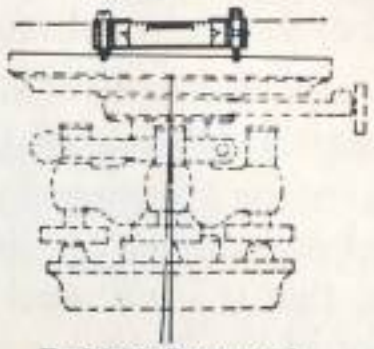


Fig. 4

Fig. 5



Bubble Centered

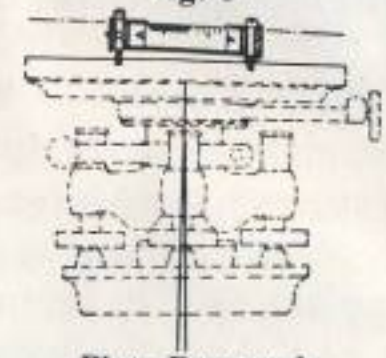


Plate Reversed

Fig. 6

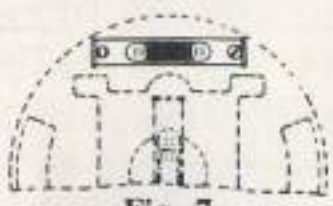
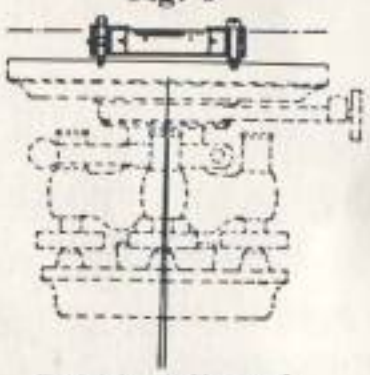
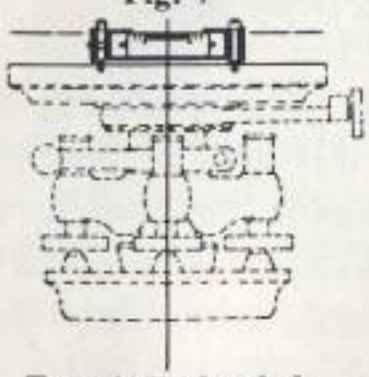


Fig. 7



Bubble Adjusted



Transit Re-leveled

To test the vertical hair sight on some distinct point, with the plates clamped but the vertical motion free. Be sure that the eyepiece is adjusted so that there is no parallax. Now slowly raise and then lower the telescope. The vertical hair should remain exactly on the point as it moves across the field of view. If the cross-hair does not remain on the point, loosen the capstan-head screws holding the diaphragm and, by tapping lightly, rotate the ring until the cross-hair is in such a position that it will stand this test. Tighten the screws sufficiently to prevent the diaphragm from moving out of place.

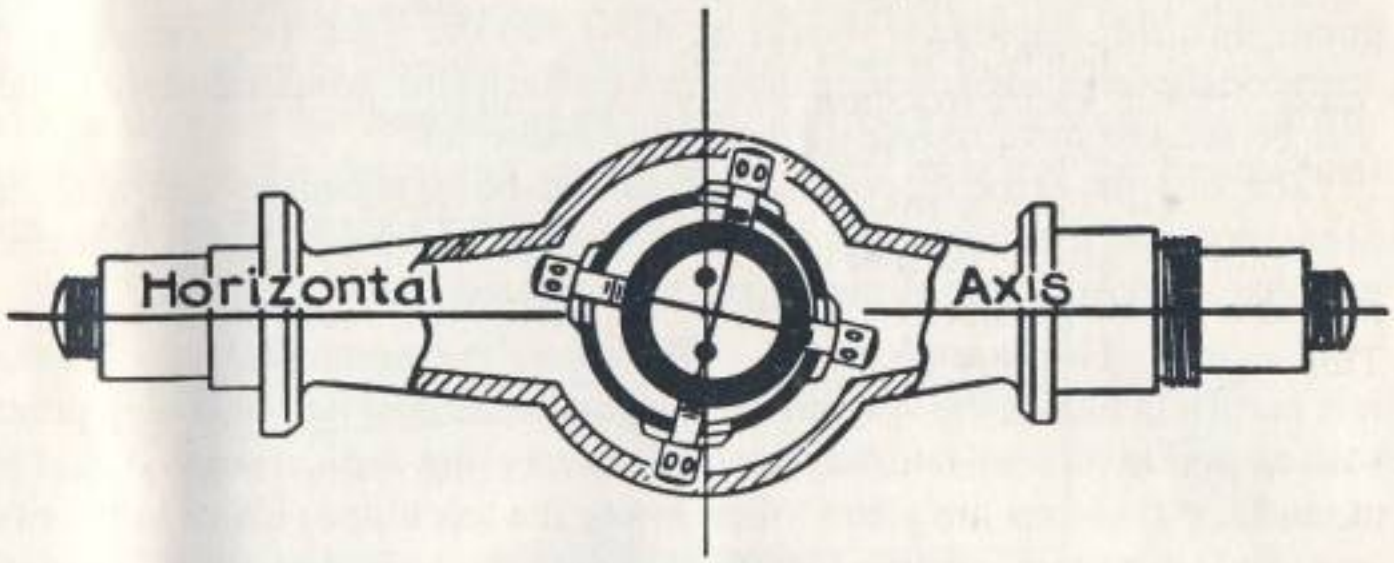


Fig. 8. Test for Verticality of Cross-Hair

To place the cross-hairs in the optical axis proceed as follows: — Move the cross-hairs so that they appear to be centered in the field of view. This assumes that the eyepiece tube was properly centered when it left the shop and that it has not been disturbed since.

3. **Collimation** — To adjust the vertical hair so that the line of sight is perpendicular to the horizontal axis try prolonging a straight line, first with the telescope normal then with the telescope inverted.

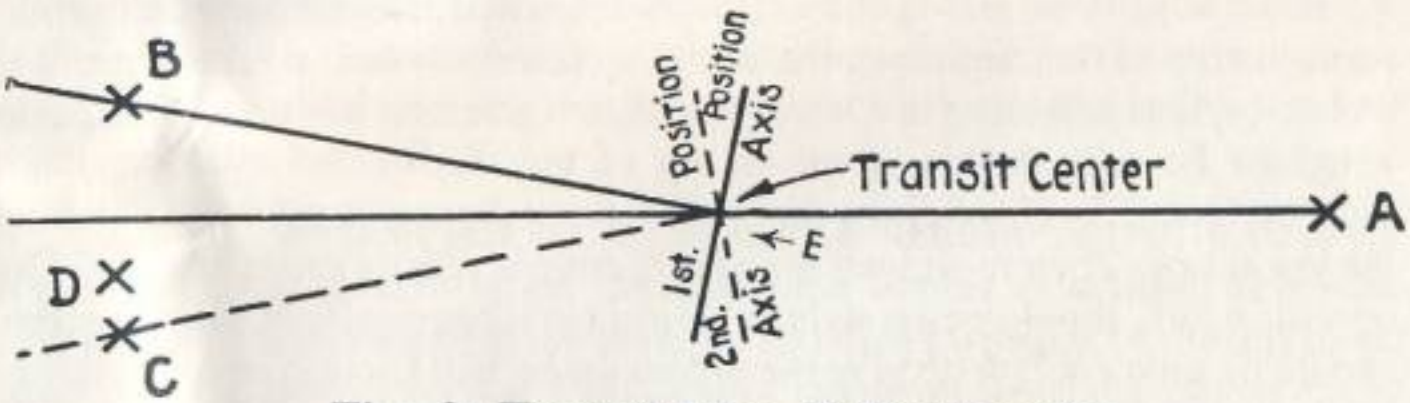


Fig. 9. Test of Line of Collimation

If the results agree, the adjustment is correct. Set up the transit (Fig. 9) at **E** and sight on point **A** with the vertical hair and clamp the plates. Reverse (plunge) the telescope and set point **B** in line with the vertical hair, and presumably in line with **AE** prolonged. Turn the telescope about the vertical axis until the vertical hair again sights **A** and clamp the plates. Invert (plunge) the telescope and see if **B** is again sighted. If not, then set point **C** in line with the vertical hair, alongside of **B.** The position of the vertical hair is in error by one-fourth the distance from **C** to **B.** To adjust, loosen the capstan-head screw at one side of the diaphragm and tighten the opposite screw until the vertical hair has apparently moved one quarter away from **C** toward **B,** that is, to point **D.**

4. **Erecting Telescope** — NOTE — Since the telescope shows objects right-side-up the image of the cross-hairs is really inverted; so we must move the cross-hair in the opposite direction from that in which it

appears that it should be moved. If the cross-hair is to the right of the true point, then the diaphragm should be moved to the right (by loosening the screw on the left and tightening the screw on the right), when the vertical hair will be seen to have moved (apparently) to the left.

The test for error of collimation should be repeated several times if necessary, and the diaphragm adjusted, in order to be sure that it is correct and that no movement of the tripod has affected the result.

5. **Horizontal Axis** — To adjust the horizontal axis so that it is perpendicular to the vertical axis, sight the vertical hair on a high point, such as a point on a tall building not too far away (the vertical angle should be at least 30°), clamp the plates, then lower the telescope (about horizontal axis) and set a point, or note the position of some point directly in line with the vertical hair and apparently vertically beneath the high point. Next reverse the telescope on its horizontal axis, turn it about its vertical axis, and sight the high point again, and clamp the plates. Lower the telescope and see if the vertical hair is again on the point previously set. If not, set a point in line with the vertical hair. Now mark a point midway between these two. The adjustment is made by raising or lowering the adjustable end of the standard until the vertical hair will travel from the high point to the midway (low) point in either position of the telescope. It is important that the instrument should not be disturbed between the two tests, and of course the leveling screws should not be touched.

If the adjustable end of the axis must be raised, loosen the axis friction screw on top of the cap, move the adjusting screw controlling the adjustable block, by first releasing the lower nut then tightening the upper one, then re-tighten the axis friction screw on top of the cap. If the adjustable block must be lowered, adjust the block by loosening the upper nut and tightening the lower one. Then re-tighten the axis friction screw on top of the cap. The opposing nuts should be brought to a firm even bearing, and the cap screw should be tight enough to give the proper amount of friction on the horizontal axis. When this adjustment is once properly made it rarely has to be re-adjusted.

6. **Telescope Level** — The long level vial attached to the telescope should be adjusted so that the bubble is central when the line of sight is horizontal. This may be done by setting up the transit **midway** (by measurement) between two stakes or other points which may be used as bench marks. If it is possible to drive the two stakes so that their tops are at exactly the same elevation, as shown by readings of a rod held on top of the stake, this will make the calculation simpler; but if you cannot, any two points may be used. The difference of elevation of the two points is given correctly even if the adjustment is in error, because the instrument is equally distant from the two points. (See Fig. 10).

Next move the transit to a point (outside) in line with the two stakes, but much nearer to one than to the other. Take rod readings on both stakes. If the two readings agree the adjustment is correct; if they do not agree elevate or depress the telescope until the reading on the distant stake is the same as the

reading just found on the nearer stake. Test again on the near stake; if a different reading is obtained re-set on the distant rod, and continue this process until the two readings agree. Then, keeping the horizontal hair on this last reading on the distant rod, move the level, by means of the capstan-head nuts, until the bubble is central.

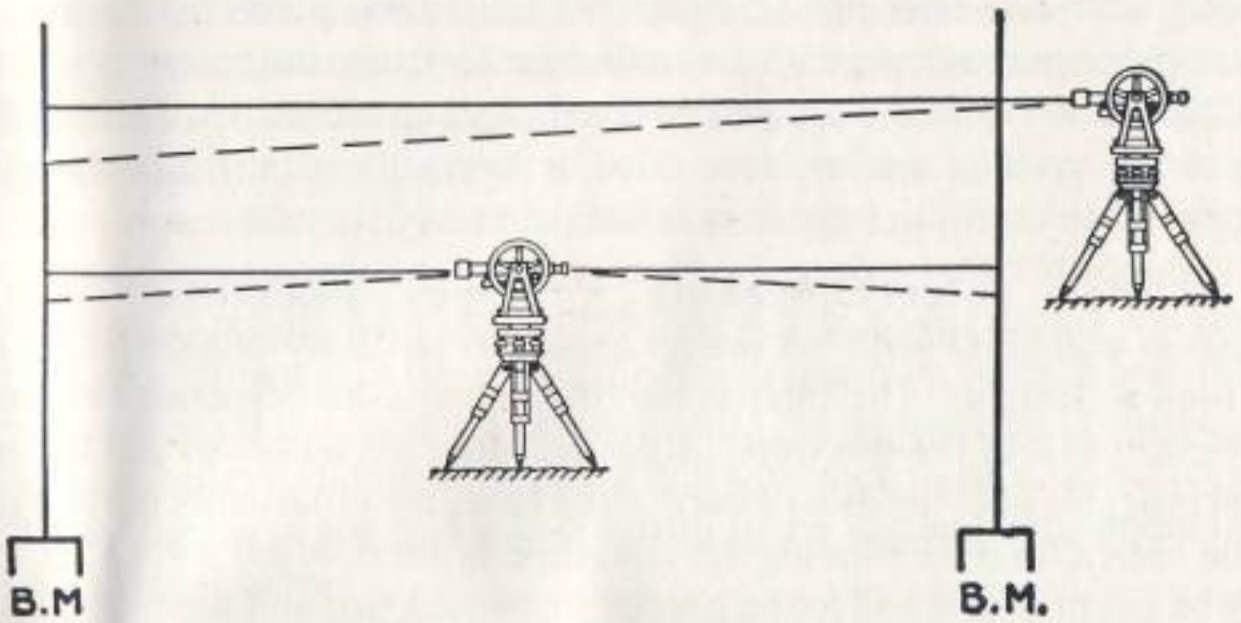


Fig. 10. Testing the Telescope Level

If, instead of using two stakes set at the same elevation, the test is made on two bench marks whose elevations differ, say 1.030 ft., it is necessary to allow for this difference when comparing the near and distant rod readings. If this is done the final result is the same as when sighting at points which are at equal elevations; that is, the line of sight is horizontal when the two readings differ by 1.030 ft.

7. **Vertical Arc** — To adjust the verniers of the vertical arc (or circle) to read zero when the telescope bubble is central, level the instrument first by means of the plate levels, then by means of the telescope level. Set the vernier so that it reads very nearly zero, which can be easily done within ½′ or ¼′. Next adjust the distance between the vernier and arc so that when the zeros coincide the 30′ lines, right and left, also coincide. To do this, set the zeros exactly together by means of the vertical tangent screw; then by moving the vernier inward a little, if the 30′ lines fall short, or outward if the vernier space is too long, this adjustment is perfected. To make the final adjustment loosen slightly the screws holding the vertical arc to the horizontal axis, center the bubble carefully, and then tap one of the spokes **very lightly** until the zeros coincide exactly. Set up the screws on the vertical arc, and repeat the test to see if the vernier reads zero when the bubble is central.

8. **Vertical Circle** — If the transit has a vertical circle with vernier at eye end, or with opposite verniers, the adjustment is to be made with the milled capstan-head screw attached to the vernier frame at the side of the standard. First level the instrument so that the telescope bubble and the plate bubbles will remain central when the telescope is turned in azimuth. The zero of the vernier is then adjusted to read zero on the circle by

turning the milled-head adjusting screw (using an adjusting pin) until the zeros coincide. The adjusting screw is then held in position by tightening the small binding screw.

9. **Vernier Level** — If the vernier of the vertical circle has a control level attached to its frame the adjustment of this bubble is made as follows: — place the line of sight in a horizontal plane by means of the telescope tangent screw, then move the vernier frame tangent screw until the zero line of the double verniers, marked **A,** is in coincidence with the zero line of the vertical circle. Now raise or lower the adjusting screw of the vernier level until the bubble is in the center of its tube.

10. **Interchangeable Auxiliary Telescope** — If the transit is equipped with an interchangeable auxiliary telescope it can be adjusted as follows: The intersection of the cross-hairs should be placed in the optical axis of the telescope. Since we place the lenses so that the optical axis coincides with the axis of bore of the tube, the cross-hairs may be placed in the optical axis by rotating the telescope in improvised wyes. Such wyes may be cut of thin wood to the proper shape and size and securely fastened. The distance between them should be such that the telescope may rest upon the collar outside the object glass and upon the tube near the cross-hairs. The adjustment is then made by first noting where the cross-hairs are pointing, then rotating the telescope 180° about its own axis in the wyes, then moving each hair halfway back to the point it first sighted, using the capstan-head screws of the diaphragm for this purpose.

To adjust the auxiliary as a top telescope, sight the vertical hair of the main telescope at some distant object and clamp the horizontal motion. Release the small nickel-silver capstan-head screw at the opposite side of the clamp having the two tangent screws. Twist the auxiliary telescope around so that it is nearly parallel with the main telescope. Then tighten up the nickel capstan-head screw again. Sight the vertical hair of the top telescope on the same distant object, using the opposing milled-head screws for this adjustment.

The position of the horizontal hair is really unimportant so long as the telescope is used only for measuring horizontal angles. If it is used for vertical angles when mounted on top it becomes important to make the line of sight parallel to the line of sight of the principal telescope. To make this adjustment, sight the horizontal hair of the main telescope at some point. Measure off above this point the distance between the two telescopes and mark a second point. Then move the diaphragm until the horizontal hair of the auxiliary telescope sights the second point.

To adjust the auxiliary as a side telescope, sight the horizontal hair of the main telescope at some distant object and clamp the vertical motion. Release the smaller nickel-silver capstan-head screw, twist the auxiliary telescope until nearly parallel with the main telescope, then tighten the nickel capstan-head screw. Then sight the horizontal hair of the auxiliary telescope at the same distant object, using the milled-head opposing screws for this adjustment.

If the side telescope is to be used for measuring horizontal angles the vertical hair may be adjusted by sighting the main telescope at an object, and measuring off the distance between the telescopes, right or left, to establish a parallel line. The vertical hair must then be moved by means of the capstan-head screws of the diaphragm until it sights this last point.

11. **The Level** — To adjust the level tube we must place its axis in the same vertical plane with the axis of the collars and also make it parallel to the axis of the collars. Since an error in either of these conditions affects the test for the other we should not consider either one complete before the other has been tested. First test the parallelism by rotating the telescope (if necessary) so that the level is exactly beneath it; center the bubble, then carefully lift the telescope out of the wyes, turn it end for end and carefully replace it in the wyes, the object end now being where the eye end was at first. If the bubble reads the same the adjustment is correct. If it does not the bubble should be brought halfway back to its original (central) position by means of the two nuts controlling the vertical adjustment of one end of the level tube.

Next test the bubble to see if it is in the same plane as the axis of the collars; this is done by rotating the telescope about its own axis some 15° or 20° from its normal position, first one side, then the other. The bubble will always move toward the higher end. To correct any error observed, move the capstan-head screws controlling the horizontal adjustment, moving them in such a way as either to lower the higher end or to raise the lower end.

C. Adjustments Of The Dumpy Level Which Can Be Made In The Field

a. **Adjustment of the Level**
   Making the level axis perpendicular to the vertical axis.

b. **Adjustment of the Cross-hairs**
   (1) Placing the horizontal hair in a plane perpendicular to the vertical axis.
   (2) Making the line of sight parallel to the level axis.

1. **The Level** — The level of the dumpy must first be made perpendicular to the vertical axis of the instrument. This is done by centering the bubble with the leveling screws, reversing the telescope end for end about the vertical axis, and noting the position of the bubble. (Fig. 11 a, b.) If it has moved out of center bring it halfway back by means of the vertical adjusting screw (at the eyepiece end). The test and adjustment should be repeated until the bubble will remain central during a revolution of the telescope in azimuth.

2. **The Horizontal Cross-hair** — First test the horizontal hair to see if it will remain on a point as the telescope is moved right and left about the vertical axis. If it will not, the diaphragm should be rotated until it will stand this test. Loosen the screws holding the cross-hair ring and tap gently on the screws until the horizontal hair is in such a position that it will remain on the same point as the telescope is moved in azimuth. (See Fig. 12).

3. **The "Peg" Adjustment** — To test the line of sight to see if it is parallel to the axis of the level two stakes or two marks may be set at the **same elevation** about 200 or 300 feet apart. This may be done with the level itself by placing it accurately midway between the stakes. If the bubble is centered carefully and the stakes driven or the marks set so that they are at the

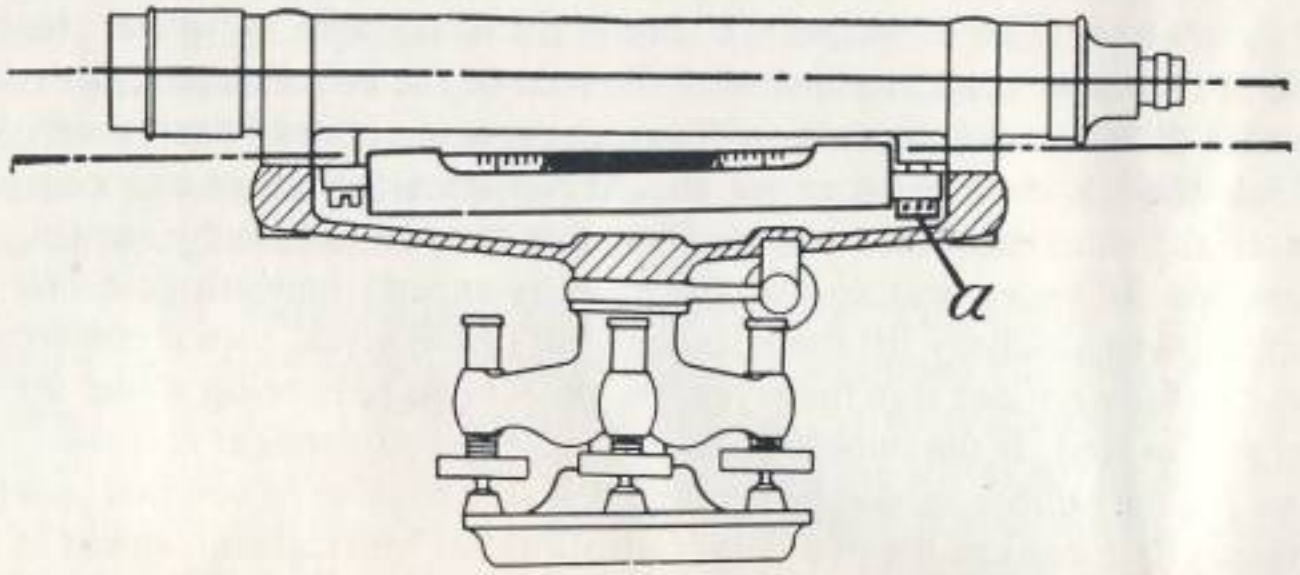


Fig. 11a. Test of Bubble of Dumpy Level (bubble centered)

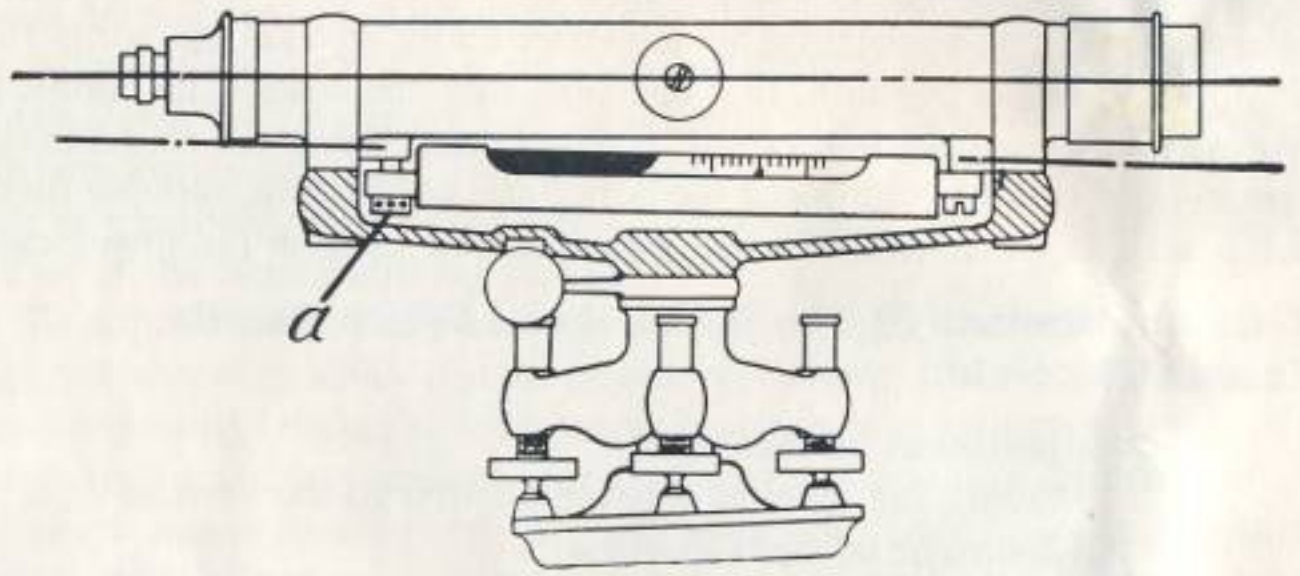


Fig. 11b. Test of Bubble of Dumpy Level (telescope reversed)

same elevation as shown by a rod reading, the points will actually have the same elevation, even though there is a large error in the adjustment of the instrument. Now set the level in line with the stakes and near to one of them. Next center the bubble and take rod readings on the two stakes. If the readings do not agree raise or lower the cross-hair ring until they do agree. This is done by moving the diaphragm until the reading on the distant rod agrees with near rod reading just found. This adjustment, however, will alter the near rod reading slightly, so the readings and the adjustment must be repeated, until finally they are made to agree. (See Fig. 10.)

Fig. 12. Test of Horizontal Cross-hair of Dumpy Level

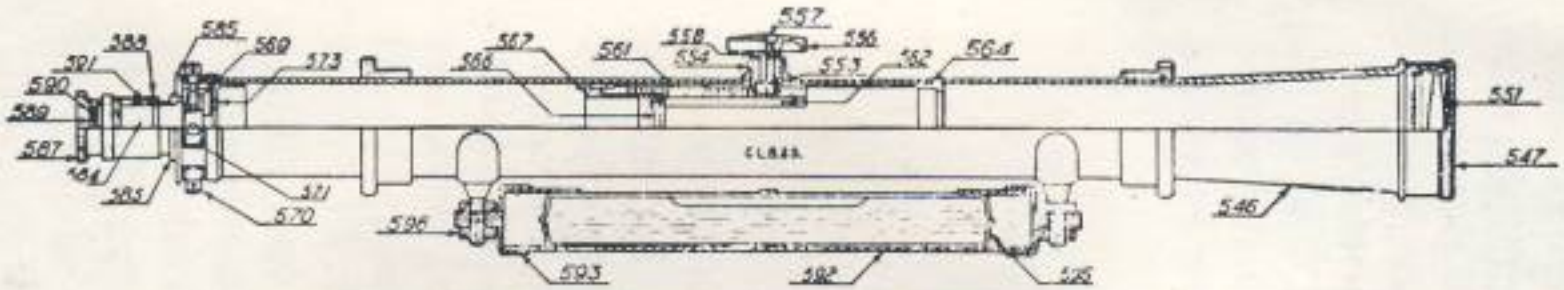
4. **Second Method** — It is not really necessary to set stakes at the same elevation. Any two bench marks may be used for testing the level, provided they can be read from the same set-up of the instrument. Set the level close to one of them so that the eyepiece is within about an eighth of an inch from the scale on the rod. Take a reading (say 4.00 feet) on the rod by looking through the object end of the telescope. Next move the rod to the distant bench mark and take another reading (say 5.90), the bubble being in the center. The difference of elevation is apparently 1.90. Now move the level to the other bench mark and repeat the operation. Suppose that the near reading is 3.80 and the distant reading is 1.70. The difference in elevation is in this case apparently 2.10. The true difference in elevation is, therefore, the mean, or 2.00 feet. Since the line of sight of the telescope is now 3.80 above the bench mark the cross-hair should read 1.80 on the distant rod. Since it actually is at 1.70 the line of sight is 0.10 foot too low. The diaphragm must, therefore, be so moved that the horizontal hair will read 1.80 when the bubble is central.

BERGER 18'' PROJECT LEVEL
Models 474 and 484

Dumpy level with horizontal circle and vernier. (Available without horizontal circle and vernier as Models 472 and 474). 33-power erecting, internal rack and pinion focusing telescope. 1.535'' diameter achromatic objective lens. Clear aperture: 1.50'' .8½ft. short focus. Focusing type eyepiece. Forged brass bar and skirt. 3-7/16'' diameter horizontal circle with double vernier reads to 5 minutes (1/12°). Dust protected micrometer clamp and tangent screws. 7¾'' precision ground telescope level vial - sensitivity, 50 secs, per 2 mm div. 4 nickel silver dust protected leveling screws. Forged brass foot plate with government standard 3-1/2'' x 8 thd. Forged shifting center for setting over a point. Carrying case, sunshade, pin wrench, plumb bob and instruction Manual. Metal wide frame stiff or extension tripod available. Also available with Power Zoom System.* Range: 28 to 44 power. Models 474 and 484 used with #873 and 874 tripods. Model 472 and 482 used with #893 and 894 tripods.
*Optional, extra.

IV PARTS LIST

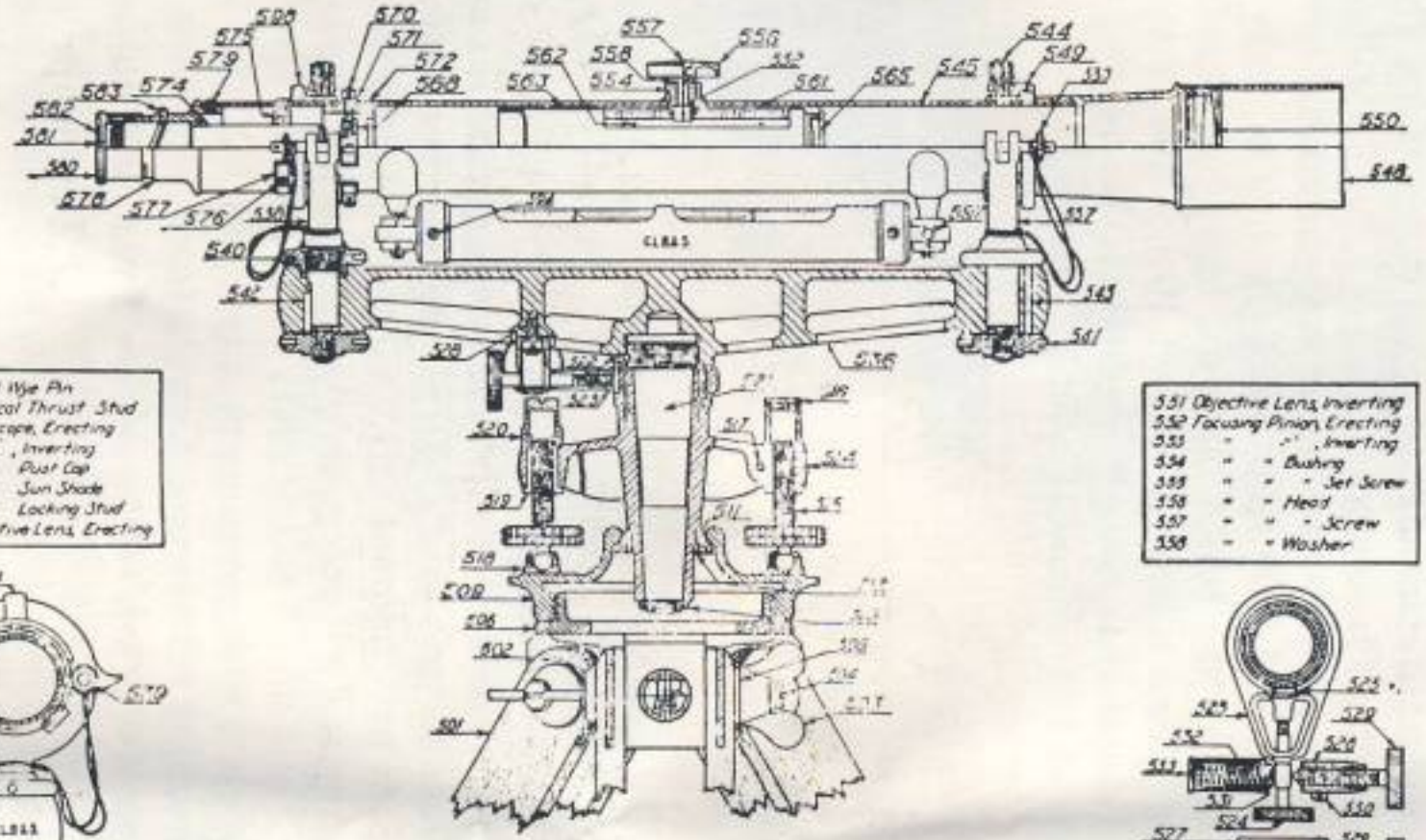
The following drawings are included as an aid for use when ordering parts. Although the drawings are of older models, the parts numbers shown are generic and apply to similar parts utilized in instruments of current manufacture. **When ordering please specify the appropriate part number and the serial number of the instrument for which the part is intended.**



501 Tripod Leg
502 " Bolt
503 " Wingnut
504 " " Locking Screw
505 " Washer
506 " Head
509 Foot Plate

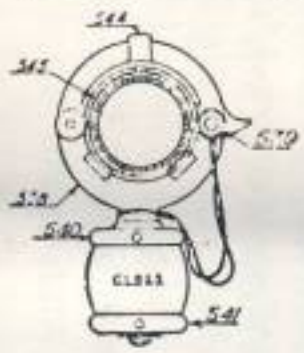
559 Focusing Pinion Spring
560 " " " Screw
561 " Rack
562 " " Screw
563 " Side, Erecting
564 " " , Inverting
565 " Lens, Erecting

Cross Section of 18 inch Inverting Dumpy Level Telescope



511 Ball Nut
512 " " Locking Screw
513 Center Nut
514 Leveling Head
515 " Screw
516 " " Dust Cap
517 " " Take-up Screw
518 " " Shoe
519 " " Replaceable Bushing
520 " " Bushing Cap
521 Center
522 " Set Screw
523 Clamp
524 " Screw
525 " Shoe
526 " Tangent Piece, Regular Type
527 " " " , Bushing Type
528 " " " Screw
529 " Tangent Screw
530 " Take-up "
531 " Tangent Piston
532 " " Spring
533 " " " Cap
534 " Replaceable Bushing
535 " Bushing Fastening Screw
536 Level Bar
537 Wye Bearing, Fixed
538 " " Adjustable
539 " " Locking Pin
540 " " Adjusting Nut
541 " " Clamping Nut
542 Adjustable Wye Key

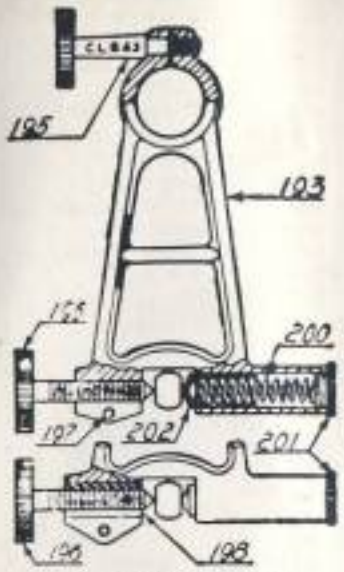
543 Fixed Wye Pin
544 Vertical Thrust Stud
545 Telescope, Erecting
546 " , Inverting
547 " Dust Cap
548 " Sun Shade
549 " Locking Stud
550 Objective Lens, Erecting



551 Objective Lens, Inverting
552 Focusing Pinion, Erecting
553 " " , Inverting
554 " " Bushing
555 " " " Set Screw
556 " " Head
557 " " " Screw
558 " " Washer

558 Focusing Lens, Inverting
559 " " Thimble
560 Diaphragm, Erecting
561 " , Inverting
562 " Screw
563 " " Washer
564 Reinforcement Rings
565 Telescope Blender
566 Erecting Eyepiece
567 " " Front Bearing
568 " " " " Screw
569 " " " " Washer
570 " " Rear Bearing
571 " " " " Screw
572 " " Cap
573 " " Dust Cap
574 " " " Screw
575 " " Spiral Groove Sleeve
576 Inverting Eyepiece
577 " " Mounting
578 " " Bearing
579 " " Cap
580 " " Dust Guard
581 " " " Cap
582 " " " Screw
583 " " Spiral Slot Screw
584 Telescope Level
585 " " Cap
586 " " " Screw
587 " " Vial
588 " " Adjusting Nut
589 " " " Screw

Parts for the Berger 18 inch Erecting Dumpy Level
Include instrument serial number when ordering parts.



TELESCOPE CLAMP

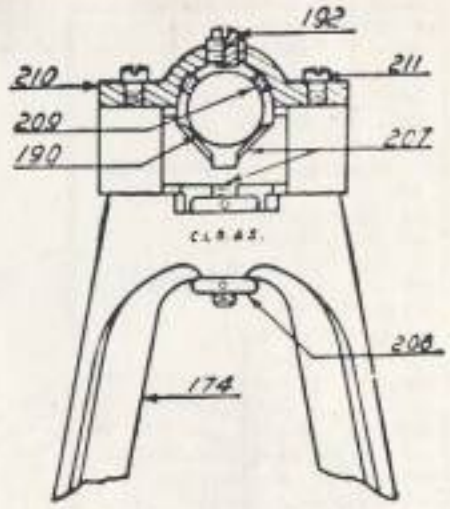
Telescope Clamp

TELESCOPE CLAMP
PARTS LIST

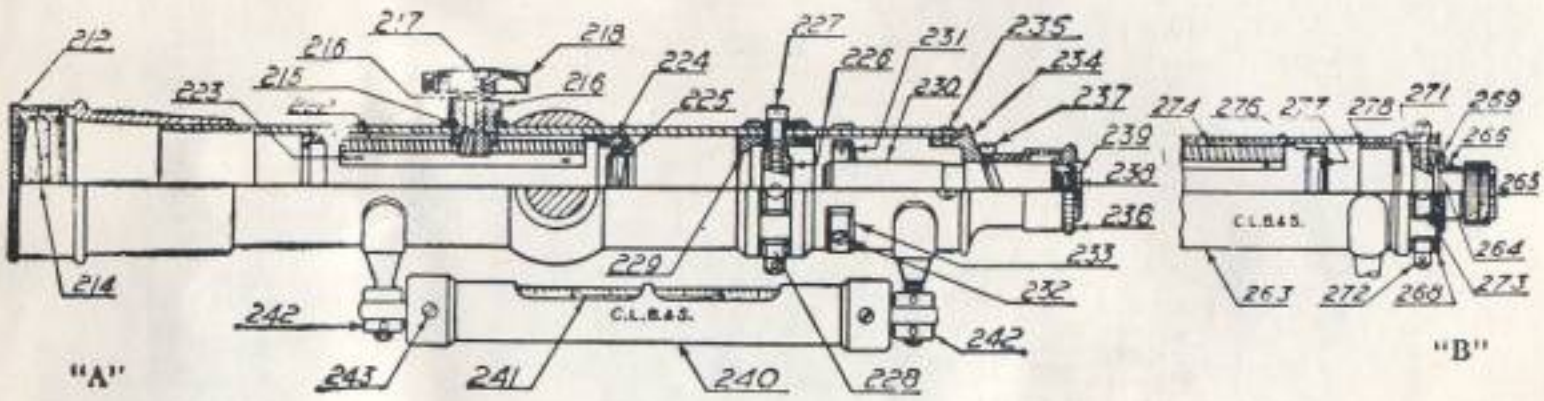
193 Telescope Clamp, Regular
194 " " „Bushing Type
195 " " Screw
196 " " Tangent Screw
197 " " Take-up Screw
198 " "Replaceable Bushing
199 " "Bushing Fastening Screw
200 " " Spring
201 " " " Cap
202 " " Piston
203 " " Nut
204 " " Tangent Stud
205 " " " " Screw
206 " " Washer

ADJUSTABLE WYE BEARING
PARTS LIST

207 Adjustable Wye Bearing & Stud
208 " " " Nut
209 Wye Bearing Felt Oiler
210 " " Cap
211 " " " Screw



"A" Standard
with Adjustable
Wye Bearing



A,—Cross Section of Erecting Transit Telescope
B,—Cross Section of Inverting Transit Telescope at eye end

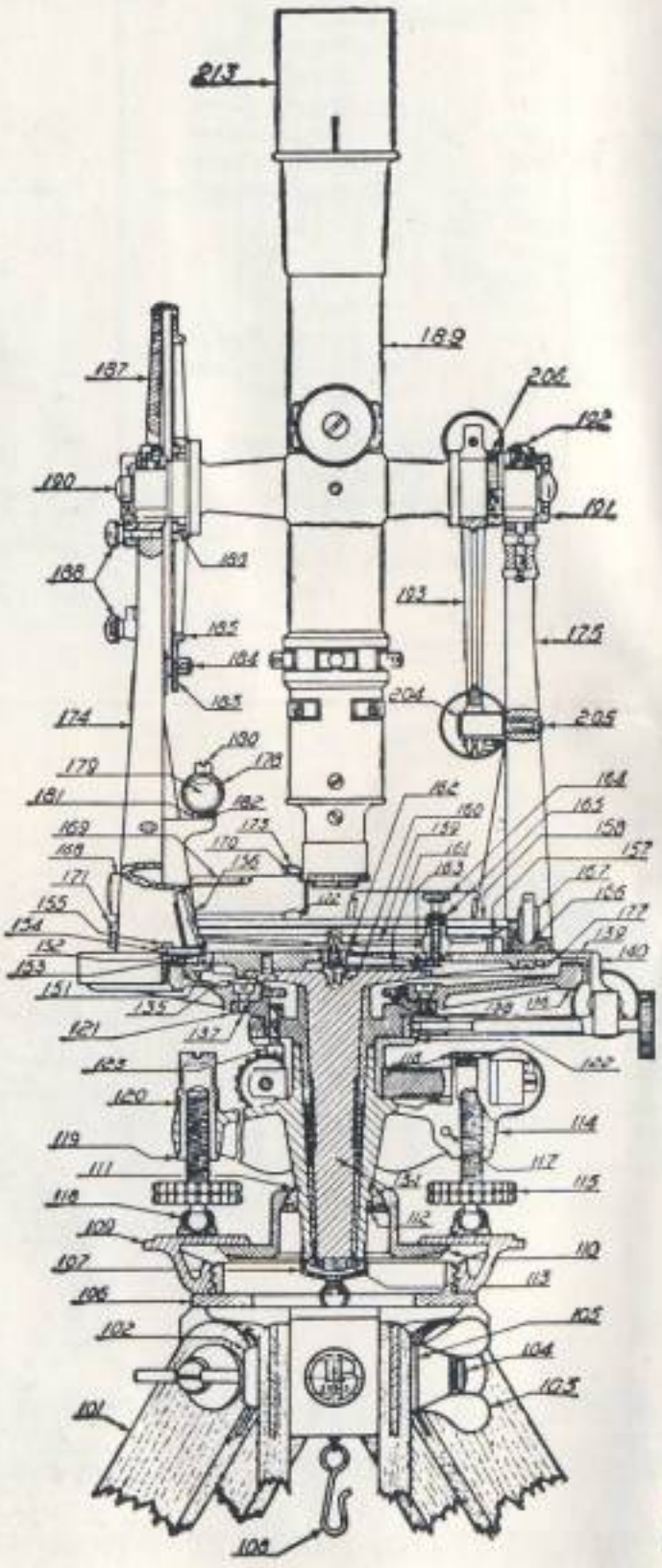
Include instrument serial number when ordering parts

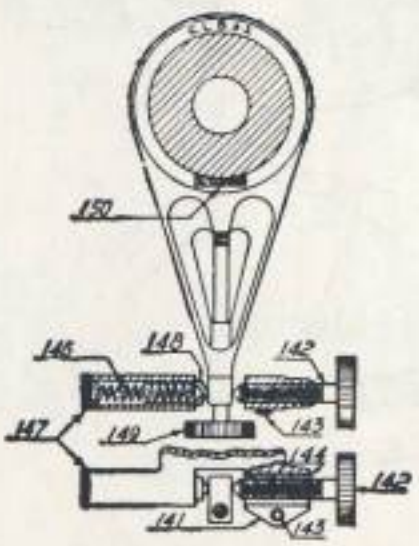
TELESCOPE PARTS LIST

212 Telescope Dust Cap
213 " Sun Shade
214 Objective Lens, Erecting
215 Focusing Pinion
216 " "Bushing
217 " "Screw
218 " "Head
219 " "Washer
220 " "Spring
221 " " "Screw
222 "Rack, Erecting
223 " "Screw
224 Focusing Slide, Erecting
225 " Lens, Erecting
226 Diaphragm, Erecting
227 " Screw
228 " "Washer
229 Re-enforcement Ring
230 Eyepiece, Erecting
231 "Front Bearing
232 " " "Screw
233 " " " "Washer
234 "Rear Bearing
235 " " " Screw
236 Eyepiece Cap
237 "Spiral Groove Screw
238 "Dust Cap
239 " " "Screw
240 Telescope Level
241 " "Vial
242 " "Adjusting Nut
243 " "Bubble End Screw
263 Telescope, Inverting
264 Eyepiece, Inverting
265 "Cap
266 "Spiral Groove Screw
267 Eyepiece Dust Cap
268 " " "Screw
269 "Bearing
270 "Mounting
271 Diaphragm, Inverting
272 " Screw
273 " "Washer
274 Focusing Rack, Inverting
275 " "Screw
276 "Slide, Inverting
277 "Lens, Inverting
278 Telescope Blender

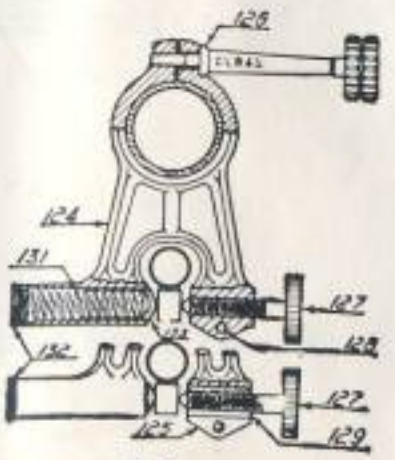
Parts for Berger Transits

101 Tripod Leg
102 " Bolt
103 " Wingnut
104 " " Lock Screw
105 " Washer
106 " Head
107 Plumb Bob Suspension Cap
108 " " Chain and Hook
109 Foot Plate
110 Shifting Plate
111 Ball Nut
112 " " Locking Screw
113 Center Nut
114 Leveling Head
115 " Screw
116 " " Dust Cap
117 " " Take-up Screw
118 " " Shoe
119 " " Replaceable Bushing
120 " " Bushing Cap
121 Repecting Center
122 Clamp Collar
123 " " Screw
124 Lower Clamp, Regular Type
125 " " , Bushing Type
126 " " Screw
127 " " Tangent Screw
128 " " Take-up Screw
129 " " Replaceable Bushing
130 " " Bushing Fastening Screw
131 " " Tangent Spring
132 " " " " Cap
133 " " " Piston
134 Inner Center
135 " " Screw
136 Horizontal Circle
137 " " Screw
138 " " Centering Screw
139 Vernier Plate
140 Tangent Bracket, Regular
141 " " , Bushing Type
142 Plate Tangent Screw
143 " " Take-up Screw
144 " " Replaceable Bushing





Vernier Plate Clamp



Lower Clamp
(For Horizontal Circle)

145 Tangent Bushing Fastening Screw
146 Plate Tangent Spring
147 " " " Cap
148 " " Piston
149 " " Clamp Screw
150 " " " Shoe
151 Horizontal Vernier
152 Vernier Cover Glass
153 " " " Gasket
154 " Shade Frame
155 " " " Screw
156 " " Glass
157 Compass Variation Ring
158 " Cover Glass
159 " Needle
160 " " Pivot
161 " " Lifter
162 Needle Lifter Bushing
163 " " Fulcrum Screw
164 " " Screw
165 " " " Housing
166 Variation Pinion
167 " " Housing
168 Front Plate Level
169 " " " Vial
170 " " " Screw
171 " " " Adjusting Nut
172 " " " Support
173 " " " Guard
174 Standard, Circle Side
175 " , Clamp Side
177 " Fastening Screw
178 Side Level
179 " " Vial
180 " " Adjusting Screw
181 " " Rocker
182 " " " Screw
183 Vertical Vernier
184 " " Screw
185 " Circle
186 " " Screw
187 " " Guard
188 " " " " Screw
189 Telescope
190 " Axis
191 End Thrust Nut
192 Axis Adjusting Stud

Cross Section of the Berger "R" Transit with Yoke Frame and Compass

Include instrument serial number when ordering parts

Vertical Circle Parts for Berger Transits

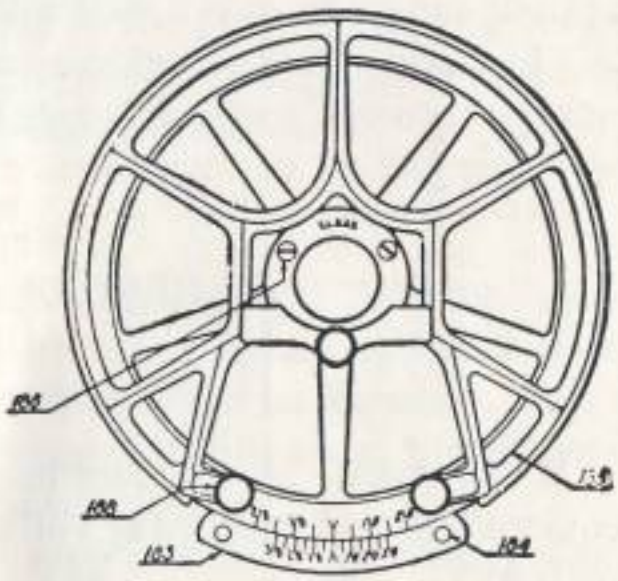
Plain Vertical Circle

Parts List

183	Vertical Vernier	
184	"	" Screw
185	"	Circle
186	"	" Screw
188	"	" Guard Screw

Vertical Circle Guard

187	For Transits with A Standards	
387	"	" U Frames



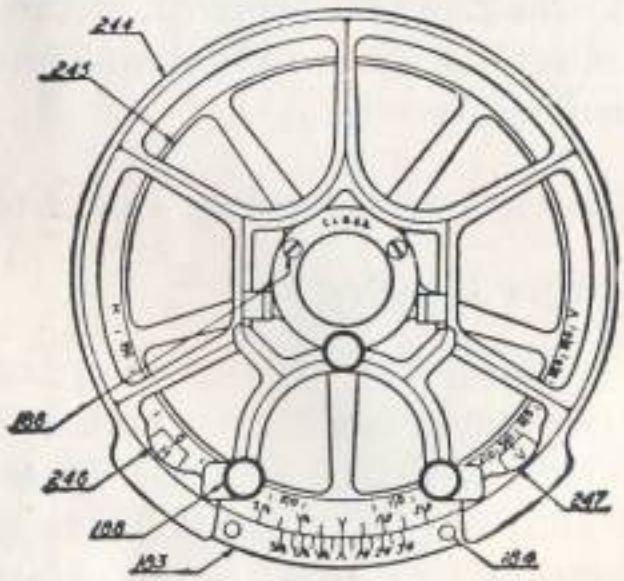
Beaman Stadia Arc (With Indices)

Parts List

244	Vertical Vernier	
184	"	" Screw
186	"	Circle "
188	"	" Guard Screw
245	Beaman "	"
246	"	Circle
247	"	Horizontal Index
248	"	Vertical "
249	"	Index Fastening Screw

Vertical Circle Guard

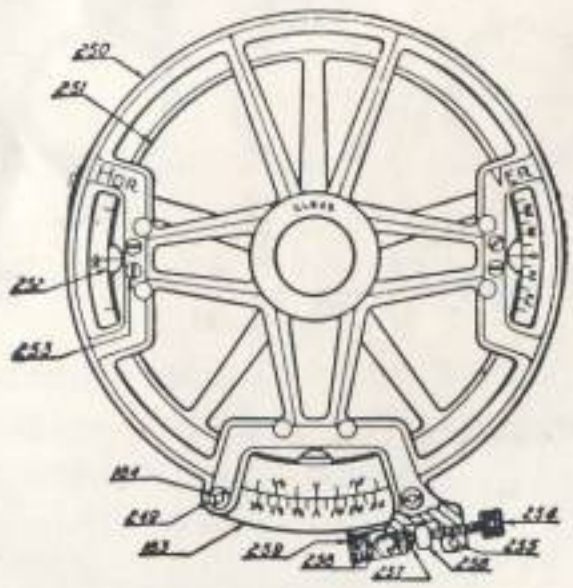
250	For Transits with A Standards	
251	"	" U Frames



Beaman Stadia Circle (Double Opposite Indices)

Parts List

183	Vertical Vernier	
184	"	" Screw
252	Vernier Adjusting Bushing	
253	Beaman Circle Guard	
254	"	Circle
255	"	Index
256	"	" Fastening Screw
257	"	Tangent Screw
258	"	" Take-up Screw
259	"	" Stud
260	"	" Piston
261	"	" Spring
262	"	" " Cap



Include instrument serial number when ordering parts

V Packing and Packaging for Shipment

Parts and/or instruments and accessories shipped to the factory for a repair estimate must be carefully packed and packaged to minimize damage in transit. Securely fasten all motions, properly position the instrument within its case, and cushion it with tightly rolled newspaper wads, foam or other packing material of suitable protective density. Then, securely fasten the case and place it in a well fitting cardboard carton (minimum test 200 lbs.) or wooden box, cushioning around the case where needed. Close the package securely, using adequate tape, staples, nails, etc. . . . and address the repair and all correspondence pertaining to it to:

Repair Dept.
BERGER INSTRUMENTS
4 River St.
Boston, MA 02126

If requested, an estimate as to nature, duration and cost of repairs required will be furnished to you at no charge soon after your instrument is received.

Note, unless approved, incoming goods will not be accepted on a freight collect basis and in all cases all freight charges will be borne by the customer making the return.

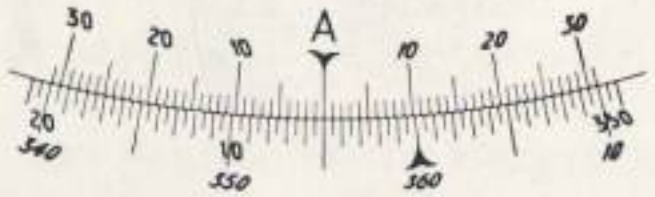
VI Berger Reticles, Leveling Rods And Tripods

Berger Reticles

Spider web or ruled on optical glass — are available in any pattern or style required. Reticles regularly furnished in Berger instruments have line widths of .00013″ to .0002″ according to U.S. Government standards. Line widths ranging from .0001″ to .0015″ are available. A few of the many possible variations are shown here.

Berger Circle And Vernier Graduations

Illustrated below are the most frequently used graduations on circles and verniers. The inner row reads 0°-360° clockwise; the outer row 360°-0°



STYLE 660

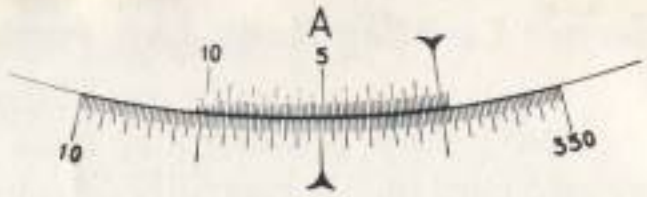
Circle graduated to 30 minutes.
Verniers read directly to one minute.

STYLE 620

Circle graduated to 15 minutes.
Verniers read directly to 20 seconds.

STYLE 630

Circle graduated to 20 minutes.
Verniers read directly to 30 seconds.



STYLE 610

Circle graduated to 10 minutes.
Verniers read directly to 10 seconds.

counter-clockwise. Figures are inclined in the direction they should read. Other types of graduations and numbering methods are available. A diagram showing the style desired should be sent with the order.

Berger Leveling Rods And Targets . . . . Deluxe Series

Built to take hard usage. Solid maple construction. Walnut finish with protective clear lacquer. Integral painted face has sharp black lines and highly legible numbers deeply engraved on white background. Foot numbers painted International Orange for ready identification. Metal foot shoe. Positive clamps with large, easy-to-handle knobs.

Unique, snap-on vernier target with quartered oval, alternately white and International Orange. Vernier reads to 1/64″ on builders' rods and to 1/1000 ft. on engineers' rods.

Builders' Models

(Graduated in feet, inches and eighths)

#62 2 section, 8 ft. clamping — cast oval target
#87 2 section, 10 ft. sliding, 5½ ft. closed, snap on target
#86 3 section, 15 ft. sliding, 5½ ft. closed, snap on target

Engineers Models

(Graduated in feet, tenths and hundreths)

#77 2 section, 10 ft. sliding, 5.6′ closed, snap on target
#76 3 section, 15 ft. sliding, 5.6′ closed, snap on target

Metric Model

(One centimeter blocks, 5 centimeter lines, numbered each decimeter in black. Meter graduations in red.)

#96 2 section, 3.35 meters, sliding, 1.75 m closed, target furnished

Berger Leveling Rods And Targets . . . . Custom Series

Heavy-duty professional rods for surveyors and engineers. Straight grained hard maple carefully selected and well seasoned to resist tough field use and to maintain straightness. Stained dark for protection and marked contrast with face. Conventional integral painted face rods and rods with replaceable white-steel faces are available. Faces recessed for protection; graduations are bold, sharp and well defined; easily operated, durable fittings. Foot numbers in red for added legibility.

Vernier targets in alternating red and white quadrants read to 1/1000 of a foot.

Engineer's Models

(Graduated in feet, tenths and hundredths)

#79 3 section, 12′ sliding, Frisco Rod only, 4′-6″ closed. Direct reading. Replaceable metal scales.

#75 2 section, 13′ sliding, Philadelphia Rod, 7′ closed. Replaceable metal scales. Manual head block adjustment. Vernier target.

#74 Same as No. 75 Rod. Micrometer target.

#73 3 section, 12′ sliding, Frisco Rod only, 4′-6″ closed.

#72 2 section, 13′ sliding, Philadelphia Rod, 7′ closed. Vernier target.

#71 2 section, 13′ sliding, Philadelphia Rod, 7′ closed. Specially mounted steel scales. Dimensional changes in wooden portions have no effect. Vernier target.

#70 Same as No. 71 Rod. Micrometer target.

Berger Standard Wide Frame Tripods For Engineers Instruments (Models 843, 844, 845, 846, 849 and 850)

Solid maple or other suitable hardwood legs and reinforcing blocks. Cast aluminum shoes with oversized push down spurs. Finished in yellow and white with black highlights. Complete with strap, protective cap for threads, and tension-adjusting wrench. Models available: U.S. Standard 3½'' x 8 thread tripod head (#843 stiff — #844 extension). European type flat-top head with ⅝'' x 11 thread instrument fastener (#849 stiff — #850 extension). Special Berger Lateral Adjuster shifting head with 3½'' x 8 thread mounting (#845 stiff — #846 extension). Latter is required for conventional 4 screw optical plummet transits; is Teflon™* coated for smooth sliding action and permits approximately a two inch shift in any direction of the transit while centering over the point. Stiff leg tripod is 60'' long. Extension tripod is 38'' closed and extends to 61.''

Reg. TM of DuPont

Berger Standard Tripods For Use With Engineers Transits And Levels (Model 841 — Stiff Leg: Model 842 — Extension Leg)

U.S. Standard 3½" x 8 thread head. Kiln-dried, straight grained ash or other suitable hardwood, painted yellow and white. Cast aluminum shoes with exceptionally strong points. Extension leg tripods have angled points to position them vertically during normal set-up and are keyed to prevent rotation. Two heavy clamps with forged brass shoes assure positive clamping and long wear. Rugged spreader ring for extra rigidity. Furnished with strap and protective cap for threads. Heavy shoes with push down spurs and replaceable steel points. Stiff leg tripod is 58" long. Extension leg type is 37" closed and extends to 59".

Berger Light Wood Tripods For Engineering Instruments (Model 821 Stiff Leg; Model 822 Extension Leg)

Kiln dried, straight grained hardwood painted yellow and white for high visibility. Cast aluminum shoes with push down spurs, durable steel points. U. S. Standard 3½" x 8 thread head. Extension legs have angled points. Tested, rugged clamps. Complete with strap and protective cap. Stiff leg tripod approximately 58" long. Extension leg type is 59" collapsing to 37".

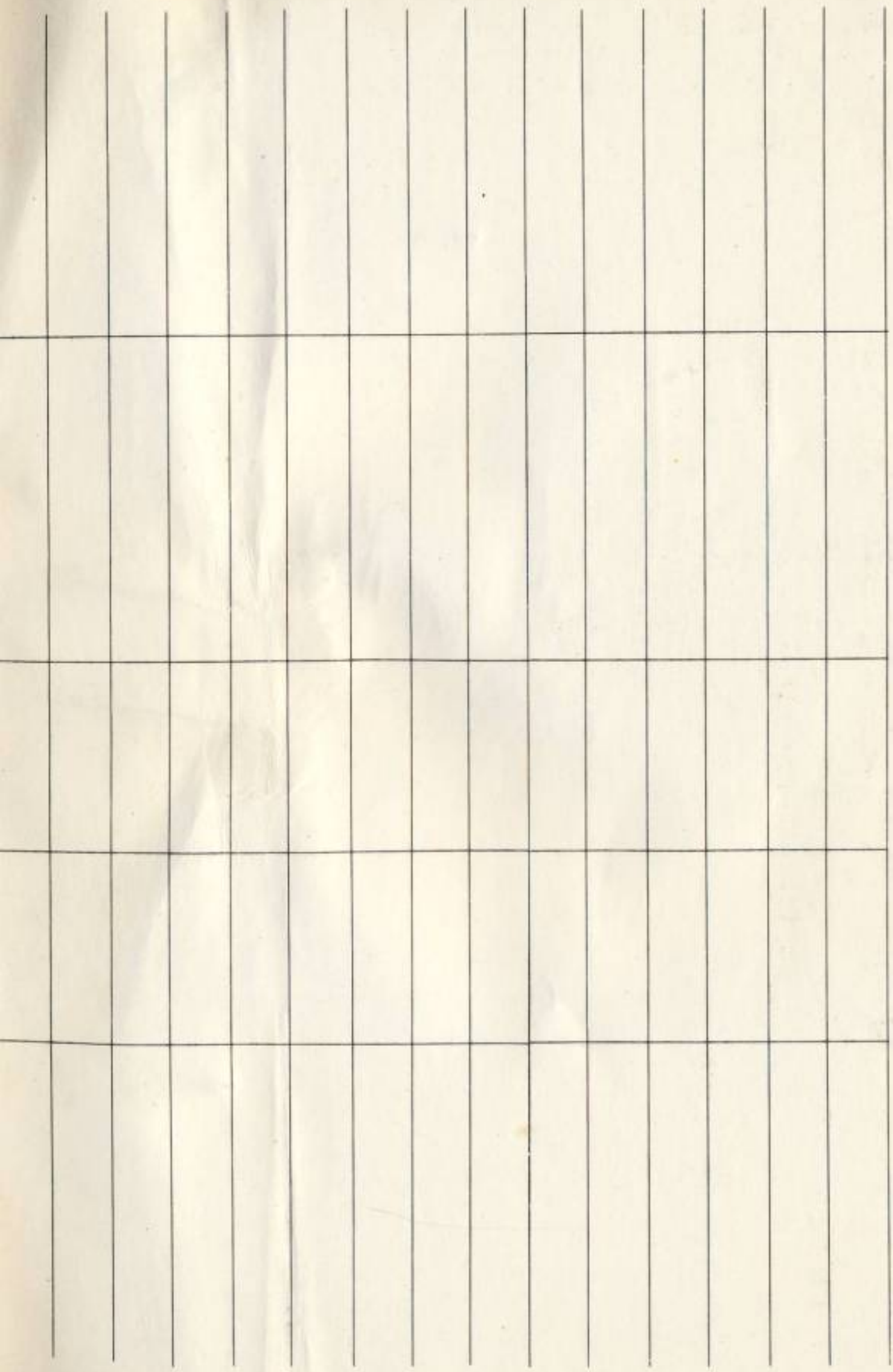
Berger Metal Wide Frame Tripods (Models 873 and 893 — Stiff Leg; Models 874 and 894 Extension Leg)

Rugged, lightweight and easy to handle. Wide frame design lessens torque and increases stability. Cast aluminum shoes with sizeable foot spurs and angled points. Finished in yellow and white with contrasting black accents for on-site safety. U.S. standard 3½ x 8 thread head. Furnished complete with strap and protective cap for 3½ x 8 threads. Heavy shoes with large push down spurs and steel points. Stiff leg models are 58'' long. Extension leg models use hard wood center sticks and extend from 37'' to 59''. Lightweight steel legs furnished as standard on all models. Aluminum legs available on special order at additional cost.

Also available with flat top head utilizing 5/8'' x 11 fastening system as model 893 (stiff leg) and 894 (extension leg).

MAINTENANCE RECORD

INSTRUMENT	SERIAL NUMBER	DATE REPAIRED	BY	WORK PERFORMED



Berger Instruments

DIVISION OF HIGH VOLTAGE ENGINEERING CORP.

4 RIVER STREET
BOSTON, MASSACHUSETTS 02126
(617) 298-0170

ENGINEERING AND SURVEYING INSTRUMENTS

INSTRUMENTATION AND APPARATUS SINCE 1871