TM 9-1624

WAR DEPARTMENT TECHNICAL MANUAL

ORDNANCE MAINTENANCE

HEIGHT FINDER M2

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WAR DEPARTMENT • 7 SEPTEMBER 1944

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This Technical Manual supersedes TB 9-1624-1, dated 1 August 1942; TB 1623-1, 1624-2, dated 5 October 1942; and TB 1623-4, 1624-4, dated 2 August 1943.

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WAR DEPARTMENT
Washington 25, D. C., 7 September 1944

TM 9-1624, Ordnance Maintenance: Height Finder M2, is published for the information and guidance of all concerned.

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G. C. MARSHALL,
Chief of Staff.

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The Adjutant General.

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(For explanation of symbols, see FM 21-6.)

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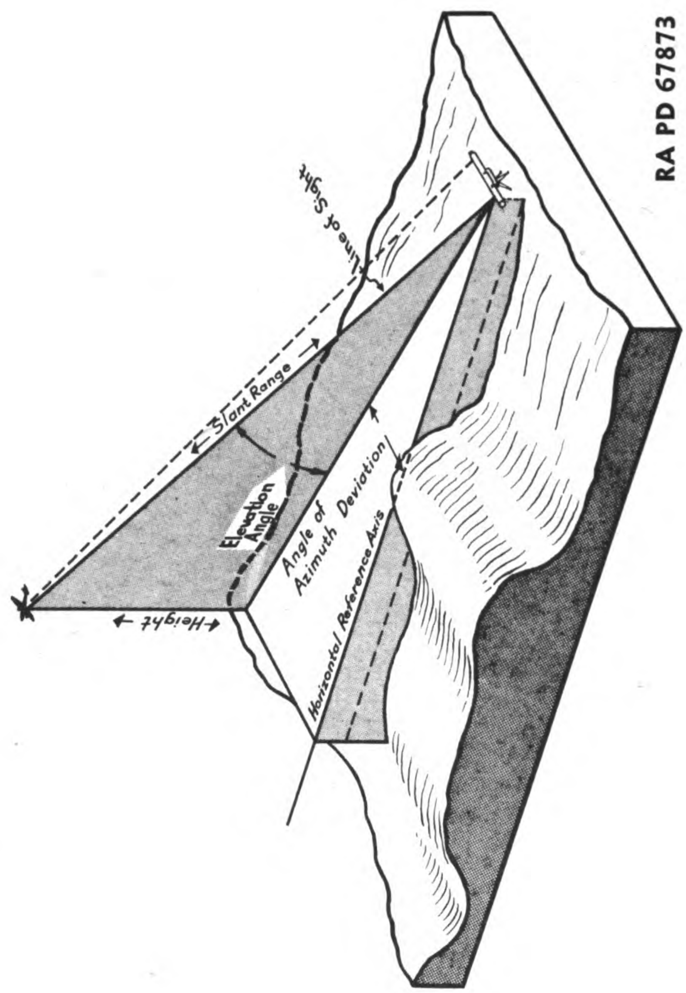

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Figure 1 — Measurements Possible With Height Finder

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This Technical Manual supersedes TB 9-1624-1, dated 1 August 1942; TB 9-1623-1, 1624-2, dated 5 October 1942; and TB 9-1623-4, 1624-4, dated 2 August 1943.

Section I

INTRODUCTION

1. GENERAL.

a. Purpose.

(1) This manual is published for the information and guidance of ordnance maintenance personnel.

(2) This manual is supplementary to TM 9-624 which should be consulted for information on the operation, adjustment, and maintenance normally performed by the using arms.

b. Scope.

(1) This manual covers the inspection, adjustment, and repair of the Height Finder M2. The operations described in this manual may be performed by authorized ordnance personnel only with the exception of certain field adjustments and inspections. The list of requirements in each paragraph on adjustment and repair indicates whether or not the operation is possible with the means at hand. No operation should be undertaken unless duly authorized.

(2) Maintenance personnel may be qualified for this work either through the successful accomplishment of a recognized course of instruction in height finder maintenance, or through adequate experience in the type of operation to be undertaken. A recognized course of instruction is defined as one having the approval of the Chief of Ordnance and the Commanding General, Army Ground Forces, for qualification in height finder repair. Determination of adequate experience will be made in each case by the responsible ordnance officer, who will take necessary action for maintenance requiring facilities beyond those available.

2. THE PURPOSE OF THE HEIGHT FINDER M2.

a. The Height Finder M2 is a portable self-contained range finder of 13½-foot base length, employing the stereoscopic principle of range finding. Theoretically it consists of a pair of high power telescopes combined into one instrument containing optical means of measuring slant range.

b. The principle involved is the measurement of the small angle between two rays of light from the target that enter the widely separated windows of the height finder. This measurement is merely the scientific extension of a person's ability to judge the distance of nearby objects by virtue of the rays of light entering the two eyes. The height finder actually serves the purpose of optically separating the observer's eyes to 13½ feet.

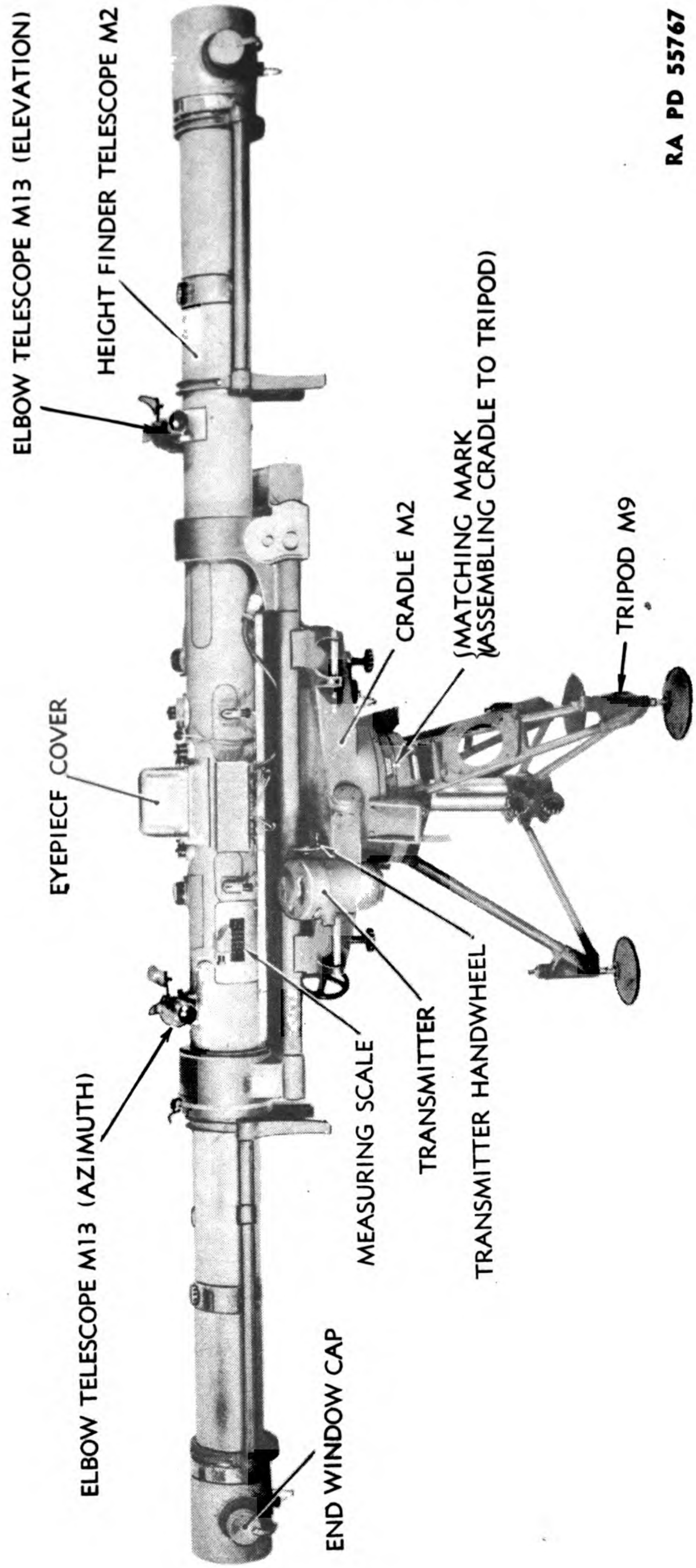

Figure 2 — Height Finder M2 — Front View

INTRODUCTION

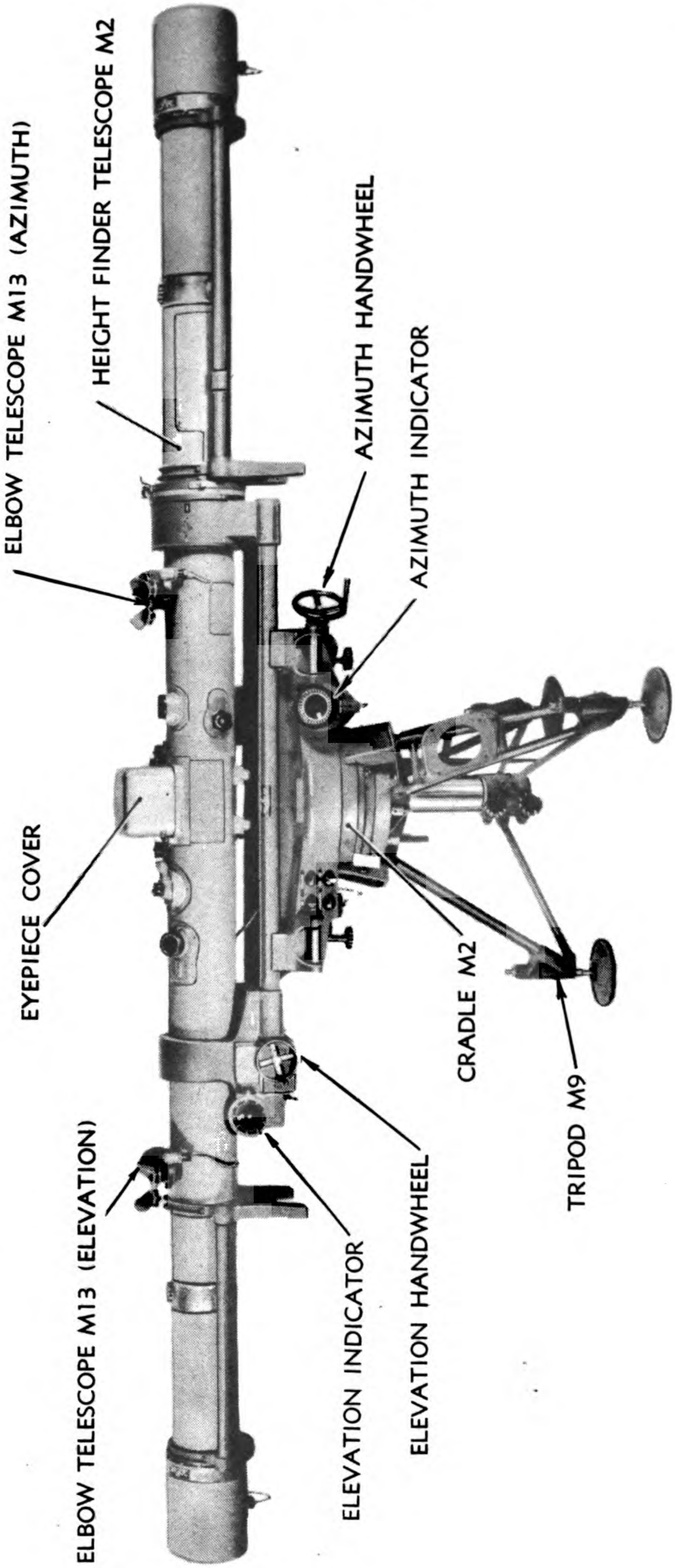

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Figure 3 — Height Finder M2 — Rear View

c. The two beams of light entering the height finder create two images of the airplane, one for each eye of the stereoscopic observer. The two images are fused stereoscopically so as to appear as an apparently single airplane image floating in space. The observer turns a knob to adjust the apparent distance of this image until it matches that of a series of reference marks which also appear to float in space. The rotation of this knob operates a scale (measuring drum) which indicates either height or range, as desired, by changing the position of a conversion ring lock lever.

d. The conversion of slant range to height is accomplished by means of a combined mechanical and optical system that computes the value of the vertical side of a right triangle of which the hypotenuse is the slant range, and the known angle is the angular elevation of the line of sight. The instrument may be elevated from zero to 90 degrees, and has unlimited traverse in azimuth, either by handwheel operation or slewing.

e. Two men (trackers) are needed to keep the instrument pointed at the target, thus simplifying the duties of the stereoscopic observer. For this purpose, two elbow (tracking) telescopes and nearby operating handwheels, one for elevation and one for azimuth control, are provided. The azimuth and elevation settings of the height finder are indicated on the graduated scales of two mechanical indicators near the trackers, which are used to assure them that the height finder and antiaircraft director are sighted on the same target. To accomplish this, the azimuth and elevation settings of the antiaircraft director telescope are received electrically by pointers at their respective indicators.

f. Another operator is required to read the height or range at the measuring scale window, and set this data on the transmitter, through which these measurements are sent through the electrical transmission system to the antiaircraft director. The range or height scale is graduated from 550 to 50,000 yards, although the transmitter is graduated only from zero to 10,000 yards.

g. The main eyepieces are provided with 12- or 24-power magnification, as desired, and fitted with filter glasses to improve the visibility of the target during varying degrees of haze and glare.

h. An internal adjuster system is incorporated in the height finder for correcting any changes in the optical alinement in the instrument resulting from changes in temperature and stereoscopic observers' differences in reading.

i. Since the angle between two beams entering the height finder is small (28 minutes 7.6 seconds at 550 yards), and changes in angle for different ranges are still smaller, the height finder must measure

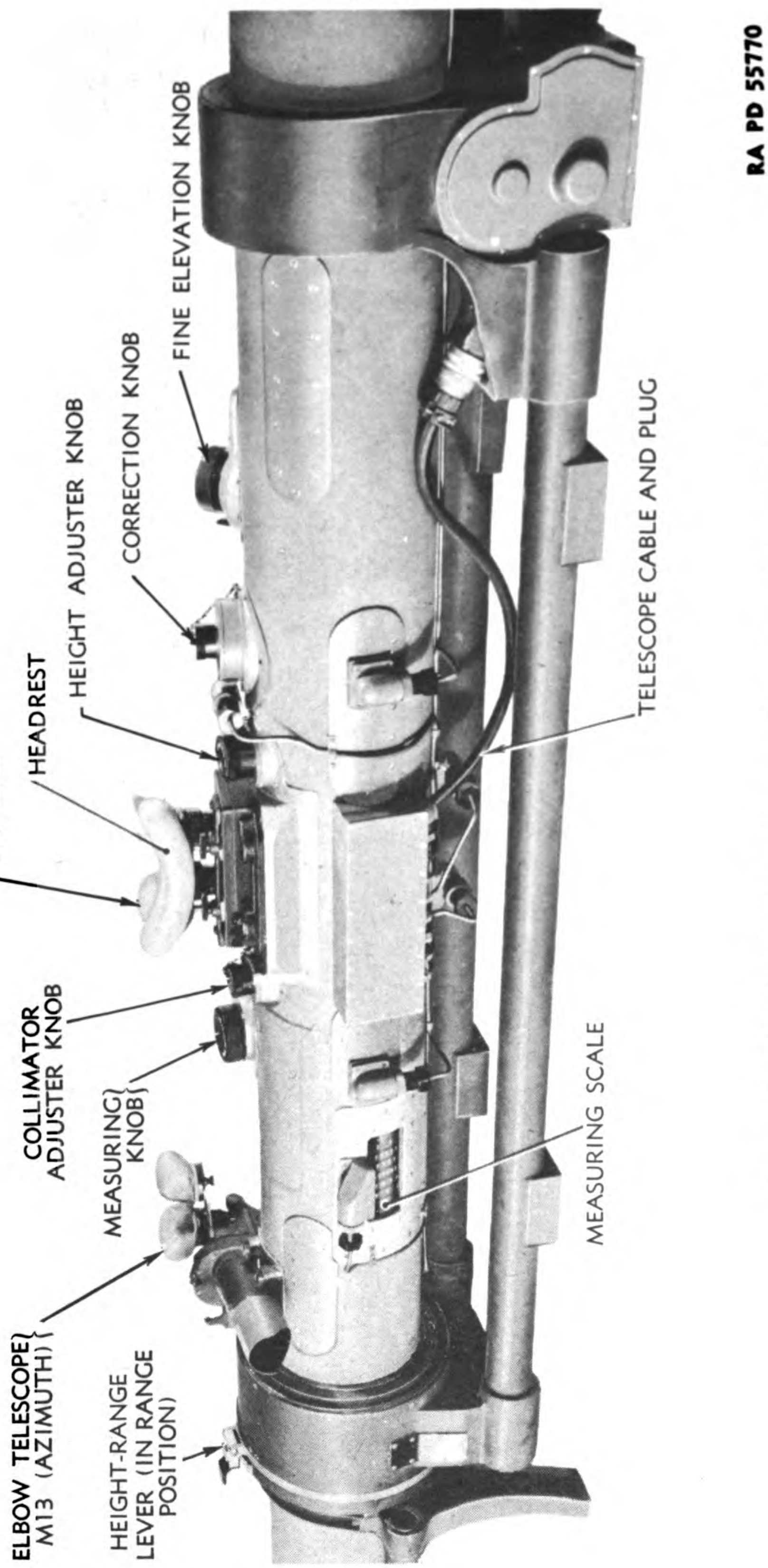

Figure 4 — Height Finder Telescope M2 — Front Center View

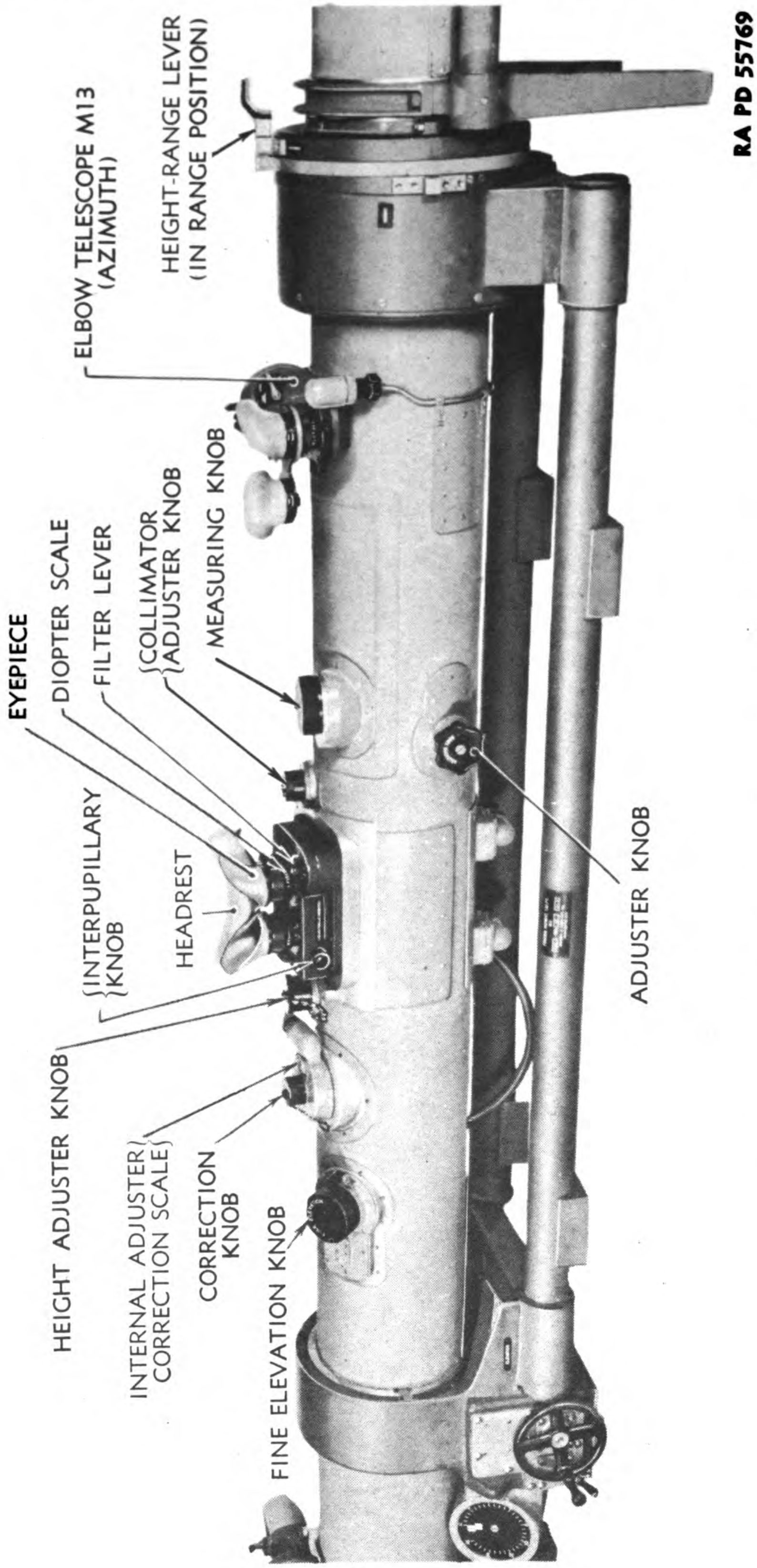

Figure 5 — Height Finder Telescope M2 — Rear Center View

small angles with great accuracy. For this reason, the height finder is, of necessity, a complicated optical instrument, built and adjusted to extreme precision. Slight displacement of optical parts will result in faulty operation, and hence great inaccuracy in readings of height and range. Such damage can be caused by rough transportation, accidental falls, concussion, damage due to bullets, shrapnel, etc. Even changes in temperature can and do affect the adjustments and, therefore, the readings of the height finder. For these reasons, it is necessary to know how to check the instrument at any time, how to diagnose any misalinement or other trouble, and how to rectify the trouble. The locating of trouble can be done systematically, once the principles of the instrument are understood and the checkup is done in the specified manner. Serious difficulties necessitate sending the instrument to the base repair shops. One thing must be emphasized above all: because of the delicacy of the adjustment of the optical and mechanical parts, it is all too easy to add to the damage or misalinement by incorrect adjustment. It is absolutely necessary that correct diagnosis be made first, and that the adjustments be made in the order outlined. No attempt should be made in the field to carry out major repairs; otherwise, the instrument may be made much more difficult to repair at the base repair shop.

j. It must be emphasized that a properly adjusted instrument in the hands of a well-trained crew is a valuable weapon. But maladjustment renders the whole instrument, procurement, installation, and personnel training utterly useless.

3. EXTERNAL APPEARANCE.

a. The height finder is composed of three major units: the Height Finder Telescope M2, including the Elbow Telescope M13 (669 pounds); the Cradle M2 (225 pounds); and the Tripod M9 (115 pounds. Each of these units is provided with a watertight steel packing chest for protection in transportation. The total combined weight of the height finder when packed in chests is approximately 2,600 pounds. For ease in withdrawing the height finder telescope, its cylindrical packing chest is provided with a carriage having absorber mounting for minimizing road shocks in transportation. This chest is airtight, and valves for charging with dry air are provided in the hinged cover.

b. The height finder is shown assembled in figure 2 as seen from the front side (that side which faces the target). The two light beams from the target enter the height finder through the end windows (shown with caps in place), then enter the range- and height-finding system inside the main horizontal tube. The base length (distance between entering beams) is 13.5 feet.

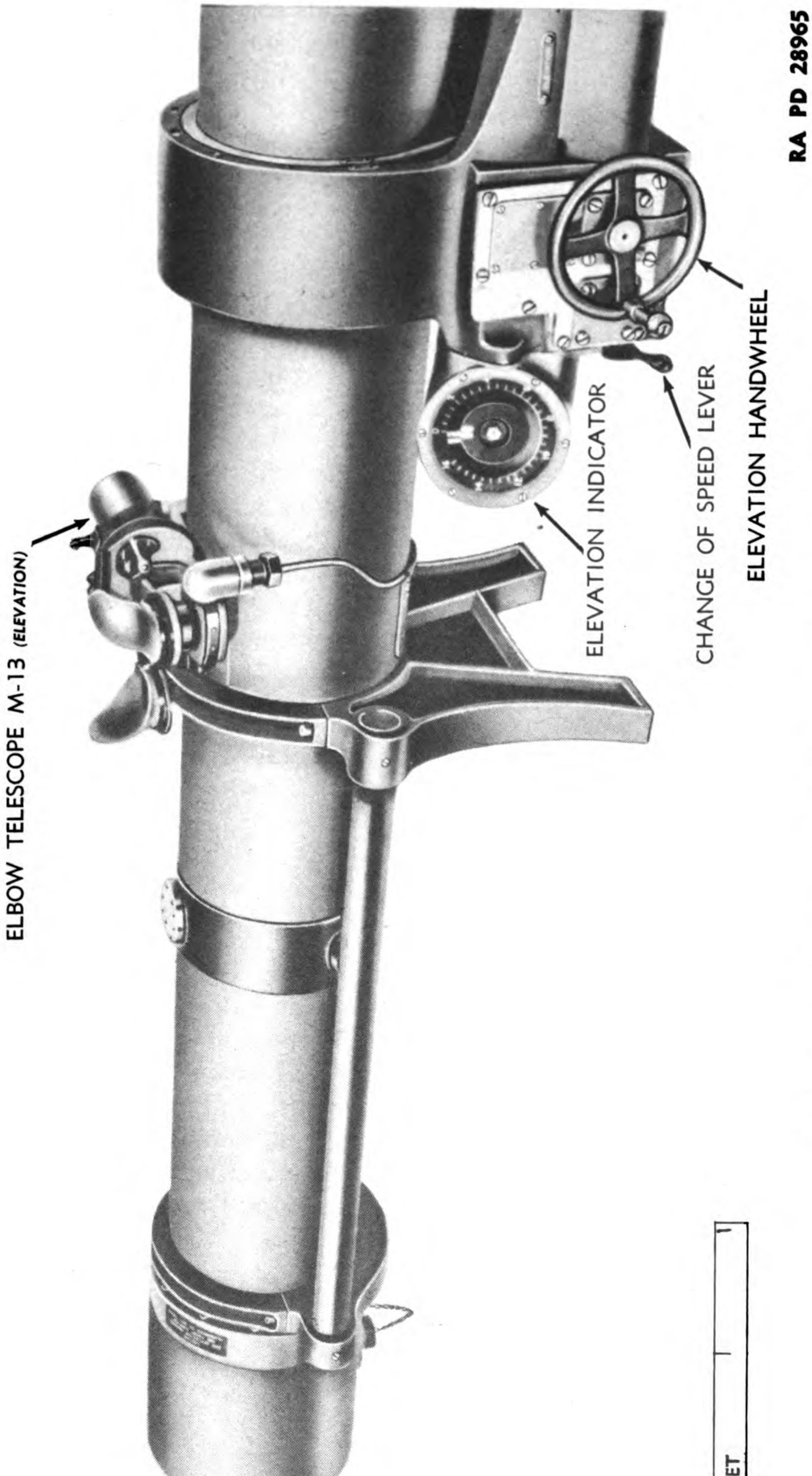

Figure 6 — Height Finder Telescope M2 — Rear Left End

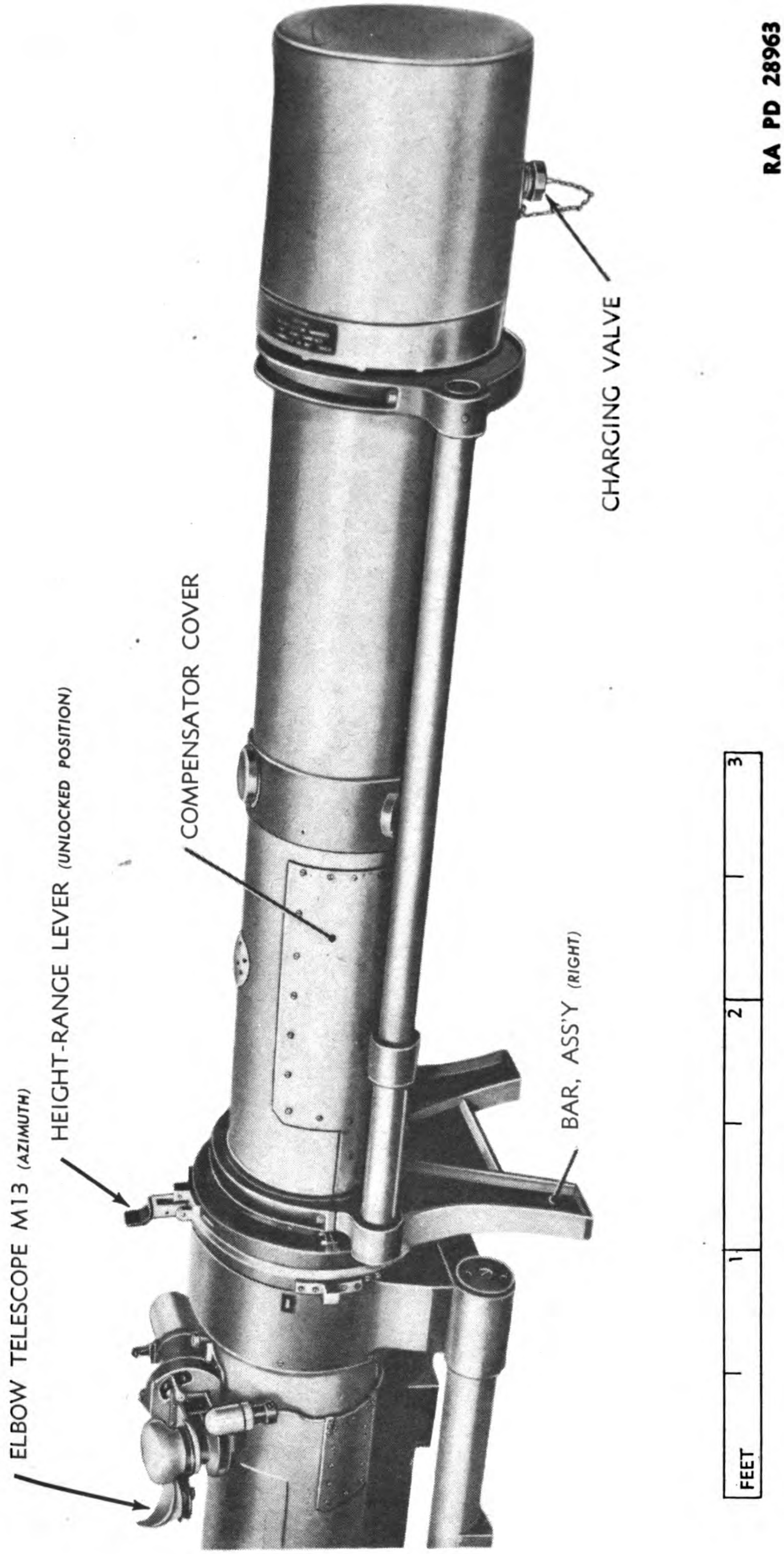

Figure 7 — Height Finder Telescope M2 — Rear Right End

c. The tracking telescopes (Elbow Telescopes M13) and their eyeshields can be seen (figs. 4 and 6) on top of the outer tube on either side of the center of the instrument.

d. The controls and other details on the observer's side (rear) of the instrument are indicated in figures 5, 33, and 34. The main eyepiece assembly (fig. 5) is for the stereoscopic observer. The measuring knob to the right of the eyepiece is operated by the right hand of the steroscopic observer, to alter the apparent distance of the stereoscopic image relative to the reticle marks. The fine elevation knob to the left is operated by the left hand of the stereoscopic observer, and serves as an accurate adjustment to position the aircraft image vertically in the eyepiece field, the elevation tracker having already brought the aircraft vertically into alinement. The change-of-magnification lever at the front of the eyepiece changes the optical power of the range-height system to either 24 or 12 power, so that a larger or smaller stereoscopic image can be obtained. To the right of the right-hand tracking telescope (fig. 4), the height-range lock lever is shown latched in position for range measurement. Another setting, 90 degrees below, is provided for this lever when height measurements are to be taken.

e. The azimuth tracking telescope appears to the right (fig. 3). The azimuth tracker operates the traversing handwheel just below, to swing the height finder around the tripod, at either high or slow speeds as selected, depending upon the speed of the target. The elevation handwheel (with change-of-speed lever) (fig. 33) is operated by the elevation tracker to raise or depress the line of sight fast or slow, as required. The azimuth and elevation indicators (figs. 33 and 34) show the azimuth and elevation settings for both the height finder and the antiaircraft director with which it is synchronized.

f. An operator is required to read the height indicated on the measuring scale (fig. 4), and to turn the nearby transmitter handwheel to set the transmitter scale to read this same value, which is transmitted electrically to the antiaircraft director by means of a button (fig. 46) on the inside of the right cradle body for signaling back to the director that the height finder is transmitting correct altitude or range. If altitude differences (vertical parallax) between the height finder and the battery have to be accounted for, a dial is provided to correct the height value transmitted.

g. **Production Differences.** Height finder instruments with numbers 1 to 12 differ in a great many respects from instruments with numbers 13 and above. Instruments with numbers 1 to 12 are in the hands of schools and arsenals for training purposes, and it is understood that they will never be used by troops or repaired by maintenance men in the field. This manual deals with only those instru-

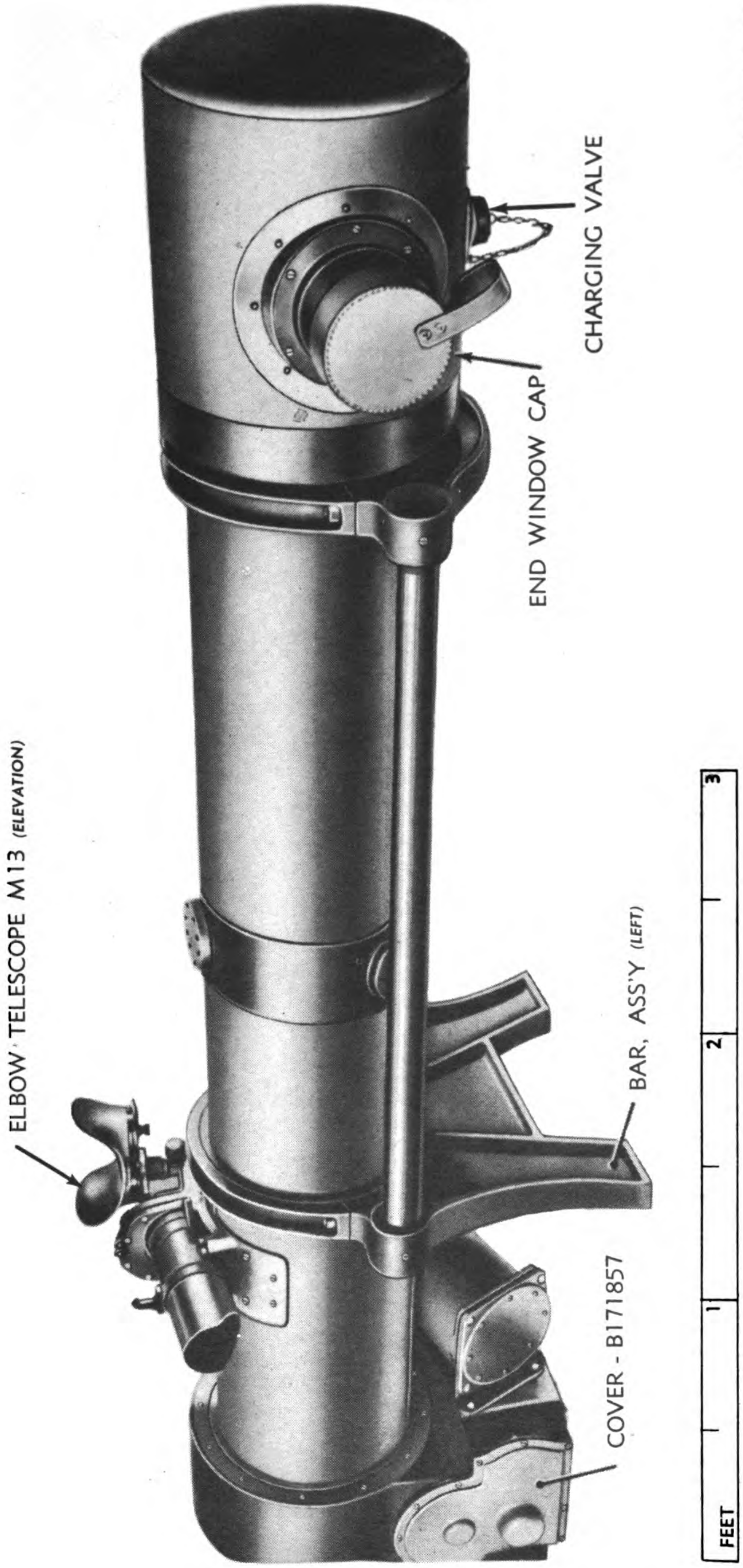

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Figure 8 — Height Finder Telescope M2 — Front Left End

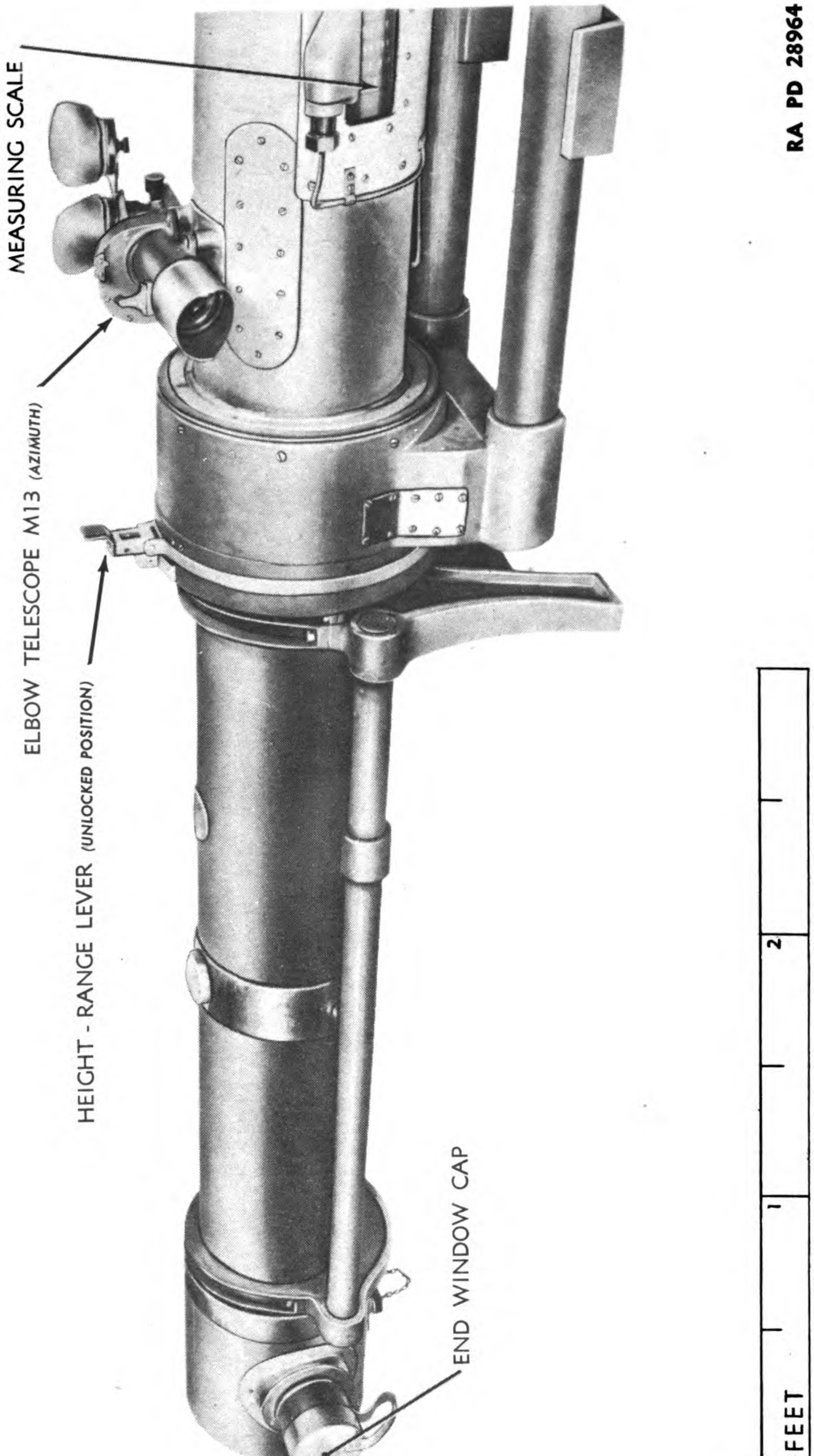

Figure 9 — Height Finder Telescope M2 — Front Right End

ments of serial number 13 and above. Minor changes have occurred in height finders since number 13, but they do not affect any of the instructions in this manual except where noted.

Section II

PRINCIPLES OF OPERATION

4. LENSES.

a. Lenses are optical elements which are capable of forming images of objects. The light rays from an object point which pass through the lens, are bent and converge on a corresponding image point. If the object is at a considerable distance from the lens, and the lens is a positive one, an image of the object will be formed on the opposite side of the lens. One of the rays from each point on the object passes through the optical center of the lens and proceeds in the same straight line* to a corresponding point on the image. Therefore, the image is upside down with respect to the object. An image can be seen and understood readily in the following way: Take any camera, open its back and, with the shutter and lens diaphragm wide open, look through the lens from about a foot back of the camera. An upside down image can be seen where the film would ordinarily be placed. Only part of this image can be seen at one time, that part being limited by the size of the lens. The whole of this image can be seen by placing a ground glass or even a thin sheet of paper across the back of the camera, since the ground glass scatters the light in all directions and some enters the eye from every part of the image.

b. It will be noticed in the ground glass that images of all *distant* objects are sharp, no matter what their distance. The size of the image increases with decreasing object distance, but the image position does not change much until the object is relatively close to the lens. The position or plane occupied by the ground glass or film for such distant objects is called the focal plane of a lens. The distance to this plane from a fixed point in the lens is called the focal length. The focal length is determined by the construction of the lens.

c. It will be noticed that the ground-glass image of an object only a few feet away is not sharp unless the distance from lens to ground glass is increased. In other words, the image of a nearby object falls behind the focal plane, and the nearer the object, the farther back is its image.

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*This discussion intentionally ignores the nodal points.

d. Image size depends not only on object distance, but on focal length as well—the greater the focal length, the larger the image and the greater its distance from the lens.

e. Each part of the object and the corresponding part of the image are connected by an imaginary straight line which passes through the optical center of the lens. One imaginary line passing through this optical center, and through the centers of curvature of the surfaces, is called the optical axis. The mechanical and optical axes coincide if the lens has been properly centered. It will be appreciated that any mounting which decenters the lens will throw the image sideways by an amount depending on the amount of decentration.

f. The type of image so far described is called a "real" image (fig. 10). It can be projected on a ground glass, photographic film, or other surface. This image is actually a light pattern which exists in space. Another type of image, called a "virtual" image, can be seen through a lens, but does not actually exist in space and so cannot be shown on a ground glass. For example, a virtual image can be seen through a lens when the object concerned lies between the focal plane and the lens (fig. 11). Such a lens is usually of short focal length, and the image appears to be distant, magnified, and right side up. A hand magnifier used in the ordinary way produces such a virtual image. In contrast to the relation between focal length and image size for real images, the shorter the focal length, the larger the virtual image. The object so viewed can be an image created by another lens. A hand magnifier can be used to look at the aerial image in the camera experiment described earlier. An aerial image also serves as object in the height finder eyepieces as explained later.

5. OBJECTIVES, OCULARS, ETC.

a. Different types of names are used for various lenses, depending on the part they play. The term "objective" is applied to the lens which creates the first image of the actual object. In the case of the height finder, this object is the aircraft. Range finder and telescope objectives are usually long in focal length to secure a large image.

b. A collective lens is a lens which is placed in the plane of the image formed by the objective. This lens converges the beam which has formed the image, so that all the rays will enter the next lens in the system, and thus the entire image within the collective lens can be seen. In the absence of a collective lens, only the central part of the image would be visible, just as in looking at the aerial image in the camera without a ground glass. The collective lens does the same thing as the ground glass, but with a smaller light loss.

c. An erector lens (or erecting lens) is one which forms a second image of the first image formed by the objective, for the purpose of

PRINCIPLES OF OPERATION

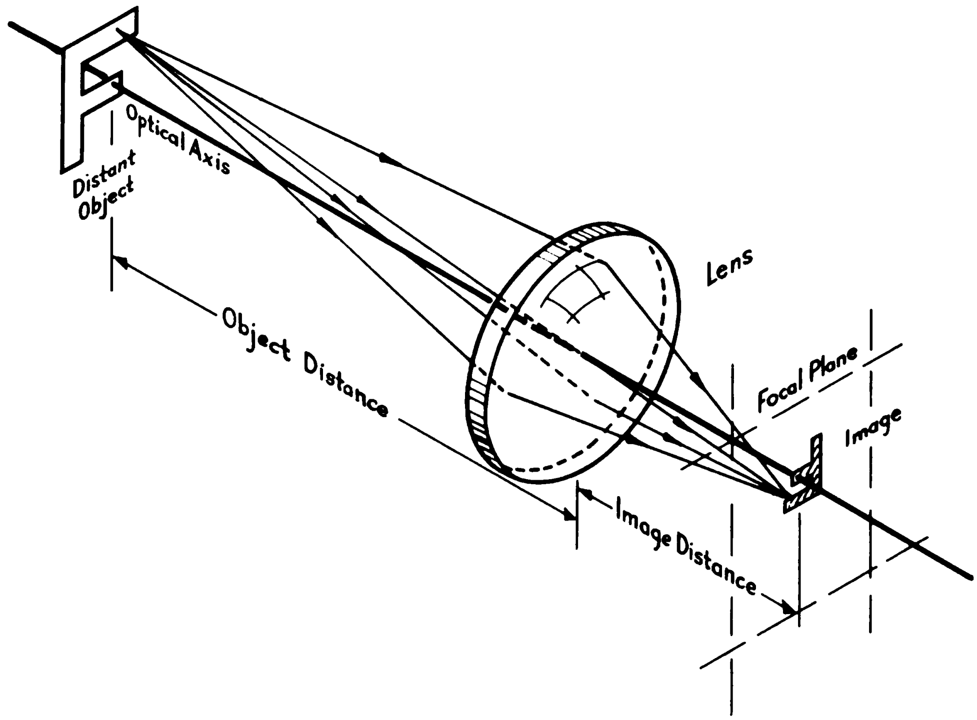

Figure 10 — Formation of a Real Image by a Lens

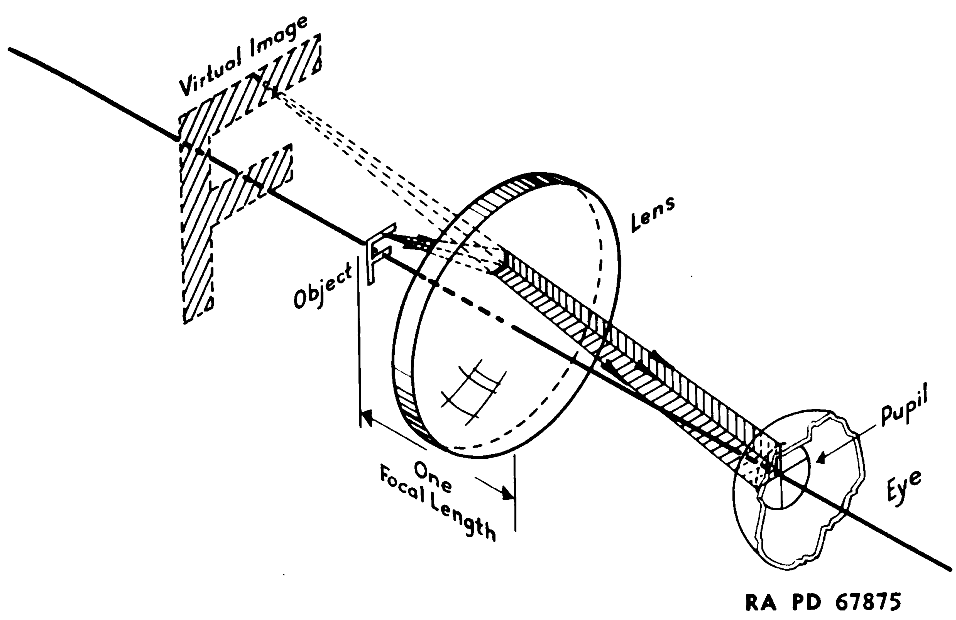

Figure 11 — A Virtual Image Seen Through a Lens

providing a right-side-up or erect image. The first image is inverted, and the second image is again inverted, which makes it erect. The second image can be larger, smaller, or equal to the first image in size, depending on the focal length of the erector lens and its distance from the first image. The erect image is naturally farther from the objective than the first, inverted, image. In other words, the erector lens has added length to the optical system. The erect image is formed in the focal plane of the ocular and, therefore, the observer sees an erect image.

d. "Ocular" or "eyepiece" applies to the magnifying lens which allows the observer to see the final image. This lens presents a large, erect, virtual image of the small, real image created by the other lenses of the system. Oculars are short in focal length to give a magnified image.

e. A collimating lens is used to provide a so-called artificial infinity, that is, a virtual image at a very great distance. The function of this lens as used in the height finder is described in detail later.

6. REFLECTING PRISMS AND MIRRORS.

a. A reflecting prism is a block of glass with polished flat surfaces, so arranged that the light enters, is reflected while inside the glass, and comes out in a new direction. Reflecting prisms, of which there are several different types in a height finder, can be thought of as mirrors or combinations of mirrors. Prisms are used rather than mirrors because a prism can be mounted in a simpler and more permanent mount than the mirror could be, and can produce complicated reflections which would be impractical with mirrors.

b. The simplest reflecting prism is the ordinary *right-angle prism* in which a ray of light enters one face, is reflected by the long face of the prism, and comes out the other face (fig. 12). If the incident ray (entering ray) is perpendicular to the first face of the prism, then the angle between the incident and emergent rays is 90 degrees. If the right-angle prism is rotated in the plane of the rays, then the angle between the incident and emergent rays is altered by an amount equal to twice the angle through which the prism has been rotated. Mounts for such prisms must therefore be adjusted accurately.

c. Another very simple type of prism is the so-called *penta prism,* two of which are used in the internal target system of the height finder. The penta prism (A and B, fig. 13) reflects the light ray through an angle of 90 degrees, just as the right-angle prism does, but by two reflections from silvered surfaces. Because of the arrangement of these two reflections, turning the prism in the plane of the light rays has no effect on the reflected light ray. For this reason, this type is used in the internal target system where the angle of reflection

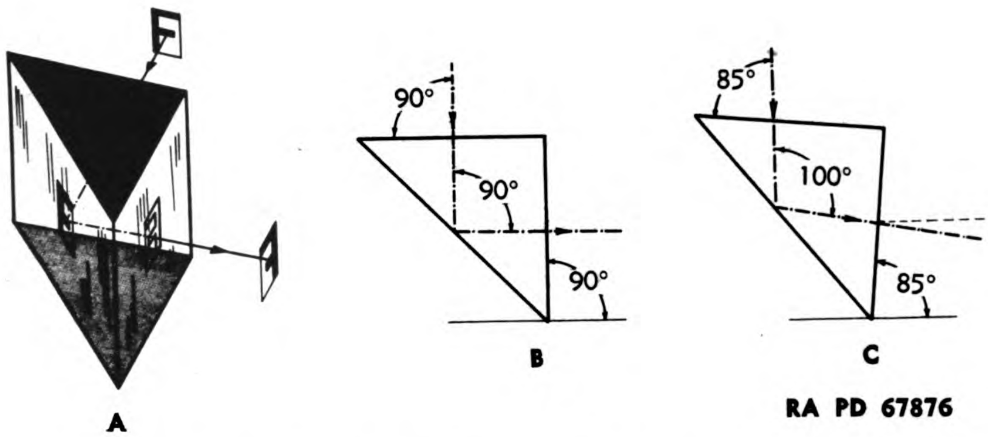

Figure 12 — Reflection by a 90-degree Prism

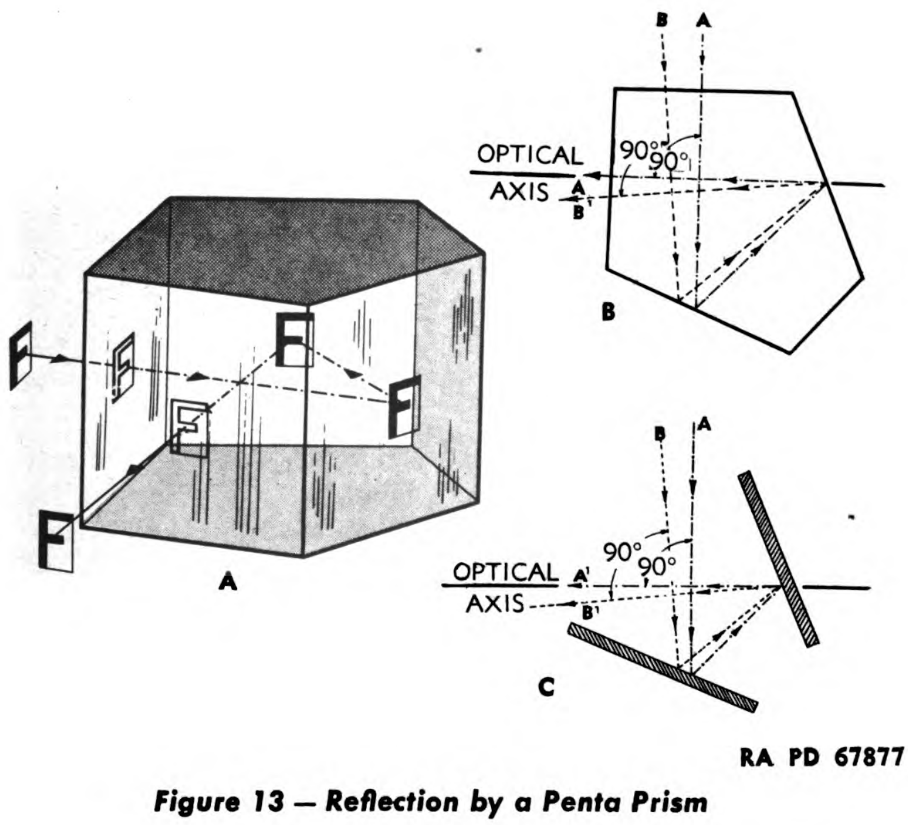

Figure 13 — Reflection by a Penta Prism

between the ray entering and the ray leaving must remain absolutely constant. Penta prisms could be used in the ends of the height finder to reflect the incoming rays from the aircraft, but in this instrument such prisms would be prohibitively large. For this reason, two mirrors are used to replace the two reflecting surfaces of a penta prism. The mount of the two mirrors as a whole is no more sensitive than that of the penta prism, but the mounting of each mirror individually is very sensitive.

d. The mirrors used in optical instruments are not the ordinary household type made of plate glass. In the first place, ordinary plate glass is not good enough optically, that is, does not have a sufficiently flat surface. This surface in an optical mirror must be obtained by grinding and polishing, just as a lens is manufactured. In the second place, the ordinary household mirror having the reflecting back surface has, in addition, a faint reflection from the front glass surface, so if such a mirror is used, for example, in place of a right-angle prism, there is a main image and, in some cases, a "ghost image" some distance to the side of it. This ghost image will not be visible if the surfaces of the mirror are accurately plane parallel, or have their reflecting surface on the front face. These are so-called first-surface or front-surface mirrors. The reflecting surface is a thin film of metal chosen for its resistance to tarnish. These metal films are easily scratched and therefore must be handled with care.

e. Another type of prism is the *double right-angle prism* (fig. 14) which may be considered as two right-angle prisms with two of their short faces in contact. Two 90-degree reflections occur in the prism, the second at right angles to the plane containing the original incident and reflected ray. Such a prism is used in the range-finder system to turn the beam into the eyepiece system. The prism actually used in this instrument is designed to depart slightly from a 90-degree angle at the second reflection, so that the eyepieces may be placed in the most convenient position for observing targets at various angles of elevation.

f. A *rhomboid prism* (fig. 15) is one in which the light ray undergoes two right-angle reflections, so that the ray emerging from the prism is displaced from, but parallel to, its original direction. The rhomboid prism and the ocular may be rotated about an axis which passes perpendicularly through the center of the rhomboid prism's forward face. This principle is used in the interpupillary adjustment of the height finder so that the fixed separation of the rays entering the eyepiece system may be varied to match the separation of the observer's eyes.

g. A *roof prism* may be thought of as a right-angle prism which has been modified so that, in reflecting the light through 90 degrees, two reflections rather than one are involved. This is to obtain an image that is correct left to right (or top to bottom) as explained later. A roof prism differs from a simple right-angle prism in that the long face, which does the reflecting in the right-angle prism, is

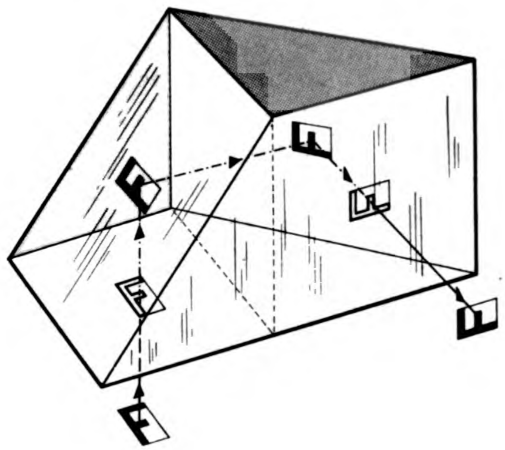

Figure 14 — Two Reflections by a Double 90-degree Prism

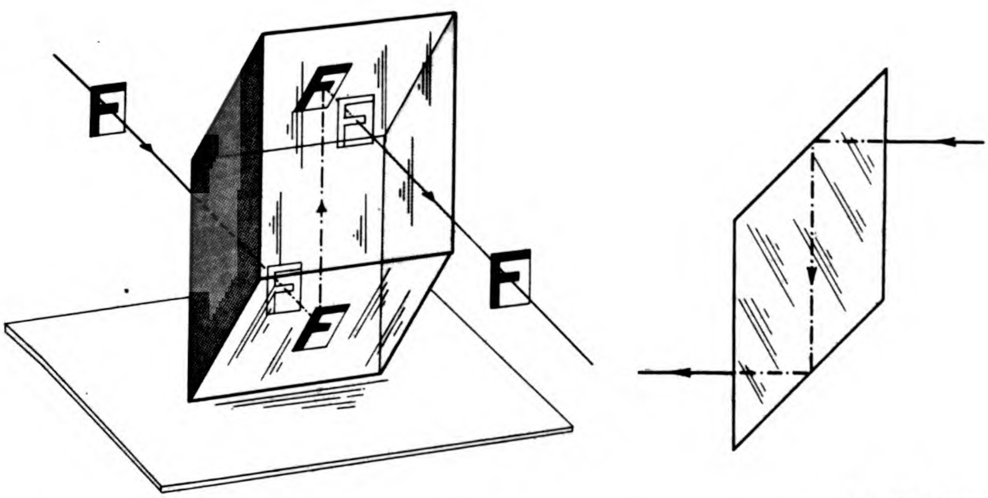

Figure 15 — Two Reflections in the Same Plane by a Rhomboid Prism

raised into a roof (fig. 16). (For ease in tracing the light ray, the perspective view shows the prism as though taken apart.) The peak of this roof has an angle of 90 degrees. As in the right-angle prism, light traveling horizontally, for example, enters one short face, strikes one side of the roof, is reflected upwards obliquely, and strikes the other side of the roof which reflects it straight upward. The light then leaves the other short face in a direction at right angles to that in which it entered the prism. Usually the parts of the roof prism not used by the light rays are removed, which affects the prism's appearance but not its fundamental shape and function.

h. One important fact about any reflections from prisms or mirrors is this: A single reflection reverses an image left to right; the image you see of yourself in a mirror is one example. A second reflection reverses it again, which makes it correct. Hence, an odd number of reflections always gives rise to left-to-right reversal, and an even number gives a correct image. This left-to-right reversal should not be confused with the inverted image created by a lens. Such an image is still correct, though inverted, but a reversed image cannot be made to look correct, no matter how it is turned around. For these reasons, it will be found that in the tracking telescopes and in the range-finder system, the total number of reflections is even, so the images are erect.

7. REFRACTING PLATES AND WEDGES.

a. When a ray of light enters any polished glass surface at any angle other than a right angle, the ray is bent or refracted, as it enters. The refracted ray makes a smaller angle with the "normal," which is an imaginary line perpendicular to the glass surface at the point where the ray enters the glass. When the ray of light leaves the other side of the glass, it is again refracted, this time away from the "normal." If the piece of glass is a plate with parallel faces, the direction of the light ray coming out is parallel to, but displaced from, the ray coming in. The more oblique the plate with regard to the light ray, the more will be the sideways shift in the light ray that leaves the plate. Such a plate is used in the height finder to obtain a slight parallel shift of light rays in the height-of-image adjustment (A, fig. 17).

b. If the piece of glass through which the ray passes is not parallel-faced but is wedge-shaped, the angles of refraction at the two surfaces are not equal, and so do not cancel one another. The emerging ray will therefore make an angle with the ray's original direction. Such a device is called a refracting prism or wedge. The greater the angle between the two sides of the wedge, the more the light is deviated. It also happens that the different colors of light making up white light are not all refracted to the same extent, that is, the colors are dispersed by an amount depending on the type of glass. It is possible, however, to combine two prisms of different types of glass so that the combination still deviates the beam as a whole with negligible dispersion of the colors (D, fig. 17). This combination is called achromatic, that is, free from color. The same principle is used in many lenses. This accounts for the use of positive and negative lenses used together, either cemented or air-spaced. (Negative lenses are thinner in the center than at the edges.) Were this correction not made in the refracting prisms and lenses in the height finder, the image would be blurry and fringed with color.

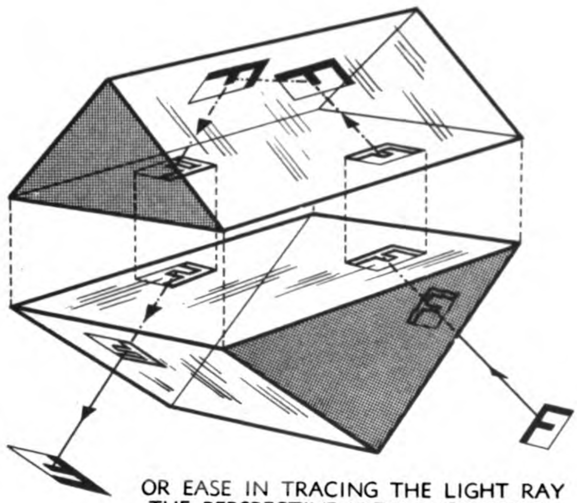

Figure 16 — Ray Reflected Twice by Roof Prism

8. THE BASIS OF RANGE FINDING.

a. Since the height finder is merely the combination of a range finder and an elevation angle measuring device, it is, therefore logical to explain range finding first. In figure 18, "O" and "Q" schematically represent the two end windows in a range finder, and the outer black line represents the range finder tube. The range finder is sighted on the distant object so that rays coming from the distant object enter opening "O" at right angles to the long axis of the instrument. From the very distant object "E," the rays of light "EB" and "E'A," entering "O" and "Q," are parallel. To see the effect on the light ray entering "Q," suppose the object is moved up to position "D." As before, the instrument is so lined up that the ray entering "O" from "D" is still at right angles to the instrument. But now the light ray "DC" makes a considerable angle with the original light ray that came from "E." In other words, the angle between "DB" and "DC" increases as the object gets closer to the range finder.

b. It is not practical to measure the angle without changing the direction of the ray "DC." Actually, as the ray "DC" enters the opening "Q," a means is provided to deviate the ray back to the position "A." The means of deviating is by the use of a glass wedge arrangement of variable power or deviation. Since "D" may be at any distance—in other words, since the angle at "Q" may be any one of a number of angles—a wedge arrangement whose power can be varied is used. In "B" (fig. 18), the wedge is shown at "Q" deviating the

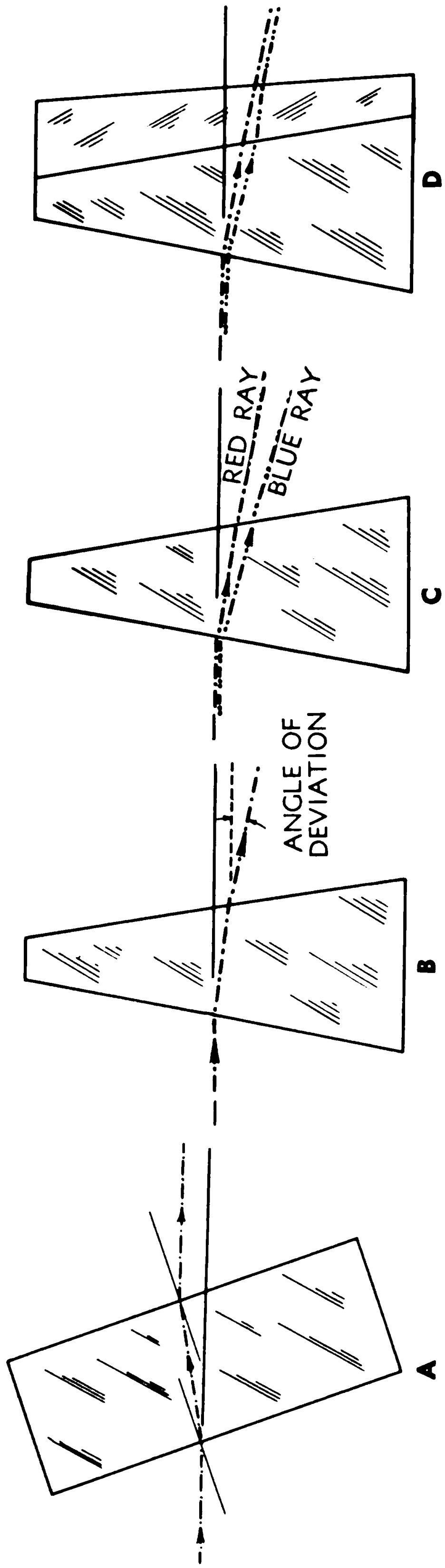

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Figure 17 — Displacement of a Ray by a Parallel Glass Plate and Deviation by a Wedge

PRINCIPLES OF OPERATION

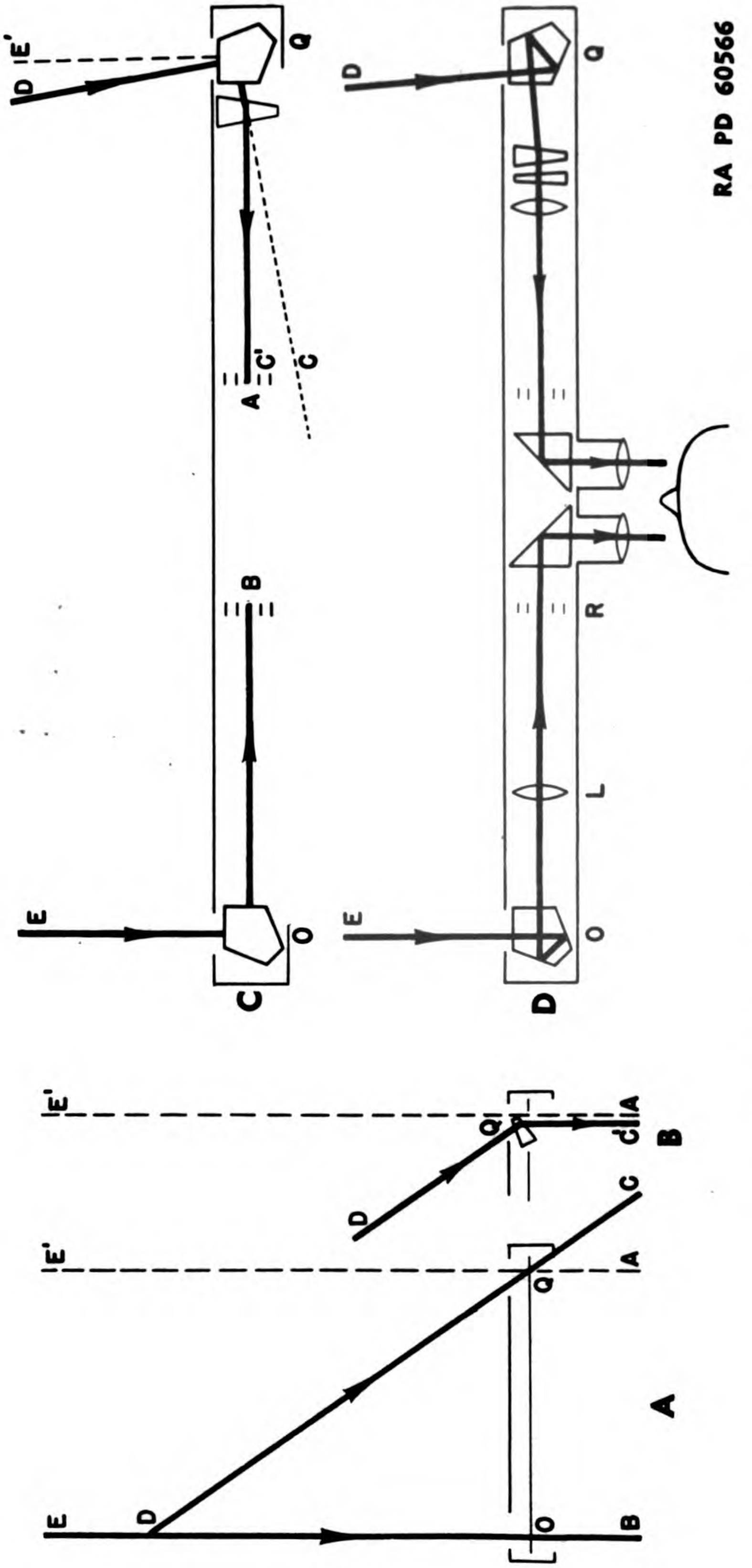

Figure 18 — Path of Ray of Light Through a Simple Range Finder

ray "DC" over to "C" which coincides with "A." The line is shown separately to clarify matters. Actually, "A" and "C" are the same point. Such a variable wedge can be obtained by a combination of two wedges in a manner to be described later. The angle, and therefore the distance of the object, can be measured from the amount of deviation of the light ray needed from the wedge. Mathematical relationships are of course involved in this, but it is possible to actuate a suitably engraved scale by the adjustment that varies the deviation of the wedge so that the scale reads distance directly.

c. The problem comes up of how it can be told when the light from "D" has been deviated sufficiently so that it does coincide with "A." The method used is shown in "C," figure 18. The two rays from "D" are each reflected through a right angle at "O" and "Q," so that both come toward the center of the instrument and both fall on scales at "B" and "A." When the ray from "Q" is deviated the proper amount by the wedge, it will strike the same point on the scale "A" as the ray from "O" strikes on the scale "B." When the two rays do strike the same part of each scale, actually the center of the scale, the range or distance from "O" to "D" can be determined by the amount of deviation introduced by the wedge.

d. The simplest way of seeing where the light rays strike the scales is to make the light rays form images of the distant object which will fall on the scales in such a way that the images can be seen. This is done as shown in "D," figure 18. Each ray from "D" is reflected toward the center of the instrument by a penta prism at "O" and "Q." The penta prism is used instead of a right-angle prism for reasons explained previously. The ray from "O" enters the objective lens "L," which forms an image of the object "D" at the scale "R." The scale consists of a series of lines on a transparent glass plate, known as a reticle. The image of "D" is, therefore, seen against these lines. The light rays then proceed from "R," are reflected out by a prism, and pass through an ocular so that the reticle and image at "R" can be easily seen by the observer. By this means, the observer can see both reticles and images, one with each eye. The ray on the right side of the system coming from "Q" behaves in the same way, except that the variable wedge in front of the objective brings the ray to the proper place on the right-hand reticle.

9. THE IMAGE-FORMING SYSTEM.

a. There are several additional image-forming optical parts in the system. Each side of the system can be thought of as a telescope. In fact, the range finder amounts to a telescope for each eye with parts added for the purpose of range finding. A simple telescope is shown in figure 19. A distant object is imaged by the objective in an inverted manner, and the reticle is located at the image position. The

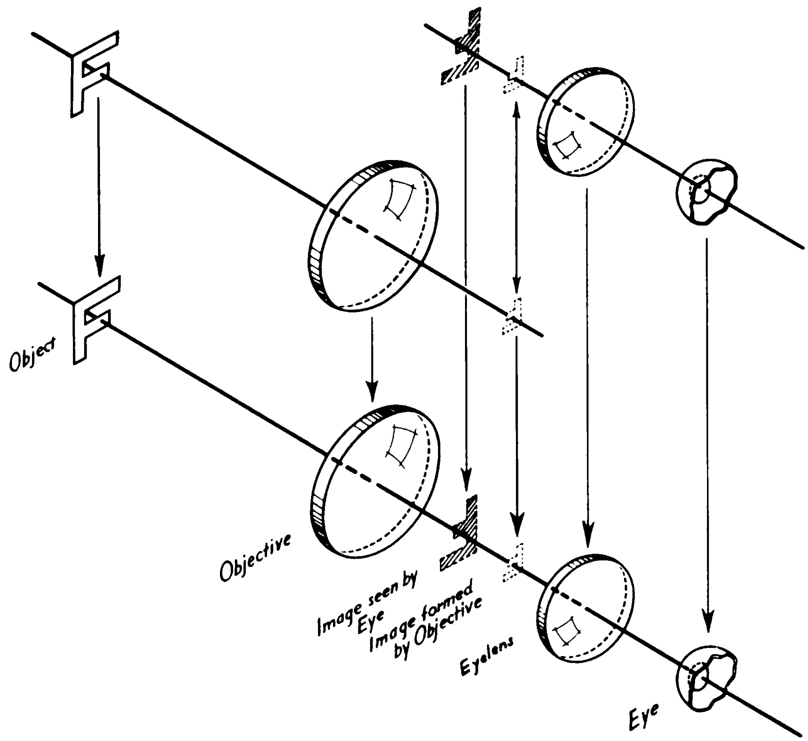

Figure 19 — Optics of a Simple Telescope Which Produces an Inverted Image

ocular acts as a magnifier to present an enlarged virtual image of this inverted image to the eye.

b. Seeing a distant target inverted is not convenient in stereo range finding, so another element is added to the telescope system to provide a right-side-up or erect image. The added element is the erecting lens. Figure 20 shows the erecting lens placed at a suitable distance in back of the inverted image so that it forms an erect image still farther back. The focal length of the erecting lens is such that, when in the position indicated by the dotted lines, the erect image is larger than the inverted image. The ocular is located behind the erect image; therefore, the eye sees a large erect virtual image. In fact, it is larger than the image from the simple system in figure 19.

c. The addition of the erecting lens not only provides an erect image, but also makes it possible to change the size of the image. If the erecting lens is moved to the position indicated by the dotted lines, the erect image will be larger than the inverted image. By proper choice of the two positions of the erecting lens, the erect image in both cases can be brought in focus at the same setting of the eyepiece. Figure 20 is suitable for demonstrating the principles in-

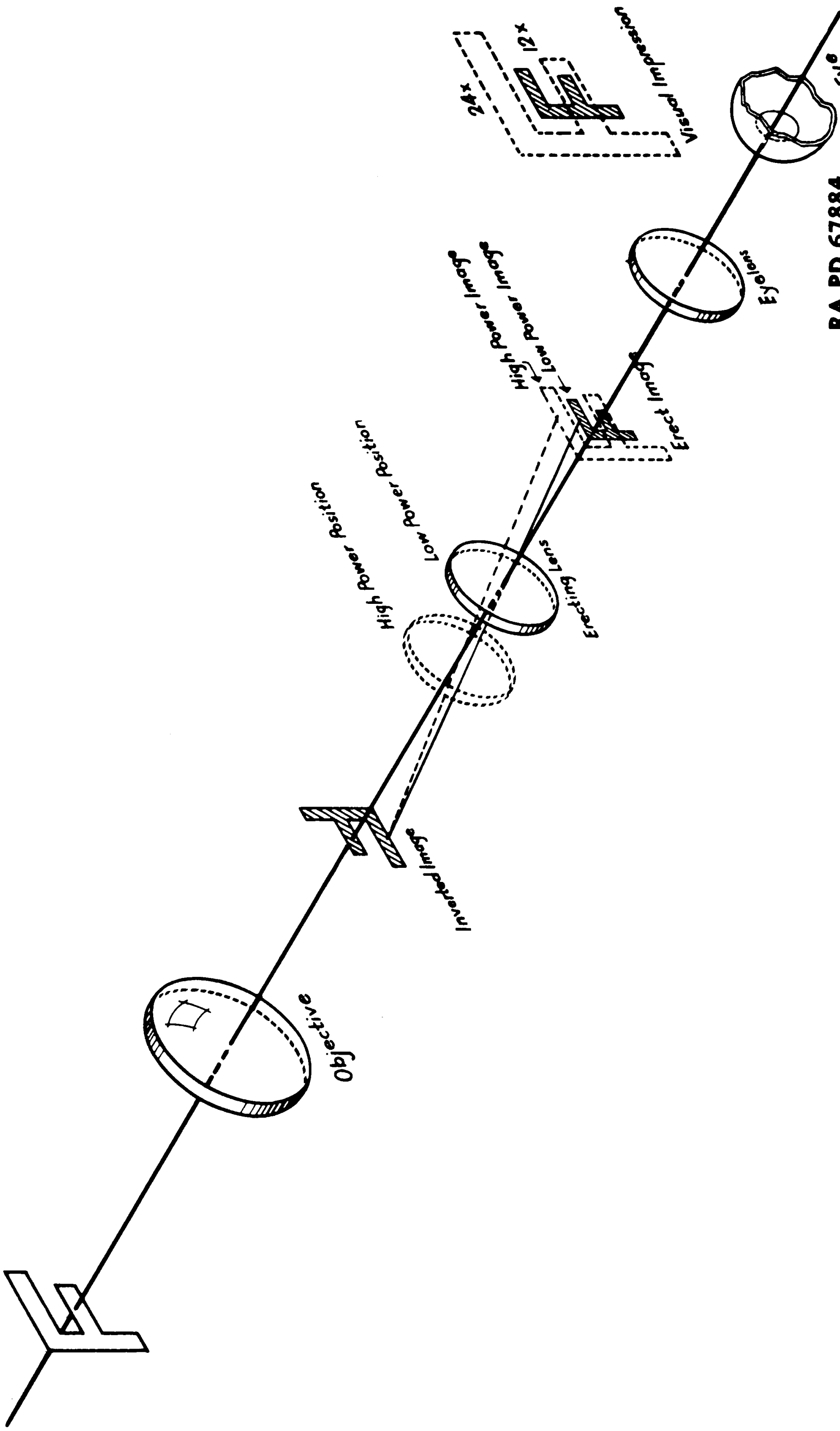

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Figure 20 — Addition of Erecting Lens to Telescope — The Two Positions of This Lens Offer a Choice in Magnifying Power

volved in erection and change of magnification. However, in the Height Finder M2, additional elements are involved before erection and change of magnification are accomplished. These elements are shown with considerable simplification in figure 22. The lens cemented to the ocular prism collimates the light from the target image formed by the main objective; the negative lens forms a virtual image of the target image; and the change-of-magnification lens forms an image of this target image in the focal plane of the eyepiece. The change-of-magnification lens may occupy two positions; in the lower position the magnification of the instrument is 24x and in the upper position, 12x. Change of magnification is desirable because high magnification, under ideal weather conditions yields greater precision in range or height measurements. Since a wider angle of sky is included at low power, the 12x-setting is generally, used for preliminary ranging. In addition to the change in image size, there is another change of practical importance. When the image is small, assuming all the rays from it can enter the pupil of the eye, it appears brighter because all the light available to form the larger image is compressed into the smaller image. This is decidedly helpful at dawn, dusk, or night and, in general, when visibility is poor.

d. The telescope system shown in figure 21 is not practical, because the rays from the objective which go to the outside edges of the system would pass by the erecting system, as shown by the dotted lines in figure 21. In this case, only the rays from the center part of the image would enter the erecting system, and therefore only the center part of the image could be seen. For this reason, a collective lens is added, right at the inverted image. This lens converges the light beams after they form the image so that all rays enter the erecting system. Therefore, the erect image is not cut off at its edges. Since the lens just added is at the first image, and since the reticle scale must also be at the same image, the reticle scale is simply engraved on a thin glass plate cemented to the flat face of this collective lens.

e. The question naturally comes up as to what converges the rays forming the erect image into the ocular. Actually, no provision is needed, since the image is small and close to the ocular. The drawing, in the interests of clarity, shows the image very much out of scale. The erect image, particularly, is shown much larger in relation to the eyepiece than is actually the case.

f. In figure 22 are shown, diagrammatically, the various image-forming elements in the main system of the Height Finder M2. Such simple elements would produce very unsatisfactory images and, therefore, other elements must be added. The additional image-forming elements required may be seen by comparing figures 22 and 32. In

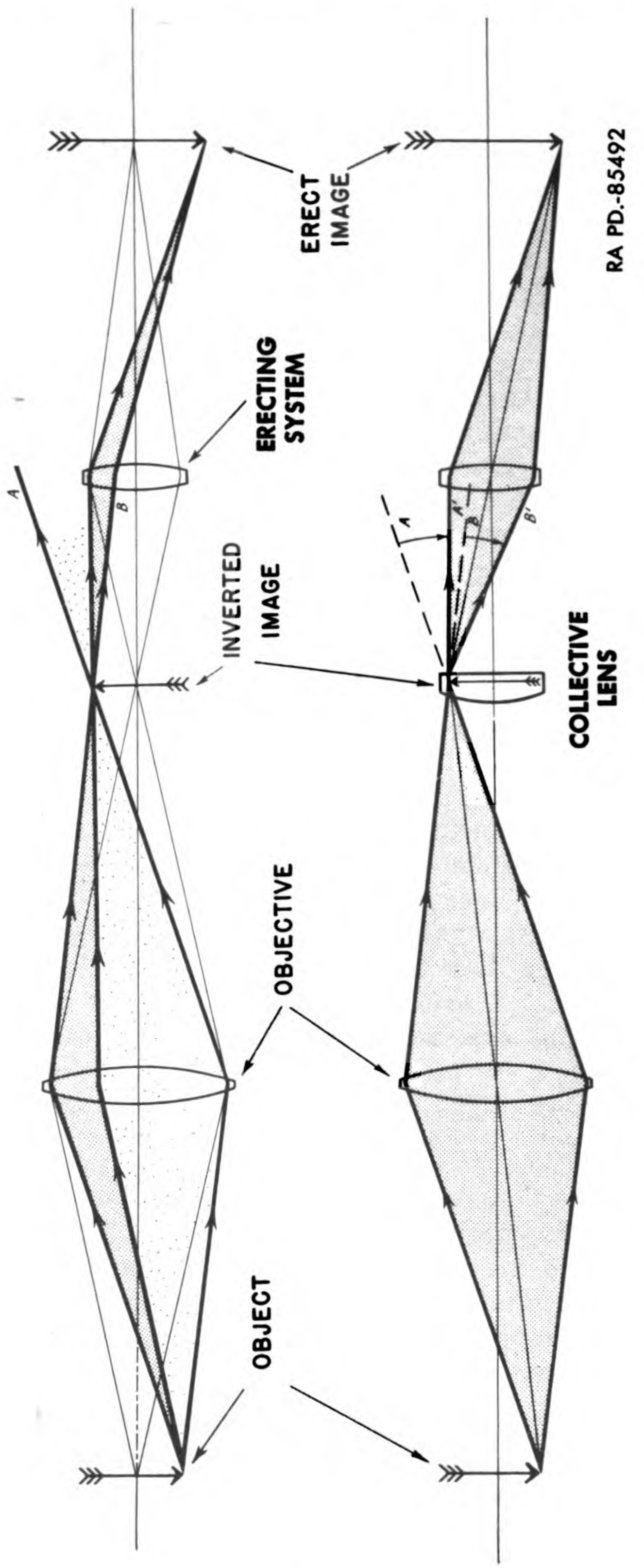

Figure 21 — The Collective Lens Deviates Beams, Such as AB at A'V' To Enter the Erecting System and Hence Form the Edges of the Erect Image

PRINCIPLES OF OPERATION

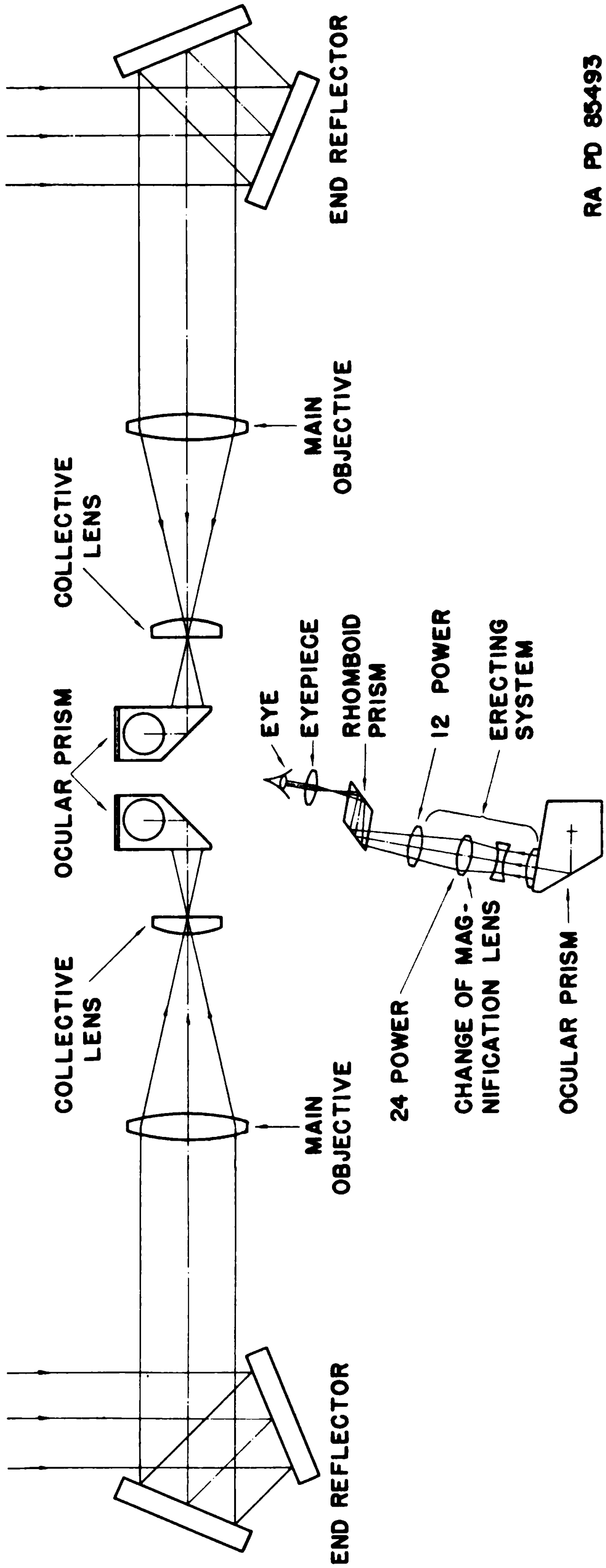

Figure 22 — Simplified Diagram of Image-forming Elements of Height Finder M2

addition to these lenses, end reflectors and prisms are used to direct the light from the target into the eyes of the observer.

10. THE RETICLES AND STEREOSCOPIC VISION.

a. As stated before, the height finder is correctly adjusted when each image of the aircraft falls at the same point on each of the two scales. It is not necessary for the observer to measure the images with reference to their exact position on the scale; in fact, this is impractical with a target in motion. Because of the depth sense resulting from two-eyed or stereoscopic vision, it is possible to tell immediately whether or not the images fall at the corresponding points in the two fields. Exact correspondence in position makes an apparently single aircraft image float in space in the same plane as an apparently single reticle scale. If the images do not fall at a corresponding point on the two fields, the aircraft image appears to fall in the space behind the scale or in front of it, depending on the right or left displacement across the field of one image relative to the other. Each aerial image itself does not fall behind or in front of the reticle; it is always in the same plane as the reticle. It is because of the relative positions of the two aircraft images across the two reticles that the sense of depth results. This depth sense or stereoscopic effect can be illustrated in the following way: Figure 23 represents a flat board with three pins located across the board. The observer's eyes are indicated at "L" and "R." The triangle stands on the board on the side of the pins farthest from the observer and between two of them. The left eye sees the triangle fairly close to the center pin, as shown; the right eye sees the triangle as farther to the *right*. Likewise, the ball on the near side of the pins is displaced to the left in the right-eye view. The two eyes therefore see different images of the same scene. This is the basis of all stereoscopic vision and depth sense. Look at the objects about you first with one eye, then with the other. You are conscious of a difference in the relative positions of various objects as seen by the two eyes. In this connection, it is interesting to look at several pencils along the line of sight of one eye. To the other eye, they appear quite different in position. If the two photographs for a hand stereoscope are examined, they will be seen to differ, particularly in the position of nearby and very far objects. These differences, then, in the images inside the two eyes, whether they arise from looking at an actual scene or from looking at two different photographs or two different drawings, result in a mental sense of depth. Therefore, if the two views in figure 23 are looked at in the stereoscope, even though the drawings are flat, the difference in position of the triangle immediately gives rise to the sensation that it is farther away than the pins. Similarly, the ball appears on the near side.

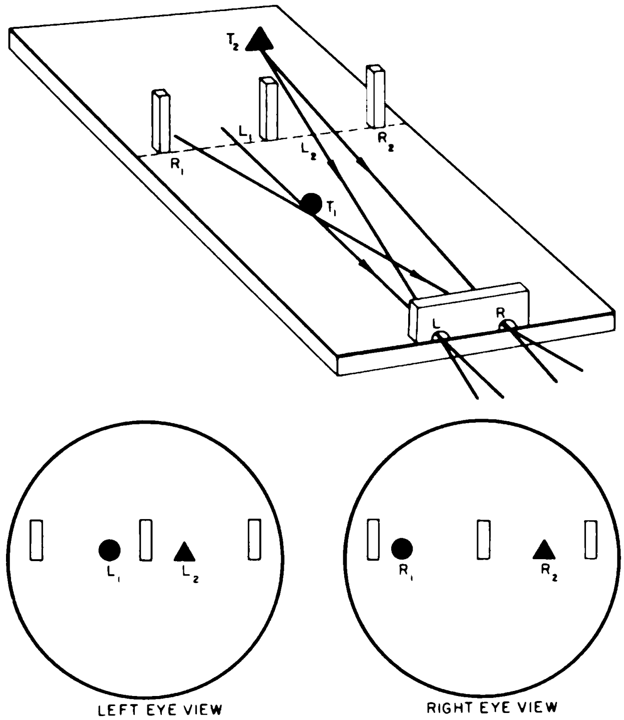

Figure 23 — Differences Between Right- and Left-eye Views in Stereoscopic Vision

b. Therefore, if the row of lines in figure 23 are now regarded as the main scales of the right and left reticles of the height finder, and the image of an aircraft is placed in the position of the triangle, the observer will immediately sense the aircraft image as behind the main reticle scale. The observer then operates the wedges in the height finder until the two images occupy the exact corresponding positions in the two fields of view. Stereoscopic vision then makes the aircraft appear in the same plane in space as the main reticle scale. The instrument is then correctly adjusted and the range drum scale can be read.

c. Actually, the aircraft image need not come among the scale divisions or close to any of them. It can come anywhere in the field and, as long as its position in both fields corresponds exactly with reference to the main reticle scale, it is seen in the same plane as the scale, that is, stereoscopic contact is obtained. It is of course simpler to make the adjustment if the aircraft image is just above the main reticle scale.

d. The reticles consist of more than a main scale identical in both. Additional marks are added and are made sufficiently different in position in the two fields so that, because of the observer's depth

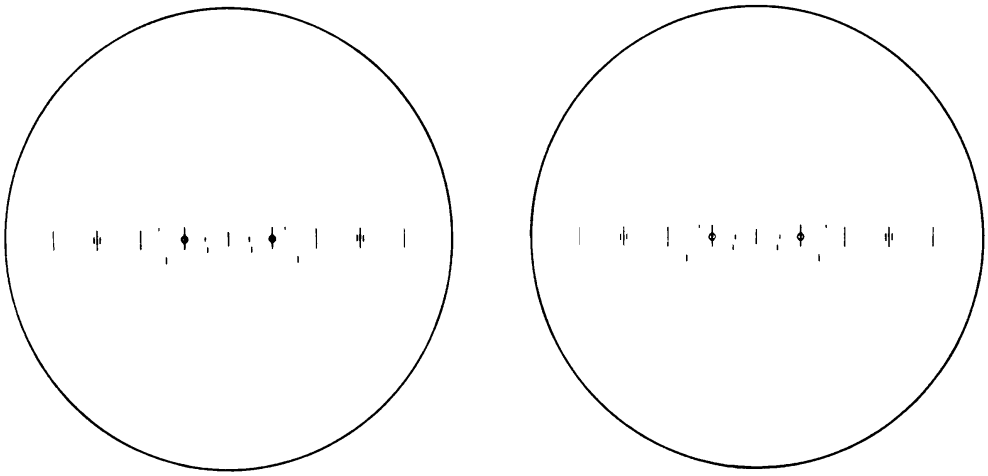

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Figure 24 — Appearance of Left- and Right-eye Reticles From Ocular Side

sense, the marks appear to fall in front of or behind the main scale. The presence of these "fore and aft" marks aids in the observer's judgment of the target's position in space. Note in figure 24 that the upper mark, to the right of the central mark, is relatively farther to the right in the right-eye scale than the corresponding mark in the left-eye scale. When viewed stereoscopically, this causes the mark to appear farther from the observer than the main scale. The outermost mark lying above and to the right of this mark differs still more in its relative displacement to the right, and it therefore appears to lie even farther away. The two marks above and to the left of the center mark also appear to recede because of their displacement. By reversing the relationship, marks engraved below the main scale appear to lie closer to the observer than the main scale. That is, for a given mark, the right-eye mark is displaced toward the left. The result of the placing of these marks is a series of optical "fence posts" whose pattern makes an X lying in space, as shown in figure 25. The observer can see whether the image of an aircraft is in the plane of the farthest pair of marks, the next pair, or the main scale, and so on. The appearance of the aircraft among these various planes aids the observer in adjusting the instrument. It is also possible to use these marks to locate shell bursts behind or in front of the aircraft.

11. COMPENSATOR WEDGES (MEASURING WEDGES).

a. The ability to displace or deviate one image, which is required to bring the two images of the target into stereoscopic contact with the reticle marks, is offered by the compensator wedges. While the

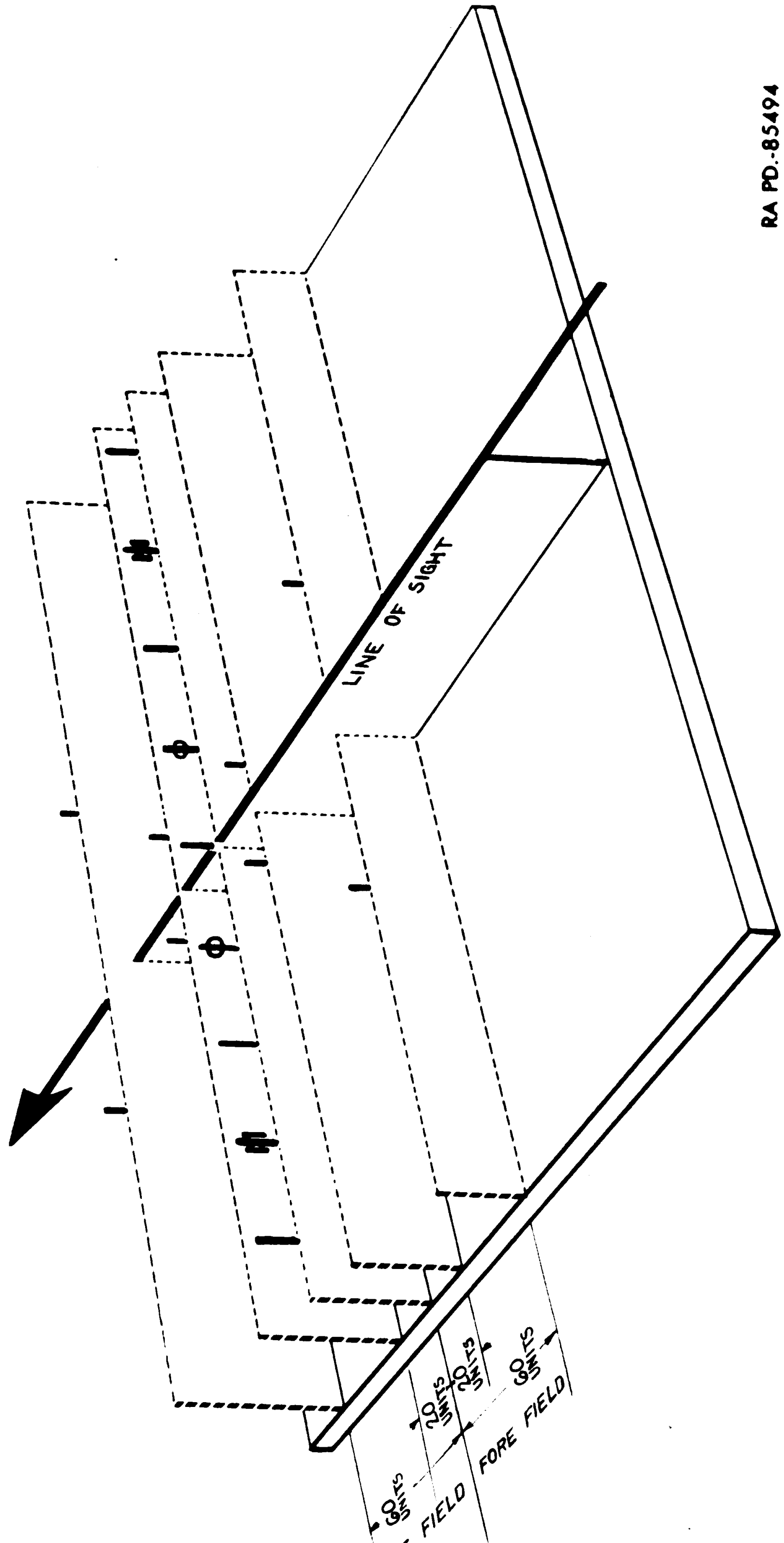

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Figure 25 — Stereoscopic Impression of Reticle Markings

compensator wedge unit actually contains four individual wedges, each composed of two pieces of glass to make it achromatic, the whole unit affects the displacement of the right-hand image to the right or left, like a single wedge of variable power.

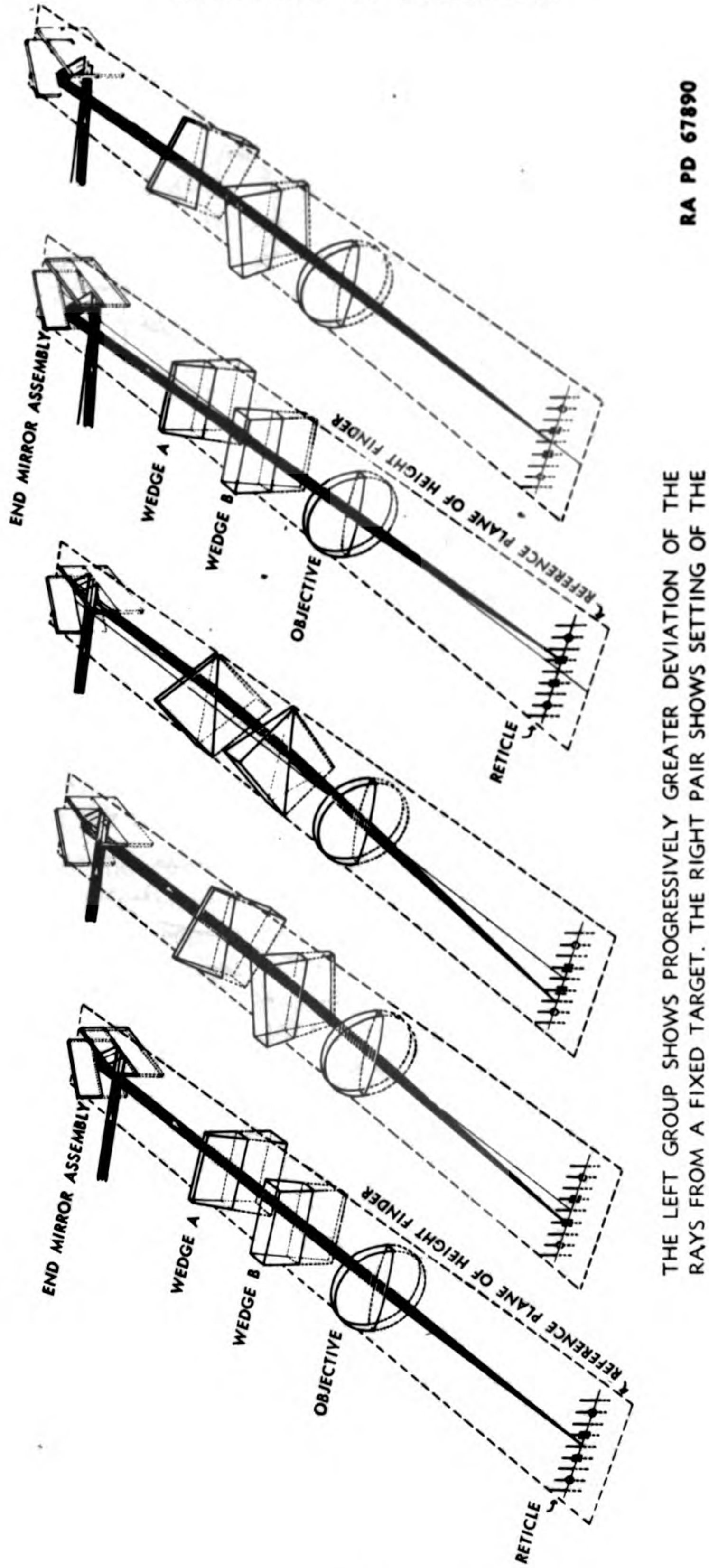
b. The variable power, which produces the variable deviation, is produced by rotating the wedges with respect to each other. The effect can be illustrated by the following mechanical analogy: Consider two wooden shingles placed with both butts together and both thin edges together. The wedge angle between the outside surfaces of the two shingles will be twice that for either one alone. If, now, the shingles are turned so that the butt end of one is next to the thin end of the other, the slopes cancel each other and the two outer surfaces are parallel with no wedge effect. For various positions between these two extremes, the effective wedge angle varies from zero to twice the angle of one shingle.

c. In the same way, when two optical wedges are placed with their bases in the same direction, the wedge effects add, and the total image displacement is equal to twice that of a single wedge. If the two wedges are now rotated 90 degrees, but in opposite directions, the base of one will come next to the thin edge of the other, the wedge effects cancel, and the image is not displaced. Intermediate positions cause a displacement which increases as the base of one rotates farther from the thin edge of the other (fig. 26).

d. **Measurement of Range.** For simple measurement of range, only two individual wedges would be needed. Actually, the four wedges of the height finder system divide into two pairs—1 and 3 and 2 and 4—and, as far as the range mechanism is concerned, each pair acts as one of the single wedges of a simple measuring wedge combination (fig. 27). These wedge pairs are rotated relative to each other by a shaft and gearing from the range measuring knob. The relative positions of the wedge pairs 1 and 3 and 2 and 4 determine the readings of the scale on the range drum which is also geared to the measuring knob shaft assembly. The scale is calibrated to read the range directly, in yards, which corresponds to the deviation produced by the wedge setting. In order to make the scale long enough for convenient and accurate reading, the gearing is arranged to make the drum turn much faster than the wedges. The graduations on the scale are not uniformly spaced, but come closer together at the high end of the scale.

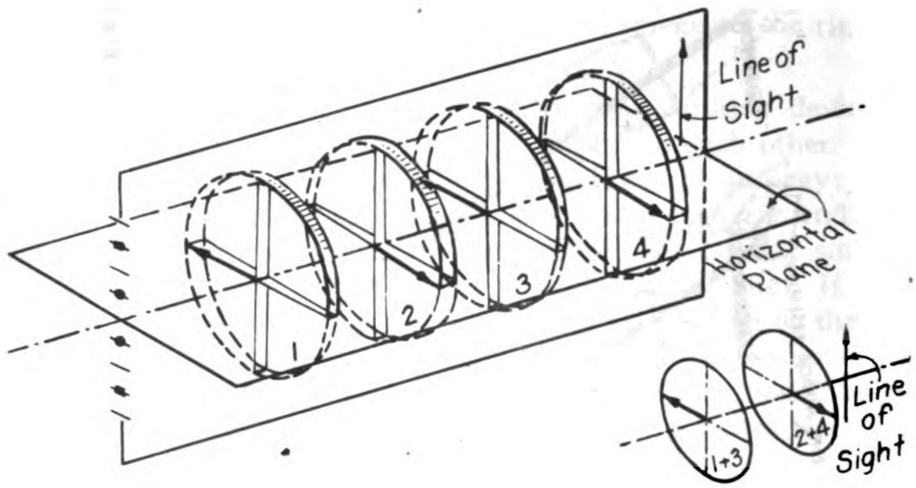
e. **Measurement of Height.** In antiaircraft fire control, it is the height or altitude of the target that is determined by the height finder. The height conversion mechanism automatically combines the range along the line of sight from the instrument to the target, and the elevation angle to determine the vertical height which is shown di-

PRINCIPLES OF OPERATION

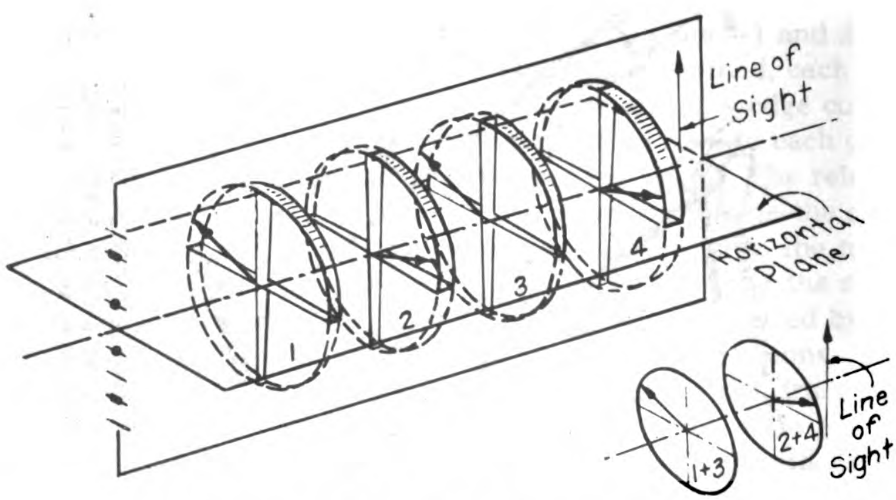


THE LEFT GROUP SHOWS PROGRESSIVELY GREATER DEVIATION OF THE RAYS FROM A FIXED TARGET. THE RIGHT PAIR SHOWS SETTING OF THE WEDGES TO CENTER THE RAYS FROM A TARGET.

Figure 26 — Action of Two Wedges Operating for Range Measurement



A. Compensator Set for Height Infinity



B. Compensator Set for Medium Height

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Figure 27 — Action of Measuring Wedges — Line of Sight Vertical

rectly on the scale of the range drum. This conversion takes place continuously as the elevation tracker keeps the instrument alined on the target. *Thus, the reading on the drum is constant for an aircraft in level flight, even though the range is changing.* Since the variations of target height are normally quite small, stereo contact can be made and maintained on a flying target in spite of the rapidly changing range. This frees the operator from the strain of trying to keep pace with continuously changing readings, and enables him to make more deliberate and accurate stereoscopic settings.

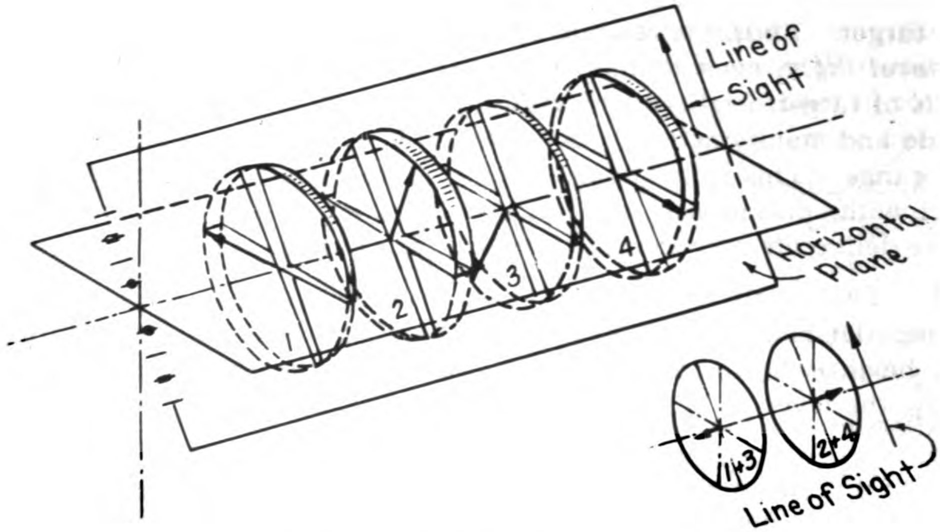
f. The height conversion mechanism is put into operation by lifting the height-range lever from the range position, and rotating the height-range conversion ring around the height finder tube to allow the lever to be locked in the height position.

g. When the target is directly overhead, the range and height are identical. When the height finder is elevated to make the line of sight vertical, the range and height positions coincide, and the locking lever can be thrown to either position without moving the height-range ring. For any direction other than vertical, the range is greater than the height, but the conversion mechanism changes the deviating power of the range wedges. Thus, when the drum, and therefore the range wedges, are rotated to the position which shows the height in yards, the deviation actually produced by the wedges corresponds to the range of the target.

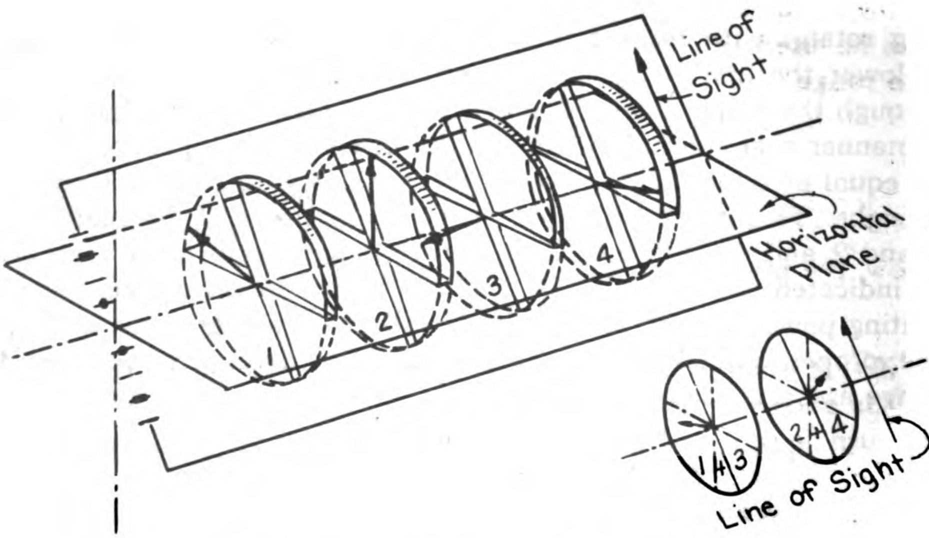
h. When the conversion mechanism is set for height, the conversion ring is fastened to the stationary bearing housing, so that the ring rotates with respect to the tube as the height finder is turned to lower the line of sight from vertical. This motion is transmitted through the height conversion gears to the measuring wedges in such a manner that the individual wedges in each range pair are rotated by equal amounts, and in opposite directions with respect to the line of sight. This mutual rotation of the components of the pairs 1 and 3 and 2 and 4 turns the bases of the wedges away from each other as indicated in figures 27, 28, and 29. This reduces the effective deviating power of each pair, as explained in subparagraph c, above, by the proper amount to compensate for the difference between the range and the height of the target.

12. ACCURACY—THE UNIT OF ERROR (UOE).

a. Based on the uncertainty of observation, an error is introduced in ranging by the observer himself, and this error must be taken into consideration in evaluating the accuracy of the instrument. It has been found that, in using the stereoscopic principle, the average observational error among competent observers represents an angle of 12 seconds at the eye. This disparity angle, known as the *unit of*



A. Compensator Set for Height Infinity



B. Compensator Set for Medium Height

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Figure 28 — Action of Measuring Wedges — Line of Sight Inclined

error (UOE), and expressed in radians for convenience, enters into all calculations for yardage errors in ranging. For example, the UOE multiplied by the square of the range in yards, and divided by the product of range finder base length and magnification, will give the error in yards (known as "range error equivalent to 1 unit of error") based on the uncertainty of observation.

b. As mentioned above, the ranging error in yards, based on the uncertainty of observation, can be calculated from the formula:

$$\text{error in yards} = \frac{\text{UOE} \times R^2}{B \times M}$$

where UOE is the unit of error expressed in radians, **R** is the range in yards, **B** is the base length, and **M** is the magnification. Since one radian is equal to 206,265 seconds, the UOE becomes $\frac{12}{206{,}265}$ or approximately 0.0000582 radians. The base length is 4.5 yards, and the magnification 12 or 24, depending on the position of the change-of-magnification lever.

Example:

What is the probable error (E) in ranging a target at 5,000 yards, using a magnification of 24?

$$PE = \frac{0.0000582 \times 5000^2}{4.5 \times 24} = 13.5 \text{ yards}$$

c. It is evident that UOE and base length are constants, so a multiplying factor can be calculated for the two magnifications which can be used to obtain the probable error direct from the square of the range.

$$\text{Factor for 12 power } (F_{12}) = \frac{0.0000582}{4.5 \times 12} = 0.00000108$$

$$\text{Factor for 24 power } (F_{24}) = \frac{0.0000582}{4.5 \times 24} = 0.00000054$$

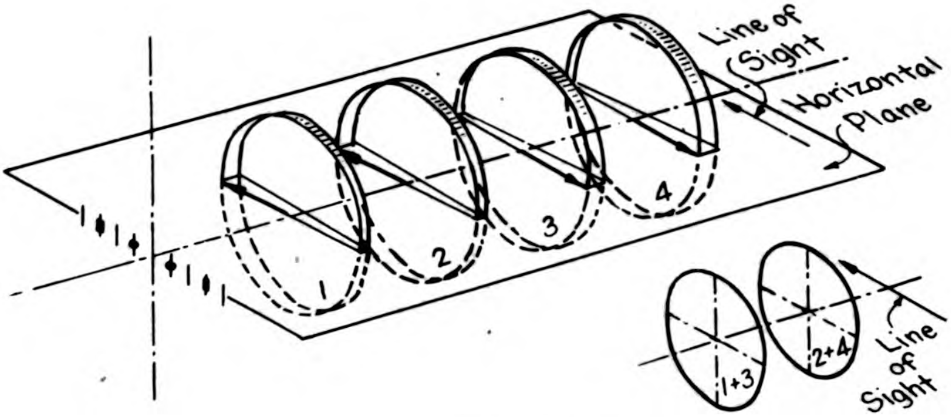
Now, the previous calculation becomes:

$$5000^2 \times 0.00000054 = 13.5 \text{ yards}$$

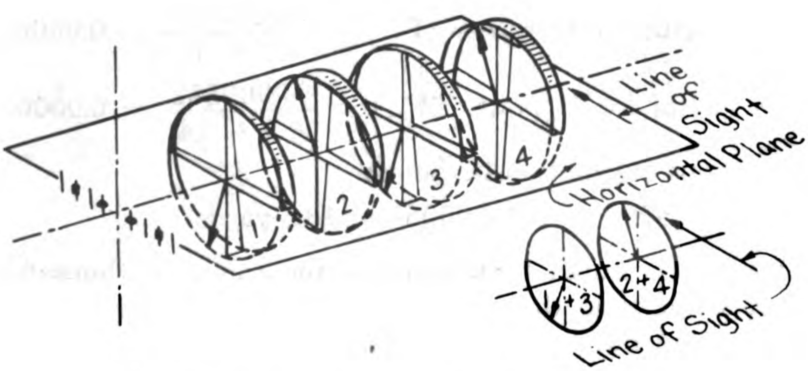
d. It should be noted that squaring the range in thousands of yards adds six places to the square of the "thousand" figures, which in turn is canceled out by the number of places in the multiplying factors F_{12} and F_{24}. These, then, become 1.08 and 0.54, respectively, as multipliers for the square of the first significant figures.

$$5^2 \times 0.54 = 13.5 \text{ yards}$$

e. Now, since these factors approximate 1 and ½, respectively, a sufficiently accurate (within 10 percent) result can be obtained mentally by squaring the figure representing thousands of yards when



A. Compensator Set for Height Infinity



B. Compensator Set for Medium Range

RAPD 85497

Figure 29 — Action of Measuring Wedges — Line of Sight Horizontal

low power is used, or taking one-half the square when high power is used.

$$\frac{5^2}{2} = 12.5 \text{ yards (for high power)}$$

f. Obviously, the calculation of probable error results in a plus or minus figure, that is, the range may be read long or short of the target by the number of yards indicated. Also, the above examples are based on one unit of error, while the tolerance allowed for the instrument itself is higher. Even so, it is evident that measurements of high precision are still obtainable. The height error which arises from uncertainty of observation is less than the range error, in the same proportion that height is less than range. However, height measurement is affected by other factors, such as inaccuracy in leveling the instrument and atmospheric conditions. The effect of these two factors is greatest at low elevation angles.

Section III

DESCRIPTION

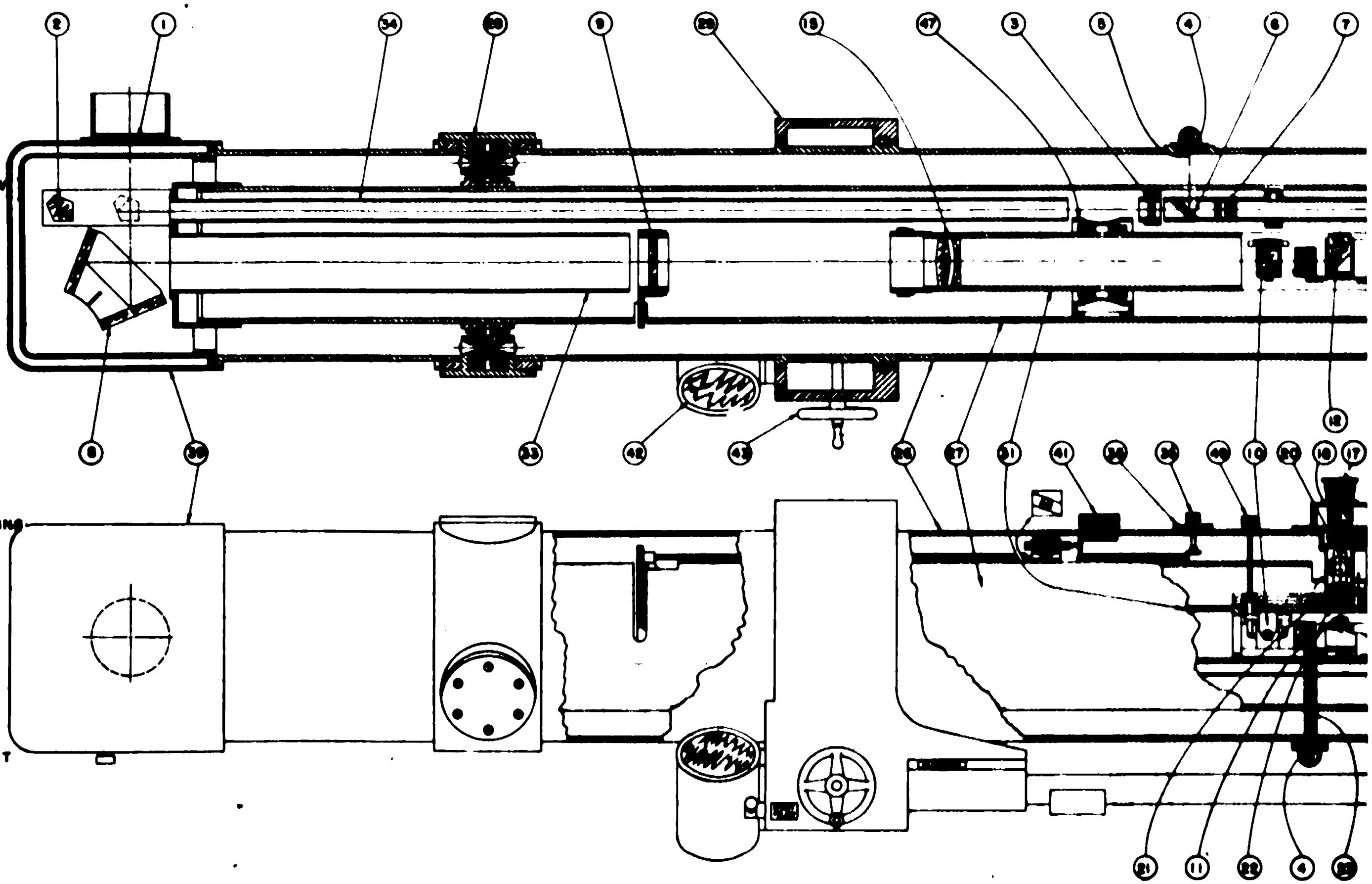
13. MECHANICAL AND ELECTRICAL ARRANGEMENT OF THE HEIGHT FINDER TELESCOPE.

a. General. The main structural elements of the Height Finder Telescope M1 consists of three tubes: the main outer and inner tubes, which together form a double-walled body tube, and the optical tube. The outer tube serves as a main frame, and carries the exterior mechanical and optical units. It also supports the inner tube which, in turn, supports the optical tube containing some of the major optical units. The inner tube is so mounted that all the central optical units and end reflectors can be rotated, thereby providing a fine elevation adjustment. The outer tube is covered with a layer of heat insulating material of hair felt covered with canvas to retard temperature changes in the height finder and for added protection against rough handling.

b. Sealing.

(1) The height finder telescope is hermetically sealed* and filled with desiccated (dried) helium, thus preventing the internal optical parts from becoming fogged due to condensation of moisture resulting from temperature changes. All adjustment of movable parts inside the instrument is effected through rotating shafts which enter the tube through airtight packing glands.

*Due to unavoidable leakage, periodic desiccation (drying) is needed.



1. WEDGE END WINDOW
2. COLL. ADJUSTER PENTA PRISM
3. COLL. ALINEMENT WEDGE
4. ILLUMINATOR CLEAR WINDOW
5. ILLUMINATOR FROSTED WINDOW
6. COLLIMATOR MIRROR
7. COLL. OBJECTIVE RETICLE
8. END REFLECTORS
9. CORRECTION WEDGE
10. HEIGHT ADJUSTING DISK
11. RETICLE ASSEMBLY
12. OCULAR PRISM-LEFT
13. OCULAR PRISM-RIGHT
15. MAIN OBJECTIVE LENSES
20. RAYFILTERS
21. ERECTING LENSES
22. AUXILIARY LENSES
23. RETICLE ILLUMINATING ROD
26. OUTER TUBE
27. INNER TUBE
28. INNER TUBE SUPPORT BEARING
29. OUTER TUBE SUPPORT-LEFT
31. OPTICAL TUBE
33. OBJECTIVE TUBE
34. ADJUSTER TUBE
35. CORRECTION WEDGE SCALE
36. CORRECTION WEDGE KNOB
39. END BOX
41. FINE ELEVATION KNOB
42. ELEVATION RECEIVER
43. ELEVATION HANDWHEEL
47. OPTICAL TUBE GIMBAL JOINT
49. HEIGHT ADJUSTER KNOB

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Figure 30 — Schematic Sectional Views of Height Finder Telescope — Left Side

DESCRIPTION

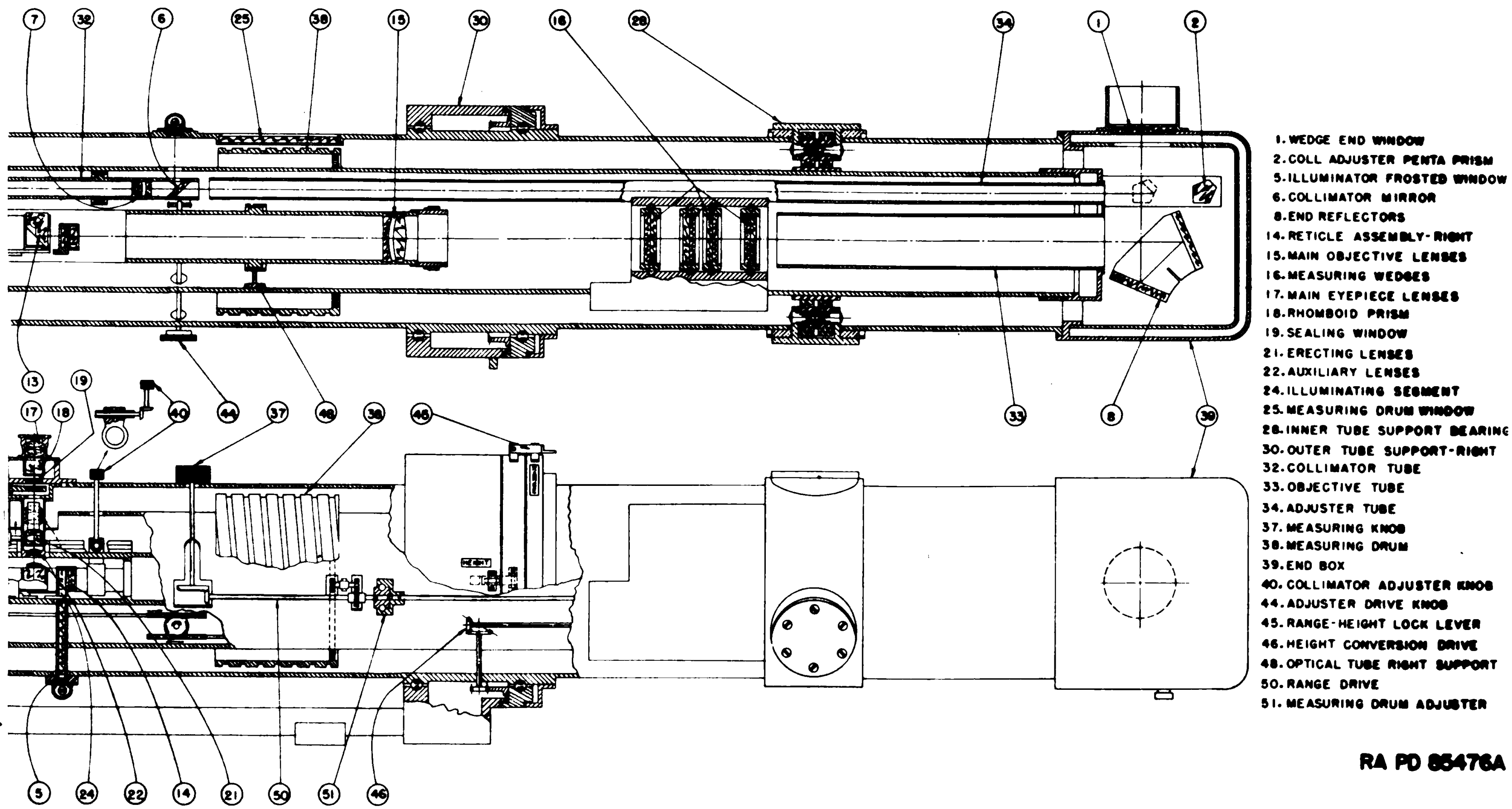

Figure 31 — Schematic Sectional Views of Height Finder Telescope — Right Side

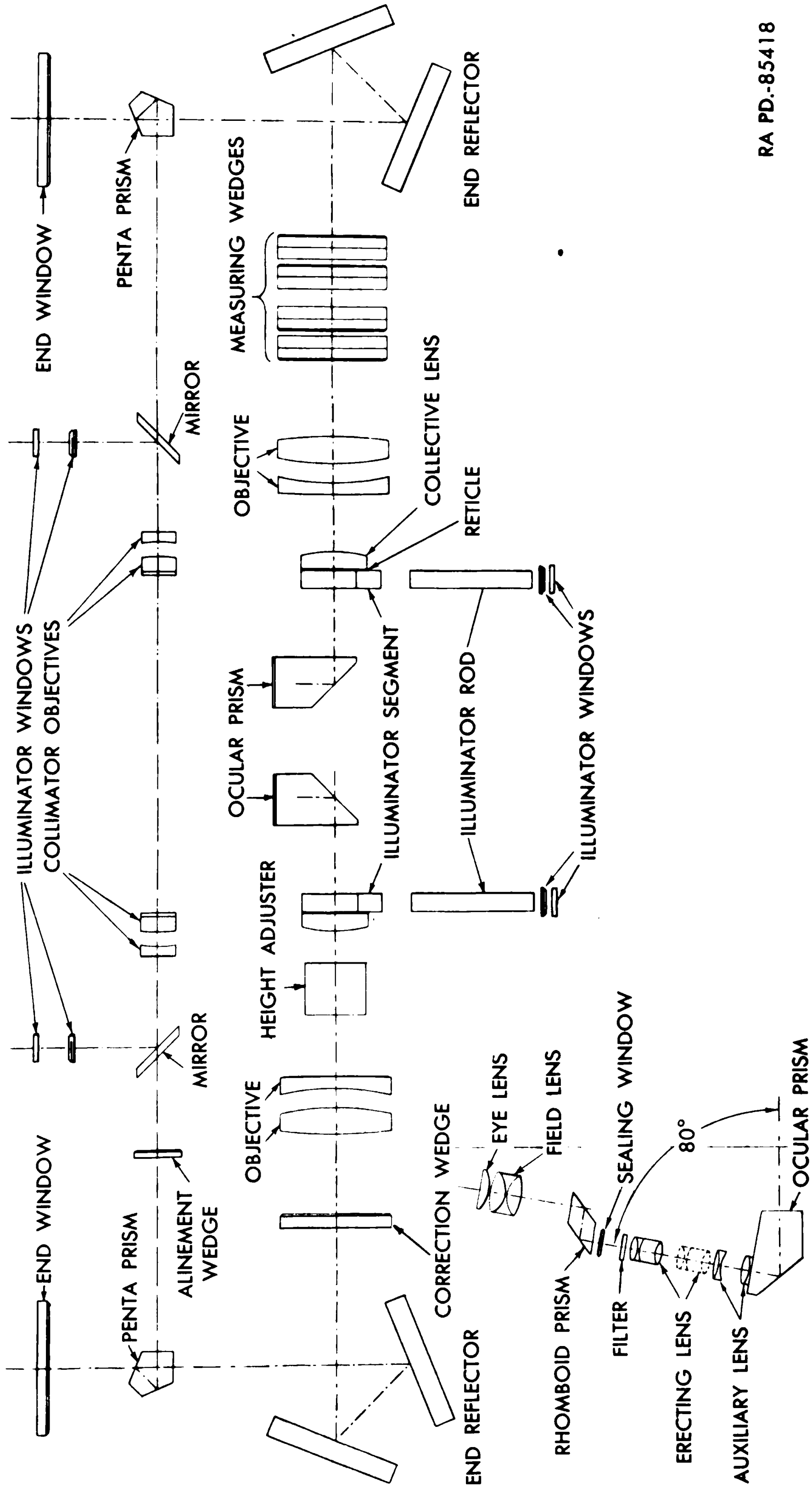

Figure 32 — Schematic Arrangement of Optics in the Height Finder Telescope

DESCRIPTION

(2) The eyepiece plate assembly, which has several moving parts, is mounted in a well-shaped housing having circular glass windows at the bottom of it, which separates it from the sealed interior of the instrument. The outer and inner tubes are both made of seamless steel tubing, and cadmium-plated to prevent corrosion.

c. Outer Tube.

(1) The outer tube (26, fig. 30) serves as a rigid housing for the instrument proper, and supports the inner tube. The outer tube turns in elevation on ball bearings, one row on each side of the center of the tube. The outer ball races are mounted in housings attached to the cradle that supports the height finder on the tripod when the instrument is set up. The inner ball races are attached to the outer tube, permitting the height finder telescope to be rotated freely in elevation.

(2) Carrier handles mounted near the ends of the outer tube provide hand grips for eight men or more when the instrument is being lifted on or off the cradle. Feet extending below the carrier handles support the height finder telescope when it is necessary to set it on the floor or ground.

d. Inner Tube. The inner tube (27, fig. 30) is enclosed in the outer tube, and cannot be reached without breaking the hermetic seal of the instrument. It supports the end reflectors and other sensitive optical parts of the height finder telescope that must remain stable and in perfect alinement. The inner tube, therefore, is supported in the outer tube in a manner which permits the inner tube to expand or contract freely, so that it will not be affected by minor deformations of the outer tube. The two bearings (28, fig. 30), on which the inner tube is supported, are so located that the tube is properly balanced and will not sag in the center or at the ends. The inner tube can be rotated slightly inside the outer tube by means of the fine elevation adjustment knob (41, fig. 30).

e. Optical Tube.

(1) The optical tube (31, fig. 30) carries the main objective lenses (15, fig. 30) and the reticles (11 and 14, figs. 30 and 31, respectively), the rigidity of which determines the precision of the entire instrument. The optical tube also contains the central ocular prisms. It is one of the most important mechanical parts of the instrument and is made with the greatest degree of precision.

(2) The optical tube is supported in the inner tube by a gimbal joint support on the left (47, fig. 30) and a ball and cylinder joint on the right (48, fig. 31). This arrangement prevents any strain or deflections in the inner tube from being transmitted to the optical tube or the elements in the optical tube.

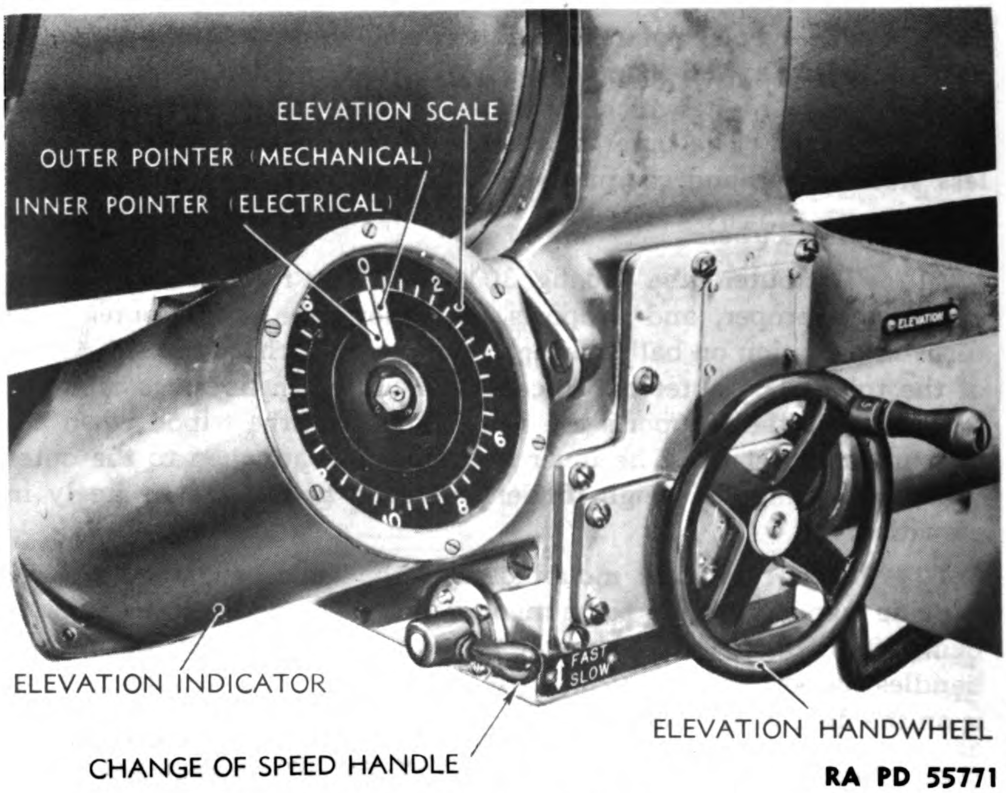

Figure 33 — Elevation Indicator and Handwheel — Rear View

f. Elevation Indicator (fig. 33). An elevation target designating indicator mounted on the left outer tube support housing and just below the elevation tracking telescope is equipped with "follow the pointer" dials. The inner or electrical index of the indicator is fastened to the rotor and is positioned electrically by the antiaircraft director. The mechanical index of the elevation indicator is connected through gearing to the worm that engages the elevation worm segment on the height finder outer tube.

14. OPTICAL UNITS OF THE HEIGHT-FINDING SYSTEM.

a. The optical units of the height finder shown schematically in figure 32 are described in the following paragraphs.

15. END WINDOWS.

a. The end windows (figs. 30, 31, and 191) serve two purposes: first, they form a transparent seal for the outer tube; and second, they provide a means for the manufacturer or an optical repairman for final adjustment of the instrument to read the correct range. Although all of the optical parts of the height finder are carefully calculated and made, and the mechanical parts accurately fitted, slight errors which cannot be detected by ordinary measurements may ac-

DESCRIPTION

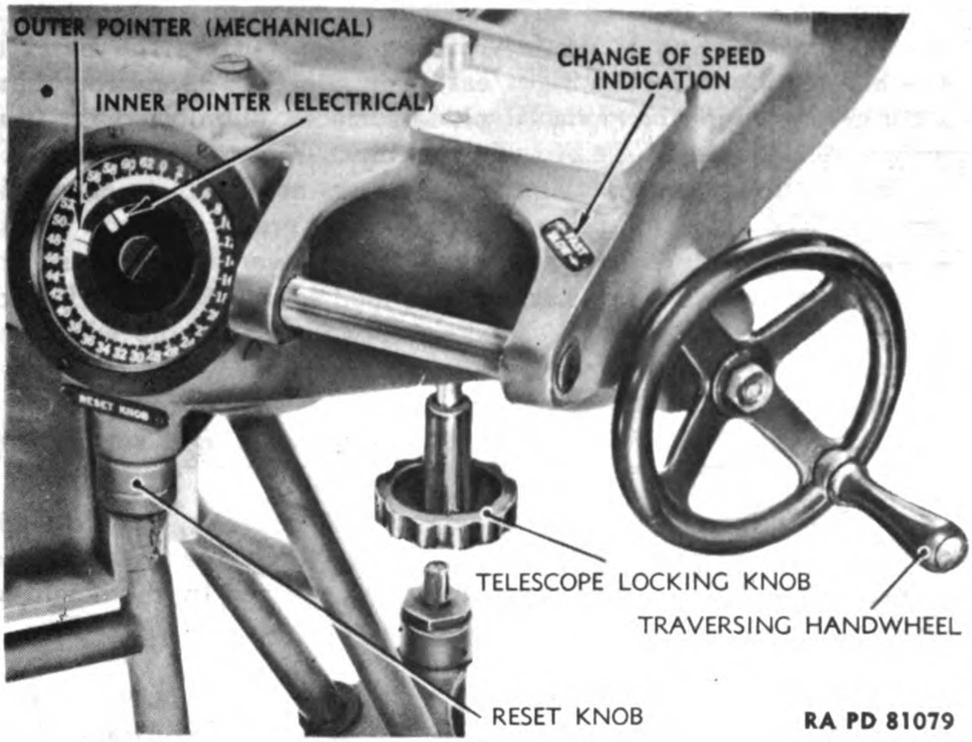

Figure 34 — Azimuth Indicator and Handwheel

cumulate enough to be detected in a finished instrument. The end windows are optical wedges of very small angles, and are so mounted that they can be rotated to compensate for the accumulated errors in the whole optical system; the adjustment is used as a final correction after the instrument has been assembled or repaired.

16. END REFLECTORS.

a. In order to maintain acceptable accuracy, it is essential that the light rays entering the end windows be reflected at right angles to their original direction. If a simple prism or mirror were used, the angle of reflection would be very sensitive to any inaccuracies or variations in the angle of the reflecting unit as a whole to the incoming ray, such as might be caused by flexure of the tube. To avoid this difficulty, the end reflectors (8, fig. 30) are designed like penta prisms; they contain two reflecting surfaces very rigidly mounted with an included angle of 45 degrees. With this type of reflector, the angle of reflection remains constant, even if the reflector as a whole is rotated slightly or the direction of the entering ray is varied.

b. While the angle of reflection is not affected by rotation of the mount as a whole, it is very sensitive to any changes in the angle between the two reflecting surfaces. Therefore, the reflector unit is constructed so as to keep any possible variation to a minimum. A built-up construction is used, with two glass mirrors the bases of which are mounted to a rigid cast iron plate. The mirrors have accurately ground and polished plane surfaces, aluminized for front surface reflection, and are of sufficient thickness to retain their shape, but not so thick that changing temperatures are likely to cause distortions. The mounting plate is made of fine grade cast iron having an expansion coefficient approximately the same as that of glass. The edges against which the mirrors are clamped are at 45 degrees to each other, and each mirror is held against two raised spots which are accurately finished and polished. Two pads, faced with hard rubber, are forced against the base of each mirror by screws contained in a cast iron mount having three-point bearing on a rigid support fastened to the end of the height finder inner tube.

c. The only effect of movement of the reflector, due to slight deformations of the inner tube, would be to throw the images out of adjustment in height. This can readily be corrected by the height-of-image adjustment, as explained in paragraph 40.

17. OBJECTIVES.

a. The objective lenses (15, fig. 30) which form images of the target on the reticles must have as nearly as possible the same focal length; otherwise, the magnification of the two images will differ, and range readings will vary between the center and sides of the field. Therefore, the objectives are carefully selected and adjusted to work in pairs, allowing for the rest of the system.

b. Since the surfaces of the wedges, end reflectors, and windows, etc., may have very slight curvature and therefore optical power, the sum of all these powers plus the optical power of objective for each side must balance. The main objectives are achromatic doublets, the elements of which are separated by an air space slightly less than one-half inch. By increasing or decreasing the thickness of the air space, the focal lengths of the right and left objectives may be equalized.

c. Each objective is composed of a positive lens of crown glass and a negative lens of flint glass. These lenses are mounted in special steel cells held by threaded steel rings and separated by metal spacing rings. The mounting and spacing must be carefully adjusted to give the correct focal length, and the lenses must be held firmly in their mounts without strain. Any sideways shake of the elements would give a very serious range error.

18. RETICLES.

a. The reticles (figs. 35 and 36) consist of a stereoscopic pattern of reference and depth marks with which the positions of the images

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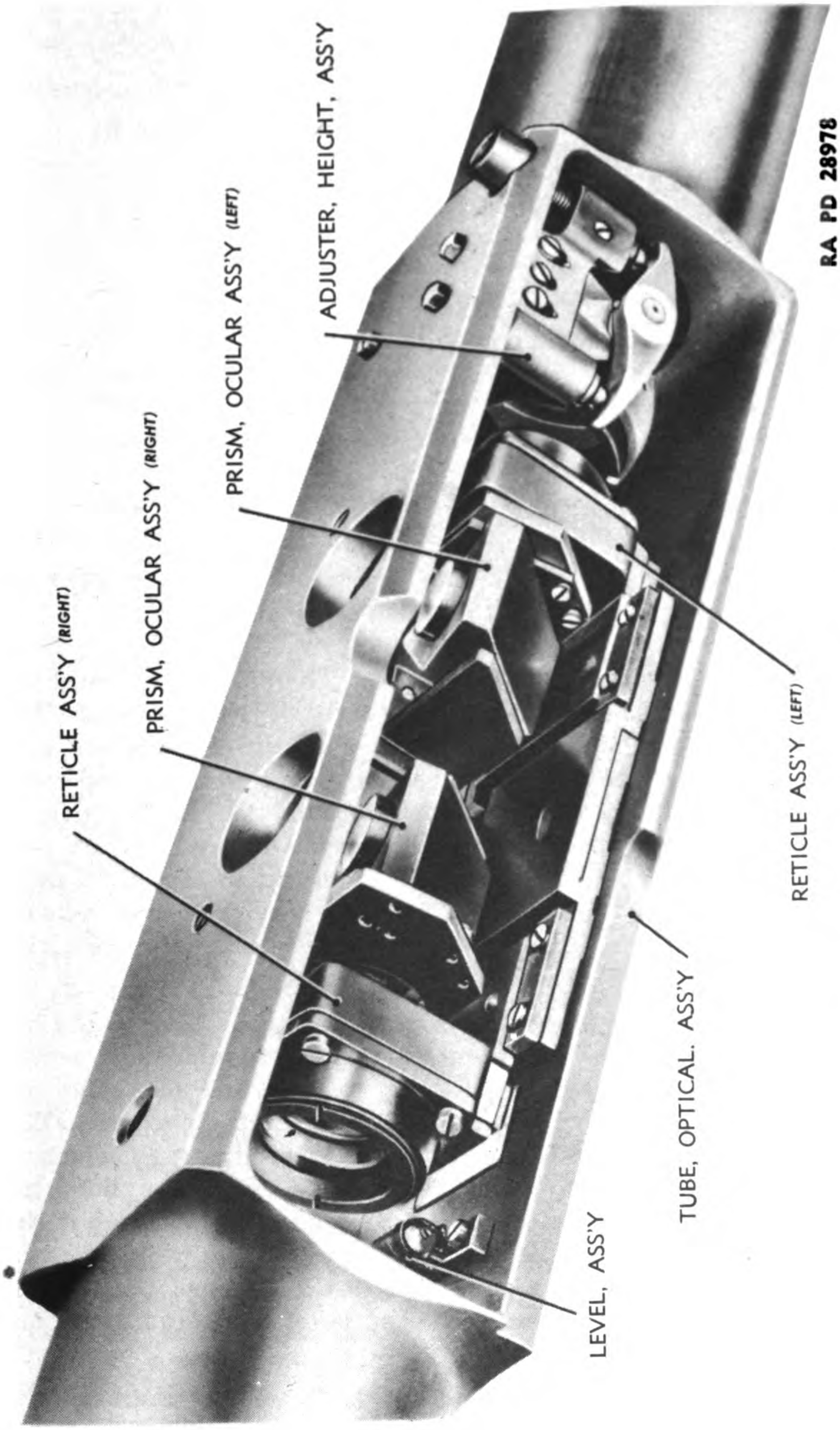

Figure 35 — Central Optical Elements in the Optical Tube

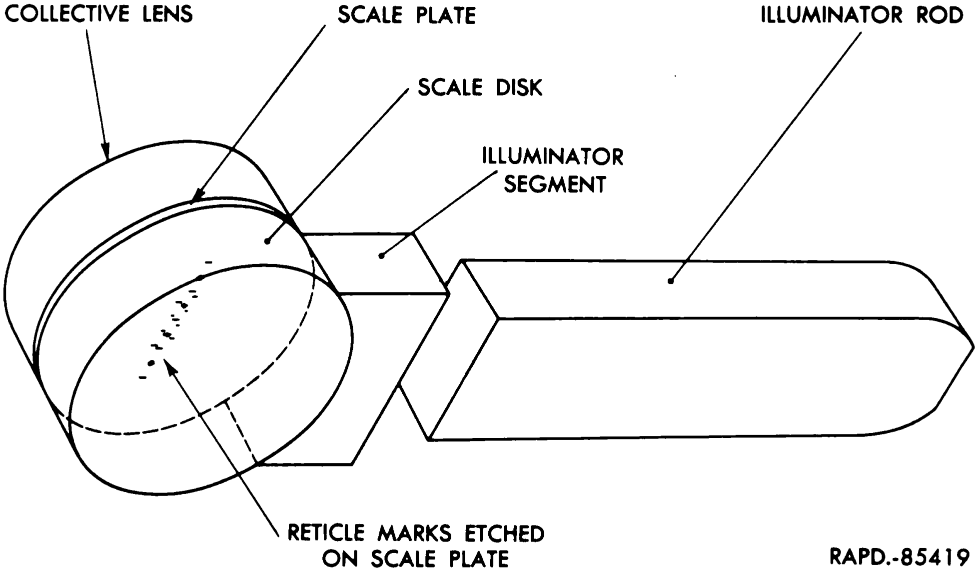

Figure 36 — Perspective Drawing of Stereo Reticle Assembly Showing Illuminators

formed by the objectives are compared. Therefore, they must be mounted with the marks in the principal focus of the objectives. The reticle is mounted so that it is in proper focus in the eyepiece, and then the objective assembly is moved in or out to make the focal plane coincide with the plane of the reticle marks. Each reticle is mounted in a bracket which allows movement in any direction perpendicular to the optical axis of the instrument, so that the center mark can be alined with optical axis of objectives. However, moving either reticle mount will disturb adjustment of height finder, and also necessitate that the hermetic seal of instrument be broken.

b. The reticles are engraved on a thin glass plate cemented between an illuminator disk and a plano-convex lens which also serves as a collective lens to converge the image rays so that eventually the whole field will be imaged in the focal plane of the eyepiece. The reticle markings are etched into the surface of the plate which is mounted facing the objective lens. The etched marks are filled with an opaque material so that they will be readily visible against the background of the field. The markings can be illuminated at night by light transmitted through glass rods to the edges of the reticles. The light enters the illuminator disk and is reflected from the inner surfaces of the filled lines.

c. The placing of the fore and aft depth marks differs for the right- and left-hand reticles, in order to produce the stereoscopic separation as described in paragraph 142. Therefore, the reticles cannot be interchanged on the two sides of the height finder. Furthermore, the reticles for each height finder are matched and should be used only in matched pairs.

19. ERECTING LENS SYSTEM.

a. The converging rays from the objective lens are further converged at the front surface of the reticle collective lens by the convex surface of this lens. The rays of the image thus formed on the reticle itself will have such characteristics as to eventually present a full field of view to the erecting lens system (21, fig. 31) in the eyepiece assembly.

b. Each erecting lens consists of a quadruplet combination mounted in a cell that can be moved along its axis by a pinion and rack connected to the change-of-magnification lever on the eyepiece plate. As the lever is turned, the rack draws the erector lenses toward or away from the central ocular prisms. An off-center tension spring on the rack pinion holds the lens cell in either of its two alternate positions. The distance through which the erectors move is such that the effective optical distances between the reticle and erector, and the eyepiece and erector, are interchanged, so that the objective distance for one position is equal to the image distance for the other position. Thus, the erector focuses either a magnified or a reduced image of the reticle at the focal plane of the eyepiece.

20. CENTRAL OCULAR PRISMS.

a. The two ocular prisms (fig. 35) at the center of the optical tube turn the rays away from the axis of the instrument, out to a position where they can be observed through the eyepieces. Each ocular prism is of the double right-angle type, although the second reflection departs intentionally from a right angle. The first reflecting surface turns the rays at 90 degrees from the axis toward the front of the instrument; the second surface then directs the rays upward at a suitable angle into the eyepiece unit. The departure from the second right-angle reflection inclines the beam toward the observer by 10 degrees. The two reflections keep the image from being reversed, and offset the rays from the center line of the tube enough to allow insertion of the rhomboid prisms in the eyepiece unit. To the upper surface of each ocular prism is cemented a doublet auxiliary lens (fig. 32) which collimates the light from the stereoscopic reticle.

b. The ocular prisms are held securely in special steel mounts, which are capable of adjustment in any direction in a plane perpendicular to the optical axis.

21. EYEPIECE UNIT.

a. The parallel rays of light emerging from the ocular prism pass out to the eyepiece plate assembly through windows sealed in the

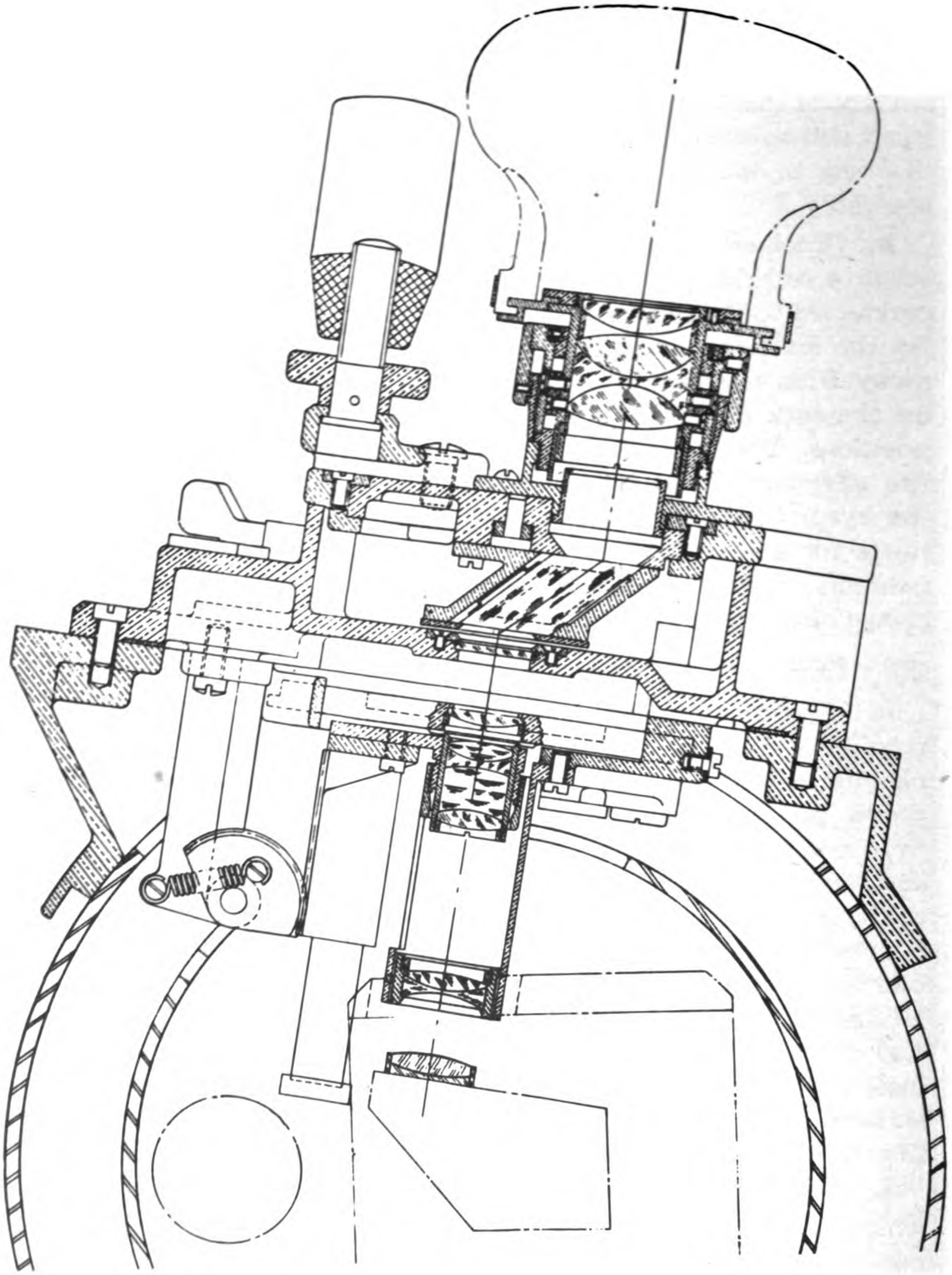

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Figure 37 — Cross-sectional View of Main Eyepiece Assembly

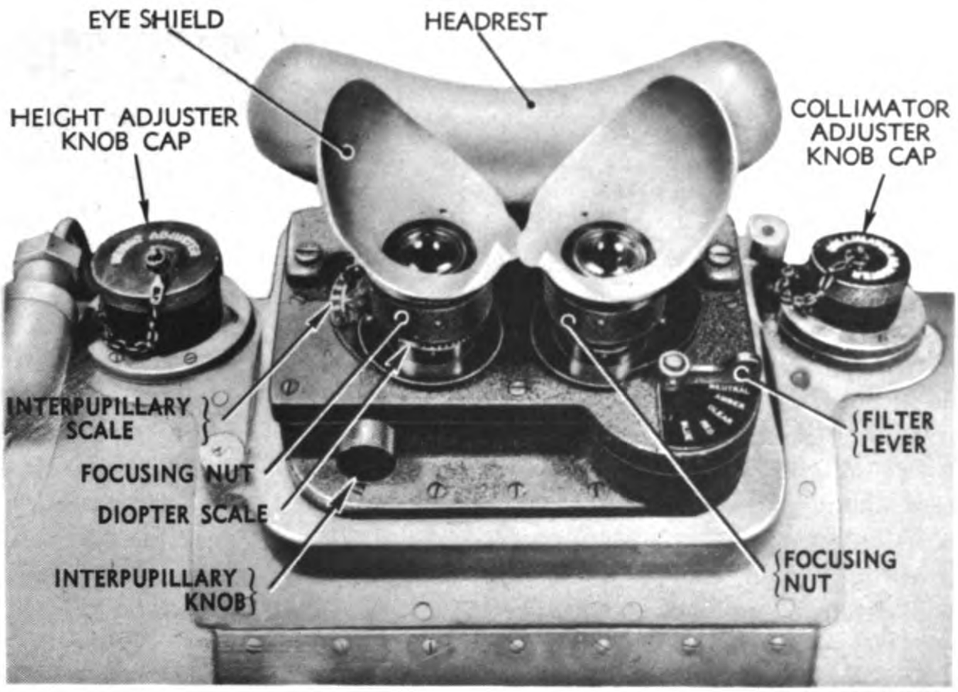

Figure 38 — Eyepieces — Rear View

eyepiece bracket. The eyepiece assembly (figs. 37 and 38) contains two auxiliary lenses for collimating, two sets of eyepiece objectives (achromatic diverging lenses), two erecting lenses, two sets of filters, two sealing glasses, two rhomboid prisms, and two eyepieces. Just below the erecting lenses are two auxiliary lenses which collimate the light from the ocular prism.

b. Each eyepiece is made up of a cemented triplet and single lens in a focusing cell. Thus, each eyepiece can be individually focused for the observer's eye. The focus setting is shown on a diopter scale below the eyepiece ring.

c. The rhomboid prisms (18, fig. 31) offset the light rays without changing their direction. Since each prism provides two reflections, the image is not reversed. By rotation of the rhomboid prisms and eyepieces around the fixed center lines coming from the ocular prisms, the distance between the two eyepieces can be adjusted to fit the separation between the observer's eyes. This movement is effected by means of a screw operated by a knurled knob, and the interpupillary setting is indicated on an external scale calibrated in millimeters.

d. The filters or colored glasses are used for sighting against a brilliant sky, through haze, and on camouflaged targets. Red, amber,

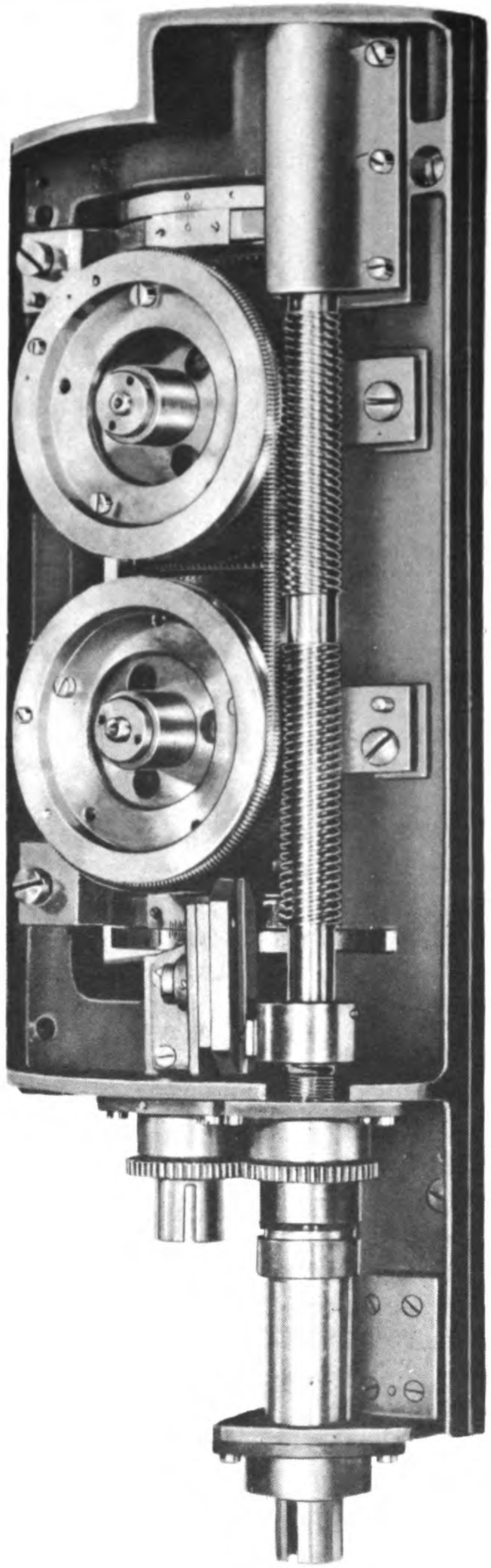

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Figure 39 — Compensator — Assembled View

blue, and dark neutral filters are provided. These filter glasses are arranged and mounted so that the turning of a single lever brings a glass of the same color into the field of each eye.

e. The eyepiece objective lenses are achromatic diverging lenses whose function is to present a virtual object, as a result of these diverging rays, to the erecting system. NOTE: *Thus the complete eyepiece assembly can be considered as a simple telescope without an erecting system.*

f. The eyepiece assembly is mounted to the outer tube and, since it is used only as a reading device, slight changes in the outer tube will not affect the accuracy of the range readings. Because of the various sliding parts, the eyepiece plate assembly is not made a sealed part of the height finder. Thus it can be removed and cleaned without breaking the hermetic seal of the instrument. This must not be done, however, unless a divergence tester is available to check the alinement when the assembly is replaced. A metal cover is provided to protect the external parts of the eyepiece assembly when not in use. When the instrument is in use, this cover is removed and attached to one tripod leg.

g. An adjustable headrest helps the observer to keep his eyes properly placed above the eyepieces while the instrument is being traversed in azimuth and elevation.

22. COMPENSATOR (MEASURING) WEDGES.

a. The compensator or measuring wedge assembly (fig. 39) is located between the right-hand objective (15, fig. 31) and end reflector (8, fig. 31). Thus, it is not sensitive to any slight shifts in position and, since it must be geared to the height conversion ring, this assembly is mounted on the inner tube. The achromatic wedges are circular in form and are mounted in cells secured in four large bevel gears. These cells are supported on ball bearings and are rotated by mating bevel gears driven through a connecting gear system, by the height conversion mechanism and the measuring knob.

b. The range scale is engraved on the measuring drum (fig. 40) which rotates just inside the outer tube, so that the scale is visible through a window at the front of the outer tube.

c. The measuring knob, mounted on the outer tube in a convenient position for the right hand of the stereo observer, is coupled to the range drum (fig. 40), through gears and a shaft, and then to the compensator wedge assembly. Thus, when the measuring knob is turned, both the scale and the wedges are rotated the proper relative amounts.

23. HEIGHT CONVERSION MECHANISM (numbers in parentheses refer to figure 41).

a. The height conversion motion of the measuring wedges is controlled by a ring (6) which can be rotated around the outer tube in the right main bearing housing (8). This ring carries a lever (5) which can be swung to the right at top ("range" position) to engage a lock bracket on cover (4) fastened to the outer tube, or to the left at center ("height" position) to engage a lock bracket (15) on the bearing housing which is secured to the cradle. On the side of the ring (6) is a bevel gear (7) which engages a bevel pinion (20) which serves to transmit height conversion motion to the compensator wedges.

b. The action of the conversion mechanism in relation to the measuring knob, measuring drum, and compensator (measuring wedges) is described herewith in range drive and height drive positions. Refer to schematic diagram (fig. 41).

(1) "RANGE" DRIVE (CONVERSION LOCK LEVER SET IN "RANGE" POSITION). Rotation of the measuring knob (1) transmits motion through the bevel gears (12) to spur gears (14) and pinion meshing with rack inside measuring drum (3). The range (or height) of the target is indicated by a pointer (13) moving in a spiral slot adjacent to the scale on the measuring drum which is graduated from 550 to 50,000 yards. Rotation of the measuring knob also transmits motion to the compensator through the shaft (16) and spur gear (17) to the sleeve gear (25) which has a threaded bore turning on the screw sleeve (26). The sleeve gear is restrained from moving endwise and, when rotated, acts as a nut causing the screw sleeve to move the worm shaft (27) to the right or left. The worm shaft is prevented from rotating by means of the stop lug (23) engaged in the slot in the coupling (24) and acts as a rack only, causing both of the worm wheels (11) to rotate in the same direction, as indicated on diagram.

(2) "HEIGHT" DRIVE (CONVERSION LOCK LEVER SET IN "HEIGHT" POSITION). When the height finder is elevated or depressed, the conversion ring gear (7) drives the bevel pinion (20) causing a rotation of the height drive shaft (22). This rotation is transmitted to the worm shaft through coupling (24) and stop lug (23). Since the worms on shaft are cut right and left, rotation of the worm shaft causes worm wheels (11) to rotate in opposite directions. The arrows in the diagram indicate the direction of rotation for decreasing range.

24. HEIGHT-OF-IMAGE ADJUSTMENT.

a. In order to produce the proper stereoscopic effect, the images formed in two sides of height finder must appear at the same height relative to their respective reticles. A height adjuster is provided

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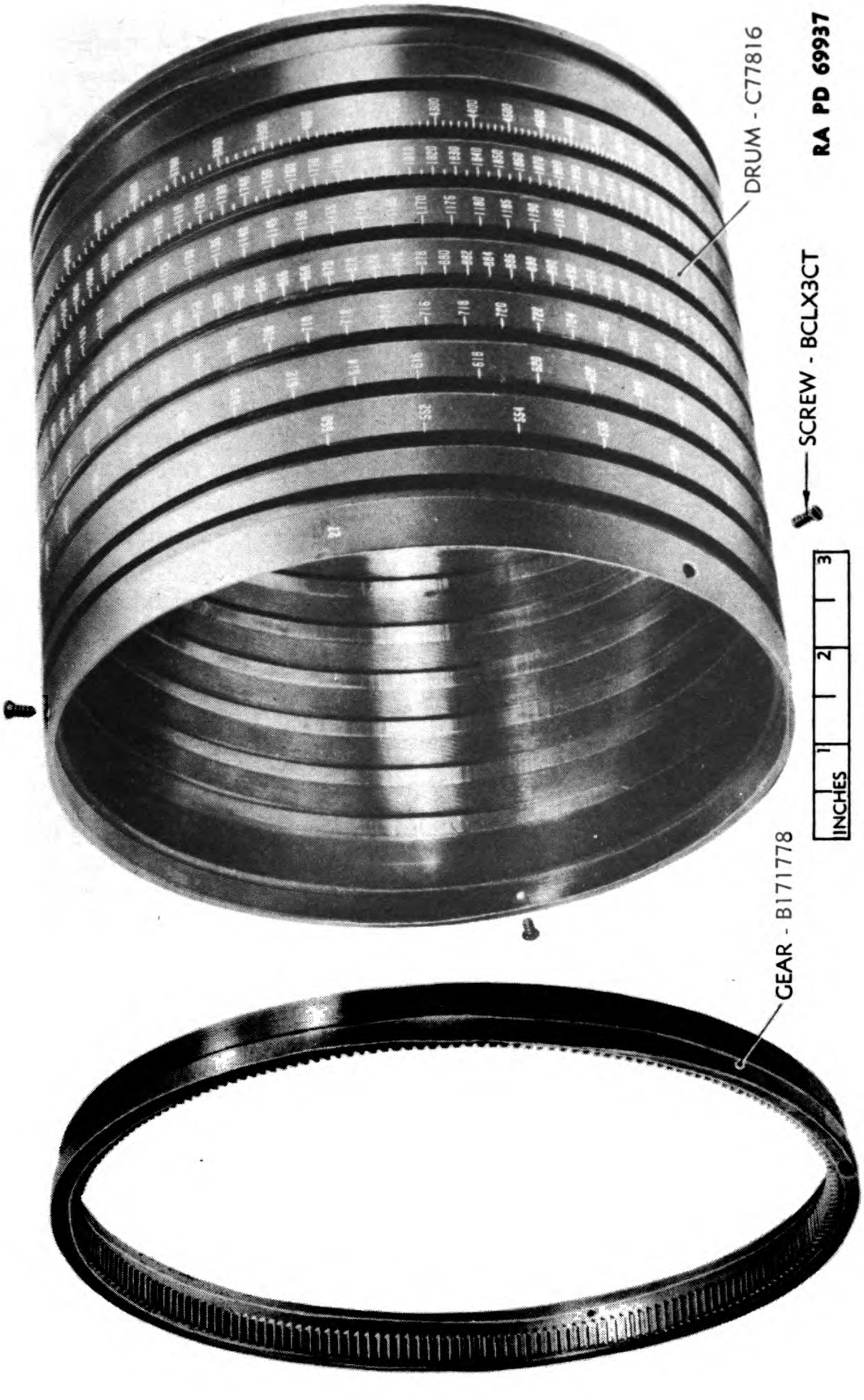


Figure 40 — Measuring Drum Scale — Gear Removed

in the left-hand side of the height finder which allows the left image to be raised or lowered to match the height of the right image.

b. The height-of-image adjustment is accomplished by means of a thick glass plate with parallel surfaces (10, fig. 30). This glass plate is held in a mount which can be tilted mechanically, with its horizontal diameter as an axis. This results in raising or lowering the rays as they pass between the left objective and the left reticle. The adjustment is made by rotating the height adjuster knob.

25. FINE ELEVATION ADJUSTMENT.

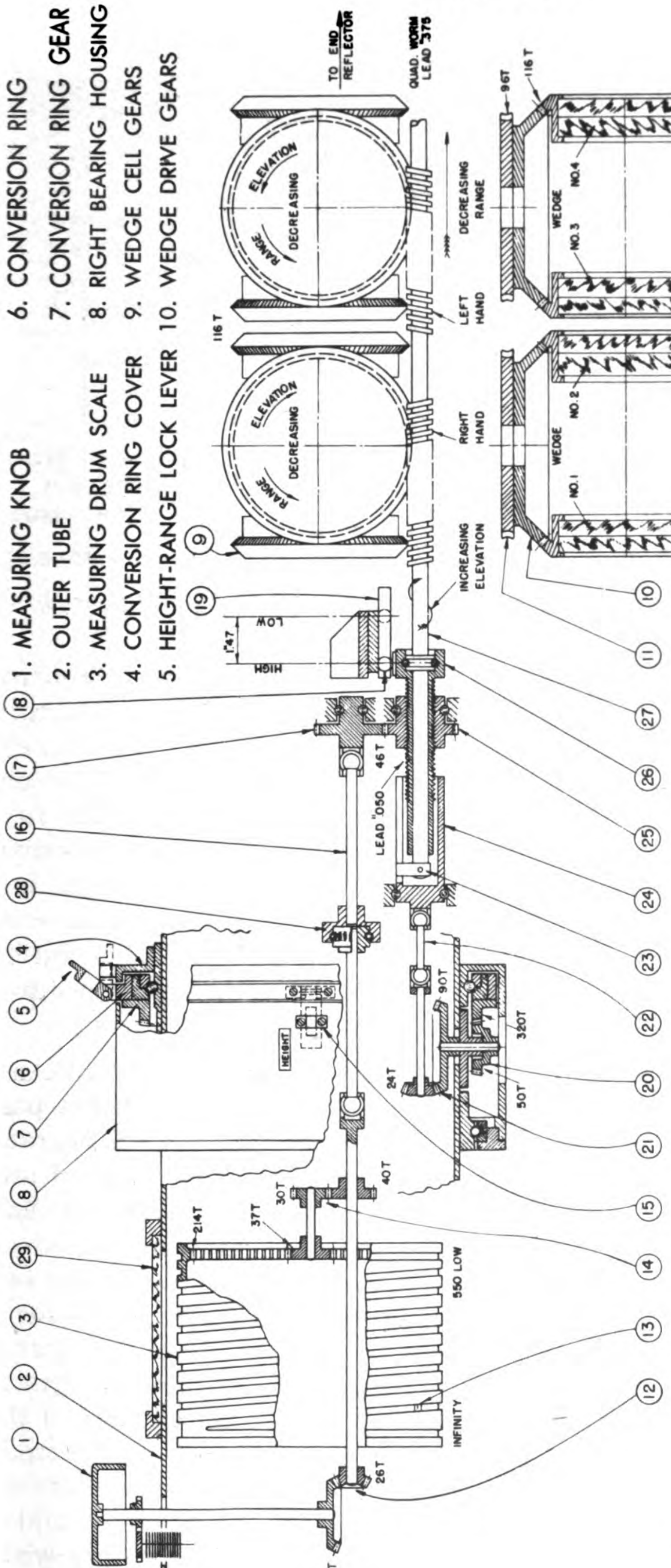
a. The purpose of the fine elevation adjustment is to allow the stereoscopic observer some freedom in the vertical placing of the target image. In ranging on a moving target, the trackers keep the instrument trained on the target so that it is visible in the small stereoscopic field. The stereoscopic observer reading the instrument sees a horizontal line of marks in the reticle field, any one of which he may use as the reference mark. If, however, the target image is much above or below the markings, the observer will be unable to read accurately without the fine elevation adjustment, which permits him to place the target near the reticle marks. The motion is confined to the inner tube and all the parts fastened to it, including the end reflectors. The inner tube is mounted so that it can rotate within the outer tube. The fine elevation adjustment knob is connected by bevel gears to a threaded shaft which operates a slide carrying a spherical follower. This follower operates in an angular slot in a cam secured to the inner tube which is caused to turn slightly with relation to the outer tube, due to the longitudinal motion of the follower. The total movement amounts to a maximum of 1 degree and 15 minutes of rotation.

26. INTERNAL TARGET SYSTEM.

a. An internal target system is incorporated in the height finder to furnish an artificial infinity target for use in correcting optical misalinement caused primarily by temperature change, and also for compensating observers' individual differences in readings. These variations of the optical alinement are corrected by means of a wedge located in the optical system, the effect of which is the same as measuring the distance of a target at infinity. A similar adjustment could be made on a target at infinity, such as a star or the edge of the moon's disk. This method has the disadvantage that in daytime and on cloudy nights the celestial targets are not visible.

b. A self-contained sight or internal target system was designed to meet these difficulties. In order to be effective, complete assurance is required that the internal adjuster will not be subject to the same errors in optical alinement that occur in the optical system of the

DESCRIPTION



1. MEASURING KNOB
2. OUTER TUBE
3. MEASURING DRUM SCALE
4. CONVERSION RING COVER
5. HEIGHT-RANGE LOCK LEVER
6. CONVERSION RING
7. CONVERSION RING GEAR
8. RIGHT BEARING HOUSING
9. WEDGE CELL GEARS
10. WEDGE DRIVE GEARS
11. WORM WHEELS
12. BEVEL DRIVE GEARS
13. DRUM SCALE INDEX
14. DRUM DRIVE GEARS
15. "HEIGHT" LOCK BRACKET
16. RANGE DRIVE SHAFT
17. RANGE DRIVE GEAR
18. BALL GUIDE
19. GUIDE RAILS
20. CONVERSION PINION
21. CONV. DRIVE GEARS
22. HEIGHT DRIVE SHAFT
23. STOP COLLAR
24. STOP COUPLING
25. SLEEVE GEAR
26. GUIDE SLEEVE
27. WORM SHAFT
28. MEASURING SCALE ADJUSTER
29. MEASURING SCALE WINDOW

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Figure 41 — Schematic Diagram of Range- and Height-measuring Mechanism

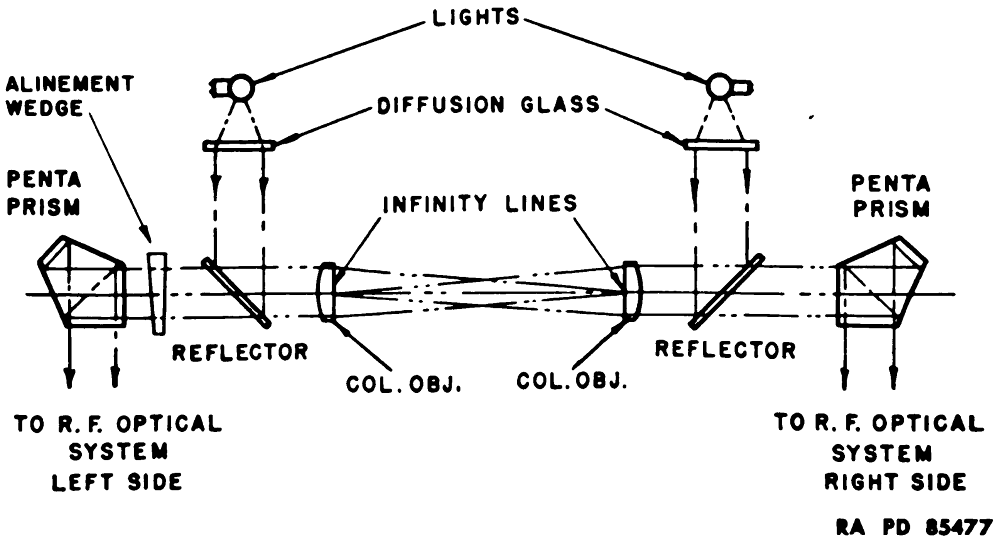

Figure 42 — Diagram of Self-collimating Internal Target System

height finder. This condition is satisfied by providing a collimating system which is simply a small double-ended collimating telescope which gives out parallel rays of light (fig. 43). The parallel rays from the internal target lines in the collimator are directed by the end reflectors through the main optical system to the eyes. The rays of light, being parallel, represent the equivalent of a target at infinity. If the height finder is in adjustment and the measuring wedges and the range scale are set at infinity, stereo contact will exist between the stereo reticle and the collimator target lines. If the height finder is out of adjustment, means are provided to adjust the optical alinement for stereo contact at infinity range.

c. The principle of the double objective, self-collimating internal adjuster is indicated in figure 42. The rays from the light bulbs pass through frosted windows to reflectors set at an angle of 45 degrees. The reflectors are optical glass, part of the light being reflected and the major portion being transmitted. Each collimating objective has a single target line which constitutes the infinity mark engraved on its plane face (double line on low-numbered instruments). The two objectives are so located that each plane face is at the principal focus of the other objective. Both objectives and target lines are illuminated by the light reflected from its adjacent lamp. The images of the target lines stand out in black against the light background of the reflectors. The images of the target lines are deflected by the small adjuster penta prisms into the end reflectors of the main optical system. The internal adjuster penta prisms are mounted on slides, and are moved into the field of view of the height finder only when an internal adjustment is to be made. When looking through the

DESCRIPTION

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Figure 43 — Internal Target Collimator Assembly

RA PD 43120

Figure 44 – Adjuster (Correction) Wedge

height finder with the adjuster prisms in position, the target line for the left objective is seen by the right eye, and that of the right objective is seen by the left eye.

d. As the parallel bundles of emergent rays from the right-to-left internal target always remain parallel to each other, the efficiency of the system is not affected by distortion or maladjustment of the height finder. When variations occur in the optical alinement of the height finder, they can be readily detected by turning to the infinity setting. If the internal target lines do not appear at the same depth relation in space as the height finder reticles when the correction knob scale is set at or near 60, and when the index is set at infinity on the measuring drum and the conversion lock is locked in "range" position, then adjustment must be made to cause stereo contact between the target lines and the reticles. This can be readily accomplished by adjustment of the optical alinement wedge. This wedge must be rotated until stereo contact between the internal adjuster lines and the range finder reticles is restored at or near 60.

e. Since the penta prisms and other parts of the internal target system may not be optically perfect, the alinement wedge referred to above is provided next to the left internal target objective, to allow the internal target lines to be brought to the proper infinity position when the instrument is being assembled, and to adjust later for any changes in the instrument.

27. CORRECTION WEDGE.

a. The correction wedge (fig. 44) is a disk of glass, ground and polished to a very acute angle (94.8 seconds). It has a deviation angle of 48.9 seconds.

b. Its purpose in the system is to compensate for the deviations which are introduced into the optical system by thermal or mechanical stresses. These deviations are compensated for by rotating the range correction wedge in a plane perpendicular to the optical axis which introduces a variable deviation in the plane of triangulation.

c. A conveniently located correction knob operates the correction knob scale* which is graduated so that several settings can be made, and the average of the scale readings taken as the true setting. Each graduation on the correction knob scale is equal to ½-second angular change, or one UOE for 24x magnification.

28. TRACKING TELESCOPES (ELBOW TELESCOPES M13).

a. In actual operation, the full attention of the stereoscopic observer is required to establish and maintain stereoscopic contact between the target image and the reticle marks. Two trackers are required to rotate the height finder in elevation and azimuth to follow the moving target.

b. Two tracking telescopes (fig. 45) are mounted on the height finder telescope to enable the elevation and azimuth trackers to keep the height finder alined on the target. Both tracking telescopes are identical, with the exception that those with numbers above 110 have the letter "A" or "E" preceding the number stamped on the filter bracket, designating azimuth or elevation, respectively. The azimuth tracking telescope has the under side of the adjusting knob cover cut away, which allows the observer to adjust the reticle in azimuth while tracking a target.

c. Light rays from the objective enter the front face of a roof prism, undergo reflection at the two roof surfaces, and emerge from the bottom face and enter the porro prism directly below (fig. 45). From here the light rays are twice reflected and then enter the eyepiece. The reticle is mounted just above the porro prism, in the focal plane of the eyepiece. The inverted image of the target formed by the objective is inverted in its passage through the prism system composed of the roof prism and the porro prism, so that an erect

*The correction knob scale is engraved on DIAL, correction wedge, adjusting B171788 (SNL F-189).

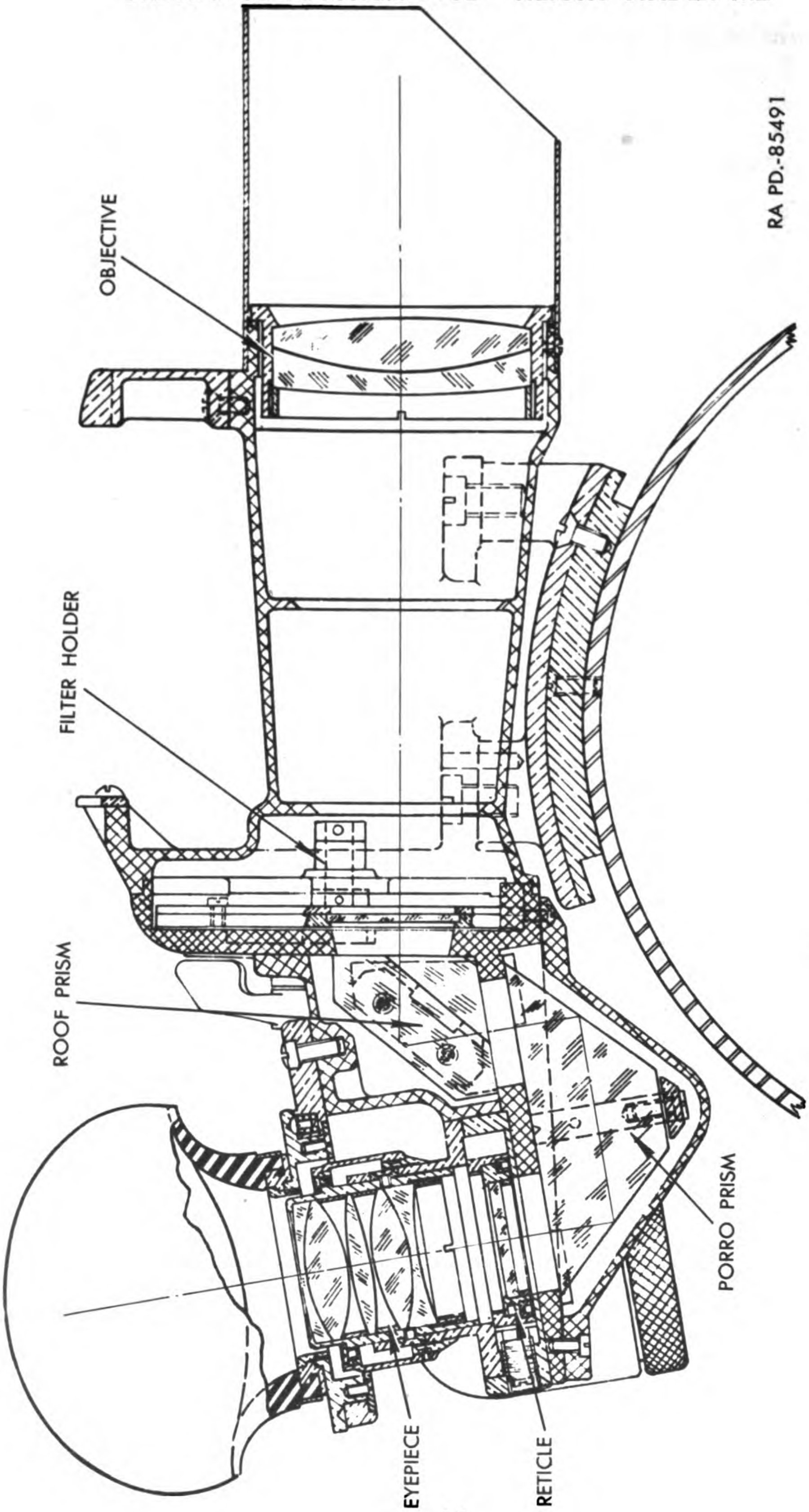


Figure 45 — Elbow Tracking Telescope M13 — Cross-sectional View

image of the target is seen through the eyepiece. A filter holder mounted just in front of the roof prism can be rotated by means of a lever at the side of the elbow telescope to place any one of three color filters, a dark neutral filter, or a clear window in the path of the light rays. The eyepiece can be focused to suit the observer's eye, and a rubber eye shield excludes stray light. A dummy eyepiece can be swung to either side of the main eyepiece to exclude light from the unused eye. A lamp at the side of the elbow telescope illuminates the reticle markings for night observations. The optical characteristics of the Elbow Telescope M13 are shown in the diagram (fig. 45).

d. In order to help the trackers bring the target initially into the field of view, each telescope is equipped with an open sight. This consists of a pointed fixed front sight and a V-notched rear sight across which the target can be quickly sighted and brought into the approximate field of view of the elbow telescope. Further observation is continued through the tracking telescope. Use of the open sight is seldom necessary when the height finder is initially brought to bear on the target by matching the index marks on the dials of the target identification receivers.

29. CRADLE M2.

a. General. The Cradle M2 (fig. 46) serves as a base to support the Height Finder Telescope M2, and contains the driving mechanism for traversing the height finder in azimuth. It also contains the electrical data transmission and azimuth receiving system necessary for use with an antiaircraft director, as well as the controls and other electrical equipment for the illumination in the height finder.

b. Controls.

(1) The main bearing housings of the height finder telescope are bolted to the finished surfaces of the height finder telescope support which, in turn, rests on finished mounting surfaces on the top of the cradle and is secured by four locking screws with knob handles. The handwheel at the right side of the cradle is connected through an internal gear and pinions to a worm that engages a fixed central worm gear. This provides a means of traversing the height finder steadily in azimuth during tracking. The traversing speed can be changed from high to low by pushing in or pulling out the handwheel, thus providing either 10- or 40-mil change in azimuth angle per revolution of the handwheel. The height finder can also be slewed around by hand without using the handwheel, as there is a friction bearing provided in the cradle for this purpose.

(2) Two levels are mounted on the top of the cradle at right angles to each other for leveling the tripod when the instrument is set up.

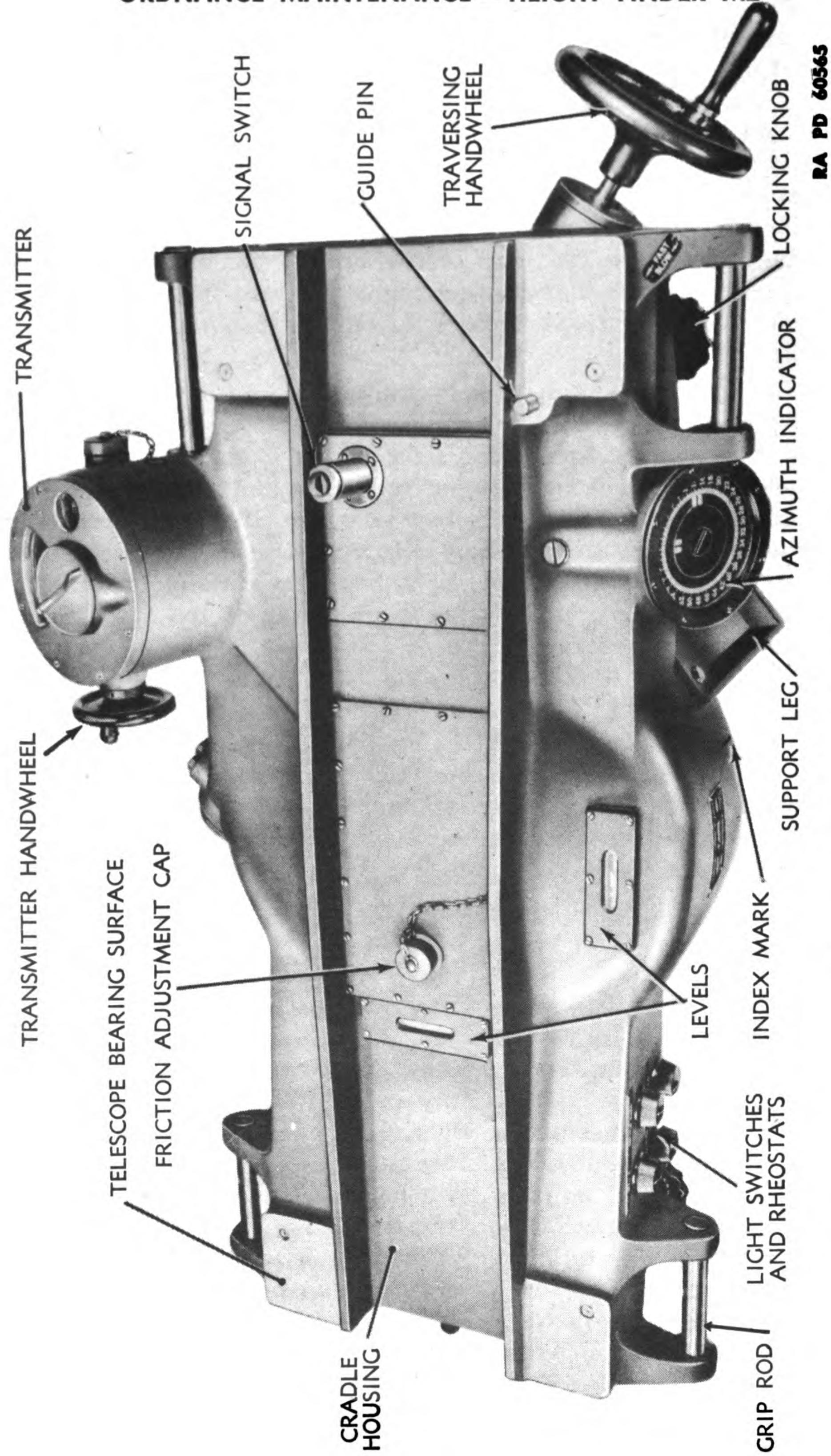
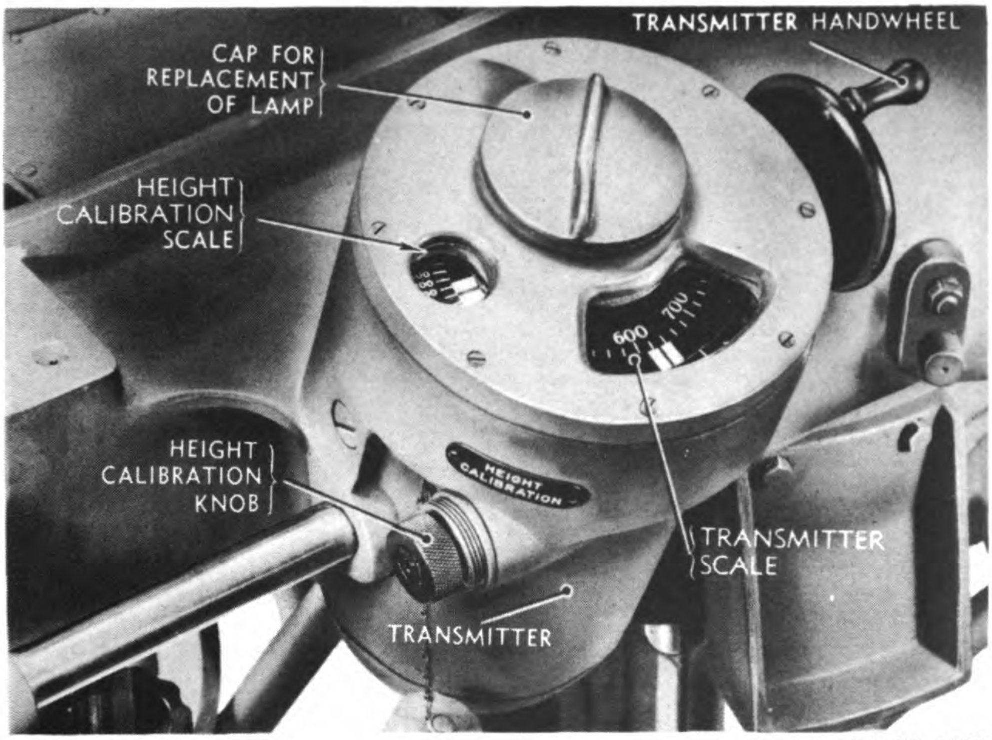


Figure 46 — Cradle M2 — Top View

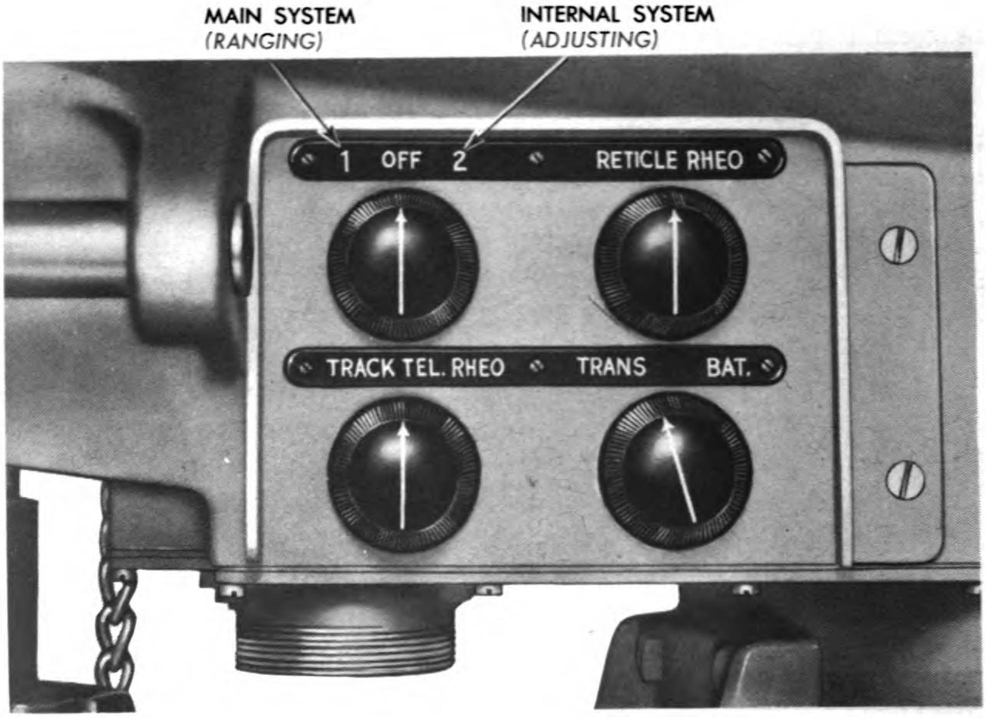


RA PD 55784

Figure 47 — Face View of Transmitter

c. **Azimuth Indicator.** An azimuth target-designating indicator at the right side of the cradle is equipped with follow-the-pointer dials. The inner or electrical index of this indicator is fastened to the rotor, and is positioned electrically by the antiaircraft director. The outer or mechanical index of the azimuth indicator is connected, through gearing, to the stationary part of the cradle, so that it will show the proper azimuth reading regardless of whether the instrument is traversed by the mechanical drive or by slewing. A knob on the side of the azimuth indicator, which is covered by a chained cap when not in use, allows the mechanical index of the azimuth indicator to be set to the correct reading when the height finder, the antiaircraft director, and the guns are initially alined on the reference point.

d. **Transmitter.** The transmitter (fig. 47) is mounted at the front of the cradle, below and just to the right of the range drum window of the height finder proper. Two circular scales, visible in the main window, are operated by the small handwheel at the right of the housing. The inner scale, which is graduated from zero to 1,000 yards with marks for every 20 yards, rotates 10 times as fast as the outer scale, which is pinned to the rotor of the transmitter and is marked every 1,000 yards up to 10,000. The rotor is connected electrically with, and moves, another rotor at the antiaircraft director,



RA PD 85438

Figure 48 — Cradle M2 — Switches and Rheostats

so that, when the reader sets the scales to agree with the range drum reading, the data is reproduced at the director. A knob under the transmitter, normally protected by a cover, turns a worm wheel to rotate the stator. This is used for correcting differences in elevation (vertical parallax) between height finder and antiaircraft director, and any other small corrections necessary when the instruments are being synchronized. The amount of correction, in hundreds of yards, is indicated by the small dial at the left. The lamp bulb for illuminating the dial and scales can be reached by unscrewing the cover at the top of the housing.

e. **Electrical Units.** The electrical junction box underneath the cradle contains the following units: a 19-pole receptacle for connecting the power supply and the data transmission system, with a screw cover for protection when not in use; a transformer to reduce the 110-volt line current to 6 volts for the various lamps which illuminate scales and reticles; and a 6-volt receptacle to allow a 6-volt battery source of current to be used for the illumination. On the rear panel of the cradle (fig. 48) are mounted a switch with two positions—"TRANS" and "BAT."; two rheostats to control the intensity of illumination; and a 3-way lighting switch—"1," the main sys-

DESCRIPTION

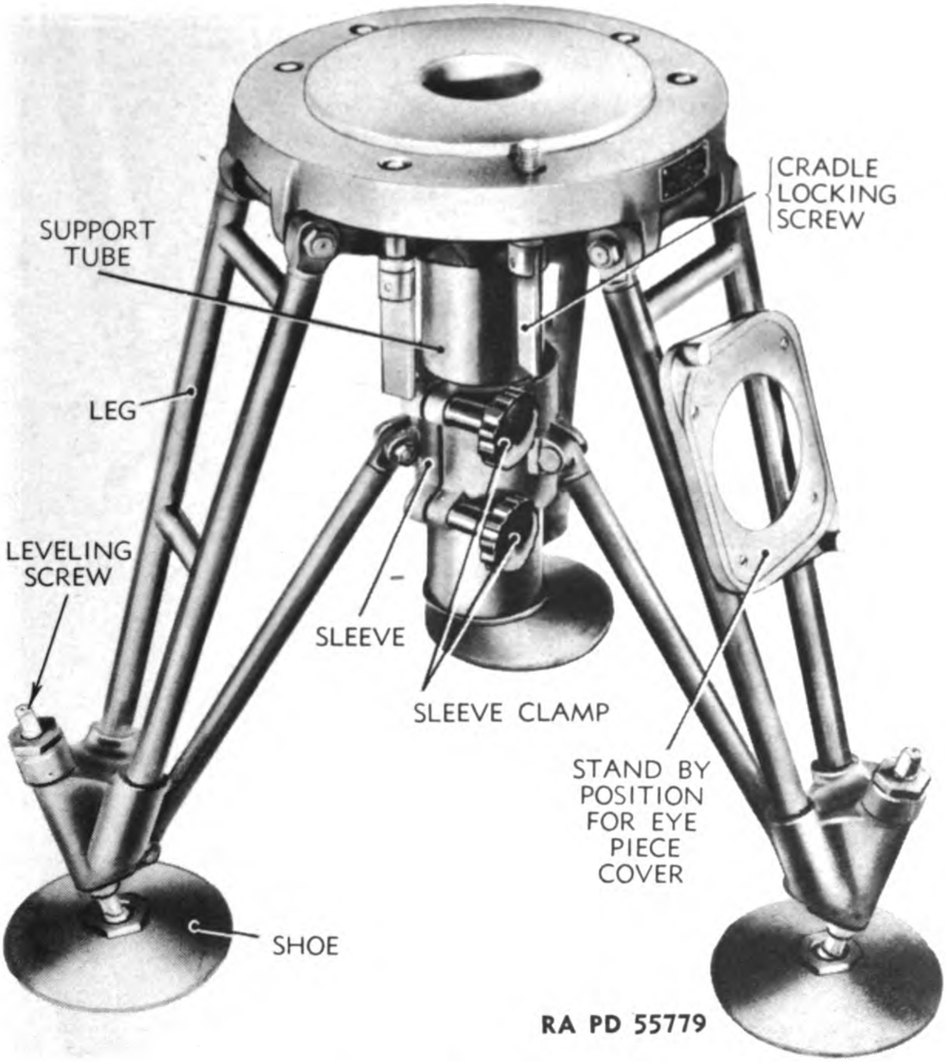
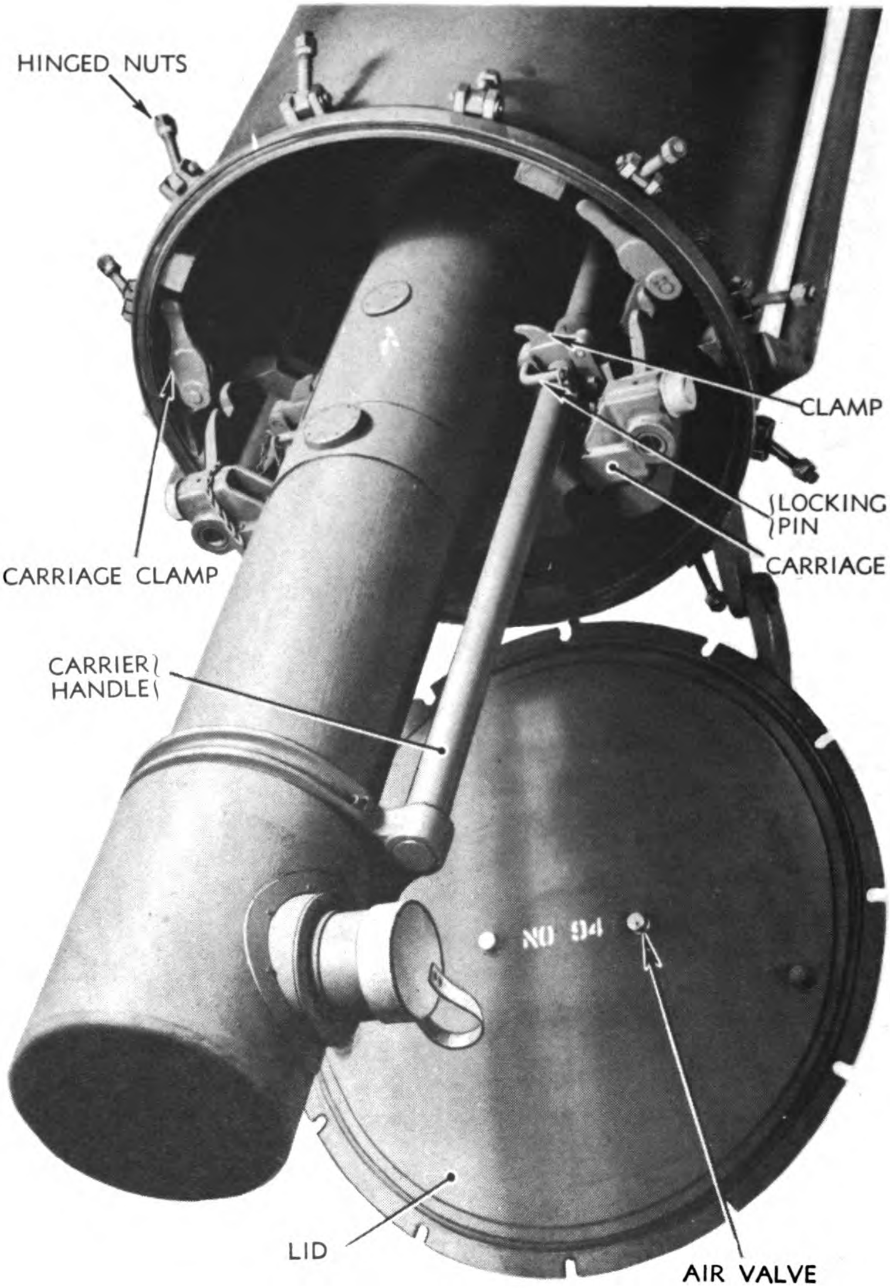


Figure 49 — Tripod M9

tem; "2," the internal system, and the "OFF" position. The points which receive illumination are as follows:

Position No. 1	Position No. 2
Range scale	Range scale
Height transmitter	Correction knob scale
Main reticles	Collimator reticles
Tracking telescopes	



RA PD 55780

Figure 50 — Height Finder Telescope Being Withdrawn From Packing Chest

30. TRIPOD M9.

a. The Tripod M9 (fig. 49) is constructed to support the cradle and height finder telescope in a firm and rigid manner. The head contains six hinged-handle screws for clamping the cradle securely in position. A central tube contained in the head serves as a guide for the sliding clamp sleeve which controls the spread of the tripod legs.

b. Large, flat shoes are attached to the tripod feet to provide firm support, and each foot is adjustable for height to allow leveling of the instrument.

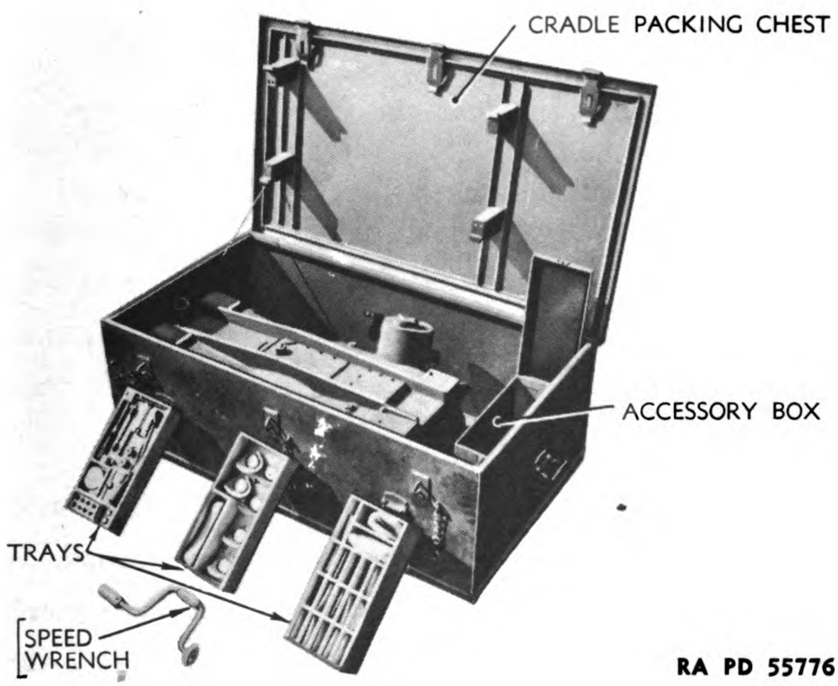


Figure 51 — Cradle M2 Packing Chest

Section IV

ACCESSORIES

31. PACKING CHESTS.

a. The cylindrical metal packing chest for the Height Finder Telescope M2 is shown in figure 50 with the instrument partly withdrawn. When the height finder telescope is fully inserted in the chest, the traveling carriage is locked in position by means of hand clamps on the inside wall of the chest just inside the cover. The end flanges contain rubber gaskets to produce an airtight seal. The front cover is hinged and kept tight by means of 12 clamping bolts. The socket wrench in the cradle packing chest fits the nuts on these bolts. The air valves in the front cover enable the using personnel to desiccate the interior of the case and thus insure long and safe storage. Hand grips are provided the entire length of the case to facilitate carrying the chest or loading it upon a truck.

b. The metal packing chest for the Cradle M2 is shown in figure 51, the lid being raised to show the cradle in position and the accessory box which contains three trays of spare parts, tools, and accessories. When the cover is closed and secured, the cradle is clamped securely in place.

c. The metal packing chest for the Tripod M9 is shown in figure 52, with the cover lifted and the tripod in storage position. When the cover is closed and secured, the tripod is clamped securely in place. The hand wrench for adjusting the leveling screws is carried in its traveling position on hooks inside the case. The lids of both chests have rubber gaskets to provide a watertight seal.

32. ORGANIZATION TOOLS AND SPARE PARTS.

a. Accessories and spare parts for Height Finder M2 delivered with each instrument are described in TM 9-624.

ACCESSORIES

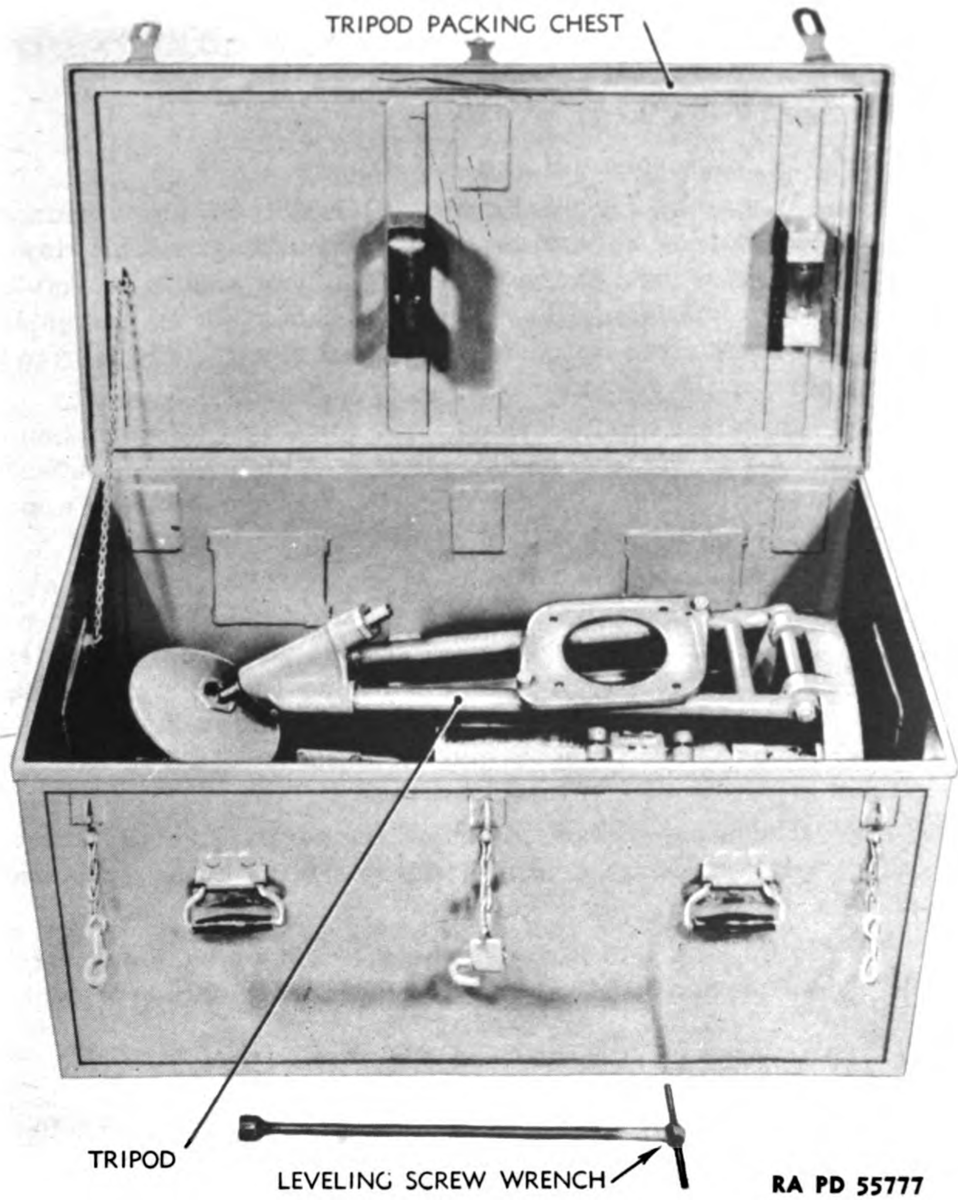


Figure 52 — Tripod M9 Packing Chest

Section V

SETTING UP AND PRELIMINARY ADJUSTMENT

33. SETTING UP.

a. Site for Inspection and Adjustment.

(1) When the Height Finder M2 is set up for inspection or adjustment, setting up is often done in a building and a distant terrestrial object is used as the target. The floor should be very solid and free from vibration. The instrument should set up as high above ground as these other considerations permit to avoid effects from heat waves close to the ground.

(2) Both end windows should face the target through open windows in the building. No window glass, even plate glass, is sufficiently flat optically; it would give rise to poor definition and other apparent faults in the instrument.

(3) Unless the Height Finder M2 is to be checked with an antiaircraft director or equivalent, an ordinary 110-volt, a-c power supply with a thin, two-pronged receptacle is adequate for all testing needs. The 110-volt receptacle will fit the two prongs, numbers 4 and 5, of the 19-pole plug (fig. 260). A 6-volt line can also be employed using the two-prong, 6-volt receptacle located near the 19-pole plug.

(4) The usual precautions about temperature equilibrium naturally apply whether the instrument is set up inside or outside a building.

b. Setting Up and Leveling. The height finder should be completely set up and leveled as described in TM 9-624.

34. ORIENTATION AND SYNCHRONIZATION.

a. Orientation and synchronization of the height finder should be checked and adjusted as described in TM 9-624.

35. PRELIMINARY ADJUSTMENTS.

a. The adjustments which must be made on the height finder before any performance tests, inspections, or adjustments can be made include: the interpupillary adjustment, the selection of magnifying power, the selection of filter, the focus adjustment, the headrest adjustment, the height-of-image adjustment, the internal adjustment, and the setting of the height-range lever. All of these adjustments are very critical. Each must be made very carefully. Most important are: the interpupillary adjustment, the height of image adjustment, and internal adjustment. A slight error in any one of these results in very inaccurate height finder readings. Accuracy in making these adjustments is just as important for the maintenance man as it is for the observer.

b. For method of making the above adjustments, see TM 9-624.

c. It is the duty of the repairman to notify the using-arm observer if he makes any adjustment on the following, since such adjustment may affect the IACS (RCS) or offset personal calibration necessary for the observer to read true heights:

(1) LEVELING ERRORS.
Level bubbles.
Tracking alinement in elevation.
Measuring knob, or height ring backlash adjustment.

(2) OPTICAL ADJUSTMENT.
Wedge adjustment (any of main system).
Realinement of internal target system.
End window adjustment.
Fine elevation knob.
Readjustment eyepiece assembly and replaced optics.

(3) MECHANICAL ADJUSTMENTS.
Change of height-range brackets.
Charge with helium.

Section VI

INSPECTION

36. INTRODUCTION.

a. Purpose.

(1) The systematic basic inspection procedure provides a means for determining whether or not the instrument is in usable condition and, if not, for determining its basic faults and the repairs necessary to put it back into serviceable condition. CAUTION: *The entire basic inspection should be carried out, as far as possible, in the order given before any work is undertaken on an instrument, so that the necessary repairs and adjustments may be made in the proper order and, again, after the work is done, to insure that all necessary repairs and adjustments have been completed.*

(2) If the instrument is charged with helium, the helium content should be checked as described in TM 9-1622 before the basic inspection is started. Reference should be made to the height finder log book for results obtained in checking the instrument by the Oliver method (TM 9-624).

b. Requirements.

(1) The inspection tests should be made by a trained maintenance man and stereoscopic observer and, where practical, range and internal readings should be checked by a second observer. The instrument must be set up in a suitable location as described in paragraph 33. The instrument should be under stable temperature conditions (no temperature change greater than 3 degrees per hour), preferably for at least 4 hours prior to beginning observations, and should not be exposed to the rays of the sun. At least one distant target of known range is necessary, and it is desirable to have several targets at short, intermediate, and long ranges. A distant target with a sharply-defined reference point or line exactly level with the height finder is also needed.

(2) The following tools and items of testing equipment are required for making the complete inspection: double collimator, collimating telescope (low power telescope), dioptometer, bumping machine or steel-wheel truck, interpupillary distance template (or ground glass, wooden blocks, and millimeter scale), and pupil loupe (or hand magnifier).

c. Tolerances. Tables of the tolerances which should be met in all of the inspection tests are given in paragraph 63.

37. CHECK THE INSTRUMENT FOR COMPLETENESS.

a. As a first step in the inspection of the instrument, it is necessary to determine whether or not the instrument is complete in all details. Check the instrument for any damaged or missing parts.

b. Height Finder Telescope. Check the instrument for M13 Telescopes, adjusting knobs, carrier handles, eyeshields, lamps, indexes, 6-pole receptacle, etc.

c. Cradle. Check the cradle for azimuth indicator, height transmitter, traversing handwheels, levels, 19-pole receptacle, 13-pole receptacle, etc. Note presence of nicks or burs on mating surfaces.

d. Tripod. Check the tripod for adjustable feet, ease in setting up, etc.

e. Chests. Note completeness and condition of fastenings and accessories.

38. OPTICAL CHECK—BASIC PERFORMANCE.

a. The basic performance test is described in paragraphs 38 to 55. This test will determine whether or not the optical elements in the height finder are in proper adjustment for taking accurate height and range readings.

39. LEVELS.

a. It is necessary that the height finder be level before any range or height readings are made, so that the field of view will be parallel to the reticle field, and that the height readings, which are dependent on the angle of elevation, will give true values.

b. Level the height finder accurately, so that the bubbles of the cradle levels do not move as the instrument is traversed through 360 degrees (par. 91). Check the positions of the bubbles with respect to the engraved marks on the vials.

c. Turn the elevation handwheel to center the bubble in the level on the height finder optical tube. This requires breaking the hermetic seal of the instrument. Traverse the instrument through 360 degrees to see that there is no movement of the bubbles in either cradle or optical tube levels.

d. If the cradle levels are not within tolerance, adjust them before proceeding further with the inspection (par. 91).

40. CHECK HEIGHT ADJUSTER FOR HEIGHT OF IMAGE.

a. In order that the value obtained on the adjuster scale for internal target readings be correct for range readings, it is essential that the height adjuster have the same adjustment for both internal target and external readings.

b. The height-of-image adjustment (external target) is made as follows:

(1) Turn the adjuster knob to external target position.

(2) Make stereoscopic contact as nearly as possible on a convenient fixed target, at 24 power. If possible, choose a target which has a sharp horizontal line across it.

(3) Slew the height finder until the target is exactly under the center reticle mark of the right reticle.

(4) Close the left eye and, by means of the elevation adjustment knob, bring up the target in the right field of view until the bottom of the center reticle mark is just separated by one line-width from the horizontal line or some special part of the target. Then take the hand from the elevation adjustment knob.

(5) Open the left eye and close the right eye. By means of the height adjuster knob, move the target up or down in the left field of view until the bottom of the center reticle mark is at a corresponding height above the same horizontal line or part of the target which was used when sighting with the right eye.

(6) Blink the right and left eye alternately to check that the target is at exactly the same height in the two fields of view (fig. 53).

HEIGHT ADJUSTER SETTING

STEP 1. Set magnification at 24 power, adjuster prism shift for external reading, and train on a distant target.

STEP 2. Look through right eyepiece and align Height Finder so that target is almost in contact with end of center reticle line (one line width separation is good practice).

STEP 3. Look through left eyepiece and set height adjuster to place the same point of the target at a corresponding height in left reticle field.

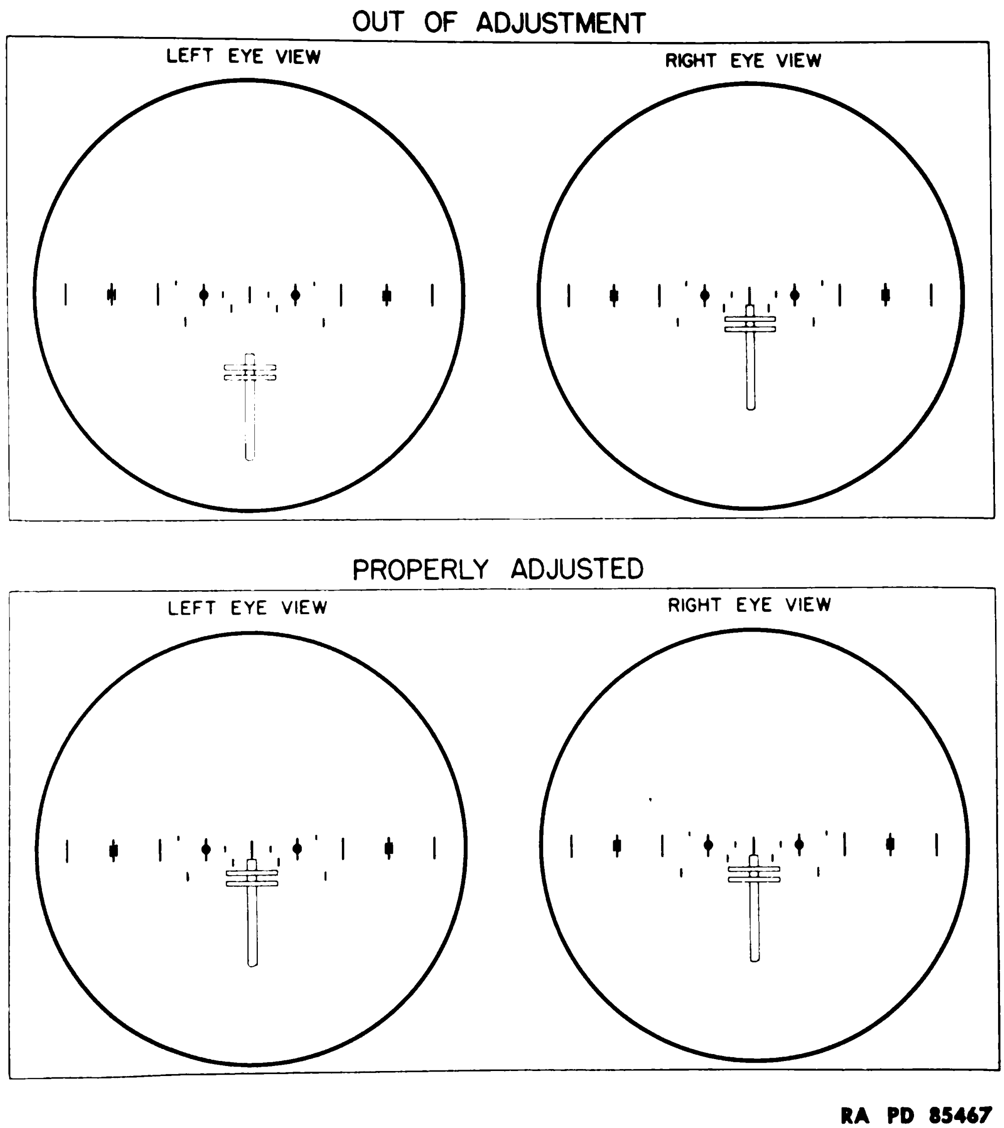


Figure 53 — Setting the Height Adjuster

INSPECTION

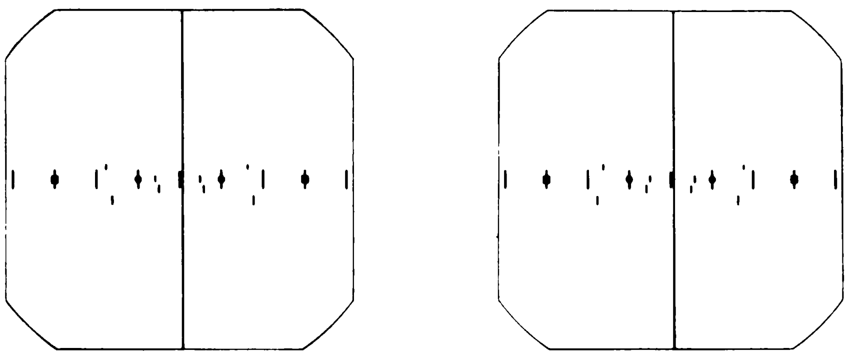
Inspection of
HEIGHT OF INTERNAL TARGET

STEP 1. Set height adjuster for external target.

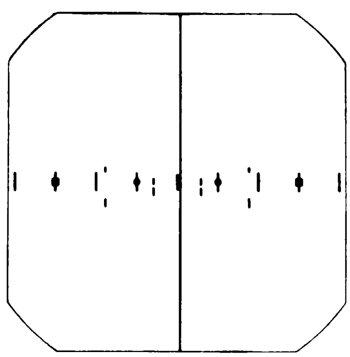
STEP 2. Turn adjuster knob for internal readings.

STEP 3. Observe through left eyepiece and note position of reticles in internal target field.

LEFT RIGHT



Reticles Viewed Individually



Reticles Viewed Stereoscopically

TOLERANCE: Reticle pattern should be centered up and down with respect to the internal target illuminated field. Right and left end reticles of reticle pattern should be positioned equal distances from illuminated field edges, (magnification set at low power).

CORRECTION: To adjust and center illuminated fields adjust penta prisms. (Paragraph 155).

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Figure 54 — Height of Internal Target Fields

c. The height of image adjustment (internal target) is made as follows:

(1) Set the height adjuster for an external target as described above.

(2) Shift the adjuster prism shift knob for internal readings and set instrument at 12x.

(3) Note the relative positions of the illuminated fields with reference to the reticles (fig. 54).

d. **Analysis.** If it is impossible to bring the external field into adjustment, it is an indication that an end reflector has become loose and shifted or is damaged. Check by leveling the height finder and sight on a target at the same height as the center of the height finder, with the fine elevation knob in the locked position and the height finder zero indexes matched. Look for trouble on the side of the height finder through which the target is not visible. Make the necessary adjustments as in paragraph 94.

41. INTERNAL TARGET AND MAIN OPTICAL SYSTEMS.

a. **General.** This test will determine whether or not any of the optics in the main optical system or the internal target system are out of adjustment.

(1) Set the height-range lever at "RANGE," the measuring drum at infinity, and the adjuster prism shift knob for "INTERNAL TARGET" readings. Make five internal target readings and set the medium value on the adjuster scale. Set the prism shift knob for outside readings, and make five readings on a target at a known distance of between 2,500 and 5,000 yards.

(2) In some case it may be impossible to obtain stereo contact between the internal target line and the center line of the main reticle. In such cases, check the measuring drum infinity setting, set the correction knob scale to "60," and position the alinement wedge until stereo contact is established with the center reticle and the internal adjuster target line (par. 153).

(3) If it is impossible to obtain stereo contact of the internal target with any marks in the height finder reticle field, set the instrument for outside readings, and the measuring drum at the known target distance. Attempt to bring the external target into stereo contact with the center height finder reticle line, using the adjuster scale.

b. **Internal Target Reading Within Tolerance — External Range Reading Within Tolerance.** Main optical system and internal target optical system are within adjustment. At a stable temperature, the height finder, if desired, can be brought up to a 58 to 62 adjuster reading by adjusting the internal target alinement wedge and the end windows (pars. 153 and 160).

c. **Internal Target Reading Within Tolerance — External Range Reading Outside Tolerance.** The internal target optical system is in adjustment. The end windows will require adjustment to bring the range reading within tolerance (par. 160).

d. **Internal Adjuster Reading Possible but Outside Tolerance —External Range Reading Inside Tolerance.** The internal target optical system is out of adjustment. The main optical system is in adjustment.

(1) CORRECTION WEDGE ASSEMBLY. Spur gear may not be properly alined to correction wedge assembly gear segment.

(2) PENTA PRISMS. Prisms with wrong deviation may have been installed.

(3) CORRECTION WEDGE. This may not be properly alined in correction wedge mount.

(a) Check for backlash between correction knob gear assembly and correction wedge gear assembly.

(b) Check parallax of both right and left internal collimator objectives (par. 153).

(4) MEASURING WEDGES. These might be out of adjustment. Check as indicated in paragraph 134.

(5) ALINEMENT WEDGE. This might be out of adjustment. Check as indicated in paragraph 153.

e. **Internal Target Reading Impossible To Obtain.** If it is impossible to obtain an internal target reading against either fore or aft marks, it is an indication that the internal target system is out of adjustment, and that the height finder optical system may or may not be out of adjustment. If it is possible to obtain contact on an outside target with the adjuster scale when the range drum is set to read at the known target distance, the height finder optical system is in adjustment. If, however, it is impossible to obtain contact with the target by means of the adjuster scale, both the main optical system and the internal target system are out of adjustment.

f. **Possible To Obtain Contact on Outside Target With Adjuster Scale.** Carefully inspect the internal target system to locate the difficulty. Set the prism shift knob for internal readings. Note the relative position of the internal target fields which should be superimposed upon each other and centered about the height finder reticle lines (stereoscopic view, fig. 54). Also note the relative position of the internal target line in the height finder reticle field with

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Figure 55 — Lean of the Internal Target Line

the adjuster scale set at 60. Both lines should be in the same relative position in both fields (fig. 54). Also check for tilt and lean of the target line, both in stereo and through each eyepiece individually (fig. 55). From the information thus obtained, it should be possible to locate the difficulty. If the target line in either eyepiece is out of its normal position, either the internal target objective cell adjusting screws, or bracket holding screws, are stripped or loose. Either one of these conditions will affect the position of the target line. If the target lines cannot be returned to their normal position with the correction knob adjustment, check setting of the range drum, and check tilt or lean in each eyepiece. Remove the illuminator covers of the internal target collimator and check the internal target collimator position, especially the left bracket assembly, to make sure that nothing has shifted. Remove the end boxes of the height finder and check the penta prisms.

g. **Impossible To Focus to Target Line.** This is an indication that either the objective is not properly adjusted for parallax, or the target line plate has separated from the objective mount to which it is cemented. In this latter case it will be necessary to remove the objectives (par. 158). Do not attempt to recement the target line disk to the objective, but install new objectives from spare parts which have the single line. These parts are matched for accuracy when sent to the field for spare parts (SNL F-189).

h. **Impossible To Range on Outside Target With Adjuster Scale.** If it is impossible to obtain stereo contact on the outside target, it may be an indication that both the internal target and the main optical systems are in need of adjustment. This can best be done by making a full adjustment of both systems according to instructions in paragraphs 118 and 158. (The main optical system must be adjusted first.)

42. CHECK COMPENSATOR (MEASURING WEDGE) UNIT FOR ACCURACY (RANGE-INFINITY, HEIGHT-INFINITY, AND HEIGHT-900).

a. General. The purpose of this test is to check the alinement between the compensator assembly, the measuring drum, and the height conversion mechanism. When the instrument is properly leveled at zero elevation, the wedges should be in a neutral position, causing no deviation of the internal target line in the reticle field for settings at height-infinity, height-900, and range-infinity. The 90-degree conversion test (fig. 66) must be made before the compensator test is made.

b. Check for Backlash in Wedge Unit.

(1) Set height-range lever at "RANGE." Turn measuring drum to about "3000," then turn carefully up to, but not past, infinity. Take five internal target readings. Turn the drum past infinity as far as it will go, then carefully back to infinity and take five more internal target readings. Compare the medians of the two sets of readings.

(2) ANALYSIS. If the readings are not within tolerance, there is a backlash in the compensator unit, and the following points should be checked and corrected (par. 129):
Brass chips between gears (from dust cover screw holes).
Gears strike adjuster tube.
Backlash spring sticking.

c. Check Range-infinity and Height-infinity.

(1) Carefully level the cradle and height finder telescope and take five internal target readings with the height-range lever at "RANGE" and the measuring drum at infinity. Shift the height-range lever to "HEIGHT," leaving the measuring drum at infinity, and again take five internal target readings. Compare the median of the readings at both positions of the height-range lever.

(2) ANALYSIS. If range-infinity and height-infinity are not within tolerance, the range drum is not properly alined with the compensator unit. Adjust as in paragraph 127.

d. Check Height-infinity and Height-900.

(1) Check that the height finder and cradle are properly leveled. Take five internal target readings with the height-range lever at "HEIGHT" and the measuring drum at infinity. NOTE: *The conversion ring lock is to be moved down toward the height locking bracket before engaging, not up, no matter how small an amount.* Leave the height-range lever at "HEIGHT" and turn the measuring drum to "900." Again take five internal target readings. Compare the median of the readings at both settings of the drum.

Inspection of
EYEPIECE UNIT FOR ALINEMENT OF OPTICAL AXIS
(Divergence, Convergence, Dipvergence)

STEP 1. Direct height finder at clear sky or other light source to provide good illumination of reticle fields.

STEP 2. Set up divergence tester and adjust so that image of center line of right main reticle is at position shown in sketch.

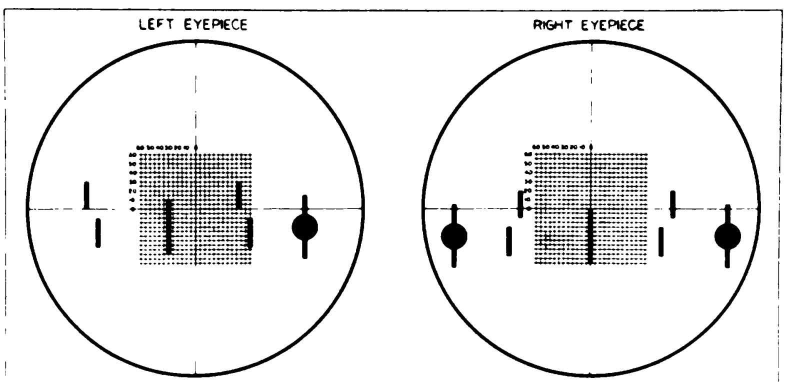
STEP 3. Note position of image of center line of left main reticle. A position to the left of that of the right reticle indicates divergence, a position to the right indicates convergence, a position above or below indicates dipvergence.

TOLERANCE: Thirty minutes divergence, no convergence, ten minutes dipvergence (up or down).

CORRECTION: For excessive divergence move eyepiece adapter as indicated at 1 (Fig. 56). Try to set about 15 minutes divergence. For dipvergence move eyepiece adapters as indicated at 2 (Fig. 56).

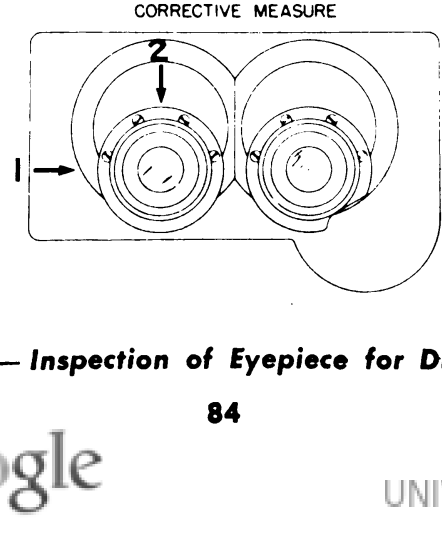
DIPVERGENCE

VIEW THROUGH DIVERGENCE TESTER



CONDITION SHOWN IS A DIVERGENCE OF 30 MIN, DIPVERGENCE (UP) OF 10 MIN (MAXIMUM PERMITTED)

CORRECTIVE MEASURE



RA PD 85471

Figure 56 — Inspection of Eyepiece for Dipvergence

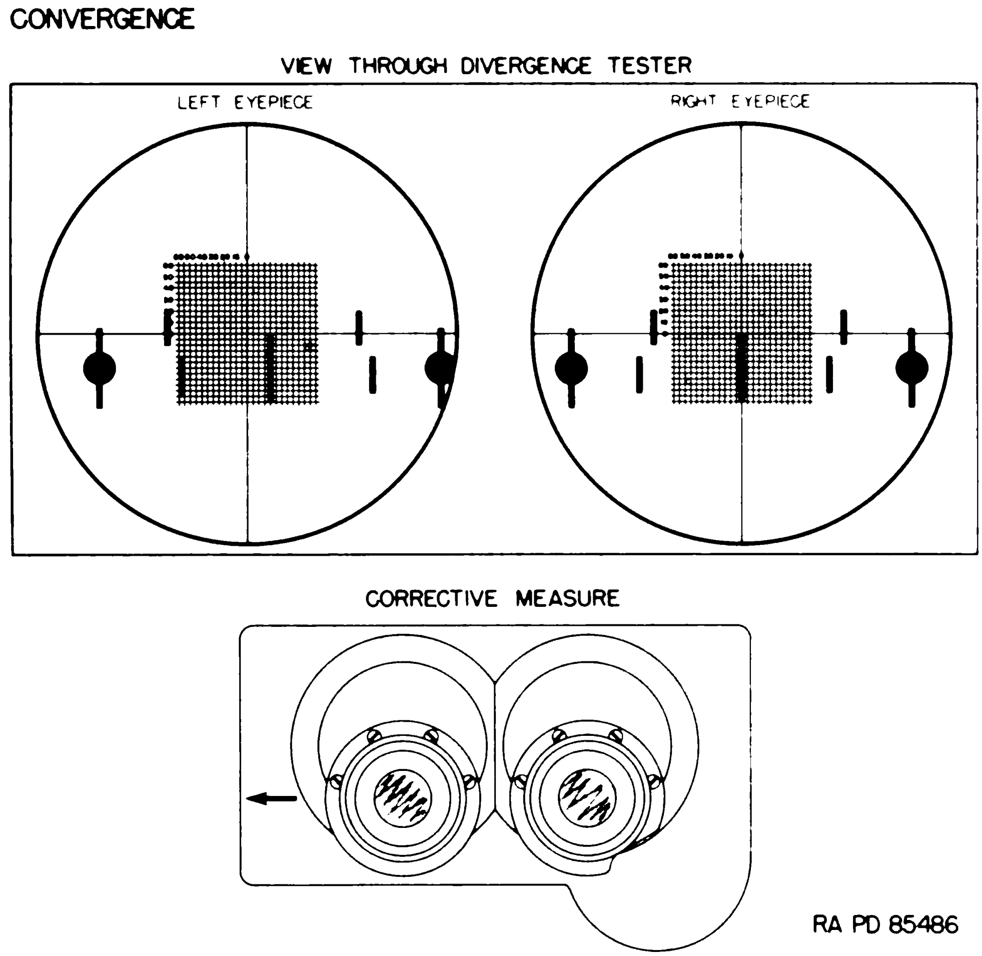


Figure 57 — Inspection of Eyepiece for Convergence

(2) ANALYSIS. If height-infinity and height-900 readings are not within tolerance, it is a sign that the bevel gear and compensator unit are not properly positioned by the height locking brackets. Adjust according to paragraph 126.

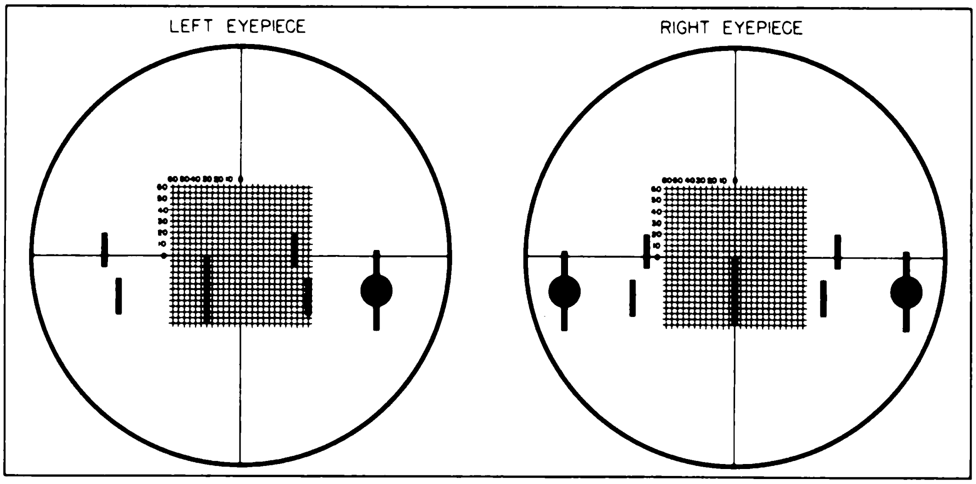
43. DIVERGENCE.

a. This test is to determine the amount of lateral divergence (divergence or convergence) and up-and-down divergence (dipvergence) present.

b. Check tightness of eyepiece plate screws. Place the double collimator (divergence tester) on the eyepiece unit and check the divergence as in figures 56 and 58. Shift the interpupillary distance knob through its travel from 58 to 72mm with the instrument in both high and low power. Note the change in position of the center

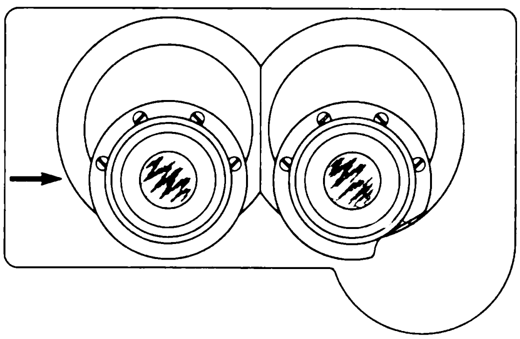
DIVERGENCE

VIEW THROUGH DIVERGENCE TESTER



CONDITION SHOWN IS A DIVERGENCE OF 30 MIN (MAXIMUM PERMITTED)

CORRECTIVE MEASURE



RA PD 85487

Figure 58 – Inspection of Eyepiece for Divergence

reticle lines with respect to each other at any setting. Use the center of the center line. This is the only point that will not vary in shifting from high to low power or from low to high power.

c. If the dipvergence is not within tolerance:

(1) If the total range of dipvergence (through travel of IPD and high and low power) is less than 20 minutes, dipvergence can be corrected by shifting eyepiece adapters (fig. 56).

(2) If total range of dipvergence is more than 20 minutes:

(a) If the change in dipvergence is more than 20 minutes on changing from low to high power, reduce by shifting eyepiece adapter.

(b) Check filters for prism power.

(c) Check all lenses for tightness in cells.

(d) Reposition erector lens adapters.

(e) Reposition auxiliary eyepiece objective supports.

(f) If change in dipvergence occurs when moving IPD from 58 to 72mm, difficulty lies in mechanical misalinement in the eyepiece assembly. Shift eyepiece adapters. Shift erector cell adapters. Refer to paragraph 107.

d. If the divergence is not within tolerance:

(1) If the total variation in divergence (through travel of IPD and high and low power) is less than 30 minutes, divergence can be brought within zero to 30 minutes by shifting the eyepiece adapters (fig. 56).

(2) If the total variation in divergence is more than 30 minutes:

(a) If the change in divergence is more than 5 minutes upon changing from low to high power, reduce by centering one (or both) eyepiece auxiliary lens supports and, if necessary, shift erecting lens adapters.

(b) If change in divergence occurs when moving IPD from 58 to 72mm, difficulty lies in either rhomboid prism and cannot be eliminated unless prisms are repositioned, or both eyepieces are shifted until centering remains in tolerance.

44. PARALLAX TEST (FOCUS OF HEIGHT FINDER OBJECTIVES).

a. The purpose of this test is to check the focus of the objectives, which should be such as to bring the images of a distant target into focus at the height finder reticles.

b. Train the height finder on a target at approximately 5,000 yards distance, and inspect for parallax by moving the head back and forth and sideways above the eyepiece (fig. 59) or check the focus with a collimating telescope (low power telescope) as follows:

(1) Place the telescope over the right eyepiece and adjust the eyepiece to bring the height finder reticle into sharpest focus with the collimating telescope reticle. Record the eyepiece diopter setting.

(2) Adjust the eyepiece for sharpest focus of the target image with the collimating telescope reticle and record the diopter setting. A difference between the two settings indicates presence of parallax.

(3) Repeat steps (1) and (2) for the left eyepiece.

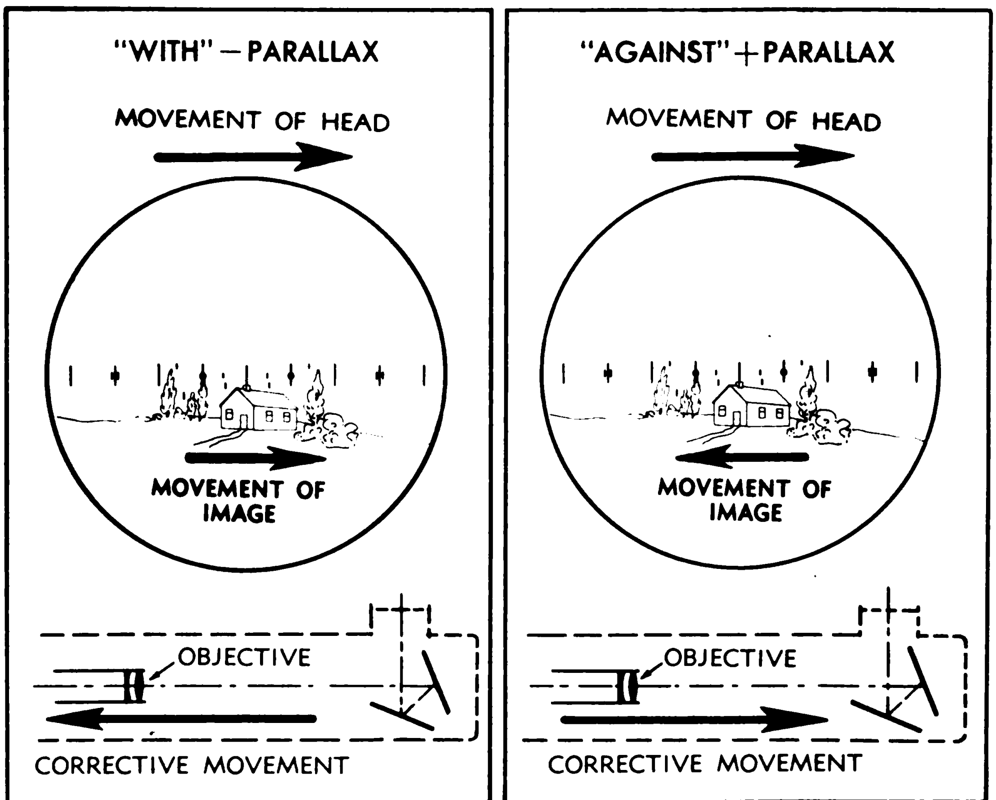
c. Analysis. If there is parallax, refocus the objectives as in paragraph 117.

Parallax Test for
FOCUS OF OBJECTIVE LENSES

STEP 1. Train height finder on a distant target.

STEP 2. Set range-height lever in "range" position and set measuring knob to bring target image into stereo contact with main reticle.

STEP 3. Inspect image in right reticle field while moving the head back and forth above the eyepiece. Relative movement between target image and reticle marks indicates parallax error or difference in plane of focus. The movement of the target in relation to the reticle may be in the same direction as the movement of the head (with), or in the opposite direction (against).



TOLERANCE: None perceptible.

CORRECTION: Focus right objective by moving in direction indicated (Par. 118)

RA PD 85472

Figure 59 — Test of Objectives

INSPECTION

45. CROSS-FIELD READINGS.

a. The purpose of comparing readings made at several points across the reticle field is to check the match of the focal length of the objectives on both sides of the height finder for equality of magnification at the reticle. This test can be made on an outside target at approximately 5,000 yards.

b. Make five readings, with the target image in each of five positions across the reticle field, as in figure 60. If the averages of the readings for the five positions do not agree, calculate the unit of error (UOE) difference (par. 50). Cross-field tests are difficult to make, and it is wise to have a second observer check the readings of the first observer.

c. Analysis.

(1) If the readings are high at one side and low at the other side of the field, it indicates that the objectives do not have the proper separation (air space), do not have the correct focal lengths, and magnification is not equal. This can be corrected by adjusting one objective to the other as described in paragraph 118.

(2) If the cross-field readings are irregular, for instance, high at the ends and low in the middle, it indicates that the focal lengths of the objectives are not properly adjusted for equal magnification. To correct, make the air space either greater or less in both objectives. In performing the above adjustments, trial only will tell the maintenance man which direction to move the air space adjusting rings.

46. BUMP TEST.

a. The purpose of the bump test is to determine the presence of any loose optics or mechanical parts which might affect the readings of the height finder.

b. The test is accomplished by use of a bumping machine of an approved design which lifts one end of the height finder and drops it with a jarring motion. If a bumping machine is not available, a substitute bump test can be carried on as follows:

(1) The height finder telescope can be carried on a steel-wheel truck and rolled over cobble stones, or equivalent, for a distance of 100 yards. The truck body and carriage should be rigidly connected and the truck should embody no cushioning devices.

(2) The following inspections should be made and the results noted both before and after the bumping:

(a) Check the divergence at 65mm setting of the interpupillary distance.

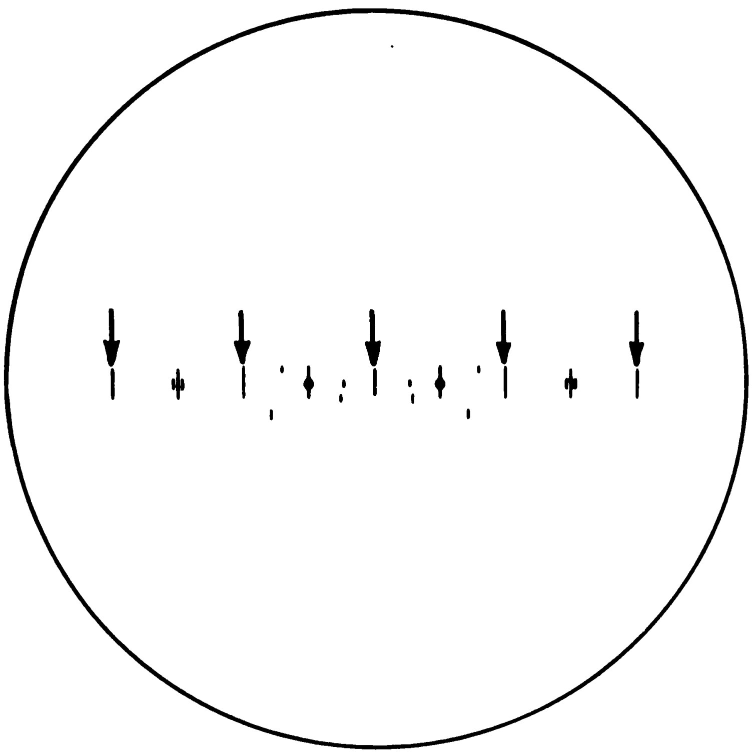
(b) Check the parallax.

Cross Field Test for
EQUALITY OF MAGNIFICATION OF IMAGE AT RETICLES

STEP 1. Train height finder on distant target. (Correct IPD and eyepiece focus is important in this test.)

STEP 2. Set range-height lever at "range" and range drum in position to bring the target into stereo contact.

STEP 3. Make five range settings for stereo contact at each of the five positions indicated in sketch. (Swing height finder in azimuth to shift target across reticle field.) Have a second observer make check readings.



TOLERANCE: The mean of five readings at any point shall not vary from the mean at the center of the field by more than 2½ units of error.

CORRECTION: See discussion in paragraph 118.

RA PD 85469

Figure 60 — Test for Equality of Magnification

(c) Check the internal target readings.

(d) Check the outside range reading.

(e) Check the shift of focus.

(f) Check the height of image with the height adjuster. Adjustment should not change more than one-half turn of the adjuster knob.
NOTE: *The bump test should be made only after complete disassembly and assembly, internal target assembly, or end reflector assembly.*

c. Analysis. Any noticeable variations in the readings after the bump test, as compared with the readings before the bump test, should be analyzed as outlined in the discussions of the various tests. Two and one-half to 3 units change of the correction knob scale is not excessive.

47. CHECK INTERPUPILLARY DISTANCE.

a. Set the interpupillary distance with an IPD Template (TM 9-624) and compare the scale reading with the actual template value. If templates are not available for values near both ends of the scale, set up a piece of ground glass and take measurements as in figure 61.

b. Analysis. If the scale reading is outside of tolerance, reset the indicating index (par. 104).

48. CHECK EYEPIECE FOCUS.

a. The eyepiece focus is checked in order to determine whether it is the same at high and low power and is as shown on the diopter scale. To check, set the prism shift knob for external readings and elevate the height finder so that it is pointing towards clear sky. Set the height finder on high power and the diopter scale to zero. Place a collimating telescope over the eyepiece and focus it for zero parallax between the height finder reticle and the dioptometer reticle. Note the mean of five readings of the dioptometer. Repeat this procedure at +2, –2, and –4 diopters on the diopter scale. Shift the change-of-magnification lever from high to low power and again measure the diopter setting at the points mentioned above. If a dioptometer is not available, use a collimating telescope (low power telescope) and determine the eyepiece settings for zero diopters.

b. Analysis.

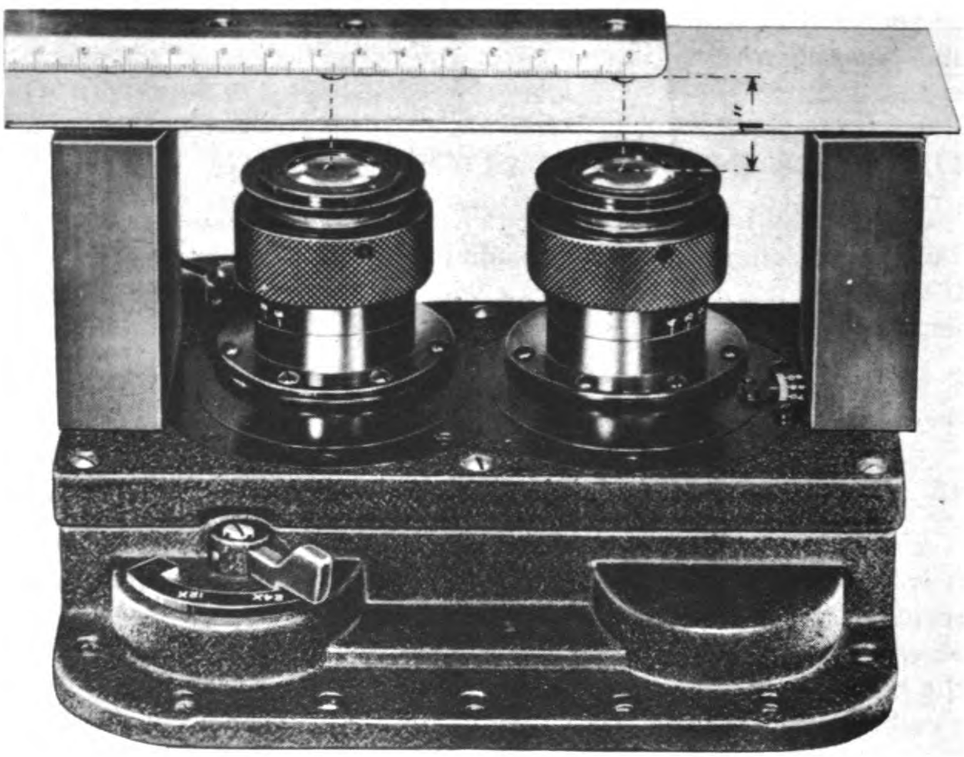
(1) If the diopter reading is not within tolerance, adjust the setting of the diopter scale as outlined in paragraph 103.

(2) If the shift of focus is outside tolerance, readjust the movement of the erector lenses (par. 103).

Inspection of
INTERPUPILLARY DISTANCE SCALE OF EYEPIECE

STEP 1. Direct height finder at bright sky, or direct light into each of the end windows. Remove eye shields.

STEP 2. Support a strip of ground glass at distance above eyepiece plate as shown in sketch and focus each eyepiece for smallest light spot on ground glass.



Checking the Interpupillary Distance Scale

STEP 3. Measure interpupillary distance (distance between centers of light spots) either by a scale marked on the ground glass or a scale laid on it. Measure at 58, 65, and 72mm scale settings.

TOLERANCE: The interpupillary distance as measured should correspond to the scale setting within ± 1/2 mm.

CORRECTION: Shift scale to bring setting within tolerance.

RA PD 85446

Figure 61 — Checking the Interpupillary Distance Scale

49. CHECK FILTERS.

a. Check the filters by turning the filter change knob to each indent and check for the same color filter in each eyepiece and against the reading on the filter scale.

b. Analysis. If not within tolerance, repair according to instructions in paragraph 112.

50. CALIBRATE INTERNAL ADJUSTER CORRECTION WEDGE (VALUE OF ADJUSTER SCALE DIVISIONS).

a. The internal adjuster correction wedge (range correction wedge) calibration is tested by determining the value of the adjuster scale divisions in terms of UOE. To make the test, range the height finder on an outside target. Make five range readings with the adjuster scale set at each of the following points: 0, 30, 60, 90, 120; and determine the mean value of the readings for each adjuster scale setting. Calculate the value of the divisions of each interval on the adjuster scale by substituting the mean values of the range readings in the following formula:

$$\text{Units of error (UOE) per division} = \frac{R_2 - R_1}{0.5386 \times \left(\frac{R_1 R_2}{1000^2}\right) \times 30}$$

where R_1 and R_2 are the mean values for a successive pair of readings, such as those for the 0 and 30, or the 30 and 60, settings of the adjuster scale.

b. Analysis. If the value of the scale divisions is outside tolerance at either end of the scale, the correction wedge is improperly mounted and should be reset in an "image down" position (par. 120). If the value of the scale divisions is outside tolerance after the wedge has been properly set, it indicates that the wedge has incorrect deflecting power and should be replaced.

51. CHECK HEIGHT ADJUSTER DISK.

a. The purpose of this test is to determine whether or not the axis of rotation of the height adjuster disk is perpendicular to the optical axis and in the plane of the line of sight. This is determined by taking internal target readings at the extreme ends of the height adjuster disk travel. Set the prism shift knob for internal target readings and set the height adjuster disk at one extreme of its travel. Obtain the median of five adjuster scale readings at this point. Turn the height adjuster knob to the other extreme of its travel and obtain the median of five readings on the adjuster scale at this point. NOTE: *The internal target line should have been adjusted to remove all tilt, which otherwise would affect the reading in this test.*

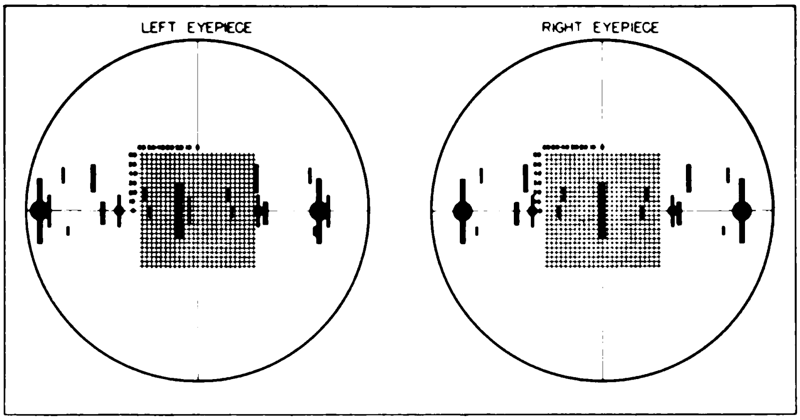
Inspection of

CENTERING OF RETICLES

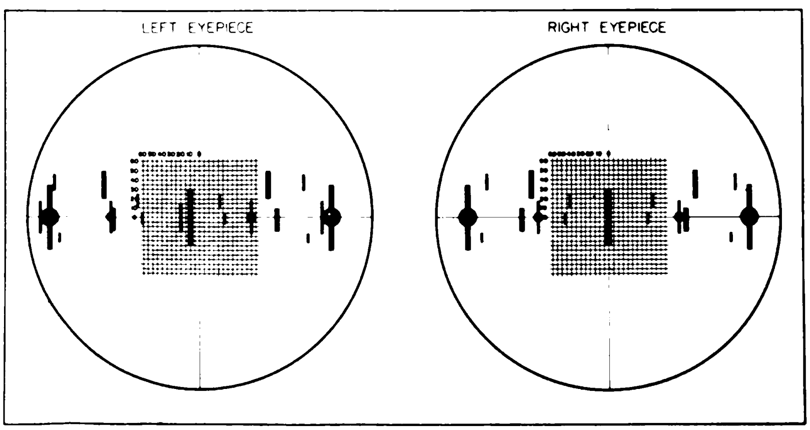
STEP 1. Direct height finder at bright sky or direct light into each end window.

STEP 2. Set up divergence tester or dioptometer on eyepieces and focus on height finder reticle. Align at 24 power so that center reticle mark is centered in tester graticule. (Broken image in sketch.)

STEP 3. Shift power to 12 power and note positions of center reticle marks for both eyepieces.



Reticles Shown at 12 and 24 Power
Figure A—Centering Errors



Reticles Shown at 12 and 24 Power
Figure B—Centering Errors

TOLERANCE: Combined movements of right and left center reticle marks must not exceed five minutes sideways and up or down.

CORRECTION: Center reticles to bring jump within tolerance. (Paragraph 100.)

RA PD 85474

Figure 62 — Inspection of Centering of Reticles

b. Analysis. If not within tolerance, reposition the height adjuster support assembly in the optical tube (par. 148) or adjust the penta prisms (par. 159).

52. CHECK RETICLES FOR CENTERING AND TILT.

a. This test is to determine the accuracy of the centering of the reticles, and of the alinement of the reticle field with respect to the image of the external field.

b. Centering.

(1) Centering is tested by observing any jump of the center reticle lines as the erector lenses are shifted from high to low power, as detailed in figure 62.

(2) ANALYSIS. If the reticle jump is outside tolerance, center the reticles (par. 100).

c. Tilt.

(1) Tilt is tested by ranging on an outside target and swinging the height finder so that a fixed point on the target is compared with the marks at the two sides of the reticle field, as in figures 63 and 64.

(2) ANALYSIS. Check end reflectors first (pars. 40 and 41). If the end reflectors are in adjustment, check the reticle. If the reticles are tilted, square up as described in paragraph 142.

53. CHECK FOR DIRT ON OPTICS.

a. The purpose of this test is to determine what optical surfaces in the height finder are dirty so that they can be cleaned, if necessary, with the least amount of effort. Direct the height finder toward the sky or other source of good illumination, and observe through a pupil loupe or a high-power hand magnifier which is moved up and down above the eyepiece so that images of the various optical surfaces are successively brought into focus. Repeat for the other eyepiece.

b. Analysis. Determine the position of the dirt with the aid of the chart (fig. 65). Clean the dirty element as outlined in paragraph 86.

54. ILLUMINATION OF RETICLES.

a. Reticles—Height Finder.

(1) With the height finder set on the internal target system and the internal target lights off, turn on the reticle illumination. Check for stray light in the reticle field, for equal brightness in both reticles, and for centered illumination.

(2) ANALYSIS. Stray light is generally caused by light entering around the shutters on the internal target penta prism bracket. Another source of stray light is reflection from the optical tube level.

Inspection of
RETICLES FOR TILT OF FIELD
USING AN OUTSIDE TARGET

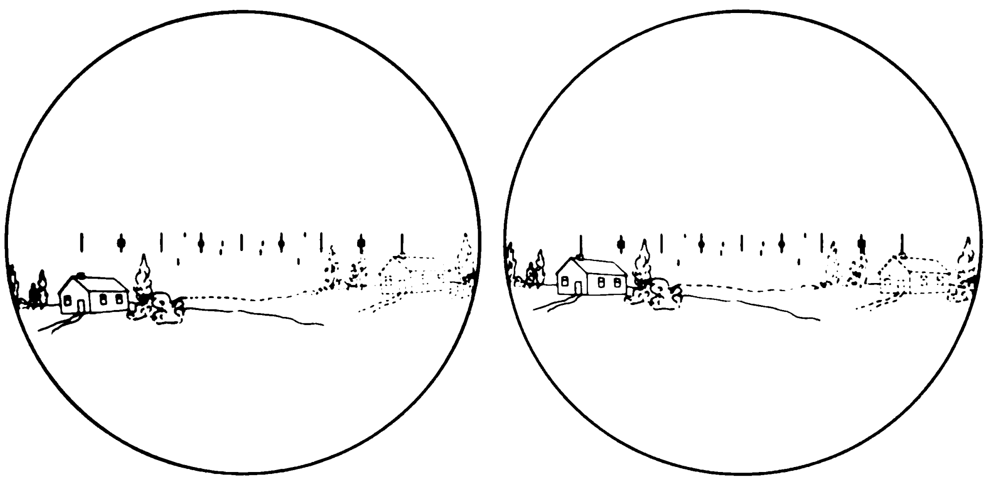
STEP 1. Turn fine elevation knob to center locked position.

STEP 2. Turn height of image knob to center position, check height adjuster disk as in paragraph 51.

STEP 3. Level cradle and align Height Finder so that target image is separated by one line width from top or bottom of end reticle line. (Dotted image in sketch.)

TOLERANCE: Target image should fall at same height at both ends of reticle field within one-half width of a reticle line.

CORRECTION: Stone bosses of end reflector bases. (Paragraph 96). Adjust right end reflector first, then adjust left end reflector to match.



Reticle Tilted　　　　Reticle Level

RA PD 85473

Figure 63 — Inspection of Reticles for Tilt of Field

Paint the sides of the level with dull black lacquer to eliminate this. Unequal brightness can be corrected by making adjustments on the reticle illumination lamp or lamp bracket.

b. **M13 Telescope Reticles.** Check the reticle illumination of the M13 Tracking Telescope by turning on the reticle switches and placing the hand over the sunshade. Note whether or not the illumination is centered and equal throughout. If not, make adjustments as outlined in paragraphs 191 and 207.

Inspection of
RETICLE TILT OF FIELD USING A "Y"—LEVEL OR TRANSIT WHEN THE HEIGHT FINDER IS SET UP IN A BUILDING

STEP 1. Turn fine elevation knob to center locked position, check height adjuster disk as in paragraph 51.

STEP 2. Level cradle and height finder telescope, using the optical tube level (Par. 92).

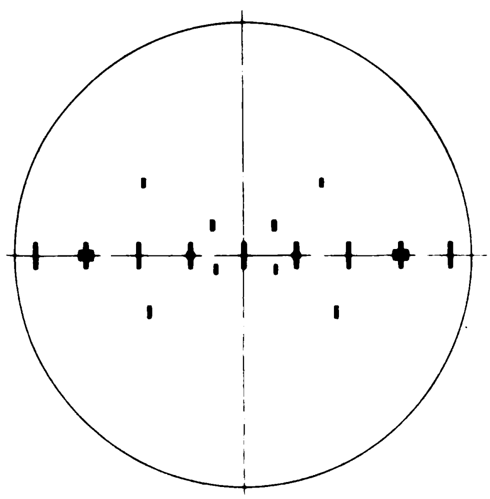
STEP 3. Remove end boxes (Par. 164).

STEP 4. Locate line level or transit about three feet in front of the right end reflector with the tripod legs adjusted so the transit tube when leveled will sight at the center of the end reflectors.

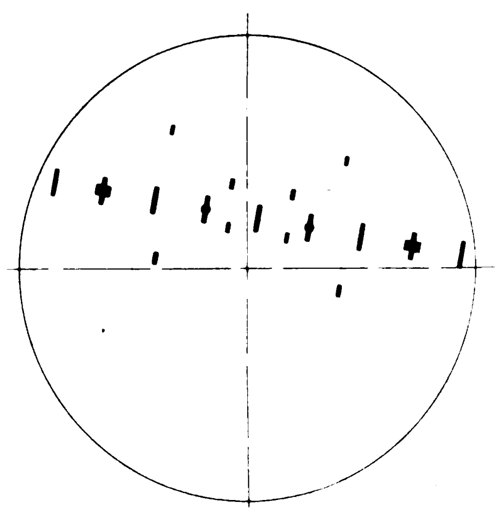
STEP 5. Place a source of illumination above the height finder eyepiece. Move the transit telescope in azimuth and focus to the reticles.

TOLERANCE: Cross lines of the transit should intersect the right and left reticles as at "A."

CORRECTION: If conditions as illustrated at "B" exist, it will be necessary to stone the bosses on the base of the end reflectors. (Par. 96).



A. Reticle Level



B. Reticle Tilted

RA PD 85468

Figure 64 — Checking Reticles for Tilt

ORDNANCE MAINTENANCE — HEIGHT FINDER M2

LOCATING DIRT ON HEIGHT FINDER OPTICS BY INSPECTION WITH THE PUPIL LOUPE

(CHANGE-OF-MAGNIFICATION LEVER MUST BE SET AT LOW POWER)

<table>
<tr><th>POSITION OF DIRT CHANGES UPON TURNING POWER SHIFT LEVER.</th><th>ANY DIRT WHERE ILLUMINATED AREA FLAT ON BOTTOM AND SIDES AS</th><th>ROTATES UPON TURNING ADJUSTER SCALE OR HEIGHT CONVERSION RING</th><th>CHANGES RELATIVE POSITION WITH RESPECT TO ILLUMINATED AREA WITH SHIFT IN POWER.</th><th>MOVES UPON TURNING FILTER LEVER</th><th>ROTATES UPON CHANGING INTERPUPILLARY DISTANCE</th><th>DIRT IS ON THIS ELEMENT</th></tr>
<tr><td rowspan="6">YES</td><td colspan="5">YES</td><td>END WINDOW OR END MIRRORS</td></tr>
<tr><td rowspan="5">NO</td><td colspan="4">YES</td><td>WEDGE UNITS</td></tr>
<tr><td rowspan="4">NO</td><td colspan="3">YES</td><td>ERECTOR</td></tr>
<tr><td colspan="3" rowspan="3">NO</td><td>OBJECTIVE</td></tr>
<tr><td>HALVING DISK</td></tr>
<tr><td>RETICLES</td></tr>
<tr><td colspan="4" rowspan="5">NO</td><td colspan="2">YES</td><td>FILTER</td></tr>
<tr><td rowspan="4">NO</td><td rowspan="3">NO</td><td>OCULAR PRISM FIRST SURFACE</td></tr>
<tr><td>OCULAR PRISM LAST SURFACE</td></tr>
<tr><td>EYEPIECE BRACKET WINDOW</td></tr>
<tr><td>YES</td><td>RHOMBOID PRISM FIRST SURFACE</td></tr>
</table>

LOCATING CAUSE OF SHADOWS ON INTERNAL TARGET

(CLEAN TOP SURFACE OF EYEPIECE BEFORE BEGINNING)

<table>
<tr><th>ROTATES UPON CHANGING INTERPUPILLARY DISTANCE.</th><th>FOCUS CHANGES UPON TURNING EYEPIECE FOCUSING NUT.</th><th>MOVES UPON TURNING ADJUSTER SCALE OR RANGE KNOB.</th><th>SHARP FOCUS</th><th>DIRT IS ON THIS ELEMENT</th></tr>
<tr><td rowspan="2">YES</td><td colspan="3">YES</td><td>RHOMBOID PRISM</td></tr>
<tr><td colspan="3">NO</td><td>EYEPIECE EYELENS OR EYEPIECE FIELD LENS</td></tr>
<tr><td colspan="2" rowspan="3">NO</td><td colspan="2">NO</td><td>MAIN RETICLE</td></tr>
<tr><td rowspan="2">YES</td><td>YES</td><td>INTERNAL ADJUSTER OBJECTIVE OR REFLECTOR</td></tr>
<tr><td>NO</td><td>INTERNAL ADJUSTER REFLECTOR</td></tr>
</table>

1. POSITION OF INDIVIDUAL SURFACES MUST BE DETERMINED BY TRIAL AS PUPIL LOUPES DIFFER IN MAGNIFICATION.
2. SMALL PITS WHICH CAUSE NO HARM SOMETIMES HAVE THE APPEARANCE OF DIRT.
3. BE POSITIVE OF THE LOCATION OF DIRT BEFORE ATTEMPTING TO CLEAN OPTICAL SURFACE.
4. CLEAN ALL OPTICS WHILE MOUNTED IN THE HEIGHT FINDER, WHEN POSSIBLE.
5. THE PUPIL LOUPE WILL NOT FOCUS TO DIRT ON THE RETICLE.

RA PD 85478

Figure 65 — Charts for Position of Dirt on Optics

c. Internal Target.

(1) The illumination of the two internal target fields should be of equal intensity so that readings will be more easily made. Check the illumination by setting the prism shift knob for internal target readings, and turning light switch to No. 2 position and "TRANS.-BATT." switch to transformer if 110-volt power is used.

(2) ANALYSIS. If the internal target fields are not equally bright, check the positioning of the internal target lamps in their brackets (par. 207). If it is impossible to bring the illumination up to the desired intensity in one of the fields, check the penta prism aperture for full light transmission. This can be done by using a pupil loupe, as in checking for dirt (par. 53), focused on the penta prism aperture, and noting any interference or shadows at the bottom or top of the penta prism. If such a condition is noticeable, the penta prism aperture is not being filled, which may be caused by damage or shifting of the penta prisms, or shifting of the internal target collimator tube (par. 153).

55. CHECK THE M13 TRACKING TELESCOPES.

a. Reticles.

(1) Check the tracking telescope reticles for the position of the lines in the reticle field.

(2) ANALYSIS. If the reticle lines are not vertical and horizontal when checked on vertical and horizontal reference lines of a target, readjust the reticle (par. 190).

b. Focus of Objective.

(1) The objective should be focused to bring the image of the target in the plane of the telescope reticle. Train on an outside target over 1,000 yards distant. Check the parallax with a collimating telescope or by moving the eye across the eyepiece and noticing any movement of the target image with respect to the reticle. Check the elevation telescope for parallax in the vertical plane, and check the azimuth telescope for parallax in the horizontal plane.

(2) ANALYSIS. If the parallax is outside of tolerance, refocus the objective (par. 115).

c. Alinement and Tilt.

(1) It is necessary that the tracking telescopes be properly alined in relation to the height finder telescope, so that in traversing or elevating the instrument, the three optical units will sight on the same target. See the relations between the various axes as shown in figure 226.

(2) To check the alinement in azimuth:

(a) Sight on a target at approximately 5,000 yards.

(b) Center the height finder so that the center reticle line is superimposed upon some point on the target.

(c) Check the position of the vertical lines of the tracking telescope reticles with respect to that point on the target.

(3) To check the alinement in elevation:

(a) Be sure that the cradle is level, and that the height finder telescope is level (par. 91).

(b) Observe a distant target at exactly the same height as the height finder, and check the position of the horizontal reticle lines of the tracking telescopes against this target. NOTE: *When the same target is centered on the height finder reticle, the fine elevation knob should be in the locked or mid position.*

(4) Check the tracking telescope reticles for tilt by traversing across a target that is level with the instrument, noting the relative position of each end of the horizontal reticle lines against a selected point on the target.

(5) ANALYSIS. If out of tolerance, realine the telescope as directed in paragraphs 150 and 151.

56. OPTICAL CHECK—FINAL PERFORMANCE.

a. The test as to final performance of the instrument should be made only after all previous tests, as outlined in paragraphs 38 to 55, have been performed. If those tests have passed tolerance, the tests herein should be readily passed. Before making the final performance test, recheck the end windows and adjust them as accurately as possible on a target at a known distance of between 5,000 and 10,000 yards, as described in paragraphs 160. After this has been done, proceed with the final optical check.

57. CHECK RANGE FINDER.

a. Accuracy.

(1) This test is performed for the purpose of determining the accuracy of the height finder in ranging upon targets at different distances under different conditions. It is divided into two similar tests run on two subsequent days.

(2) Check to see that the height finder is level and the height range lever is in range position: Set the instrument at high power. The instrument should have been at a stable temperature for at least 4 hours, and the temperature should be between 30° F and 90° F.

(3) Make five internal target readings with the instrument at high power, and set the median reading on the adjuster scale. Set

the instrument for external readings and make 10 readings on a target at a distance less than 4,000 yards, 10 readings on a target at a distance of between 6,000 and 8,000 yards, and 10 readings on a target at a distance of between 10,000 and 12,000 yards. Again set the instrument for internal target readings, make 5 readings, and compare the median with the original adjuster setting. If the final and preliminary internal target readings do not agree within 1½ UOE, set the second reading on the adjuster scale and repeat the range readings.

(4) Repeat the above test with the instrument set at low power. The same series of tests made on three ranges and in high and low power should be repeated and rechecked on the following day.

(5) ANALYSIS. If the instrument does not come within tolerance, reset the end windows, using a target at a distance of about 5,000 yards, and balancing the readings so that the short and long ranges can be brought into tolerance. If still not within tolerance, repeat the basic performance tests. Try another observer.

b. Repeatability—High and Low Power.

(1) The purpose of this test is to determine the repeatability of settings in terms of the average deviation from the true range in both high and low power.

(2) This test is performed by setting the instrument at low power and ranging on a target at a distance greater than 3,000 yards. Record each of 10 range readings and the deviation of each of these readings from true range. Obtain the average of the range readings and the median of the deviations, and note. Repeat the above test with the instrument at high power.

(3) ANALYSIS. If not within tolerance, repeat the basic performance tests. Try another observer.

58. CHECK HEIGHT FINDER.

a. The purpose of this test is to determine the performance accuracy of the height conversion mechanism by setting in fictitious angles of elevation on the height conversion ring. To perform this test:

(1) Level the cradle, and match the zero elevation indexes. NOTE: *If the indexes are damaged, level the height finder telescope with the optical tube level.*

(2) Set the height-range lever in "RANGE" position.

(3) Attach the microscope and arc to the height conversion ring and right housing (fig. 66) as described in paragraph 92.

(4) Check the zero and 90-degree positions as described in paragraph 92. This test is made on a target at the same level as the

GRADUATED ARC MOUNTED ON THE HEIGHT FINDER RIGHT BEARING HOUSING

READING MICROSCOPE MOUNTED ON THE CONVERSION RING

STEP 1. Remove 2 screws in bearing housing at the approximate position of the graduated arc in the illustrations.

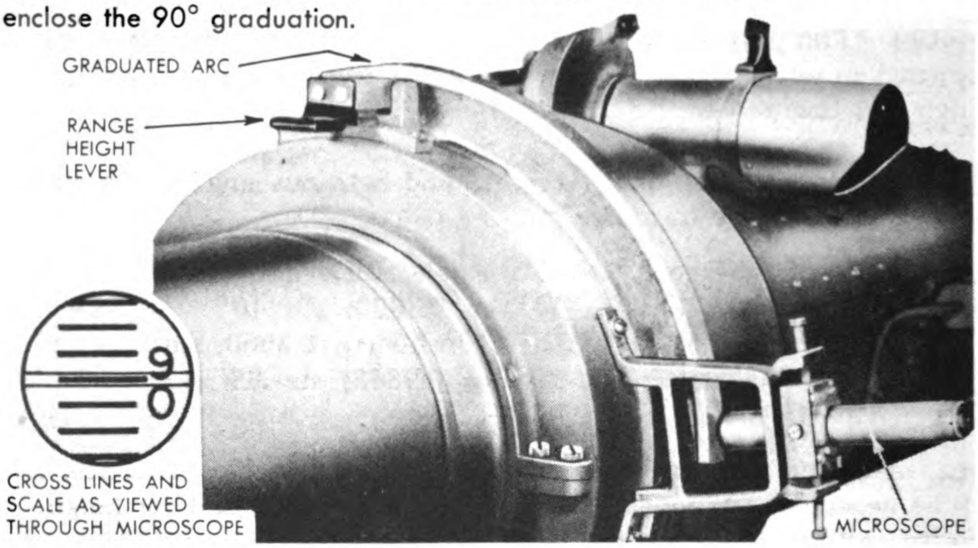
STEP 2. Mount the graduated arc on the right bearing housing with the Zero graduation near the range locking lug. Secure with two 8-36 screws.

STEP 3. Remove two screws in conversion ring and mount reading microscope with two 8-36 screws.

STEP 4. Level the instrument. Make range infinity, height infinity, height "900" adjustments

STEP 5. Adjust the microscope cross lines so they enclose the zero line of the graduated arc when the conversion ring lock lever is positioned over the height locking bracket.

STEP 6. Rotate the conversion ring lock to and over the range locking bracket. Check the reading in the microscope field, the cross line should enclose the 90° graduation.



CORRECTIONS: If the cross lines do not enclose the 90° graduation, reposition and repin the range locking bracket when conditions under 4 to 6 (above) are fulfilled.

ADJUSTING THE MICROSCOPE: When such a mount as illustrated is used the feet of the bracket are adjustable to position the microscope over the arc, the two projecting screws are for fine adjustment of microscope cross hairs. The microscope tube is moved up or down in the bracket collar to focus.

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Figure 66 — Graduated Arc and Microscope Mounted in Position

height finder at three different distances. The height finder may be lowered or raised to read on target lower or higher than the height finder by lowering or raising the entire instrument with one leveling screw. CAUTION: *Do not rotate the height finder telescope after it is leveled.*

(5) Make five internal target readings and set the median value on the adjuster scale.

(6) With the height finder at zero elevation, make five range readings on the target.

(7) With the height finder still at zero elevation, rotate the height conversion ring to the angles specified below.

(8) Make five readings at each of these points.

(9) This prccedure is repeated for the two other targets and for the angles specified below.

TARGET DISTANCES AND ELEVATION FOR HEIGHT ACCURACY TESTS

Target Distance	Height Conversion Ring Angle Instrument Level at Zero-degree Elevation
Between 3,300 and 5,000 yards	85°, 70°, 50°, 30°, 10°
Between 6,000 and 8,000 yards	80°, 70°, 50°, 30°, 10°
Between 10,000 and 12,000 yards	60°, 40°, 30°, 10°

b. For each of the above targets and fictitious angles, compute the height, using the formula:

Height = Range × sine of Angle of Elevation (sin 10° = 0.1736; sin 30° = 0.5000; sin 40° = 0.6428; sin 50° = 0.7660; sin 60° = 0.8660; sin 70° = 0.9397; sin 80° = 0.9848; sin 85° = 0.9962).

c. Analysis. If the height readings are not within tolerance, it will be necessary to recheck the setting of the wedge unit for height-infinity and height-900 as set forth in paragraphs 127 and 128.

59. CHECK INTERNAL ADJUSTER.

a. Accuracy Test.

(1) This test is performed to determine the accuracy with which continuous readings can be made on the instrument. Before making this test, be sure that the instrument has been at a stable temperature for at least 4 hours.

(a) Focus the eyepiece for an outside target, and switch the prism shift (adjuster) knob for internal target readings.

(b) Set the instrument at low power and take five readings on the

adjuster scale. When making the final setting of each reading, turn the adjuster scale in a clockwise direction.

(c) Repeat this test with the instrument in high power.

(2) ANALYSIS. If the spread of the adjuster scale readings is outside of tolerance, check the internal target optical system (pars. 152 and 153).

b. Quality Test.

(1) This test is performed to determine the accuracy at which readings can be made when the final settings are made in either direction.

(a) Set the instrument for internal target readings and on high power.

(b) Take five readings on the internal target, making the final setting in a counterclockwise direction.

(c) Take five more readings on the internal target, but make the final settings in a clockwise direction.

(d) Repeat this procedure by again taking five more readings of each direction.

(2) ANALYSIS. If the spread of the two averages is outside of tolerance, check the correction wedge and adjuster scale for backlash and correct (pars. 124 and 125).

c. Elevation—Depression Test.

(1) The purpose of this test is to check the accuracy of the instrument at various positions through its elevation.

(a) Set the instrument for internal target readings with the height-range lever at "RANGE."

(b) With the elevation dial at zero and the height finder level, make five internal adjuster readings.

(c) By turning the elevation handwheel, elevate the instrument to an angle of 30 degrees and make five more internal target readings.

(d) Repeat this performance up the scale at settings of 60 degrees and 90 degrees, and down the scale at 60 degrees, 30 degrees, and zero.

(2) ANALYSIS. If the instrument is not within tolerance, the following are probable causes:

(a) Air turbulence inside instrument—check again after 4 hours at constant temperature.

(b) Errors greater than 2½ units may be due to:

Loose optics.

Improperly fitted optical tube supports.

Instrument not temperature-stabilized.
Illuminators striking optical bar or inner tube.
Dust tubes striking optical bar gimbal.
Height adjuster connecting tube too long.
Height adjuster knob not set to proper center.
Optical tube balance.

NOTE: *To properly balance the optical tube, there are two or three flat steel weights placed on the center section of the optical tube and adjustable lead weights at each end (fig. 67).*

(c) If the average of the readings taken at 90 degrees differ from the average at zero degree by more than 2½ units, inspect for errors listed of under or over 2 minutes. If none are found, rebalance the optical tube according to the following rule: If the readings are high when the instrument is elevated, put additional weight (3 is the limit) on the center of the tube, or move end weights in toward the center of the tube. The opposite applies if the readings decrease as the tube is elevated.

d. Height Adjuster Ball Connector Tube.

(1) Set the instrument for internal readings, with the target line and center reticle moved close together. Elevate the telescope to 90 degrees. Observe the reticles and internal target line and move the height adjuster knob from stop to stop.

(2) ANALYSIS. If the target line appears to jump away from the reticles before a knob stop is reached, the ball tube is too long.

(3) CORRECTION. The height adjuster knob assembly and height adjuster disk assembly should be checked for proper position (par. 148).

60. ELECTRICAL CHECK.

a. The purpose of the electrical check is to determine the repeatability and accuracy of the elevation and azimuth indicator and the height transmitter scale and dial, and to check the illumination on the various elements in the height finder.

b. Check Indicator and Transmitter.

(1) To check the indicators and transmitter, it is advisable to have a height finder test instrument or an Antiaircraft Director M4, M7, M9, or M10. It is possible to check the zero position of the indicators and transmitter using only 110-volt, a-c source of electricity. In testing the indicators and transmitter with the height finder testing equipment, attach the testing equipment to a 110- to 120-volt line, and its 19-pole plug to the corresponding receptacle on the height finder. Rotate the dials for elevation and azimuth on the height finder

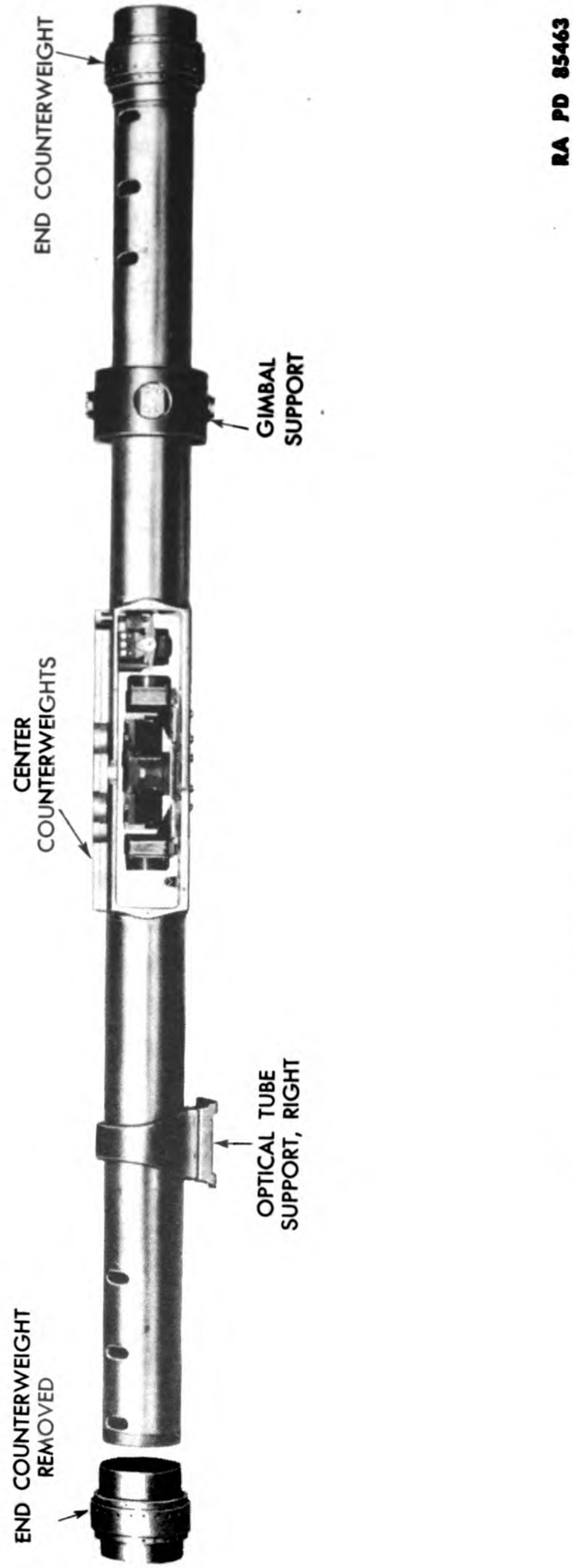

Figure 67 — Optical Tube Showing Counterweights

testing instrument through their complete travel, noting the readings on both the testing instrument and the height finder throughout the travel. In checking the height transmitter, rotate the scale from zero to 10,000 yards, noting the relative readings on the height finder scale and testing equipment. Also set the transmitter at zero and check the height finder transmitter correction dial by rotating it from zero to +500 yards and from zero to –500 yards, checking each setting against the testing instrument. If the height finder testing equipment or an antiaircraft director is not available, check the zero settings as outlined in paragraph 212.

(2) ANALYSIS. If these units are not within tolerance, reset the dials as instructed in paragraphs 212 and 213.

c. **Check Illumination of Scales and Dials.** Check the illumination of the range drum, internal adjuster correction scale, and height transmitter dial to see that it is adequate for night reading. If the illumination is inadequate on any of the dials, it can be corrected by changing the light bulbs or checking through the electrical circuit as described in paragraph 207.

61. MECHANICAL CHECK.

a. The mechanical check is made to see that all of the adjusting knobs and mechanically operating parts work smoothly and properly, and that the mechanical stops are properly adjusted.

b. **Check Levels.**

(1) CRADLE. Check the cradle levels to see that the vials are tight in their mounts and that the etch and fill are satisfactory. Make any replacements or changes in the levels as outlined in paragraph 91.

(2) HEIGHT FINDER TELESCOPE. Check level in the height finder optical tube to see that the vial is tight in its mount and that the etch and fill are satisfactory. Make any replacements or changes on the height finder level as described in paragraph 91.

c. **Check Mechanical Operation.** To check the mechanical operation of the various mechanical parts of the Height Finder M2, go through the check list (pars. 62 to 67). In making repairs to any parts, refer to the appropriate paragraph on disassembly and assembly.

d. **Check Carrier Handles.** During transit, the Height Finder M2 rests entirely on the carrier handles. It is, therefore, important that the carrier handles be parallel. Check this by matching the zero elevation indexes on the left side of the telescope and left bearing housing. Set the height finder telescope on a level floor with the carrier handle caps mounted loosely, and check the deviation from the horizontal with the eye. Rotate the telescope in the carrier supports until it is horizontal, and secure the carrier handle caps.

e. **Pressure Test.** Test the instrument for retention of pressure (TM 9-624). The pressure tests should be performed after completion of all adjustments requiring breaking of hermetic seal, to insure that adapters have been mounted properly and all covers are properly sealed.

f. **Painting and Protection.** Inspect canvas covering. Inspect paint on all external surfaces.

g. **Packing Chests.** Inspect packing chests. Note condition of bodies, covers, hinges, hasps, etc. Inspect gaskets and sealing surfaces. Check instrument supports and clamps. Check for full complement of specified tools and spare parts.

62. INSPECTION AND TOLERANCE SUMMARY—COMPLETENESS.

Test	Requirements
a. **Telescope.**	Complete with M13 Telescopes, elevation indicator, elevation handwheel, zero elevation indexes, adjusting knobs, carrier handles, eye shields, lamps, 13- and 6-pole receptacles, etc.
b. **Cradle.**	Complete with azimuth indicator, height transmitter, traversing handwheel, levels, 19-pole receptacle, switches, rheostats, etc.
c. **Tripod.**	Complete with adjustable feet, locking knobs, lock handles, etc.

63. INSPECTION AND TOLERANCE SUMMARY—BASIC OPTICAL CHECK.

a. **Levels.**

(1) CRADLE.	Bubble to be centered within one-third of space between engraved marks throughout 360 degrees traverse.
(2) TELESCOPE.	When bubble of optical tube level is centered, movement of height conversion ring to be 90 degrees between locking brackets.

INSPECTION

Test	Requirements
b. Height Adjuster.	In changing from the external to the internal system, the relative height of the images in each eyepiece should not shift.
c. Internal and Main Optical Systems.	
(1) INTERNAL TARGET READINGS.	The mean of five internal target readings to fall between 50 and 70 on the internal target scale.
(2) RANGE READINGS.	The mean of 10 range readings on a target known distance should be within 1½ UOE of the true range.

ERROR IN YARDS EQUIVALENT TO 1.5 UNITS OF ERROR (UOE) AT 24 POWER

Range*	Error	Range*	Error	Range*	Error
1,000	0.8	5,500	24.4	10,500	89
1,500	1.8	6,000	29.1	11,000	98
2,000	3.2	6,500	34.2	11,500	107
2,500	5.1	7,000	39.6	12,000	115
3,000	7.3	7,500	45	12,500	126
3,500	9.9	8,000	52	13,000	136
4,000	12.9	8,500	58	13,500	147
4,500	16.3	9,000	65	14,000	158
5,000	20.2	9,500	73	14,500	170
		10,000	81	15,000	182

d. Check Wedge Unit.

Test	Requirements
(1) BACKLASH.	Correction knob scale readings for up-scale drum setting and down-scale drum setting to agree within 2 UOE.
(2) RANGE-INFINITY, HEIGHT-INFINITY, AND HEIGHT-900.	90-degree conversion travel must be checked (fig. 64). Correction knob scale reading to agree within 2 UOE at 3 positions, when the conversion ring lock is located over the height locking bracket coming directly down and over the locking bracket. The conversion ring lock is to be moved down toward the height locking bracket before engaging it, not up no matter how small an amount.

*If the range being used is between two consecutive ranges in the above table, then the tolerance will lie proportionally between the two ranges. (This is not precisely true, but it is close enough. The error values in the table are based on the following relation: 1½ UOE = 1.5 × 0.0000005386 × (Range)^2, or 0.808 × (Range + 1,000). NOTE: One UOE = 0.5386 × (Range + 1,000).

e. **Divergence.**

Test	Requirements
(1) DIVERGENCE AND CONVERGENCE.	Permissible divergence from zero to 30 minutes throughout the travel of the interpupillary lever—no convergence is permissible. The divergence to change no more than 7 minutes between any two interpupillary settings and at high and low power.
(2) DIPVERGENCE (UP-AND-DOWN DIVERGENCE).	The permissible up-and-down divergence is 10 minutes at any point through the travel of the interpupillary lever. Up-and-down divergence to change not more than 5 minutes between any two interpupillary settings and at high and low power.
f. **Parallax.**	None perceptible. With collimating telescope, difference between settings for target and reticles not to exceed 0.2 diopter. Stereo parallax should not cause more than 2 UOE difference for right and left head positions. The differences between target and reticle settings should match within 0.2 diopter for right and left eyepieces.
g. **Cross-field Readings.**	The mean of five readings at any point across the reticle field not to vary from the mean at the center of the reticle field by more than 2½ UOE.
h. **Bump Test.**	After the bump test, the performance of the instrument must remain within tolerance; 2½- to 3-unit change of internal adjuster readings within tolerance.
i. **Interpupillary Distance.**	58mm to 72mm ± ½mm at any setting.
j. **Eyepiece Focus.**	± ¼ diopter at any setting in high or low power. No more than 0.2 diopter change with shift from high to low power.

INSPECTION

Test	Requirements
k. **Filters.**	The same color filter in each eyepiece at each setting of the filter knob.
l. **Adjuster Correction Wedge.**	Correction knob scale divisions within 10 percent of true UOE for high magnification.
m. **Height Adjuster Disk.**	Correction knob scale readings at extreme ends of the travel of the height adjuster disk to be within 1½ UOE.
n. **Reticles (Centering and Tilt).**	Combined jump of both reticles not more than 5 minutes vertically and horizontally on shift from high to low power. On a fixed target with the instrument level, extreme ends of the reticle field to be at same height within one-half width of the reticle line.
o. **Dirt on Optics.**	
(1) RETICLES.	No dirt, scratches, or smears noticeable to the unaided eye.
(2) EYELENSES AND END WINDOWS.	Inner surface clean and free from scratches.
(3) OTHER OPTICS.	No dirt, smears, scratches, or bubbles at center of optic which would cut light transmission by more than 5 percent, or be noticeable in the reticle field.
p. **Illumination of Reticles.**	
(1) HEIGHT FINDER.	No stray light; equal brightness; illumination centered.
(2) M13 TRACKING TELESCOPES.	No stray light; illumination centered.
(3) INTERNAL TARGET.	Equal brightness.
q. **M13 Tracking Telescopes.**	
(1) RETICLES.	Elevation—solid vertical and horizontal line. Azimuth—solid vertical and horizontal line.
(2) FOCUS OF OBJECTIVE.	There must be no perceptable parallax (fig. 59).

Test	Requirements
(3) ALINEMENT AND TILT.	
(a) *Alinement in Azimuth.*	Vertical reticles to aline at same point on vertical target as center stereo reticle-target, approximately 5,000 yards.
(b) *Alinement in Elevation.*	At zero-degree elevation, horizontal reticles to aline on horizontal point of target that stereo reticle centered is alined to — target approximately 5,000 yards. (Fine elevation knob locked in center position.)
(c) *Tilt.*	Target image should fall at same height at both ends of reticle field, within one-half width of a reticle line (figs. 63 and 64).

64. INSPECTION AND TOLERANCE SUMMARY — FINAL OPTICAL CHECK.

a. Range Finder.	
(1) ACCURACY.	The mean of 10 range readings on each of three targets should be within 1½ UOE of true range.
(2) REPEATABILITY.	
(a) *High Power.*	Median deviation of 10 readings from average range to be not more than 1½ UOE.
(b) *Low Power.*	Median deviation of 10 readings from average range to be not more than 2 UOE.
b. Height Finder Accuracy.	The difference between the computed heights and the mean observed heights should not exceed the tolerances taken from the chart (fig. 68).
c. Internal Target.	
(1) ACCURACY.	
(a) *Low Power.*	The spread of five readings in low power not to exceed 2 UOE.
(b) *High Power.*	The spread of five readings in high power not to exceed 1 UOE.

INSPECTION

Test	Requirements
(2) QUALITY.	The average of 10 up-scale internal adjuster settings not to differ from the average of 10 down-scale adjuster settings by more than ½ UOE.
(3) ELEVATION.	The mean of five adjuster scale readings at any degree of elevation to be within 2½ UOE of the mean at any other point.

65. ELECTRICAL CHECK.

a. Indicators and Transmitter.	Must read to within one-half width of index line at all points on scale.
b. Illumination of Scales and Dials.	Illumination on range drum, height transmitter scale, and internal target scale suitable for night reading.

66. MECHANICAL CHECK.

a. Levels.	
(1) CRADLE.	Vials tight in housing. Etch and fill satisfactory.
(2) HEIGHT FINDER TELESCOPE.	Vial tight in optical tube mount. Etch and fill satisfactory.
b. Change-of-magnification Lever.	Action smooth and easy. Stops at 12 and 24 power.
c. Height Conversion Mechanism.	Snug fit, no high spots. Stops operate from beyond zero degree and 90 degrees.
d. Fine Elevation Knob.	Action smooth, no optical jump. Stops operate for a ½- to 1-degree travel.
e. Prism Shift Mechanism.	Action smooth. Both stops to make contact at the same time.
f. Measuring Knob.	Action free from high spots. Stops operate for full travel approximately one-half inch over run at extreme ends of range drum travel.
g. Internal Adjuster Correction Scale.	Action smooth, no backlash, no high spots. Stops operate for full travel (0 to 120).

Test	Requirements
h. Height Adjuster Knob.	Action satisfactory — no binding through travel at all positions of fine elevation knob. Length of travel—approximately 8.8 turns of knob.
i. Eyepiece.	
(1) FOCUSING.	Works smoothly—no backlash or high spots.
(2) INTERPUPILLARY LEVER.	Covers full scale (58mm to 72mm), works smoothly.
(3) FILTER LEVER.	Action smooth. Stops operate to position filters at eyepiece.
j. Elevation Gearing.	No backlash or high spots. Stop operates properly for full travel (0-1600 mils).
k. Azimuth Gearing.	No backlash or high spots. Full travel (0-6400 mils), no stops.
l. Height Transmitter Handwheel and Scale.	No backlash or high spots.
m. Height Transmitter Correction Knob and Dial.	Action snug—no binding. Stops operate for full travel from beyond +500 yards to beyond –500 yards.
n. Tripod—Feet.	Action firm.
o. Cradle—Friction Ring.	Tight enough so that it does not slip on turning the azimuth hand-wheel, but loose enough to allow slewing.
p. M13 Telescopes.	
(1) FOCUSING UNITS.	Work smoothly, no backlash or high spots.
(2) FILTER KNOB.	Action smooth; stops operate to position filters at eyepiece.
(3) EYE SHIELD.	Adapter to turn freely.
q. Carrier Handles.	Must be parallel.

67. MISCELLANEOUS.

Test	Requirements
a. Pressure Retention.	Starting with 4 pounds of air pressure, loss not to exceed 1 pound in 8 hours.

INSPECTION

Test	Requirements
b. Painting and Protection.	All exposed metal surfaces and corners to be painted. No fractures in canvas covering.
c. Accessories and Tools.	None to be missing.
Height finder telescope.	
Traveling carriage.	
Packing chest.	
Cradle M2	
Packing chest.	
Tools.	
Accessories.	
Tripod M9.	
Storage case.	
Tools.	
Accessories.	

68. INSPECTION RECORD.

a. The inspection report for the instrument at time of manufacture is included with each Height Finder M2. It is a complete report on the condition of the instrument and accessories, and includes the values obtained in the performance test at acceptance of the instrument. Repairman adjusting the instrument should refer to the report in order to bring a defective instrument back to its original condition. The tables of the report may guide the repairman in arranging his own form for noting test readings.

69. LIST OF CHECK QUESTIONS.

a. Are the tripod feet firmly fixed so that the instrument cannot easily be knocked out of level?

b. Is the cradle securely bolted to the tripod?

c. Is the cradle level through a 360-degree traverse?

d. Is the height finder telescope set on the cradle so that the optical tube level is centered when the elevation scale reads zero, and the zero elevation indexes on the left bearing housing are alined?

e. Is visibility of the field of view satisfactory?

f. Is the observer's interpupillary distance accurately set?

g. Are both eyepieces correctly focused for the observer?

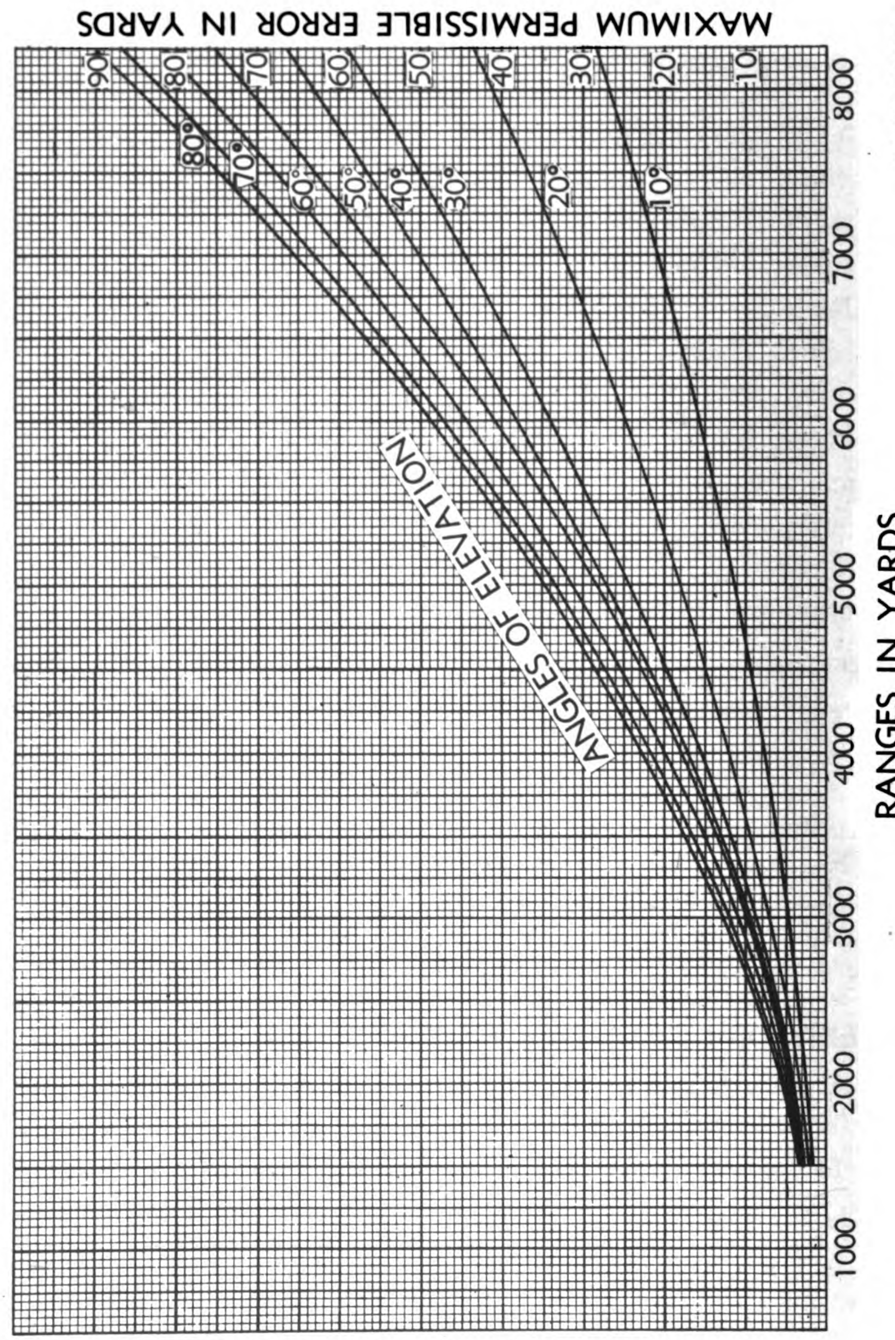

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Figure 68 — Height Finder Accuracy Tolerance Chart

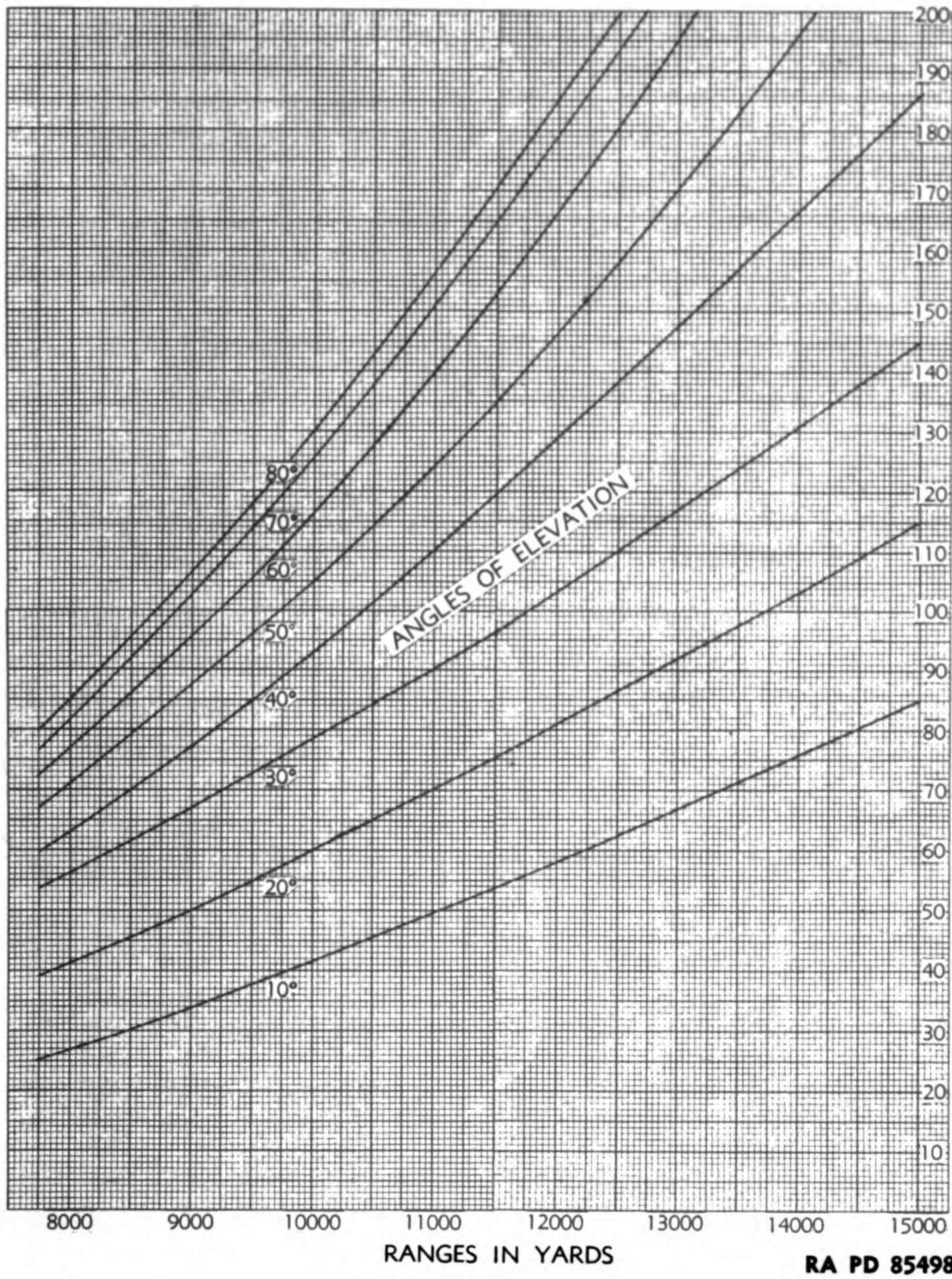

Figure 68A — Height Finder Accuracy Tolerance Chart

h. Is the headrest correctly adjusted for the observer?

i. Is the height-of-image adjustment correctly set?

j. Is the instrument in a stable condition as to temperature?

k. Is the instrument exposed to the direct rays of the sun?

l. Is the range-height lever in the correct position?

m. Is the correct filter being used?

n. Is the height finder connected to a source of electric power at the proper receptacle?

o. Is the cable from the height finder telescope to the cradle connected properly? Is the cable from the left bearing housing to the junction box connected?

p. Was the observer's correction knob scale setting (also known as range correction setting) correctly determined, and was this value set in the instrument?

q. Was the same filter used in determining the observer's internal adjuster correction (RCS) as is used for taking ranges or altitude?

r. Is the change-of-magnification lever firmly in position?

s. Are the exterior optical surfaces free of dirt, film, and moisture and free from scratches or other injuries?

t. Is there any failure of illumination due to burned-out or incorrectly positioned lamps, or to defective wiring or connections?

u. Are the tracking telescopes properly alined?

v. Are the interior optical surfaces in good condition and free from dirt, film and moisture?

w. Is reticle illumination uniform and equal in the two height finder reticles?

x. Is illumination of the internal targets satisfactory?

y. Has the compensator unit been checked recently for range adjustment?

z. Has the height conversion mechanism been checked recently?

aa. Are the end windows in adjustment?

bb. Does the instrument read true ranges within the prescribed tolerances at short, medium, and long ranges?

Section VII

TROUBLE SHOOTING

70. PURPOSE.

a. The purpose of this chapter is to provide a guide for the use of maintenance personnel when isolating and diagnosing malfunctions of the height finder.

b. These tables do not take into account all the malfunctions encountered with the height finder, but they will assist in correcting the commonplace troubles.

71. OPTICAL FAILURES.

a. Image of Reticle, Internal Target Line, or Object in the Field of View Blurred or Indistinct.

(1) POOR DEFINITION (MAIN FIELD).

Possible Cause	Possible Remedy
Eyepiece focus incorrectly set.	Refer to paragraph 103.
Change-of-magnification lever not firmly in position.	Turn lever as far to each side as it will go.

(2) POOR DEFINITION (INTERNAL TARGET LINE ONLY).

Possible Cause	Possible Remedy
See step (1), above.	See corresponding remedies.
Incorrect spacing of crown and flint elements of internal target objective.	See paragraphs 153 to 158.
Wrong filter in use.	Select proper filter.
Internal target prism shift incorrectly positioned.	Set adjuster knob in correct position.
Moisture on external optical surfaces.	Clean according to instructions in paragraph 87.

(3) FIELD OF VIEW DULL, CLOUDY, OR DARK (MAIN FIELD).

Possible Cause	Possible Remedy
Wrong filter in use.	Select proper filter.
Internal target prism shift incorrectly positioned.	Set adjuster knob in correct position.
Moisture on external optical surfaces.	Clean according to instructions in paragraph 87.
Condensation on optical surfaces within the instrument.	Desiccate (see TM 9-1622). Disassemble and clean optics (par. 87).

Possible Cause	Possible Remedy
Film or excessive dirt on optical surfaces.	Clean according to instructions in paragraph 87.

(4) FIELD OF VIEW DULL, CLOUDY, OR DARK (INTERNAL TARGET).

See step (3), above.	See corresponding remedies.
Illumination failure.	See paragraph 211.

72. ILLUMINATION FAILURES.

a. Main Field.

No input voltage.	Connect to proper voltage source.
Main switch incorrectly positioned.	Reposition switch.
Cable from height finder to cradle not connected.	Plug in at proper receptacle.
Rheostat incorrectly positioned.	Reposition rheostat.
Defective rheostat.	Replace.
Defective main switch.	Replace.
One or more lamps burned out.	Replace.
One or more lamps incorrectly positioned.	Reposition lamp which is at fault.
Wrong filter in use.	Select correct filter.
Defective wiring or connections.	Check for continuity and short circuits. Repair according to good electrical practice (par. 211).

b. Internal Target.

See subparagraph a, above.	See corresponding remedies.
Internal target prism shift not in proper position.	Set knob firmly in position at stop.
Internal target penta prism incorrectly positioned.	Refer to paragraph 155.

73. STEREO FAILURES.

a. Reticle Cannot Be Fused Into Stereoscopic Pattern (TM 44-250).

Interpupillary distance incorrectly set for observer.	Reset to correct distance (TM 9-624).

TROUBLE SHOOTING

Possible Cause	Possible Remedy
One or both eyepieces incorrectly focused for observer.	Set to correct focus (TM 9-624).
Tilted or off-center reticle.	See paragraph 142.
Broken reticle.	Replace (par. 144).
Reticle incorrectly positioned upon reassembly.	Reposition (pars. 145 and 146).
Observer is at fault.	Change observer.

b. Image of External Field Cannot Be Fused Into a Single Stereoscopic Image (Reticles Are Properly Fused).

Height of image incorrectly set.	Reset (pars. 36 and 40 and TM 9-624).
Range-height lever in "HEIGHT" with low angle of elevation.	None. Instrument will not read altitudes less than 550 yards.
Range of target less than 550 yards.	None. Instrument will not read ranges less than 550 yards.
Range scale set at value greatly different from true ranges or altitude (this causes splitting of reticles or image or both).	Set scale to read near true value.
Observer is at fault.	Change observer.

c. Internal Target Line Split Into Two Images.

Range scale at incorrect setting.	Reset to infinity.
Range-height lever at incorrect angle of elevation.	Reset to "RANGE."
Tube at incorrect angle of elevation.	See footnote[1].
Compensator badly out of adjustment for range and/or height conversion.	See paragraph 126.

d. Internal Target Line Cannot Be Moved Stereoscopically or Cannot Be Brought Into Stereoscopic Contact.

Incorrect interpupillary distance set for observer.	Rest to correct distance (TM 9-624).
One internal target lamp burned out.	Replace left lamp if right field is dark and vice versa.
Range-height lever at incorrect position.	Reset to "RANGE."

[1]Readings may be taken under two conditions with the range-height lever set in "HEIGHT": If scale is set at infinity and wedges are in adjustment, readings may be taken at any angular height. If scale is set at any value other than infinity, for example, 550 yards, then the tube must be at zero angle of elevation, that is, the height finder and the cradle must be level.

Possible Cause	Possible Remedy
Range scale setting incorrect.	Reset to infinity.
Tube at incorrect angle of elevation.	See footnote[1].
Alinement wedge for internal target incorrectly positioned.	See paragraph 153.
Compensator badly out of adjustment for range and/or height conversion.	See paragraphs 126 to 138.
Observer is at fault.	Change observer.

74. RANGE OR ALTITUDE ERRORS.

a. Incorrect Range on Fixed Targets.

Incorrect internal adjuster scale setting (RCS).	See TM 44-250.
Range-height lever not in "RANGE" position.	Set lever in "RANGE" position.
Compensator not in adjustment for range and/or height conversion.	See paragraphs 126 to 138.
End windows not in adjustment.	See paragraph 160.
Instrument in unstable condition.	See TM 9-1622.
Observer is at fault.	Change observer[2].
Instrument in need of arsenal overhaul.	Request instructions from officer authorized to order instrument shipped to base shop or arsenal.

b. Incorrect Altitude (Fictitious) Using Range-Height Lever To Set in Fictitious Angles of Elevation.

Incorrect correction knob scale setting (RCS).	See TM 44-250.
Height-range lever not set at proper displacement.	See paragraph 126.
Computed altitude not correct.	See paragraph 59.

[1]Readings may be taken under two conditions with the range-height lever set in "HEIGHT": If scale is set at infinity and wedges are in adjustment, readings may be taken at any angular height. If scale is set at any value other than infinity, for example, 550 yards, then the tube must be at zero angle of elevation, that is, the height finder and the cradle must be level.

[2]Occasionally an instrument, after having been put in apparently good adjustment in all respects, will give inaccurate ranges, the readings varying greatly from the true ranges. Before reaching a decision which would require shipping an instrument to a base shop or arsenal, make certain that it is the instrument, not the observer, which is at fault.

TROUBLE SHOOTING

Possible Cause	Possible Remedy
Compensator not in adjustment for range and/or height conversion.	See paragraphs 126 to 138.
End windows not in adjustment.	See paragraph 160.
Instrument in unstable condition.	See TM 9-1622.
Observer is at fault.	Change observer.
Instrument is in need of arsenal overhaul.	Request instructions from officer authorized to order instrument shipped to base shop or arsenal.

c. Incorrect Altitude on Aerial Targets.

Height-range lever not in "HEIGHT."	Set lever in "HEIGHT."
Cradle not level.	Level cradle correctly (par. 91).
Elevation tracking telescope not properly alined with height finder optical system.	See paragraph 189.
Incorrect correction knob scale setting (RCS).	See TM 44-250.
Compensator not in adjustment for range and/or height conversion.	See paragraphs 126 to 138.
End windows not in adjustment.	See paragraph 160.
Altitude as computed by other means incorrect[3].	Improve method of computing altitudes.
Inaccurate tracking in elevation.	Train elevation tracker to keep target on horizontal cross line.
Instrument in unstable condition.	See TM 9-1622.
Stereoscopic observer at fault.	Change observer.
Helium content low.	See TM 9-1622.

d. Ranges or Altitudes Taken Going Up the Scale Differ From Those Coming Down the Scale.

Backlash spring too loose.	Replace or tighten.
Backlash spring stuck.	Remove and readjust.

[3]Altitudes computed by tracking the target with other instrument, and reconstructing path of the target from observations recorded at intervals, frequently are subject to errors greater in magnitude than those of height finders in poor adjustment.

Possible Cause	Possible Remedy
Wedge unit gears strike adjuster tubes.	Remove compensator and file or flatten adjuster tube.
Backlash between range drive gears.	Correct backlash.
Backlash between range drive and the drum.	Correct backlash.

e. Altitudes Taken While Elevating Instrument Differ From Those Taken While Depressing.

Backlash between bevel gear and height conversion gear.	Loosen screws and move height range bevel gear adapter assembly closer to conversion gear segment. Adjust compensator bevel gears closer to worm drive gear. Adjust tension on compensator spring.

f. Noticeable Halving Error of Target When Range Drum Is Traversed From 550 Yards to Infinity.

Right reticle tilted.	Check for tilt and square up, if necessary. Also check left reticle and bring to a position parallel with right if tilted (par. 176).
Reticles or target image appear to separate as height finder is moved in angular height.	Refer to height break (par. 75).

75. CHECK FOR HEIGHT BREAK—GENERAL.

a. Height break is the halving error difference of a target with respect to the reticles as seen with both eyes as the height finder is moved through changing angular height. Refer to height adjustment (par. 40).

b. If the reticle marks separate an amount exceeding one-sixth the length of the center reticle marks, fusion of the target images will become difficult, tire the observer's eyes, and result in erratic readings.

c. Be sure to check for height break after disassembly and assembly of the height finder, and also when it is known a height finder has had extremely rough handling in transportation.

d. Height break rollers are installed in all M2 Height Finders, except numbers 1 to 12, in the opening for the adjuster knob (fig. 69). Type "A" shown in figure 69 has been installed in instruments, numbers 13 to 190. Type "B" shown in figure 70 is a more rugged

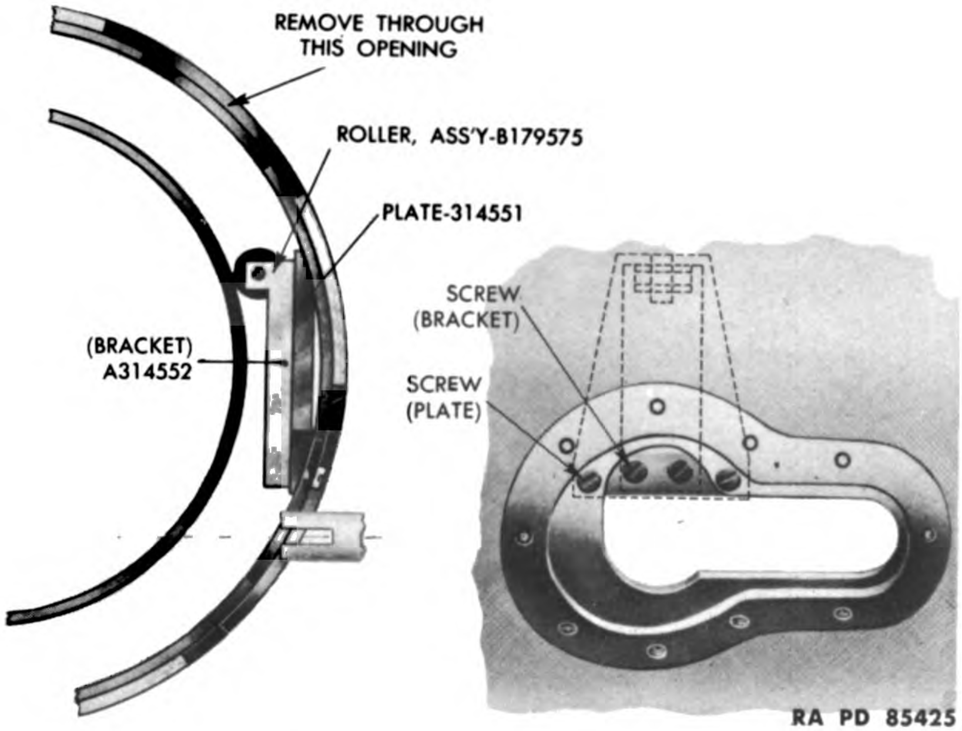

Figure 69 — Height Break Roller — Type "A"

design that has been installed on instruments numbered above 190, and in some below this number due to replacement in the field.

e. The height break roller is installed in the instrument and adjusted at the factory to support the inner tube and eliminate changes in the relative position of the optical bar and end reflectors, as the height finder is moved through changing angular height.

f. When it is definitely known that a height finder has height break, it should be serviced by a competent ordnance repairman.

g. **Possible Causes.** Contributing factors which may cause height break in height finder are listed as follows:

(1) Loosely mounted optical tube.

(2) Loose optical tube gimbal joint.

(3) Loose optical tube right support.

(4) Loose end reflectors, reflector support or support adapter.

(5) Improperly fitted inner tube bearing rollers.

(6) Improperly adjusted inner tube guide roller (height break roller).

(7) Improperly fitted carrier handle assemblies.

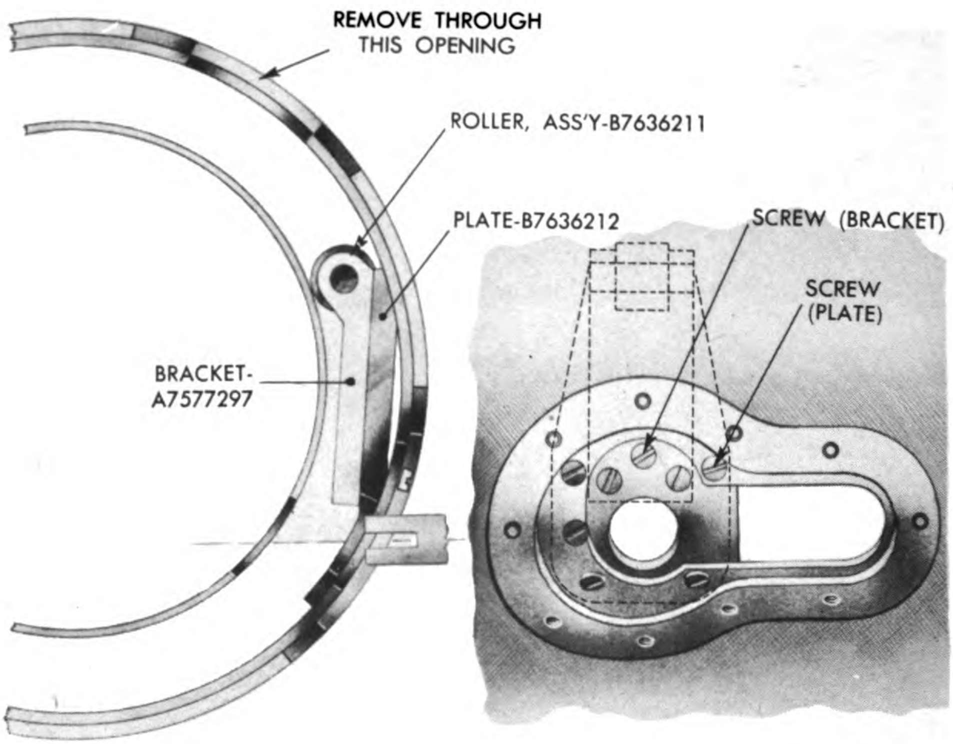

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Figure 70 — Height Break Roller — Type "B"

(8) Brinelling (indenting) of the inner tube bearings into the bearing ring on the inner tube due to transportation shocks.

(9) Loose height adjuster disk, cell, mount, or bracket.

(10) Fine elevation knob assembly not in proper adjustment.

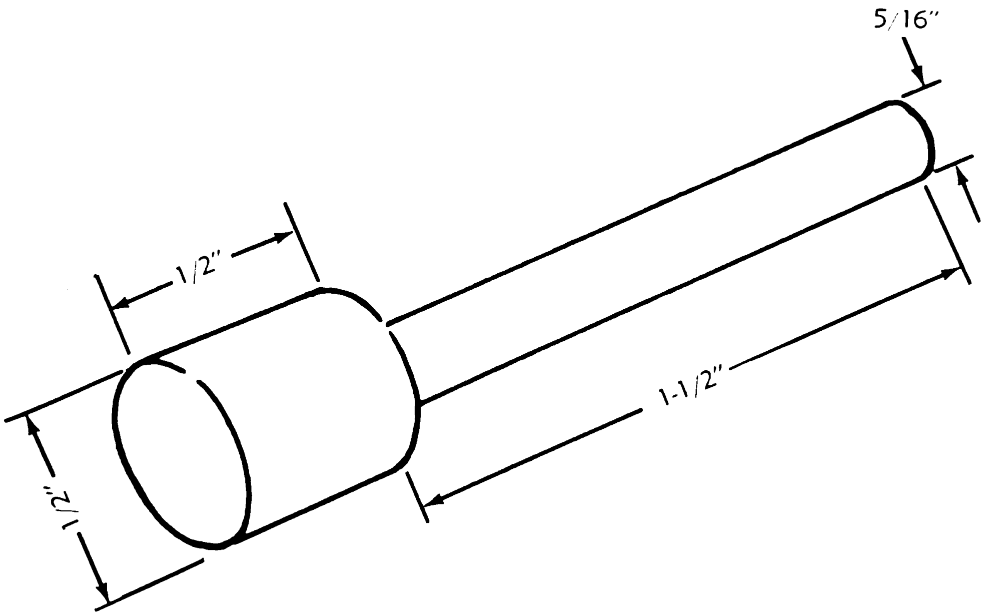
(11) Uneven sag of the inner tube fundamentally corrected by proper adjustment of the height break roller (par. 77).

76. ADJUSTMENTS TO ELIMINATE HEIGHT BREAK.

a. Remove the fine elevation knob assembly (par. 149).

b. Remove both end boxes (par. 164).

c. Check for Brinelling or improperly fitted inner tube bearings by placing the hands under the end reflector support and lifting up. If there is any shake between the inner and outer tubes on either end of the height finder, then the inner tube bearings are not properly positioned on the bearing rings on the inner tube. All the inner tube bearings must rest snugly against the bearing ring on the inner tube. There should be no shake when pressure is applied to lift the ends of the inner tube.



RA PD 60568

Figure 71 — Honing Disk

d. Place two small wooden wedges in the ends of the outer tube to support the inner tube.

e. Remove the three inner tube bearings (fig. 217) and check the condition of the bearings and the surface of the inner tube bearing ring. If Brinelling (indenting) is evident, it may be removed by stoning the Brinelled surface, using a small India stone. Move the stone with a rocking motion in order to keep the contour of the ring round, or as near so as possible. *Do not rotate the inner tube.* Force a cloth between the inner and outer tubes to catch excess metal. An alternate method, and one which is more expedient, makes use of a small electric hand drill and an improvised tool such as that illustrated in figure 71. A disk of aluminum-oxide abrasive cloth (180) is cemented to the head of the tool. The bearing ring is ground until its surface is smooth, using the same rocking motion as when stoning, as a precaution to maintain proper radius.

f. It will be necessary to remove stock from the outer tube adapter surface or the under side of the roller bearing mount to allow the support rollers to fit snugly against the inner tube bearing ring after the ring has been stoned. Bearing mounts on low number instruments may be positioned by placing shims between bearing mount and adapter. Frequent checks for shake will tell the repairman when enough stock has been removed.

g. While the end boxes are off, check the end reflector assemblies, end reflector supports, and end reflector adapters for looseness or shifting (par. 93).

h. A check for loosely mounted optical tube should be made by removing the covers over the main objective adjusting slots (fig. 106). Insert an adjusting pin in the adjusting holes of the outside adjusting rings and apply pressure up and down. If the optical bar does not spring back with the inner tube, a check of the mounting of the optical tube and gimbal support should be made.

i. To check the optical tube mounting, disassemble the height finder so that the optical bar can be removed (par. 174).

(1) Check the gimbal support C77812 (fig. 220).

(2) Check shims A314550.

(3) Check shake of the support C77812 and ring A179933 (fig. 220). If shake is found, the pivots A179935, A179934, and A179936 should be examined. All of these pivots must fit in their respective recesses very snugly.

(4) Remove and check the right optical tube support (fig. 67). It should fit over the bearing ring on the optical bar just snugly, with no shake perpendicular to the axis of the optical tube.

(5) When the optical tube is removed, examine the screws holding the height adjuster support B171743 to the optical tube. Also check the movement of screw A179913, plunger A179926, and lever A179915 (fig. 160).

j. A damaged or improperly adjusted fine elevation knob assembly will allow Brinelling of the inner tube bearings to start, causing the optical bar to strike the illuminator holders. This will allow the inner tube to strike the eyepiece support assembly and cause the compensator to strike the outer tube. The fine elevation knob is in proper adjustment:

(1) When it is positioned so that the height finder reticles are centered to a low power telescope placed on the eyepiece (par. 149 and fig. 90).

(2) When there is no shake between bevel gear B171833 and pinion B171834 (fig. 163).

(3) When there is no shake between slide A180189 and guide A180187 (fig. 164).

(4) When there is no shake between slide A180189 and pinion shaft thread B171834.

(5) When there is no shake between collar A180194 and bracket A180188.

(6) When the ball follower A180193 (fig. 164) fits snug along its travel in cam A180191 (fig. 168).

(7) When the cam A180191 is securely screwed and pinned to adapter A180192, and the adapter is securely screwed to the inner tube.

NOTE: *If the sides of the ball on the follower A180193 (fig. 164) are Brinelled, remove the screws and rotate the follower in the slide recess until the sides of the ball that are not Brinelled will contact the sides of cam A180191 (fig. 168).* Replace screws and tighten securely.

k. The eyepiece must be checked for preliminary centering (par. 100). The eyepiece must also be adjusted and checked with a divergence tester for vergence and centering (par. 102).

l. When the repairman has checked, repaired, and adjusted all the faults listed above, and the height finder has been completely assembled (except assembly of the carrier handles) and adjusted on terrestrial targets, the height break roller can then be properly adjusted to eliminate height break.

77. ADJUSTING THE HEIGHT BREAK ROLLER.

a. For repairmen in the field, the procedure outlined below for adjusting the height break roller is suggested. This procedure applies to the new roller assembly B7636211 shown in figure 70.

b. Emplace instrument where a plane may be observed at all angles of elevation.

c. Turn adjuster knob for viewing outside target.

d. Remove adjuster knob assembly (par. 159) and measuring knob assembly (par. 139).

e. By holding both plate B7636212 and bracket A7577297 in their approximate place, locate position of plate relative to the outer tube.

f. Firmly mount plate to outer tube using five number 8-36NF-3 screws.

g. With a feeler gage, locate bracket A7577297 so that the roller clears the inner tube by 0.015 inch when the instrument is at zero-mil elevation. Drill and tap bracket for three screws using number 29 drill and number 8-36NF tap.

h. Mount bracket A7577297 to plate B7636212.

i. Determine height at which target plane will fly.

j. Correct halving on a target which is at zero-mil elevation, and whose range is approximately equal to the plane's height. After this setting, cover the height adjuster knob and use it for no future adjustment during the roller assembling.

k. Place range-height lever in height position.

l. Set range drum at expected height of plane, using ball connector A180045 to turn drum.

m. With the aid of two good trackers, follow a slow-flying target plane from approximately zero mil to 1,600 mils elevation.

n. Observe for height break and, if it occurs, note position of left reticle relative to right. The amount of error permitted is one-sixth the length of a main reticle mark.

o. If the roller is not tight enough against the inner tube, the left reticle will appear lower than the right. To correct this condition, raise the inner tube, using a lever, and insert feeler gages between the roller and the inner tube to determine the necessary shim to be placed between bracket A7577297 and plate B7636212.

p. Insert shim and again check on plane.

q. If left reticle appears higher than right, the roller is too tight, requiring scraping of the plate on its surface adjacent to the outer tube. Be careful to retain proper radius and a good contacting surface. To remove roller, refer to paragraphs 171 to 173. NOTE: *It has been assumed that the target plane images remain fused and the reticle images break fusion in a vertical sense. The reticle images may remain fused and the plane images appear to break fusion vertically.*

r. Check final results with several observers.

s. Replace adjuster knob assembly and range knob assembly. Reset range drum scale.

t. Fasten carrier handle assemblies.

(1) Make careful halving adjustment on any convenient target.

(2) Fasten either right or left assembly and check halving. If a change has occurred, remove assembly and scrape caps B171867, support C77845, and bracket B77846, to permit a looser fit. Repeat until no change of halving is observed.

(3) Repeat step (2) for other side.

Section VIII

GENERAL MAINTENANCE

78. GENERAL.

a. This section describes the testing instruments and special tools, pressure tests, precautions in handling optical parts, cleaning, lubrication charts, and maintenance of packing chests.

b. The information given in section IX covers the adjustment and repair of the various optical and mechanical components of the height finder telescope. Disassembly of the height finder telescope into its component units, which is necessary to obtain access to certain of the interior optics, is described in section X, paragraphs 171 to 173. Disassembly of the individual units is included in the adjustment and repair section for each.

79. GENERAL HANDLING OF THE HEIGHT FINDER.

a. The height finder is a complex and delicately adjusted optical instrument. While it is of sturdy construction and will withstand any normal handling, care should be taken to avoid any unnecessary jolting or mishandling. The length and degree of satisfaction of the service which the instrument will give, depends upon the type of handling to which it is subjected.

b. Do not force any of the handwheels or knobs. If they stop, it is an indication that the limit of travel has been reached or that adjustment is necessary. *Persons who are not familiar with the operation of the instrument should not be allowed to manipulate handwheels or knobs.*

c. The height finder telescope, the cradle, and the tripod are provided with steel packing chests. When the instrument is not in use, the units should be replaced in their respective chests. Whenever possible, protect the instrument from the direct rays of the sun. Since temperature changes set up an unstable condition inside the instrument, making readings both difficult and inaccurate, it is advisable to avoid any sudden changes of temperature. For short periods of storage, try to keep the storage temperature the same as the outside temperature.

80. REPAIR PARTS.

a. It is important to mention the serial number of the instrument when ordering spare parts or requesting information. For complete information concerning replacement parts and replacement assemblies, see SNL F-189.

81. REPAIR SHOP LOCATION AND TEMPERATURE CONDITIONS.

a. For adjustments and repairs, the instrument should be under cover. When it is necessary to break the hermetic seal, the work should be done in a dust-free room. Freedom from dust in assembling optical units is aided by the use of a small booth, to house the work and worker's hands, into which filtered air is blown.

b. Visibility of distant targets and other considerations frequently place the instrument shop on an upper floor of a building. The height finder, because of its length and weight, is difficult to get into such a repair shop unless specific provision has been made for it. One practical arrangement is an overhead rail and traveling hoist, extending from the repair shop ceiling outside the building through a door, so the height finder can be lifted directly from the ground. Another necessary repair shop feature is a stable, vibration-free platform on which to set the height finder or other fire control instruments. Such a platform is afforded by a reinforced concrete table supported directly on the ground by a concrete column which has no solid contact with the building floors. The shop windows must be located to provide a view of one or more distant targets from the platform position.

c. Some of the adjustments, in particular those involving stereo observations of either the internal target or an external target, can be made only when the instrument has been at substantially constant temperature prior to and during the adjustment, since unstable conditions produce erratic results. In an unstable instrument, the correction knob scale setting will be in a state of change and, as various elevation angles are introduced, this change will be very noticeable. Stratification of the gaseous medium within the instrument, established by temperature differences, causes instability. It is, therefore, recommended that, whenever possible, the height finder be maintained at a substantially constant temperature under all conditions of operation and adjustment. In any case, the instrument should be sheltered from the direct rays of the sun.

82. HERMETIC SEAL.

a. The removal of certain mechanical assemblies and any optical assembly (except the eyepiece plate assembly) involves breaking the hermetic seal of the instrument. In such cases, take the precautions following:

b. Work in a dust-free room, if possible, and be sure desiccation or helium-charging equipment is available.

c. Protect the interior of the instrument from dust and dirt by covering any opening in the outer tube with heavy paper whenever the openings are not being utilized. A little sealing compound (for height finders) applied to the adapters will hold the paper in place.

d. When replacing any assemblies or parts which retain the seal of the instrument, make sure that the seating surfaces are clean and free from grit, and apply the authorized sealing compound (for height finders) between the contact surfaces of the outer tube and the adapter or the unit cover plate.

e. End windows and sealing glasses are sealed into their mounts with special rubber gaskets. If a new window has to be installed, the window must be sealed into its mount with a rubber gasket, and the end window cell sealed to the end box with Garlock packing No. 115, graphite-coated or equal.

f. The packing glands of the height adjuster shaft, measuring knob shaft, fine elevation knob, etc., are packed with Garlock packing No. 115, graphite-coated, or equal. Before obtaining a tight seal, the packing should be well run in with amorphous graphite, and then coated with light graphited grease.

83. EMERGENCY MAINTENANCE.

a. Maintenance requiring removal of the inner tube or optical tube is normally performed at a base shop, where complete equipment and qualified personnel are available. It may be third or fourth echelon emergency maintenance if the workman has completed a recognized fifth echelon maintenance height finder course, and if this work is performed at the order of a responsible ordnance officer.

84. TOOLS AND SPECIAL EQUIPMENT.

a. Tools With Height Finder.

(1) Some of the tools required for making repairs or adjustments to the height finder are included among the accessories furnished with each instrument, and are not described here. Most of the additional tools needed are the usual mechanic's tools.

(2) A few special wrenches and fixtures are necessary and are listed and described below. The optical instruments required are also included in this list.

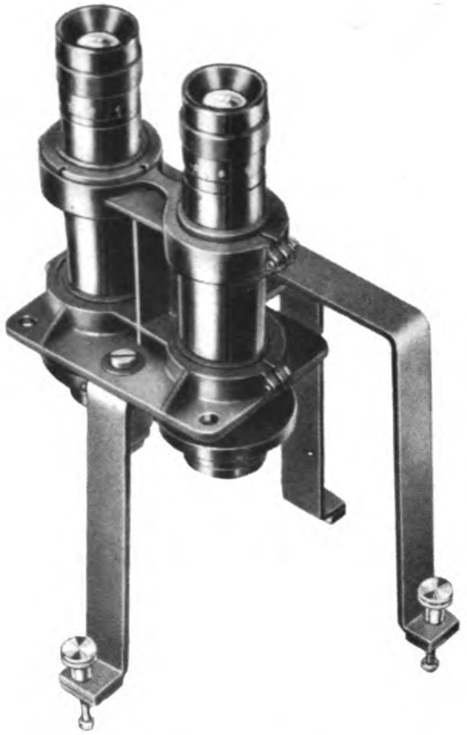
b. Optical Testing Instruments.

(1) DIVERGENCE TESTER. The tester is used for checking alinement of main eyepieces and consists of two low-power telescopes with reticles, mounted on an improvised bracket (fig. 72) to rest on M2 Height Finder eyepiece adapter. Bracket and securing strap are shown in figure 73.

(2) PUPIL LOUPE. The pupil loupe is a magnifier for examining the image of various optical parts as created by the eyepiece lenses and fits the individual eyepieces (fig. 74).

(3) LOW POWER TELESCOPE (COLLIMATING TELESCOPE) (fig. 74). This telescope is used for checking focus of main objectives, and also objectives of M13 Tracking Telescopes. It is also useful for checking eyepiece diopter scales at zero diopter.

NOTE: *The above three items are standard equipment issued for height finder work* (SNL F-272). The next three items are available in some repair shops.



RA PD 85441

Figure 72 — Divergence Tester on Bracket

(4) Optical Strain Tester or Pair of Polarizers. Two 4 by 4 inch polarizers of the polaroid type can show the existence of strain in mounted optical parts.

(5) Graduated Arc and Microscope (fig. 66). The graduated arc and microscope are used to set the range and height lugs, and to introduce various angles of elevation into the compensator without changing the elevation of the line of sight. The arc is graduated from zero degree to 90 degrees and is fastened to the right outer tube support housing. The microscope is secured to the conversion ring. Any angle of elevation may be introduced into the compensator by turning the conversion ring and taking the reading through the microscope. Figure 66 shows 90-degree position.

(6) Transit. A transit (or engineering telescope with cross hairs and leveling device) in proper adjustment will help when adjusting the height finder where visibility is not satisfactory due to heat waves, etc.

c. Special Tools and Fixtures.

(1) Helium Tank, Pressure Regulator, Purity Tester, Hose, etc. (See TM 9-1622).

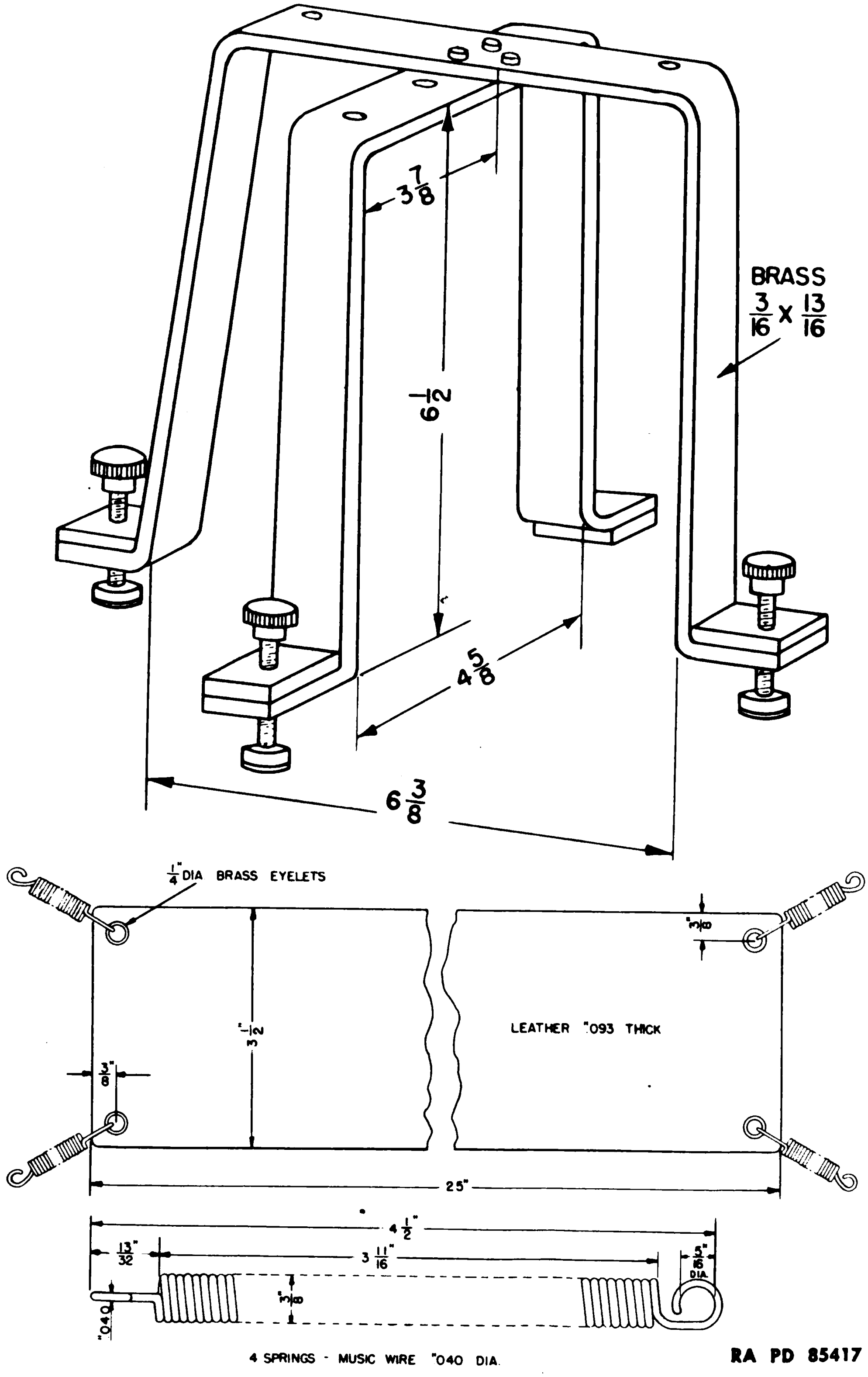


Figure 73 — Improvised Bracket and Securing Strap for Divergence Tester

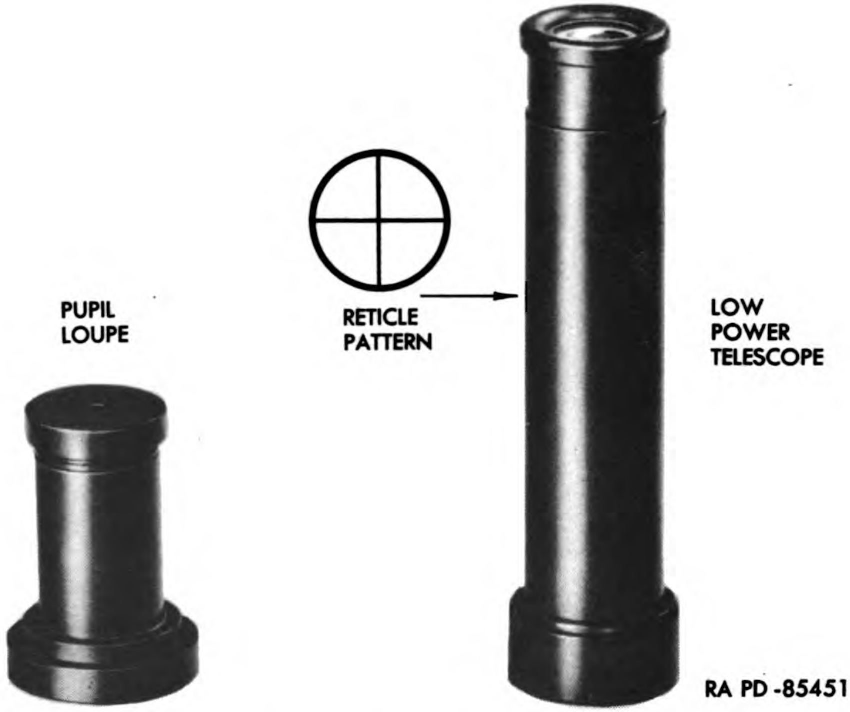


Figure 74 — Pupil Loupe and Low Power Telescope (Collimating Telescope)

(2) MAIN OBJECTIVE ADJUSTING PIN. Can be made from ⅜-inch drill rod, 18 inches long. Tapered at one end to fit into the adjusting holes on the objective adjusting rings. The pointed end should be rounded so that, if the pin slips out of a hole, it will not bur the section of the ring near the adjusting hole (fig. 76).

(3) COLLIMATOR OBJECTIVE ADJUSTING RING PIN. This pin may be made from 7/32-inch drill rod, 10 inches long. Tapered at both ends to a rounded point, and one end bent as shown in figure 76. Temper and draw the points.

(4) ECCENTRIC ADJUSTING WRENCH. This wrench is used for optical tube adjustments (fig. 77).

(5) WEDGE CELL WRENCH (fig. 77). This wrench is used for removing compensator wedge cells.

(6) MAIN OBJECTIVE CELL PULLERS. These are used for removing objective cells. The addition of a fourth wrench may be necessary, with 36 threads to take the place of wrench number 1, figure 78.

(7) SPECIALLY MOUNTED LEVEL. Refer to SNL F-272.

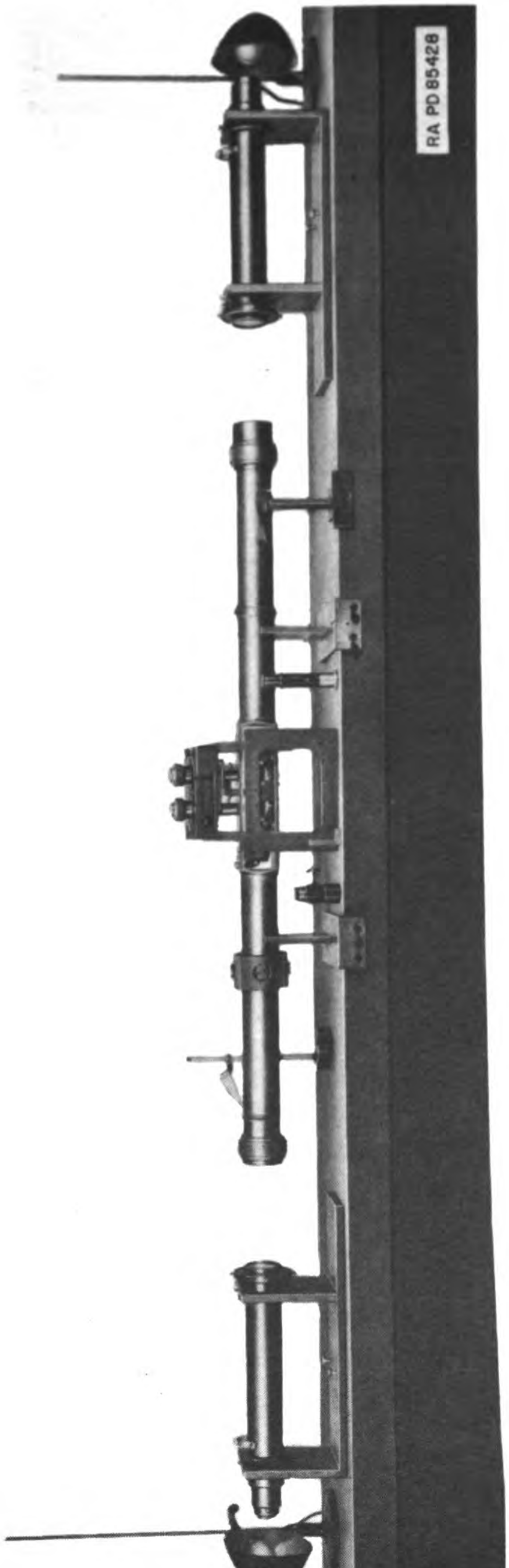


Figure 75 — Collimators and Fixtures Arranged To Adjust the Optical Tube

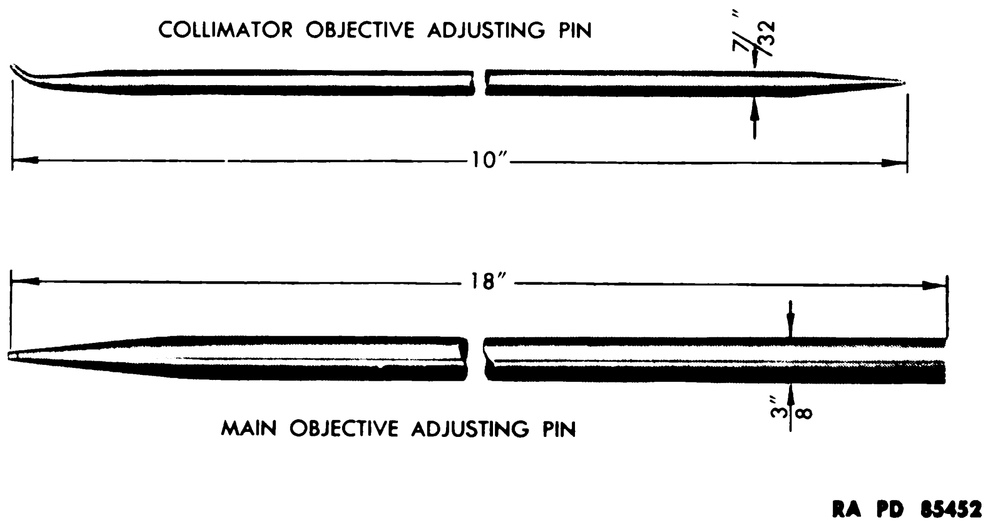


Figure 76 – Adjusting Pins

(8) TRACKING TELESCOPE OBJECTIVE CELL WRENCH. Refer to figure 79.

d. Cleaning Materials.

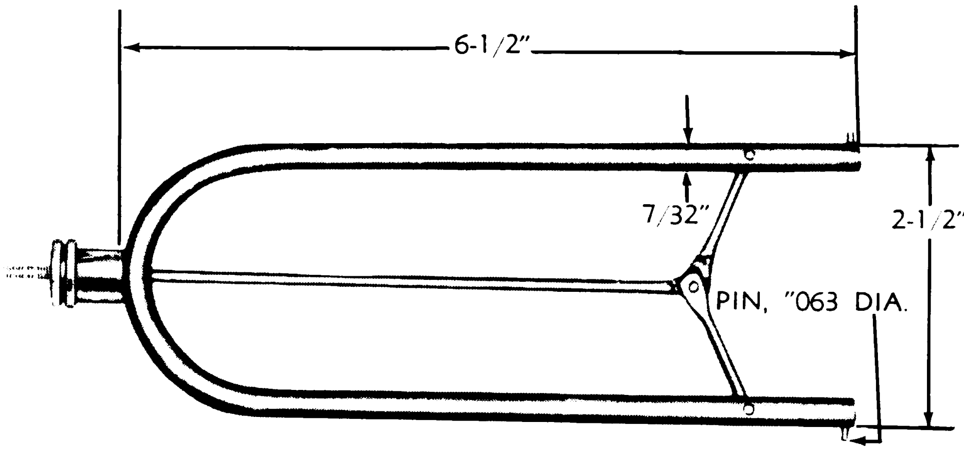
ALCOHOL, ethyl
CLOTH, batiste, white
PAPER, lens tissue
SOAP, castile, white
SOAP, liquid, lens cleaning
SOLVENT, dry-cleaning

85. THE NEED FOR HELIUM CHARGING.

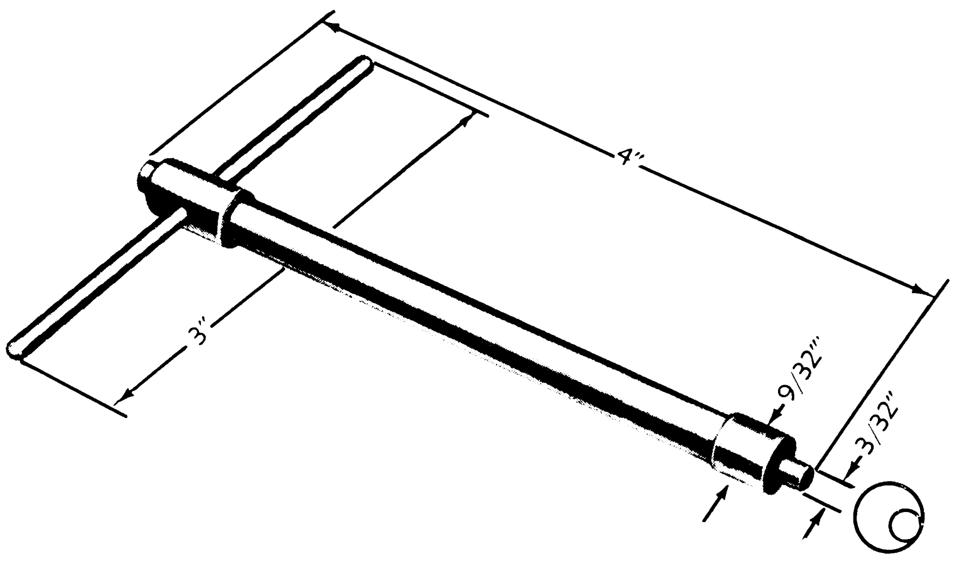
a. The Use of Helium.

(1) The height finder is normally filled with dry helium in order to keep moisture from condensing in the interior optical components of the instrument, and to minimize the effect of unstable temperature conditions. Dry air or dry nitrogen has been used, and these are satisfactory in the prevention of condensation, but give rise to undesirable temperature effects due to stratified gaseous layers of varying density, as a result of a difference in temperature between the top and bottom external surfaces of the tube. Helium, when 95 percent pure or better, minimizes this stratification effect. The helium within the tube is normally at a pressure of about 2 pounds per square inch. The tube must therefore be gastight and pressuretight. Instruments corrected for helium parallax will have parallax if helium purity diminishes.

(2) The Height Finder M2 is fitted with valves for the purpose of gaseous charging, and cylinders of helium and appropriate control



WEDGE CELL WRENCH



ECCENTRIC ADJUSTING WRENCH (OPTICAL TUBE)

RA PD 60600

Figure 77 — Wedge Cell Wrench and Optical Tube Adjusting Wrench

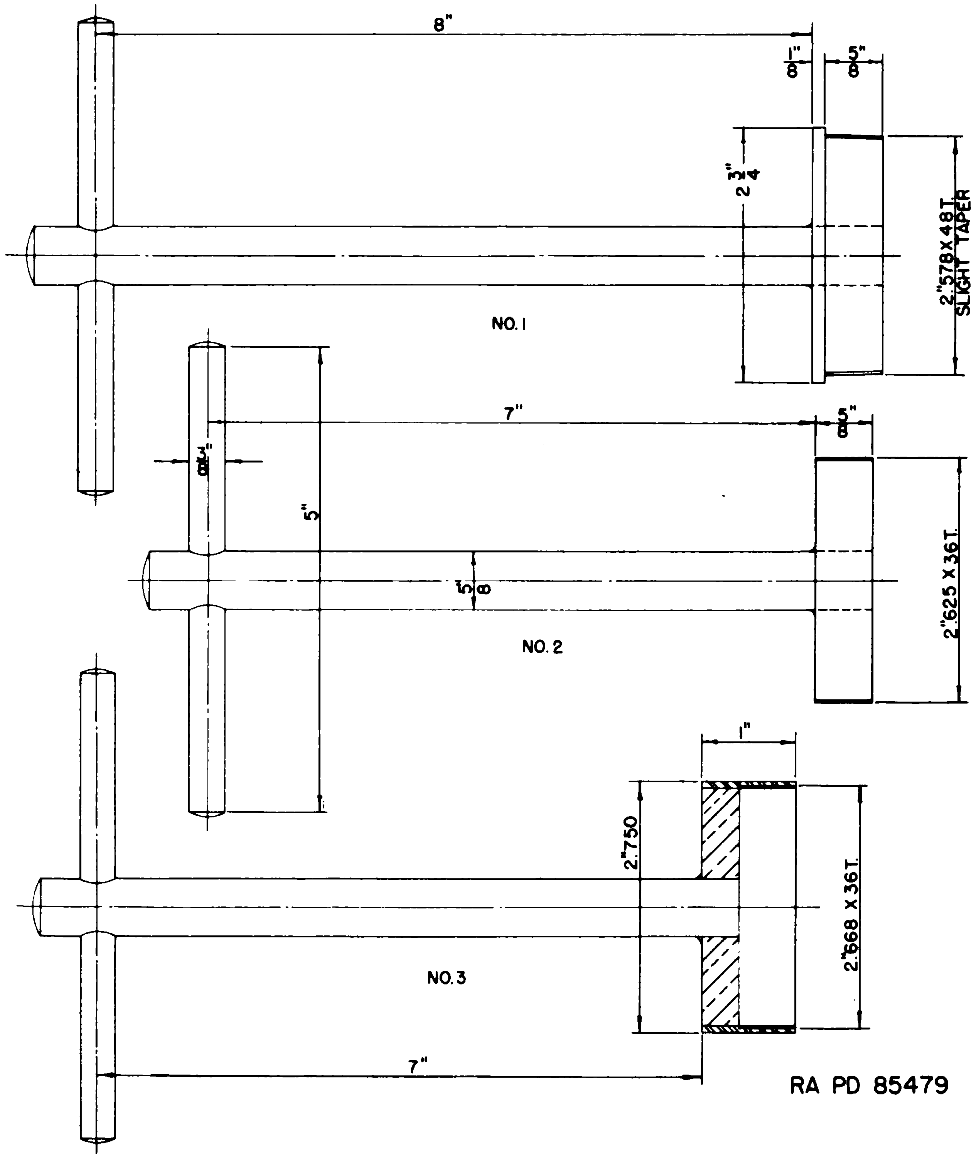


Figure 78 — Main Objective Cell Pullers

equipment are available for helium charging. Depending on the echelon of maintenance, helium charging is accomplished in one of several ways. First and second echelons should charge by the Oliver method. Third, fourth, and fifth echelons should charge using a Helium Filling Kit M6A1, which includes a helium purity indicator. The details of helium charging and purity testing are given in TM 9-1622. The Oliver method, described in TM 9-624, may be used by ordnance personnel when lack of a purity indicator makes it impossible to charge by the purity indicator method.

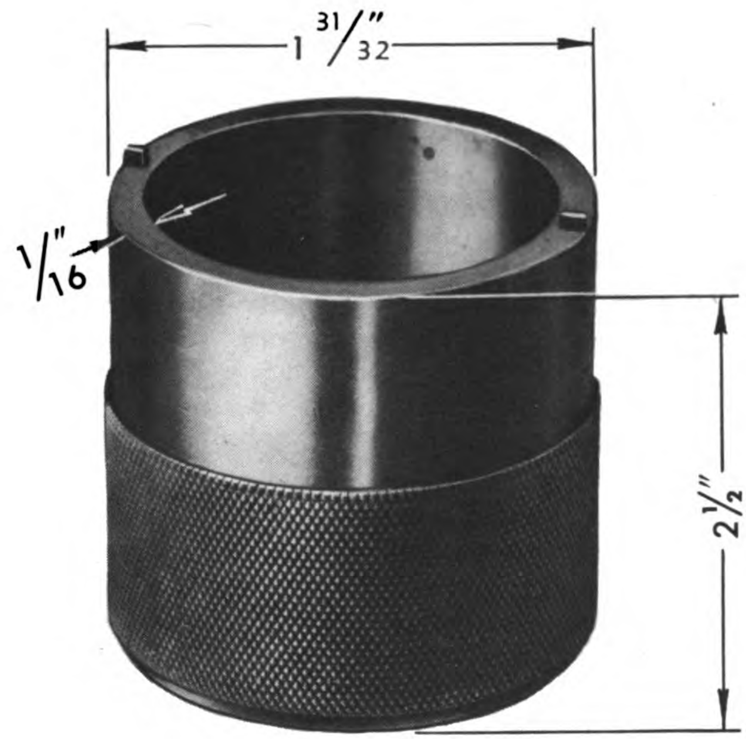


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Figure 79 — Tracking Telescope Objective Cell Wrench

b. When To Recharge the Height Finder With Helium.

(1) An instrument which has been opened for repairs must naturally be desiccated with dry gas and refilled with helium.

(2) If the instrument shows evidence of condensation of moisture on the internal optical surfaces, desiccation and recharging are indicated.

(3) If an instrument fails to hold pressure, the leaks should be traced, if possible, using a can of soap suds and a brush. The leak should be repaired and the height finder recharged.

(4) The height finder should be recharged periodically at least once a month, and more frequently if necessary.

c. Requirements for Holding Pressure.

(1) The instrument should be filled to an indicated pressure of 4 pounds per square inch. The exact pressure and temperature should be recorded. A more exact value of pressure and temperature can be obtained by taking the readings after temperature stabilization, an hour or two after filling.

(2) After 8 hours, the pressure must not have dropped below 2 pounds per square inch, allowance being made for a change in pres-

sure due to differences in starting and finishing temperature, if this change is appreciable. Roughly, a change of 30 degrees Fahrenheit in temperature, starting at 4 pounds per square inch, will cause a change in pressure of 1 pound per square inch in the same direction as the temperature change. For example, a temperature increase of 15 degrees Fahrenheit will increase the pressure one-half pound per square inch, which should, therefore, be subtracted from the final pressure to obtain a significant pressure drop, if any.

(3) If the height finder does not hold a pressure of approximately 4 pounds per square inch, apply soapy water made from mild soap to any joint, packing, screw, or plug which is a possible leak source. A leak can be spotted by local bubbling of the soapy water, and is generally accompanied by a faint hiss. Bubbles frequently come out far from the actual leak, due to the gas traveling under the canvas cover. In some cases, bubbles may not appear at all due to diffusion of a gas out through the canvas. In any case, when the actual leak is found, soldering or other appropriate repair must be done. Soapy water must then be washed off after repeating the pressure test.

86. CARE AND HANDLING OF OPTICAL PARTS.

a. Precautions.

(1) It must be remembered at all times that optical glass surfaces are extremely delicate and easily harmed.

(2) Avoid excessive rubbing when cleaning such surfaces, and apply only very gentle pressure.

(3) Keep all cleaning materials clean and free from dust or grit.

(4) The use of polishing liquids, pastes, or abrasives for polishing lenses and windows is not permitted.

b. External Optical Surfaces.

(1) The optical surfaces exposed on the main instrument are the end windows and eyelenses, and on the tracking telescopes, the objective lenses and eyelenses. These should be kept clean in order to get the most satisfactory results.

(2) Protect the optical surfaces with the covers provided at all times when the instrument is not in use.

(3) Never allow the rays of the sun to fall directly on any exposed optical surface, such as the eyepiece lenses.

(4) Keep the glass clean and dry to prevent corrosion and etching of the surface.

(5) Exercise particular care to keep optical parts free from oil and grease. Do not wipe or touch the lenses with fingers.

GENERAL MAINTENANCE

(6) For wiping optical parts, use only the chamois or polishing cloth furnished in the cradle packing chest, or lens tissue paper. Use of other cleaning cloths in the field is not permitted. To remove dust, brush the glass lightly with a clean camel's-hair artist's brush, and rap the brush against a hard body in order to knock out any small particles of dust that may cling to the hairs. Repeat until all dust is removed. Do not use a brush with coarse bristles, such as is provided for cleaning mechanical parts.

(7) To remove oil or grease from external optical surfaces, apply liquid lens-cleaning soap, or ethyl alcohol, sparingly with a clean camel's-hair artist's brush, and rub dry gently with clean lens tissue paper. Take care to avoid having the soap or alcohol seep around the edges of the glass into the mount. If soap or alcohol is not available, breathe heavily on the glass (external surfaces only) and wipe dry with clean lens tissue. Repeat as necessary until the surface is clean.

(8) Remove the rubber eye shields at frequent intervals and wash in lukewarm water, dry, and apply talc and rub in. Remove surplus talc and reinstall.

c. Handling of Optical Parts.

(1) It must be remembered at all times that optical glass surfaces are delicate and easily damaged. Special care is required, therefore, in handling any of the height finder optics, especially when they are removed from their mounts.

(2) Never remove a lens or prism from its mount unless it is necessary for cleaning or adjustment. When it is necessary to remove a lens from an instrument, note the relative position that each side of the lens faces in the instrument. It is good practice to mark an arrow with crayon or pencil on the periphery (outer edge) of the lens, indicating the direction in which the surfaces face. It is customary to indicate the surface pointing towards the objective. The mark should extend to the edge, to correspond with a mark on the mount, so the lens will not be turned from its original position when reassembled. Prisms may be marked on the unpolished surfaces. Take care not to remove the marks during cleaning. Use lens-holding clamps to hold lenses while cleaning.

(3) When remounting a lens or wedge, see that it is properly seated in its cell and that any separators and retaining rings are inserted properly without tilt. Retaining rings and clamps should be tightened sufficiently to hold the part firmly and prevent it from shifting, but not tightly enough to cause strain. Strains in glass, whether internal or caused by external mechanical stress, have a bad effect on the optical properties. If possible, after remounting any optical parts, check with polarized light and adjust for minimum lines of strain.

87. CLEANING OPTICAL PARTS WITH SPECIAL SURFACES.

a. End Reflectors.

CAUTION: *Do not attempt to clean front aluminized mirrors with lens tissue paper. Do not touch the reflecting surfaces.*

(1) Surface deposits of lint and dust may best be removed by careful use of a camel's-hair artist's brush.

(2) In more difficult cases, wash as gently as possible with a clean pad of white batiste cloth soaked with lens-cleaning liquid soap. The rubbing pressure can be increased slightly after the mirror is well covered with soap solution. Rinse off all soap with clean running water, then blot off the remaining water drops with a clean pad of batiste cloth.

(3) Dirt or irregularities on the contact surfaces of the end reflector mounts will probably change the adjuster scale readings, possibly beyond the range of the scale.

b. Reticles.

(1) Of all the optical elements, the reticle is the most difficult one to clean and requires the utmost patience and care. Any scratch, mar, or speck of dirt will be greatly magnified and brought to sharp focus when the change-of-magnification lever is shifted between 12 and 24 power.

(2) Do the cleaning in a dust-free room; otherwise the condition may be aggravated instead of improved. Prepare for cleaning by placing a strong light, diffused by a clean white paper, in front of the end windows and observe the reticles through the eyepieces in the normal manner.

(3) Do not remove the reticles from the instrument unless there is oil, grease, or other dirt which requires the use of a solvent. To remove dust or dirt specks from inside reticle lens, use camel's-hair artist's brushes or cleaning tools. Clean chamois is glued to the base of the cleaning tool. The soft wire allows this tool to be bent to reach into and contact optical surfaces that otherwise would have to be removed for cleaning.

(a) Small dust specks or lint can be removed by using a vacuum system as follows:

(b) Where a vacuum line is available, connect a rubber hose from the vacuum line to a piece of small diameter tubing.

(c) Wrap a strip of onionskin paper on the end of the metal tube to form a conical nozzle, which will prevent the metal from touching the polished optical surfaces. A nozzle having an open end with a

diameter of about one-sixteenth inch is very effective. If nozzle touches the reticle mount, cut off the tip before using it further, as it may have picked up dirt or grease which would be transferred to the reticle surface.

(d) Insert the metal tube through the opening at either side of the reticle mount, and pick off the dust specks while the reticle is observed through the eyepiece by a second operator. Do not scrub the nozzle over the reticle, but place it lightly in the vicinity of the speck.

(e) Observe the reticle while the instrument is in both high and low power, since the low-power field of the system is larger than the high-power field. The curved surface on the side opposite the reticle marks can be brought to a sharp focus by turning the eyepiece focusing nut to bring the eyepiece out about 4 diopters. Check for dirt with the change-of-power lever moved to positions between the powers.

(f) To remove oil or grease, remove the reticle mount as described in paragraph 144. Clean the reticle as described above.

c. Check for Dirt on Optics.

(1) The purpose of this test is to determine what optical surfaces in the height finder are dirty, so that they may be cleaned with the least amount of effort. Direct the height finder toward the sky or other source of good illumination, and observe through a pupil loupe, or a high-power hand magnifier, which is moved up and down above the eyepiece so that images of the various optical surfaces are successively brought into focus. Repeat for the other eyepiece.

(2) ANALYSIS. Determine the position of the dirt with the aid of the chart (fig. 65). Clean the dirty element as outlined in this paragraph.

88. CLEANING AND PAINTING.

a. Precautions.

(1) Since the height finder is, or should be, kept in its sealed carrying case when not in service, it seldom requires cleaning. If, however, cleaning is necessary, it should be done carefully to avoid possible damage. For cleaning the glass surfaces, follow the instructions in paragraph 86. The other surfaces can be cleaned with castile soap and water. All soap should be thoroughly rinsed off and the surfaces dried quickly. Care must be taken to prevent water from penetrating under the various control knobs and levers.

(2) Sealing or plugging cement is required above some screw heads, when a flush surface is desired, or to prevent unauthorized adjustment of the screw.

b. **Repacking, Cleaning, and Painting Chart.**

Part	Operation and Remarks	Suggested Frequency
Gland, measuring knob.	Repack and test for helium leak.	Semiannually.
Glands (others).	Repack and test for helium leak.	When needed.
Seals (all).	Repair and clean (CAUTION: *Avoid excess compound.*)	When needed.
Track scope mount.	Paint screws subject to corrosion.	When needed.
Cradle, tripod, telescope, and chests.	Paint.	When needed.
External optical surfaces.	Clean (par. 86).	When needed.
Internal optics.	Clean (par. 87).	When needed.

89. LUBRICATION.

a. **Lubricating Materials.**

(1) LUBRICATING OIL FOR AIRCRAFT INSTRUMENTS AND MACHINE GUNS. Apply lightly wherever oil is prescribed. Excess oil collects dust and dirt.

(2) SPECIAL LUBRICATING GREASE. Apply sparingly wherever grease is prescribed.

(3) DRY-CLEANING SOLVENT. Dry-cleaning solvent will be used to clean parts which must be dried thoroughly before lubricating.

b. **Lubricating Instructions—Tripod.** See TM 9-624 for lubricating instructions for using arm.

c. **Lubricating Instructions—Cradle.**

(1) See TM 9-624 for lubricating instructions for using arm.

(2) The mechanisms listed below are lubricated at disassembly.

Traversing mechanism bearings.

Ring gear.

Azimuth indicator.

Intermediate gear.

Azimuth receiver bearing.

Height transmitter bearing.

d. Lubricating Instructions—Height Finder Telescope. See TM 9-624 for lubricating instructions for using arm.

Part	Operation and Remarks	Suggested Frequency in Most Climates.
Right main bearing and left main bearing.	Remove the bearing housing. Clean and grease the balls and race. Readjust.	At assembly.
Eyepiece assembly.	Remove, clean, and grease. Reseal and realine, using a double collimator.	Once a year.
Inner tube support bearings and rings.	Remove the cover plates. Grease the bearings and rings. Reseal the telescope.	Once a year.
Complete range drive assembly bearings.		At disassembly.
Range drum bearings.		At disassembly.
Compensator gears and drive shaft bearings.		Once a year.

90. MAINTENANCE OF PACKING CHESTS.

a. Condition of the packing chests is quite important in that the condition of the height finder itself may be affected. Broken hinges on the cradle chest may result in a seriously damaged cradle. Likewise, a leak in the telescope chest may result in an unserviceable height finder.

b. Chest maintenance is rather simple. The chests must be kept clean, lubricated, and painted, and the internal and external hardware must function as intended. It is also important that all parts and tools in the cradle and tripod chests are present and in their proper places. The chests and their parts are shown in figures 51 and 52.

c. Inside the telescope packing chest (fig. 50), there rolls a carriage which supports the instrument for travel. Field experience indicates the necessity of checking the security of support D43459 to tube B172244 of this carriage. Several methods of holding these two parts have been used. Most carriages have a two-inch taper pin inserted three-eighths inch from the end of the tube. Since this taper pin may become sheared, it must be checked and, if necessary, replaced. Should circumstances require, it may be replaced with a larger diameter pin or bolt.

Section IX

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT

91. LEVELS.

a. **Explanation.** The height conversion mechanism is controlled by the angle of elevation of the height finder telescope with respect to the cradle. Therefore, to obtain accurate height determinations, the cradle must be accurately leveled and the height conversion mechanism and the elevation tracking telescope must be properly alined. To facilitate leveling, the cradle level bubbles should be centered when the cradle is level and, to facilitate checking the elbow tracking telescope, the level on the optical tube or the zero elevation indexes should be accurately alined with the height conversion mechanism.

b. **Requirements.**

(1) Checking, adjusting, and replacing the cradle levels and height finder zero elevation indexes can be done readily in the field. Extra level assemblies are supplied from spare parts (SNL F-189).

(2) The tripod feet should be solidly set on a firm foundation when the levels are being checked and adjusted.

(3) A specially mounted reading microscope is desirable for observing the scale divisions on the graduated arc mounted on the right bearing housing (fig. 66) when setting the range locking bracket exactly 90 degrees from the height locking bracket.

(4) After the height finder optical tube level or zero elevation indexes are adjusted, the vertical alinement of the tracking telescopes and the height-infinity and height-900 settings of the compensator wedges should be checked and adjusted (par. 42 and par. 52).

(5) The compensator level is installed to aid in alining the compensator wedges at the factory, and must be used by maintenance personnel when replacing the compensator wedges as outlined in paragraphs 129 to 138.

c. **Cradle Levels.** If the cradle levels are outside tolerance, adjust them as follows:

(1) Make sure that the tripod is well placed on a firm foundation; then swing the height finder to bring it parallel to the line between any two of the tripod feet.

(2) Turn the leveling screws on these two feet to center the bubble of the level parallel to the height finder tube. Then adjust the third foot of the tripod to center the other cradle level bubble. Check both bubbles.

Figure 80 — Cradle Level Vial and Housing

(3) Traverse the height finder through 180 degrees and note the movement of the bubbles in the levels.

(4) With a pencil, mark the position of the edge of the bubble on the vial.

(5) If a bubble has become decentered, one-half the correction should be made by removing the level vial assembly and stoning or scraping the level housing (fig. 80). The other half should be made by adjusting the leveling screws to restore the bubble to the central position.

(6) Turn the tripod leveling screws to restore the bubble to center position.

(7) Traverse the height finder through 180 degrees and again note the position of the bubbles. (They should stay centered within tolerance (par. 63) but, if they do not, repeat the above procedure until they remain centered at all positions. The adjustment is simple to make, and in leveling the instrument it is not difficult to stay well within the tolerance.)

d. Optical Tube Level (figs. 81 and 82).

(1) The optical tube (height finder) level is well protected in the height finder and will never need resetting, unless the level

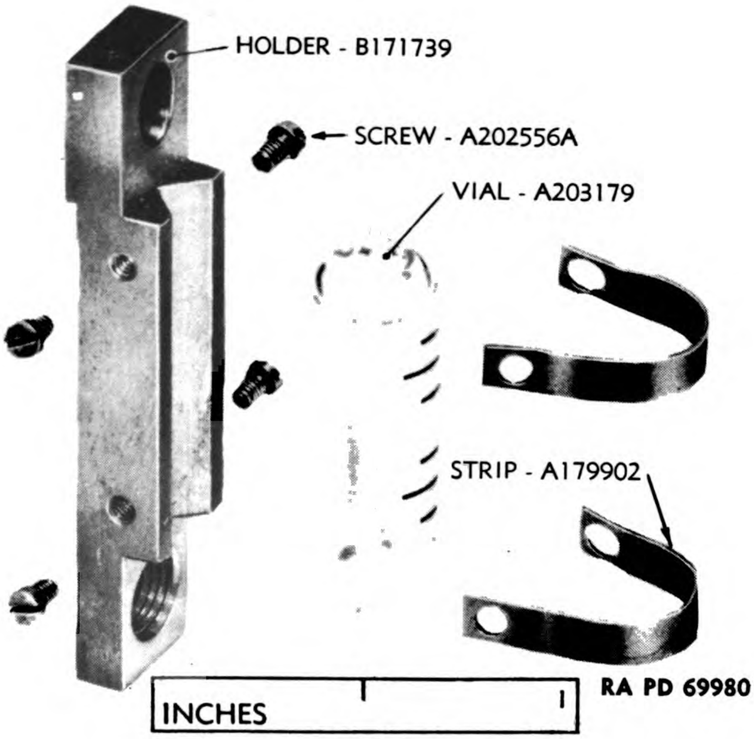


Figure 81 — Optical Tube Level — Exploded View

vial is broken by shell fire or carelessness of maintenance personnel.

(2) If a level is ever broken or moved from its position as set at the factory, the height finder telescope must be disassembled, and the optical bar removed and placed on steel V-blocks.

(3) It will be necessary to remove the adjusting plate, reticle, and ocular prism assembly (pars. 174, 176, and 178).

(a) Use a very accurately mounted hand level, vial type TT sensitive to 1 minute, placed on the ground surfaces of the optical tube from where the angle plate B171730 was removed (fig. 222).

(b) Level the optical tube by rotating the tube on the V-blocks.

(c) Adjust the optical tube level by loosening and tightening bushing A179901 and screw A202558H (fig. 82). Apply shellac varnish to the screw and bushing when the adjustment is complete.

e. Replacement of Levels. If a level should become damaged or broken, it can be replaced by one from spare parts.

(1) Unscrew the level housing screws and remove the old assembly.

(2) Install the new assembly, and replace the housing screws.

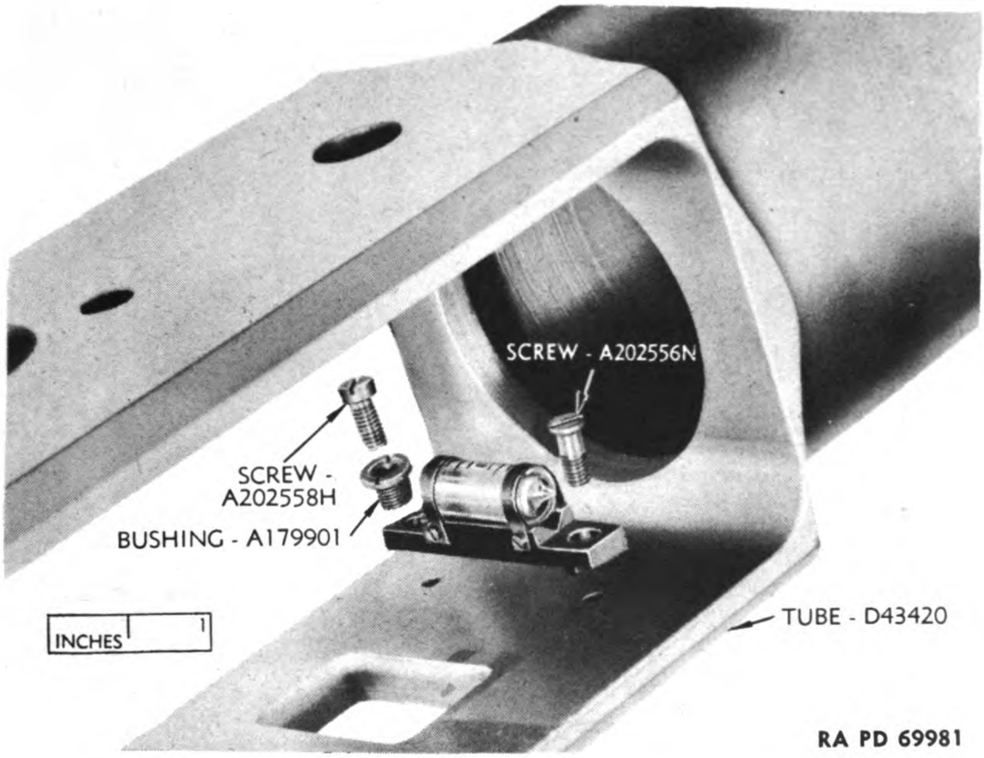


Figure 82 — Optical Tube Level Assembly

(3) Whenever a level is replaced, it should be checked and, if necessary, adjusted as described above.

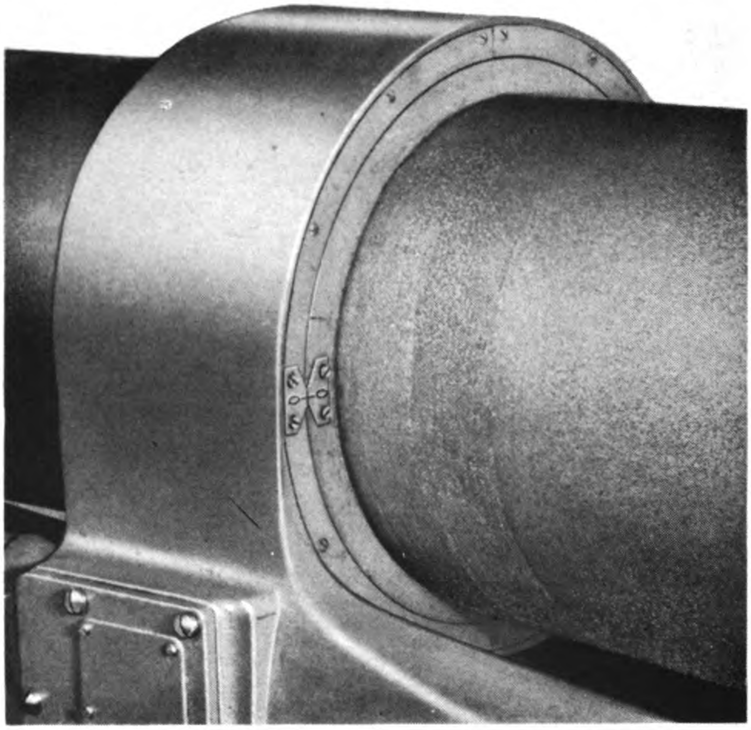
92. ZERO ELEVATION INDEXES.

a. Explanation.

(1) The zero elevation indexes mounted on the left bearing housing and the height finder outer tube are so adjusted that, when the optical tube is level and the fine elevation knob is locked in the center position, their index lines coincide. The line of sight of the height finder is then horizontal, provided the cradle on which the height finder rests is *exactly* level in any azimuth position. This adjustment can only be made by qualified ordnance personnel.

(2) There are two types of indexes installed on the M2 Height Finder. Those shown in figure 83 have been installed on most low-number instruments. Figure 84 shows the later type of index with which the height finder telescope can be leveled very accurately.

b. Method. If it is desired to check the accurate position of the indexes — 90-degree position of the range height locking brackets, range-infinity, height-infinity and height-900 settings of the compen-



RA PD 85437

Figure 83 — Zero Elevation Index (on Low-numbered Instruments)

sator wedges, or the accuracy of the instrument as a height finder — proceed as follows:

(1) Set the fine elevation knob in the central locked position.

(2) Level the cradle accurately.

(3) Remove the reticle cover plate B171740 (fig. 154).

(4) With the aid of a small dental mirror and a light, observe the optical tube level.

(5) Rotate the elevation handwheel until the level bubble is perfectly centered.

(6) Take the hand from the handwheel and recheck the level. When the bubble remains centered, check the position of the zero elevation indexes. Set them so they aline accurately. (Slot the screw holes in one of the index plates on the type illustrated in figure 83 if necessary.)

(7) If the position of the indexes is changed, check range-infinity, height-infinity, and height-900, taking the median of five readings in each position (pars. 126 to 128).

(8) Range-infinity and height-infinity should be within tolerance; if not, adjust the measuring drum adjuster under cover B171781 (fig. 123) just to the left of the right bearing housing.

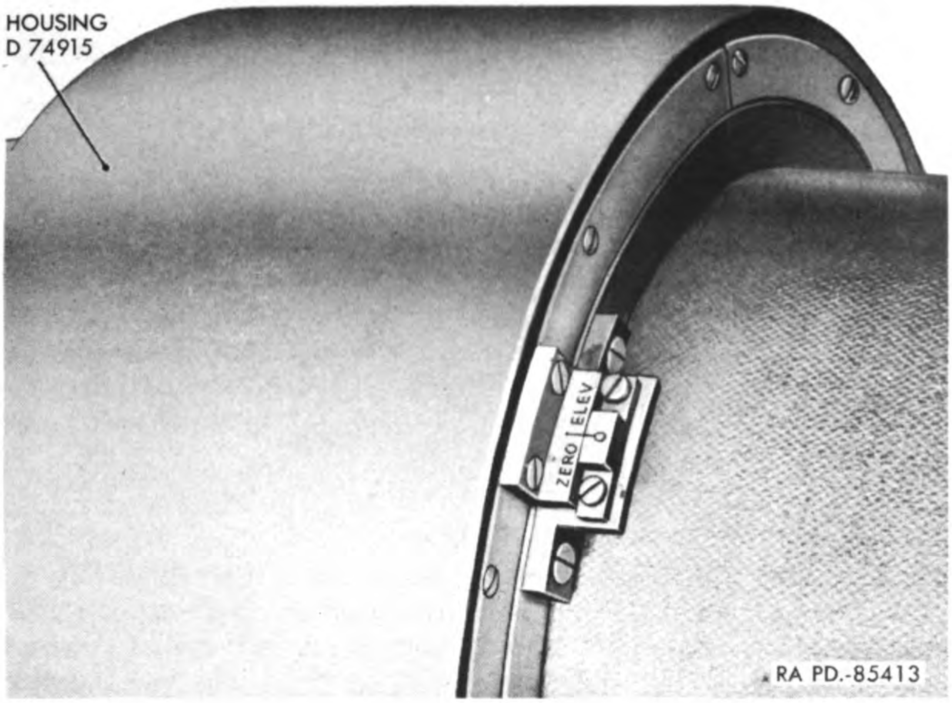


Figure 84 — Zero Elevation Indexes

(9) If the median of the height-900 position is not in tolerance with the range-infinity and height-infinity averages, the height locking bracket must be moved and positioned until the median of the readings in the height-900 positions are within tolerance.

(10) The range locking bracket must be repositioned 90 degrees from the height locking bracket, so that accurate checking of the height angles (fictitious altitude) may be determined if the height locking bracket has been moved.

(11) Procure a graduated arc and microscope, mount the graduated arc on the right bearing housing (fig. 66) with the zero mark as near opposite the range locking bracket as the slots in the graduated arc will allow.

(12) Locate and secure the microscope on the conversion lock ring, and place the conversion lock lever over the height locking adapter.

(13) Check and adjust the optical tube level.

(14) Check and adjust the indexes.

(15) Focus the microscope and adjust until the two cross hairs include the graduation zero line between them.

(16) Move the conversion ring and lock over the range locking bracket.

(17) Adjust the range locking bracket until the two cross hairs include the line at the 90-degree graduation.

(18) If the locking brackets have been moved, redrill and repair both with oversize dowel pins.

(19) The procedure outlined above establishes the line of sight of the height finder telescope in the horizontal position, and all the work must be done very carefully with frequent checks of the indexes, levels, and the range-infinity, height-infinity, and height-900 position readings. NOTE: *This procedure requires breaking the seal of the instrument.*

(20) Aline the elevation tracking telescope as directed in paragraph 189.

93. END REFLECTORS.

a. **General.** The end reflector units reflect the light from the outside field at an angle of 90 degrees and direct it into the main optical system. The exact angle through which each reflector reflects the rays must not vary, and the lines of sight from the two reflectors must lie in one plane, so that they will intersect at the target. The mirrors are mounted in a manner which is designed to provide the utmost rigidity with the minimum strain in the glass. The end reflector supports are mounted to the inner tube adapter by screws and two guide pins. The end reflector screw holes in the support are oversize to allow a slight rotation of the entire assembly in originally lining up the end reflectors. Any subsequent shifting of the end reflector base will cause misalinement.

b. **Requirements.** To adjust or replace the end reflectors, it is necessary to remove the end boxes, thus breaking the hermetic seal. A target with well-defined detail and a horizontal line at the same level as the height finder or a transit will be needed for testing. CAUTION: *The front aluminized mirrors are easily damaged and must be handled with extreme care. Do not touch the reflecting surfaces.*

94. ADJUSTMENT OF END REFLECTORS FOR MISALINEMENT.

a. If the height adjuster cannot bring the images in both fields to the same height, and the inspection (par. 41) indicates that the difficulty is in the end reflectors, determine which reflector is at fault and correct it as follows:

b. Level the height finder, and sight on a target which is at exactly the same height as the instrument.

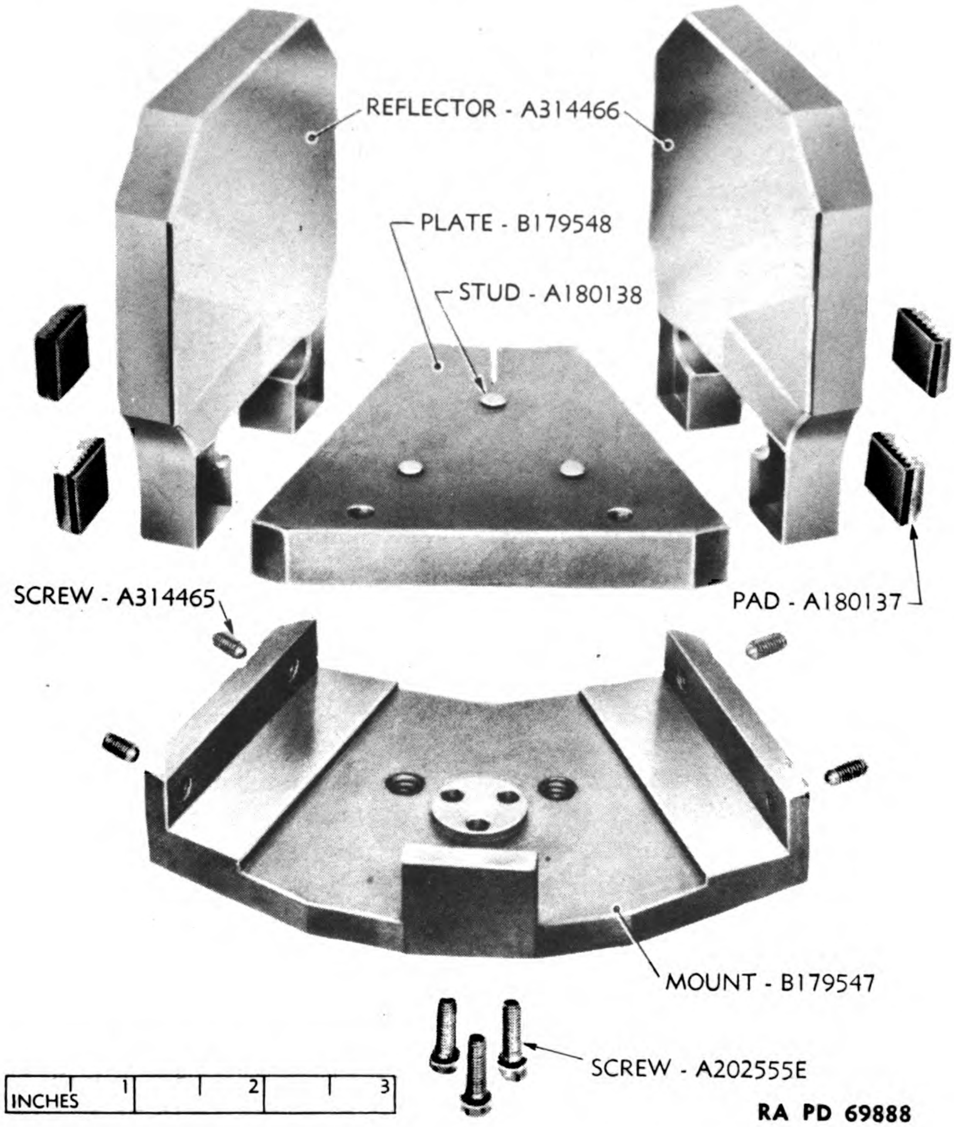


Figure 85 — End Reflector Assembly — Exploded View

c. Set the height adjuster at the mid point of its travel (par. 148) and look through the left and right eyepieces, noting relative positions of the target image in the two reticle fields.

d. If one image is decentered, possibly completely outside the field, check and adjust the corresponding end support and reflector as outlined below.

(1) Remove the end box as described in paragraph 164 and check tightness of the three hexagonal-head bolts which hold the

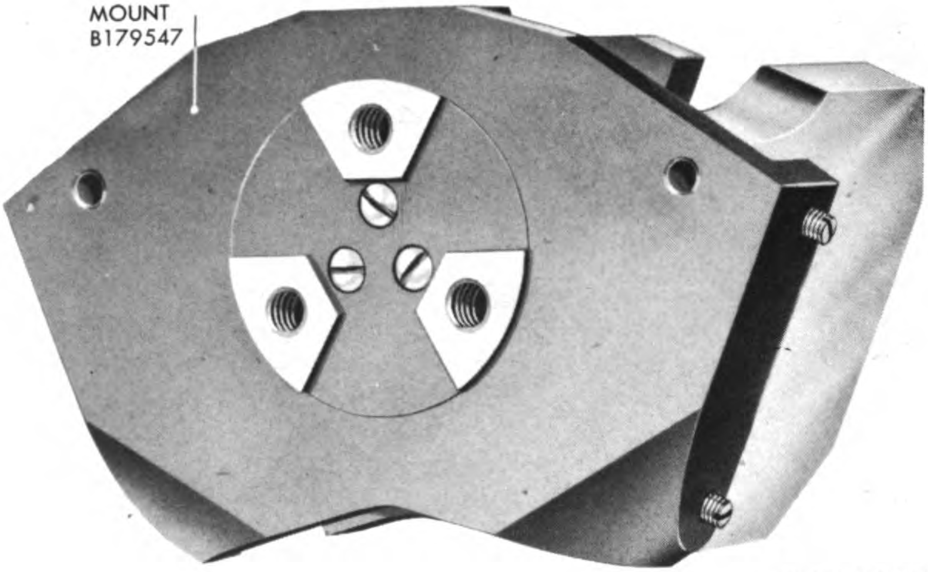


Figure 86 — End Reflector Mount — Bottom View Showing Bosses Properly Stoned

end reflector mount assembly (fig. 87) to the end reflector support (fig. 88).

(2) Check the contact surface between the bosses on the end reflector mount and the bosses on the support, using a flat plate and prussian blue over the combined surfaces of the bosses. Contact should be indicated on at least 95 percent of the surface area. If it is less than this, it will be necessary to restone the bosses as described in paragraph 96 **i**.

(3) Inspect each mirror of the end reflector assembly to see that it is held firmly in place by the pads A180137 and lock screws A314465 (fig. 85). Remove any chips or dirt from between the bosses of the reflector support (fig. 88) and bosses of the reflector mount (fig. 86). If the image can then be brought into approximate alinement with the image in the other field, and any tilt of field is simultaneously nearly or completely eliminated, the trouble has been located. A small degree of remaining tilt or adjustment of height can be corrected by stoning the bosses of the reflector mount.

(4) When the image is alined, tighten the three bolts and seal them with shellac varnish.

(5) Seal and replace the end boxes.

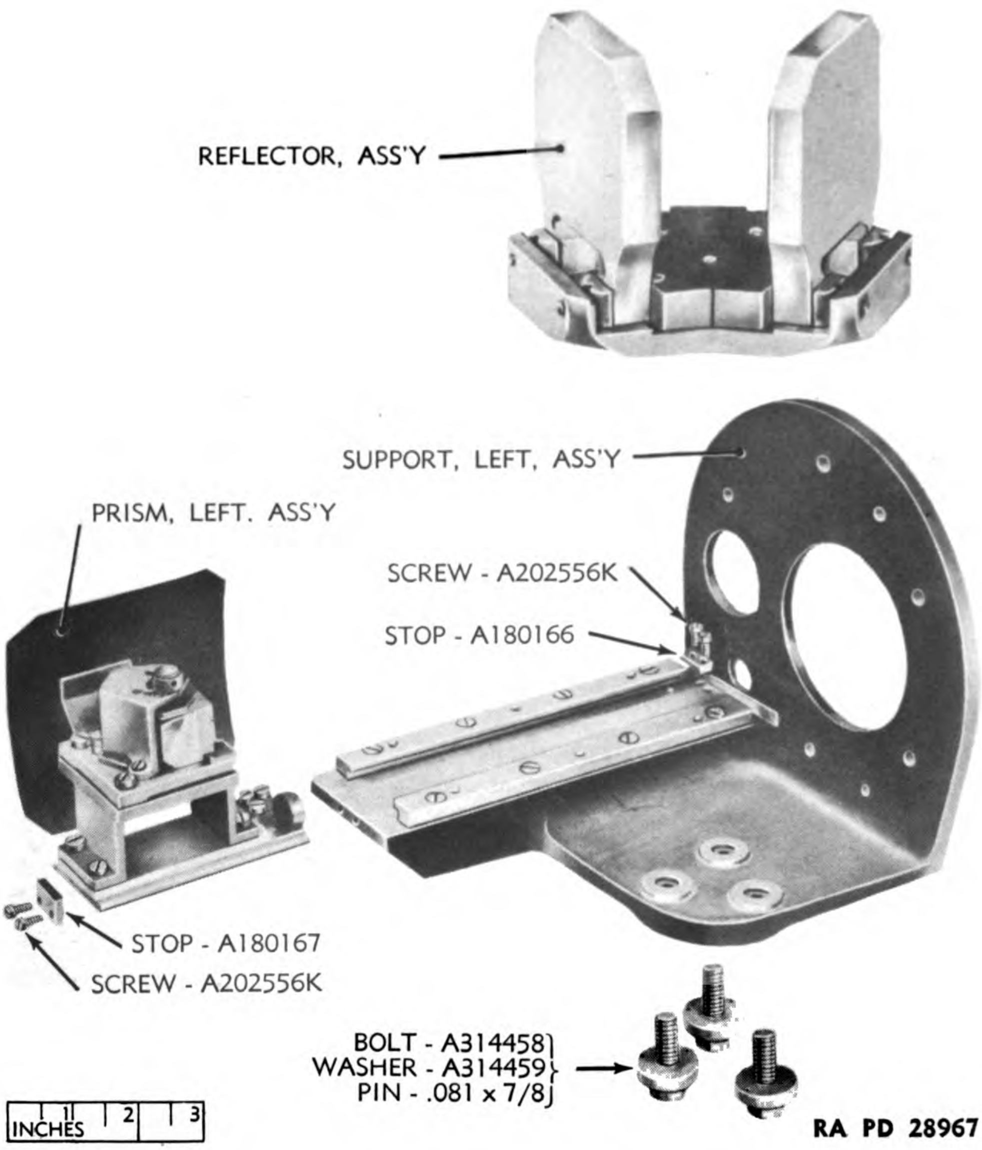


Figure 87 — Adjusting Penta Prism — Left Assembly

95. REMOVAL OR REPLACEMENT OF END REFLECTORS.

a. If an end reflector assembly has been damaged so as to require replacement, it can be removed from the support as follows:

CAUTION: *The front aluminized reflecting coating on these mirrors is very easily damaged. Handle the mirrors with extreme care.*

b. Remove the end box as instructed in paragraph 164.

c. Remove the three hexagonal-head bolts A314458, and lift out the entire reflector assembly (fig. 87).

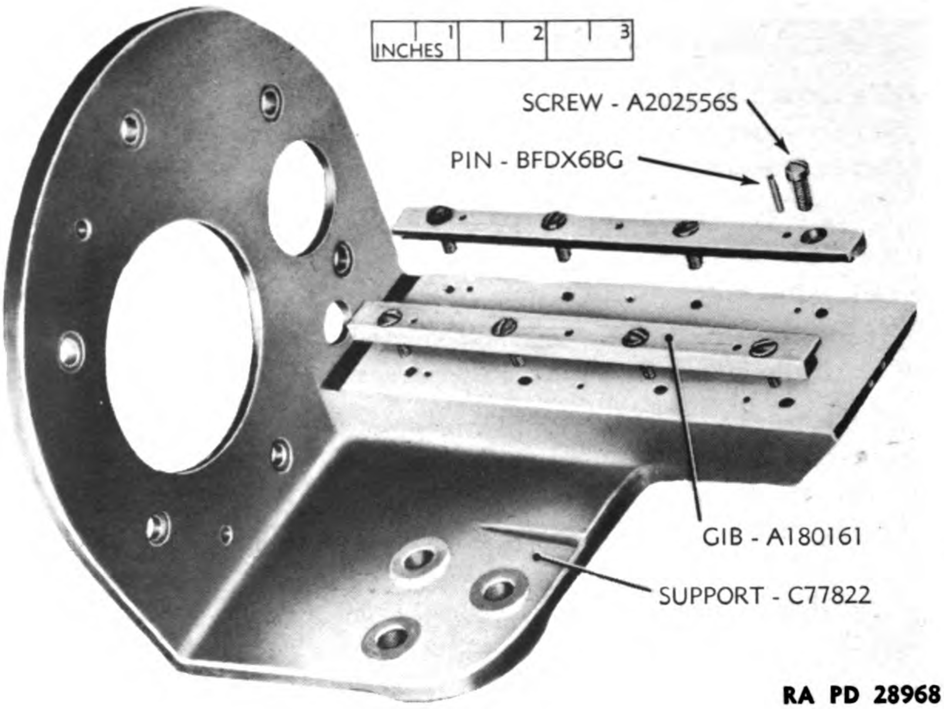


Figure 88 – End Reflector Support – Showing Gibs Exploded

d. When reassembling the new end reflector assembly to the support, make sure that all points of contact are free from dirt or grit.

e. Remount the end reflector assembly as follows:

(1) Secure the end reflector assembly temporarily in place on the end reflector support.

(2) Place a pupil loupe or dynameter with a diaphragm attachment (fig. 74) on the eyepiece, and focus it on the circular opening in the end reflector support.

(3) Cut-off in the field at the sides of the circular aperture may be equalized by loosening the holding screws and rotating the end reflector assembly slightly.

(4) Cut-off in the field at the bottom requires the lowering of the end reflector by stoning of the bosses of the reflector support.

(5) Cut-off on the left side may be caused by the correction wedge. If so, loosen screws in the base and shift the correction wedge (par. 120).

96. END REFLECTORS—RETICLE HEIGHT AND TILT ADJUSTMENT.

a. Set the height adjuster knob to mid position.

b. Set the fine elevation knob in the locked position.

c. Place an electric lamp over the eyepiece.

d. Remove the compensator covers and the optical tube cover plate and compare the compensator and optical tube levels. If they do not agree, use the optical tube level to properly level the telescope.

e. Place a transit about 2 or 3 feet directly in front of the right end reflector and level at about the same height as the center of the inner tube.

f. Focus the transit on the end reflector directly in front of the transit until an image of the stereoscopic reticles is observed.

g. If the center reference marks are exactly bisected by the horizontal cross line of the transit, as shown at "A", figure 64, then both the *tilt* and *height* adjustments of the end reflector are correct.

h. If the central reference marks are tilted and their centers appear above or below the cross line as shown in "B", figure 64, then both the *tilt* and *height* adjustment of the end reflector are incorrect.

i. The end reflector assembly must be tilted to correct these maladjustments. To determine the direction of tilt, certain rules could be recommended, but a much less confusing method consists in simply inserting strips of paper between the end reflector base and the bosses on the support separately until the conditions have been corrected. It can then be readily determined which bosses require filing (or stoning) in order to make necessary corrections.

j. Repeat for the other end reflector.

NOTE: *Before stoning or filing bosses check the following requirements:*

(1) Elevation knob is in the locked position.

(2) Height adjuster is in the mid position.

(3) Optical tube is level.

(4) End reflector is centered in the aperture.

(5) Contact surfaces between the end reflector base and the bosses on the support are perfectly clean.

(6) End reflector base is firmly secured to the support.

97. CLEANING THE END REFLECTORS.

a. Refer to paragraph 87.

98. REMOVAL OF END REFLECTOR SUPPORTS.

a. The end reflector support should not be removed except for replacement, or for a major disassembly of the height finder (removal of the inner tube). It is always necessary to remove the end reflector assembly and the penta prism mount assembly in order to remove the end reflector support. CAUTION: *Take care to avoid touching the front aluminized surfaces of the end reflectors.*

b. Remove the end box as described in paragraph 164.

c. Loosen set screw, unscrew and remove adjuster tube nut to disconnect the prism shift tube stud from the penta prism assembly. Remove the penta prism stop A180167 (fig. 87). Slide the penta prism assembly out of the gibs and remove.

d. Remove the three hexagonal-head bolts and remove the end reflector assembly.

e. Remove the six screws A202555J (fig. 190) and remove the support assembly, taking care to move the support straight off the tube adapter so as not to bend the two locating pins.

f. For disassembly of the reflector support assembly see figure 88.

g. When remounting the reflector support assembly on the adapter on the inner tube, make sure that it is properly alined with the two locating pins, and securely screw it to the support adapter.

h. Shellac varnish the six screws and the end of the two guide pins.

99. EYEPIECE UNIT ADJUSTMENT — INTRODUCTION.

a. Light rays reflected by the ocular prisms pass through the eyepiece unit (fig. 89) which is assembled to the outer tube. The eyepiece unit contains two eyepieces, two rhomboid prisms, two sets of filters, and two erecting systems. The eyepiece lenses are adjustable for focusing to suit the observer's eyes, and the diopter scale should read the correct focus of the eyepiece within one-quarter diopter, so that the observer can make a setting for this correction accurately and quickly. Incorrectly focused eyepieces may result in poor definition. If the reticles cannot be fused into stereoscopic pattern, one or both eyepieces may be incorrectly set for the observer. The focusing movement should permit maximum and minimum settings on the diopter scale; if it does not, there may be mechanical difficulty.

b. The eyepiece lenses and rhomboid prisms are rotatably mounted about the fixed centers of the ocular prisms, permitting the separation of the eyepiece to be varied to suit the separation of the observer's eyes. In order for the observer to see clearly through both eyepieces, the separation between the exit pupils must match his interpupillary distance. If the reticles cannot be fused into stereoscopic pattern, the interpupillary distance setting should be checked (TM 9-624).

c. The eyepiece filters are arranged and mounted so that the

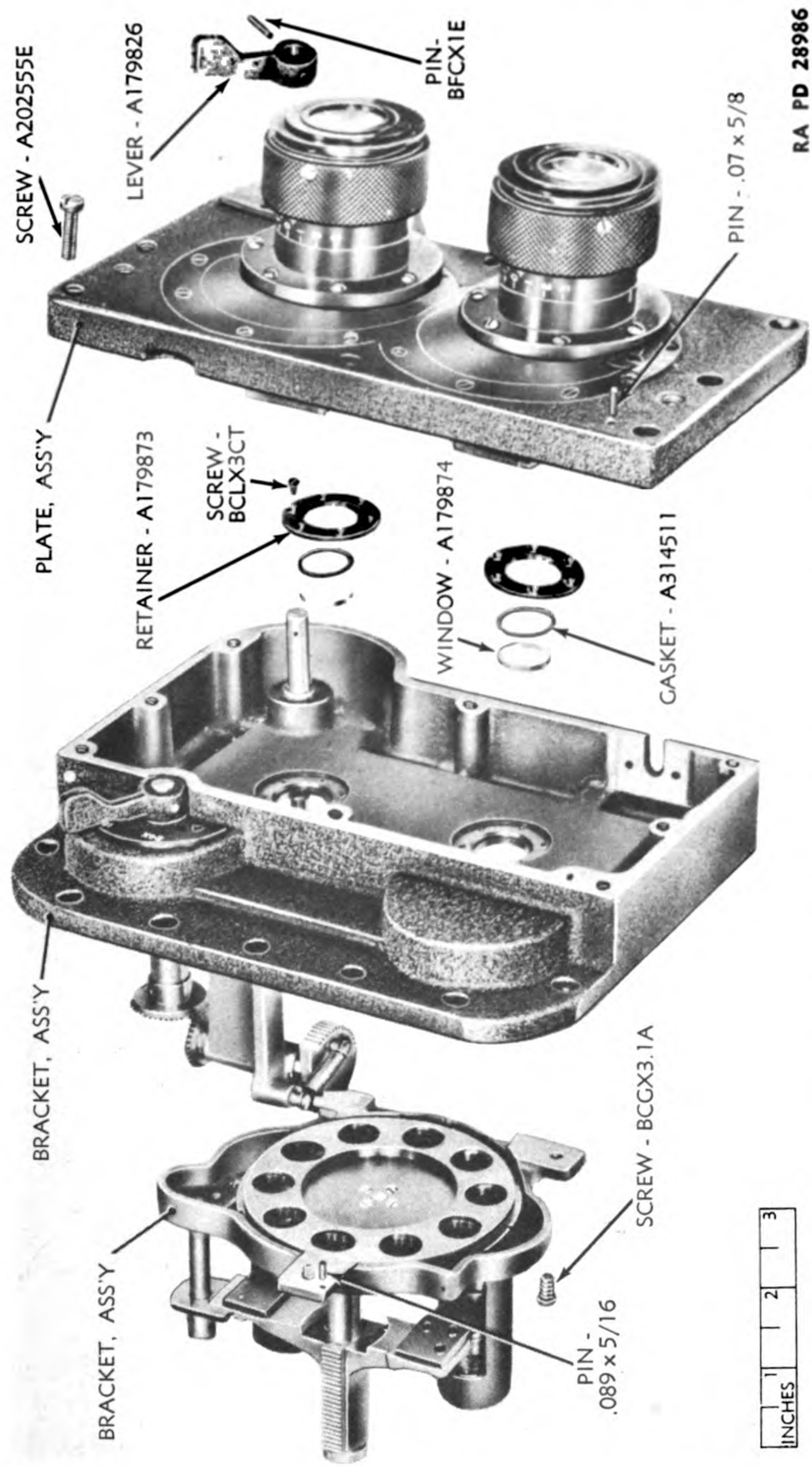
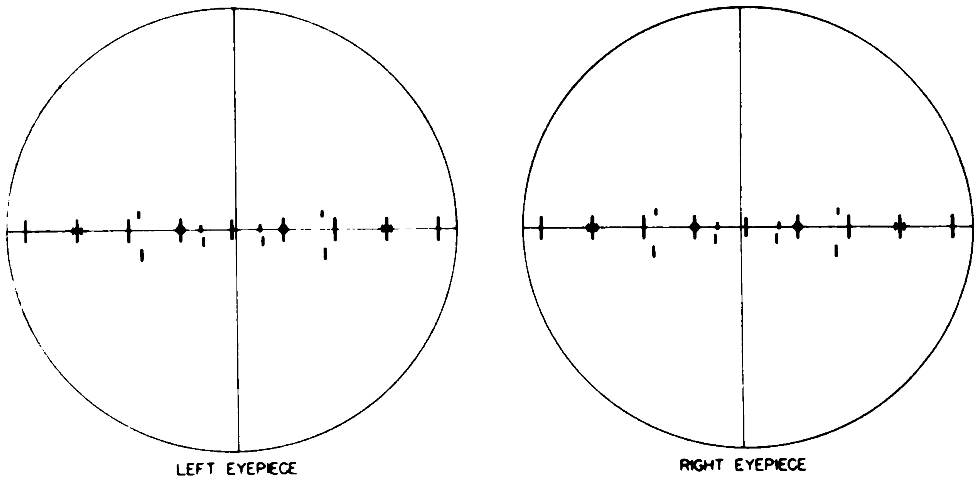
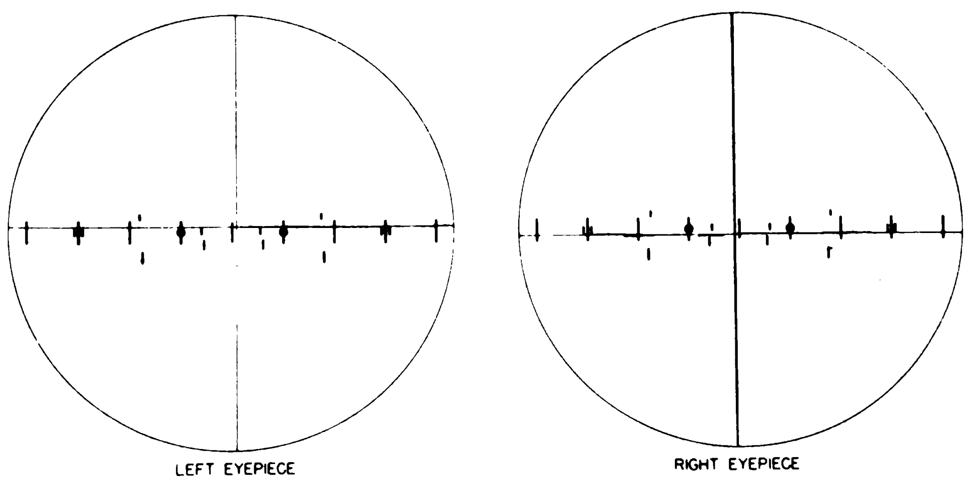


Figure 89 — Eyepiece Plate and Bracket Assemblies — Partly Exploded



A—Correct Adjustment



B—Allowable Tolerance

RA PD 85482

Figure 90 — Adjusting the Reticles

turning of a single lever brings a filter of the color indicated by the index into the field of each eyepiece. The lever should move freely and remain fixed at each detent. If the field of view is dull, cloudy, or dark, the wrong filter may be in place. Both filters should match. Check by looking through each eyepiece separately.

100. CENTERING THE HEIGHT FINDER RETICLES TO THE EYEPIECE.

a. If an eyepiece has been damaged, it will be necessary to aline the eyepiece to the reticle field of view as illustrated in figure 56.

b. The reticles must first be properly positioned before the damaged eyepiece can be adjusted. Proceed as follows:

(1) Assemble height finder telescope completely except for the eyepiece assembly.

(2) Cover the eyepiece opening and remove all paint from the surface of the eyepiece adapter.

(3) Procure a cast iron block with parallel finished sides 8 inches x 8 inches x ½ inch thick.

(4) Drill two ¼-inch holes 65 mm ($2\frac{9}{16}$ inches) apart and centered in the block.

(5) Place the block over the eyepiece opening.

(6) Place a lamp in front of each end window.

(7) Place a low-power telescope over one of the holes, then over other hole in the plate and observe the stereoscopic reticles.

(8) If the stereo reticles do not appear as illustrated in figure 90, unlock the fine elevation and move the fine elevation knob until the stereo reticles are centered to the cross lines of the low-power telescope.

(9) The stereo reticles are held in the position as illustrated in "A" or "B," figure 90, in the manner described in paragraphs 149 to 151.

(10) The eyepiece must then be adjusted (pars. 101 to 108).

101. EYEPIECE UNIT ADJUSTMENT — ERECTING LENS SYSTEM.

a. Rays of light from the image at the front surface of the reticle collective lens are converged by the convex surface of this lens through the central ocular prisms into the erecting lens system in the eyepiece assembly.

b. Each erecting lens consists of a quadruplet combination mounted in a cell that can be moved along its axis by pinion and rack connected to the change-of-magnification lever on the eyepiece bracket. As the lever is turned, the rack draws the erector lenses toward or away from the central ocular prisms' collective lenses. An off-center tension spring on the rack pinion holds the lens cell in either of the alternate 12- or 24-power positions. The distance through which the erectors move is such that the effective optical distances between the reticle and erector, and the eyepiece and erector, are interchanged, so that the objective distance for one position is equal to the image distance for the other position. Thus the erector forms either a magnified or a reduced image of the reticle at the focal plane of the eyepiece.

c. The position of the eyepiece unit in relation to the axis of the

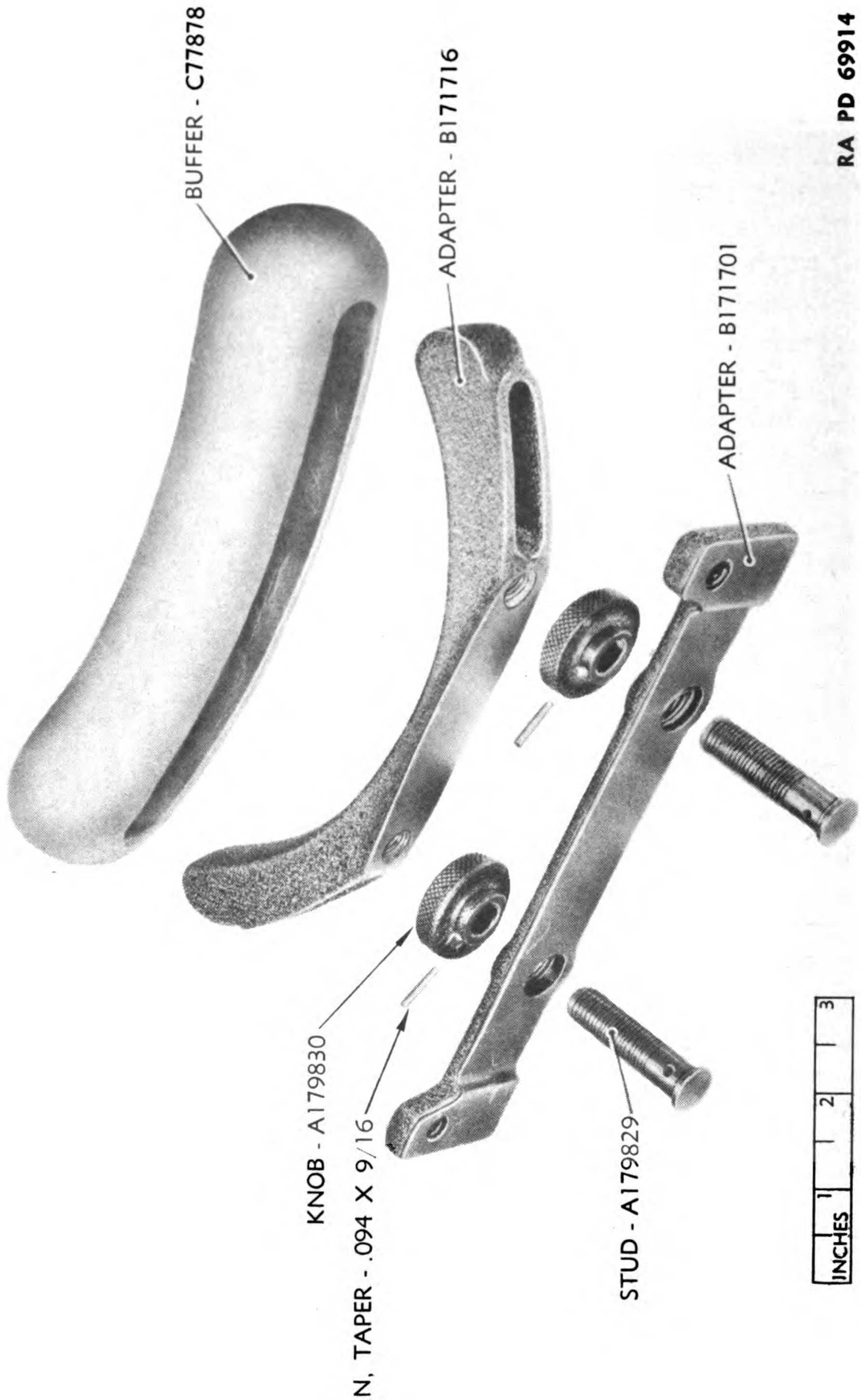


Figure 91 — Headrest Assembly — Exploded View

optical tube, and the adjustment of the rhomboid prisms, must be such that the image is observed in the same relative position through each eyepiece within specified tolerances (figs. 56 and 58). Errors greater than these tolerances will result in eye strain and impair the observer's accuracy.

d. Although the headrest is not a part of the eyepiece unit, it should be considered in this section. The headrest helps to hold the observer's head, without strain, in the position which allows him to see the greatest amount of light and the largest field. The headrest is adjustable for different heights, and the adjusting knobs should operate on the studs with no binding (fig. 91).

102. EYEPIECE UNIT ADJUSTMENT—REQUIREMENTS.

a. Checking and adjustment of the diopter setting, the interpupillary distance, and the dipvergence (up-and-down divergence) can be done without removing the eyepiece bracket assembly from the instrument. Adjustment or replacement of the rhomboid prisms requires removal of the eyepiece plate assembly. While this does not involve breaking the hermetic seal of the instrument, the eyepiece units should be removed in a dust-free room. Removal of the eyepiece bracket assembly for access to the change-of-magnification assembly, or adjustment or replacement of filters, involves breaking the hermetic seal of the instrument.

b. A collimating telescope (low-power telescope) (fig. 74) on divergence tester is needed for checking of the diopter setting and for adjustment of the diopter scale. A dioptometer may be used if available locally.

c. A divergence tester *is necessary* for checking and adjusting both lateral and up-and-down divergence. Adjustment for the latter *must* be made whenever the eyepiece assembly is removed and remounted on the instrument.

103. EYEPIECE UNIT ADJUSTMENT—DIOPTER SETTING.

a. The eyepiece focus is a check to determine the diopter scale setting for 12 and 24 power, and to determine if there is a difference between the focus of the two powers.

b. Check the focus of the eyepieces as follows:

(1) Set the adjuster prism shift knob for external readings and elevate the height finder so that it is pointing toward the clear sky.

(2) Set the change-of-magnification lever at 24 power, and the diopter index to zero.

(3) Place a collimating telescope or a dioptometer over the eyepiece and focus it for zero parallax between the height finder reticle and the dioptometer reticle.

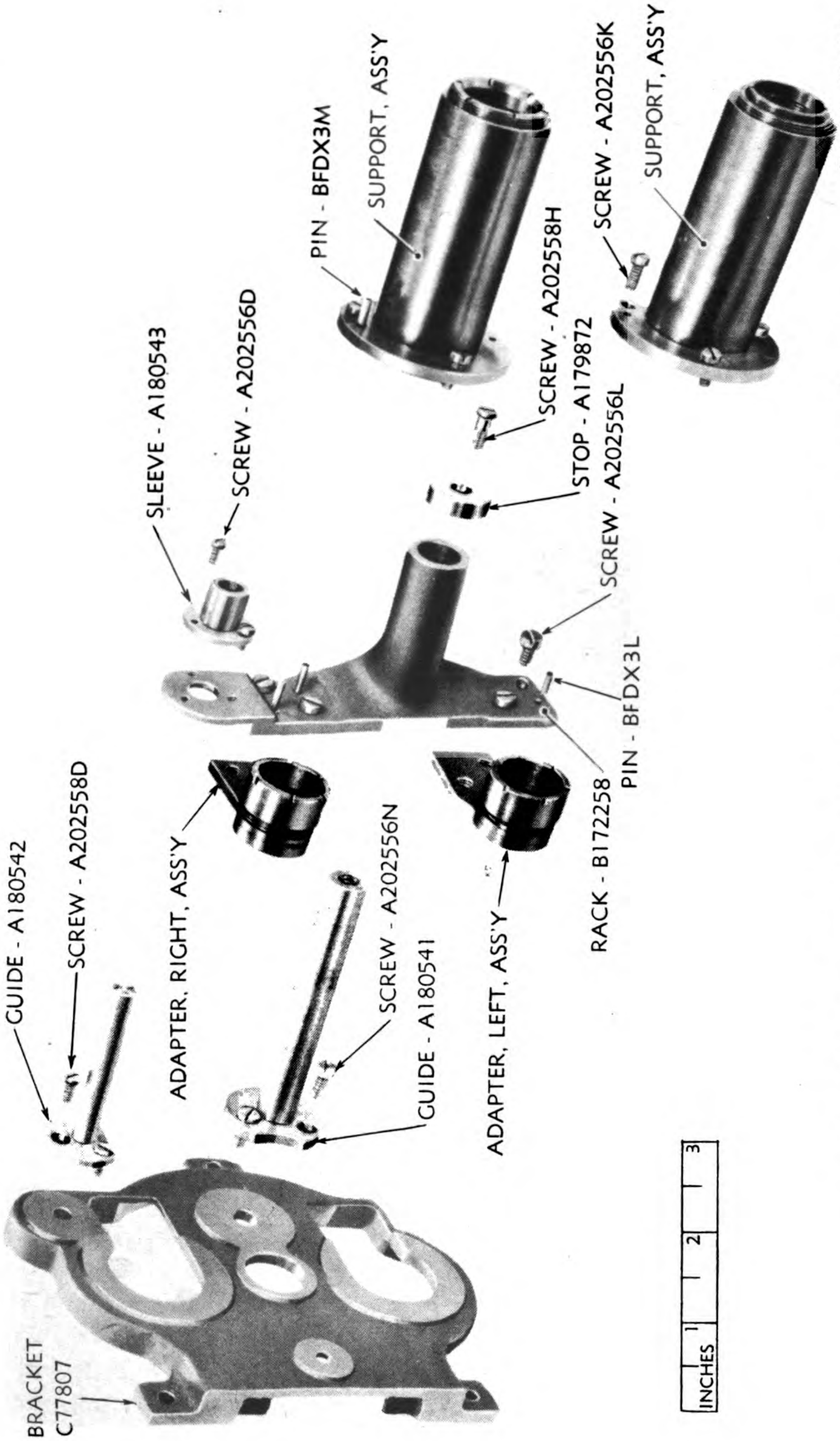


Figure 92 — Disassembling the Change-of-magnification Mechanism

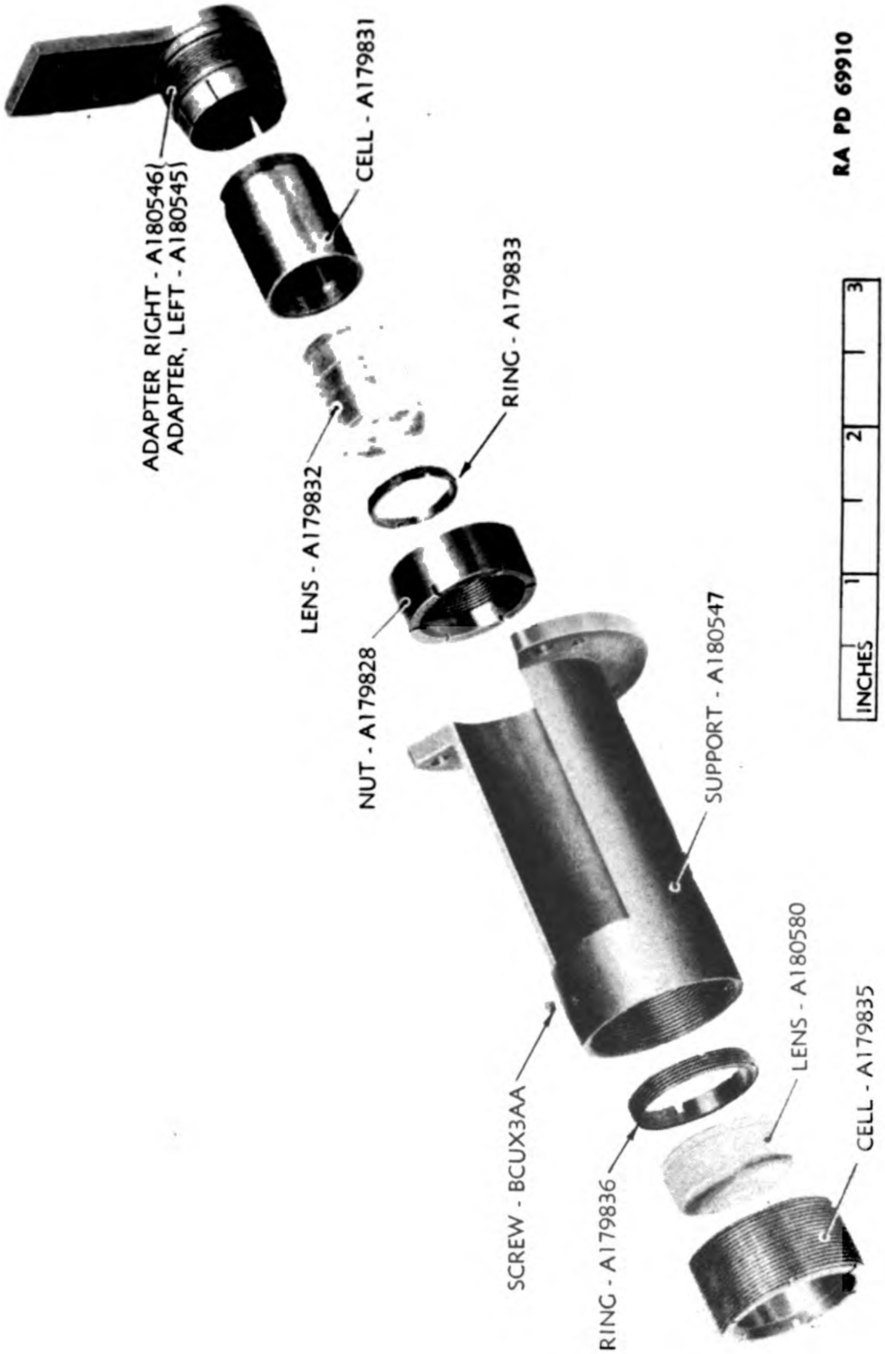


Figure 93 — Erecting Lens Assembly — Exploded View

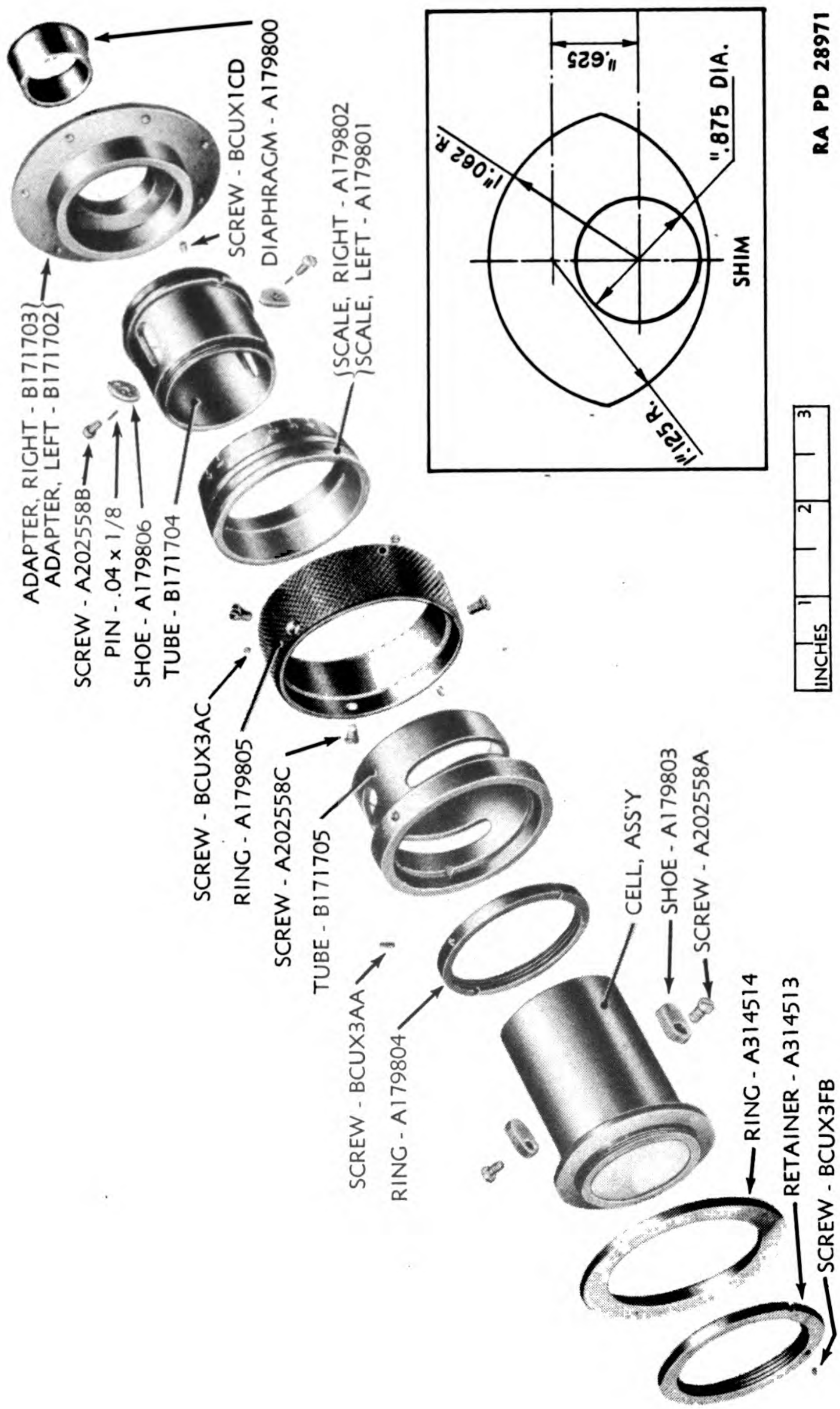


Figure 94 — Disassembly of Eyepiece Cells

(4) Obtain the median of 5 readings of the collimating telescope. Repeat this procedure at +2, –2, and –4 diopters at low power, and again measure the diopter setting at the points mentioned above. Recheck by another observer.

c. **Analysis.**

(1) Focus is in tolerance when the focus difference between 12 and 24 power is not greater than 0.2 difference on the diopter scale.

(2) Focal difference will result between 12 and 24 power if:

(a) An erecting lens is installed.

(b) An erecting lens cell has been shifted.

(c) An auxiliary objective lens has been rotated.

(d) The eyepiece objective supports have been struck by the inner tube.

d. If the diopter reading is not within tolerance, adjust the setting of the diopter scale as follows:

(1) Set the change-of-power lever to 12 power, check the focusing ring for end-to-end movement, and set the zero of the diopter scale in the center of the movement.

(2) Direct the height finder toward clear sky.

(3) Check focus of the height finder reticles at 12 power with the low-power telescope.

(4) Shift to 24 power and check focus.

e. If the focus is not sharp and clear, and within tolerance, the eyepiece objective lenses must be rotated until both magnifications focus at the same place on the diopter scale.

(1) To accomplish this adjustment the eyepiece assembly must be removed from the height finder as described in paragraph 109.

(2) Secure the eyepiece plate assembly to the eyepiece bracket assembly when the screws have been removed which secure the eyepiece bracket assembly to the height finder (fig. 89).

(3) Remove the eyepiece assembly from the height finder.

(4) Loosen the set screw in the auxiliary eyepiece objective support A180547 (fig. 93) of the eyepiece that does not have proper focus.

(5) Rotate the auxiliary objective cell A179835 (fig. 93) slightly, secure the set screw and place the eyepiece assembly back on the height finder and secure temporarily with two screws. Check focus of 12 and 24 power.

(6) Repeat the above procedure until the focus adjustment is in tolerance.

(7) When adjustment is complete, place small spot of shellac

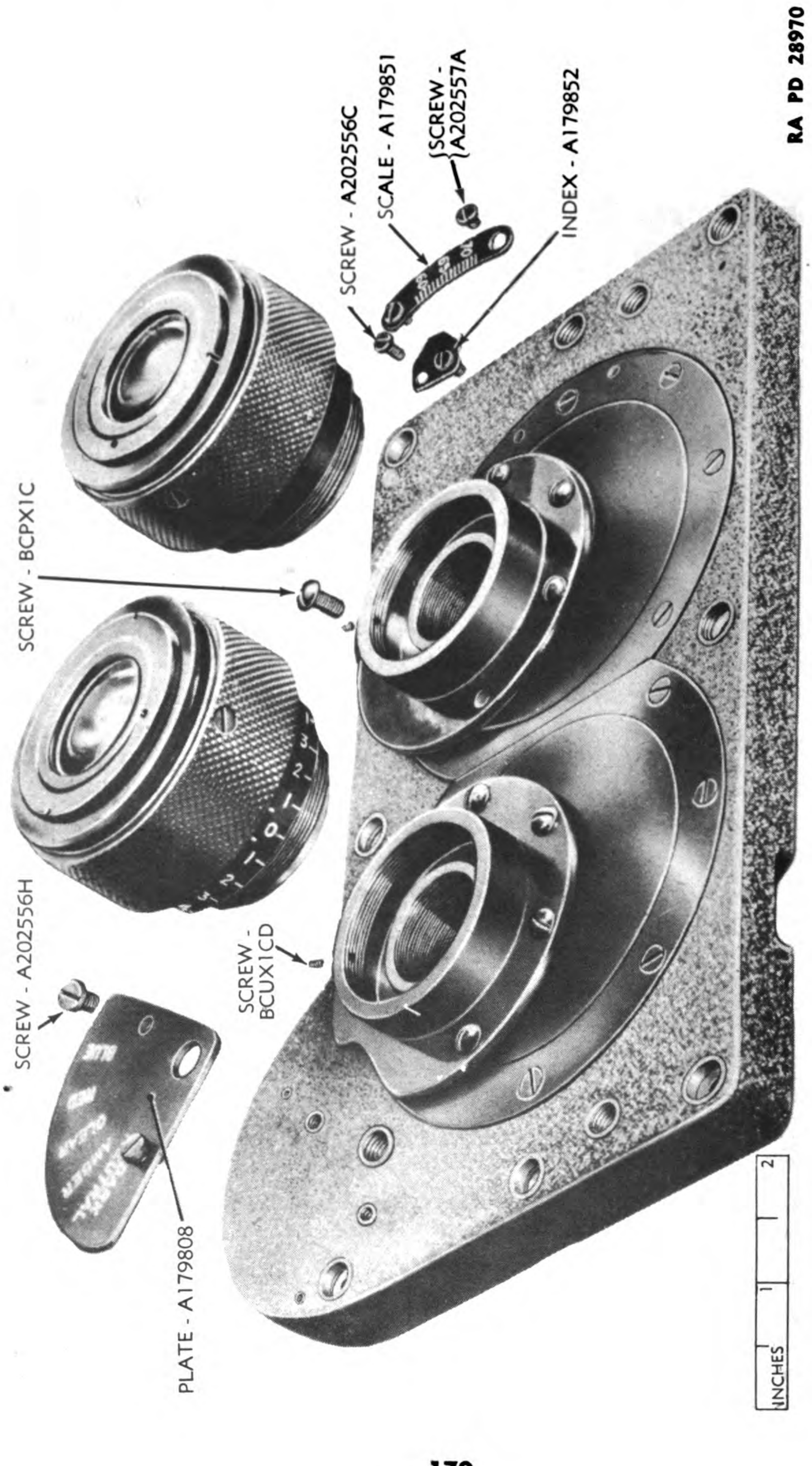


Figure 95 — Eyepiece Plate Assembly — Partly Exploded

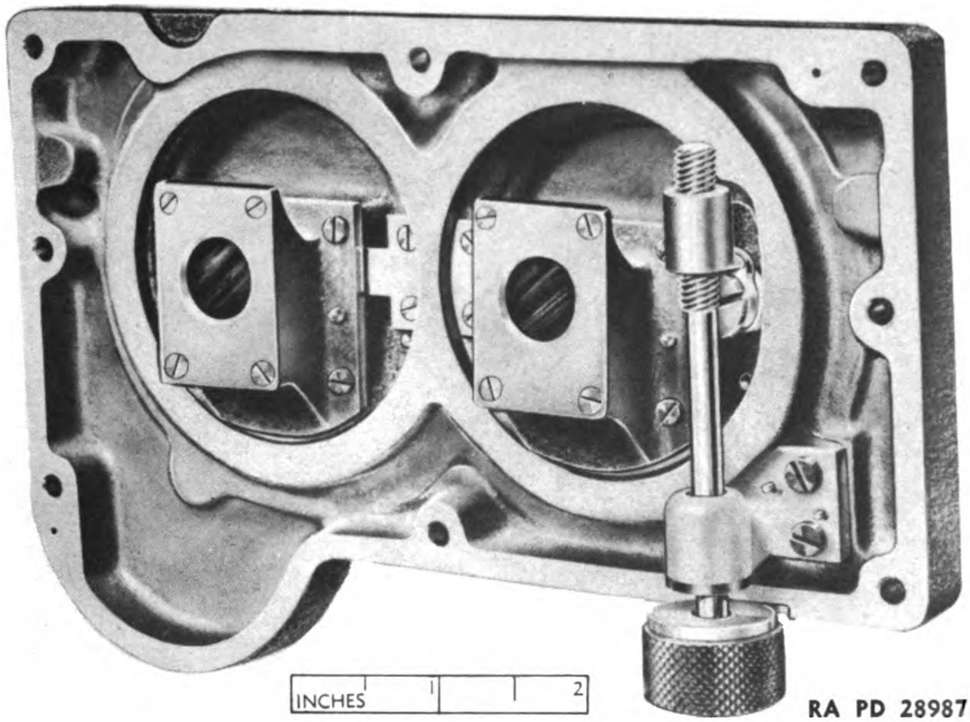


Figure 96 — Eyepiece Plate Assembly — Bottom View

varnish on the objective cell set screw, and on the edge of the cell and support.

(8) Replace the eyepiece assembly on the height finder. NOTE: *Changing the focus between the powers will cause a new zero-diopter setting.*

(9) Use the low-power telescope and observe the sharpest focus of the reticle in both powers.

(10) Loosen the three diopter scale set screws and hold the focusing ring.

(11) Rotate the scale until the zero diopter setting is opposite the index and tighten the three diopter scale set screws.

(12) Check the movement of the diopter scale from plus 3 to minus 4.

(13) If complete movement is not reached, set the diopter scale until the full movement is obtained.

(14) Refocus to reticles and read the diopter scale.

(15) If focus reads plus, make and place a shim (fig. 94) of proper thickness to obtain full movement of diopter scale, between eyepiece plate and ocular adapter B171702 or B171703 (fig. 94).

(16) If focus reads minus, stock must be removed from the ocular

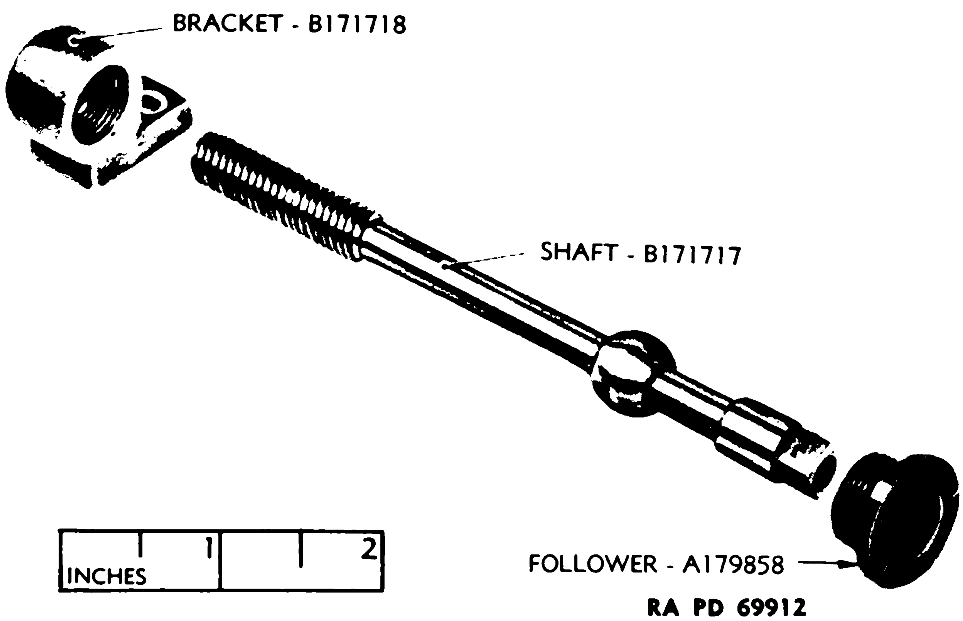


Figure 97 — Interpupillary Adjusting Shaft — Exploded

adapters B171703 and B171702 (fig. 94). This operation must be done carefully to retain true surfaces. One diopter is equal to one-half mm, or approximately 0.020 inch.

NOTE: *Rotation of the auxiliary eyepiece objective lens, removing the eyepiece assembly, or moving the eyepieces (oculars) will change lateral vergence and up-and-down vergence (dipvergence).*

104. EYEPIECE UNIT ADJUSTMENT — INTERPUPILLARY DISTANCE.

a. The interpupillary distance adjustment knob, index, and scale are set at the factory for an interpupillary distance movement from 58 mm to 72 mm. The index should indicate the actual distance within one-half mm. This distance can be checked with an interpupillary distance template (TM 9-624), or with a ground glass and scale (par. 47, fig. 61).

b. Adjustments should not be required, but if the measured interpupillary distance does not correspond to the scale setting, proceed as outlined below.

(1) With the hands, move the right and left eyepieces together or apart until the interpupillary distance measures 65 mm (or fits the IPD template) (TM 9-624).

(2) Loosen the two screws holding the interpupillary index A179852 (fig. 95).

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT

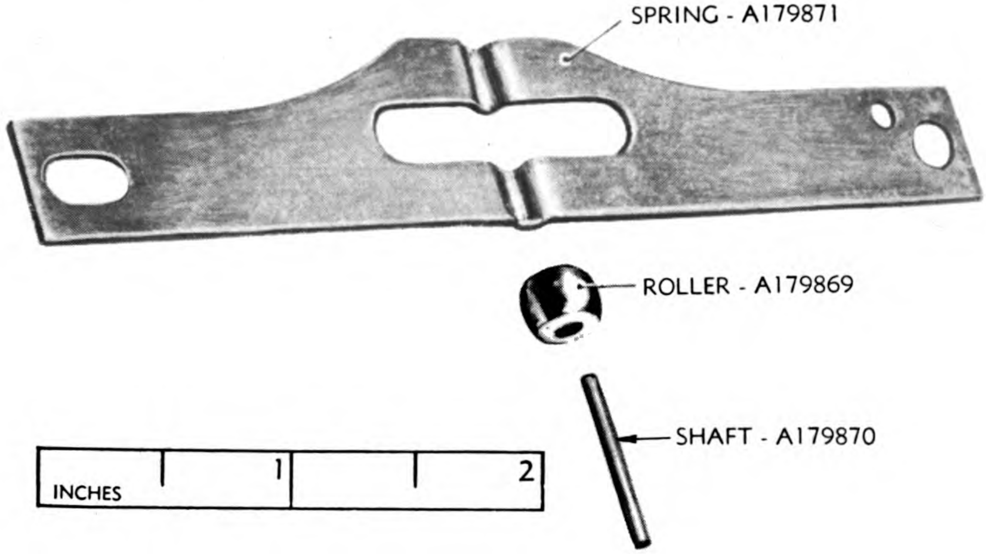


Figure 98 — Filter Disk Detent Spring and Roller

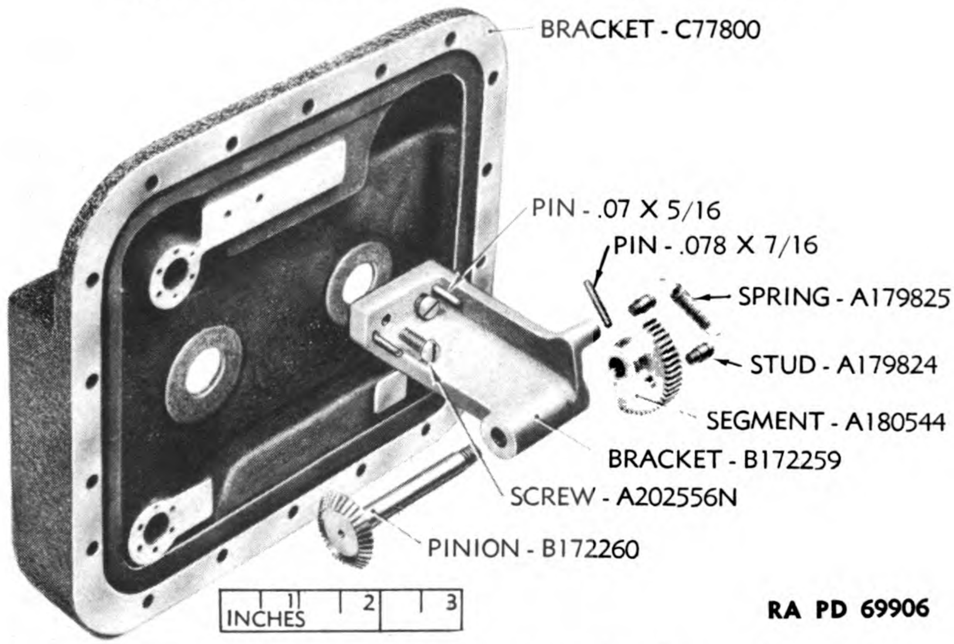


Figure 99 — Change-of-magnification Gear Bracket — Exploded View

(3) Hold the eyepieces at this separation and move the index until the scale reads correctly.

(4) Retighten the two screws holding the index.

(5) Recheck the distance between the exit pupils.

c. If the interpupillary distance changes when the observer's face is pressed against the eye shields, it indicates that there is not enough

Figure 100 — Rhomboid Prism and Mount Assembly — Exploded View

tension on the interpupillary adjuster knob ball assembly (fig. 97). It will be necessary to remove the eyepiece plate assembly as described in paragraph 109, and inspect for the source of the trouble as follows:

(1) Remove interpupillary shift knob A179849, and ring A179848 (fig. 100).

(2) Remove the set screw in follower A179858, and remove follower (fig. 97).

(3) Remove screws and gently pry up the ball bracket B171718 (fig. 100) over the two pins. It will be necessary to screw the shaft B171717 (fig. 97) in, until the ball bracket can be removed.

(4) Stone off a small amount on the face of the bracket, B171718, and clean and coat the ball socket lightly with lubricating grease, (special).

(5) Replace the ball bracket and secure to the eyepiece plate assembly.

(6) Replace the follower, adjust, and secure with set screw until the eyepieces do not separate under hand pressure.

(7) Replace eyepiece plate. Reassemble filter nameplate, shift lever, interpupillary shift ring, and knob.

105. EYEPIECE UNIT ADJUSTMENT — FOCUSING ERECTOR LENSES.

a. Focusing of the erector lenses will only be necessary when replacing a damaged or shifted erector lens.

b. Remove the eyepiece bracket assembly from the height finder as described in paragraph 109 **c**.

c. Assemble the eyepiece plate assembly to the eyepiece bracket assembly.

d. Remove the damaged erector lens in the following manner:

(1) Remove the screws of the eyepiece auxiliary objective support A180547 (fig. 93) that encloses the damaged erector lens assembly and gently remove the support from bracket C77807 (fig. 101), taking care not to bend the guide pins or bend or damage the support.

(2) Unscrew locking nut A179828 from erector lens cell adapters A180545 and A180546 (fig. 93) and slide the erector cell out of the adapter.

(3) Unscrew retaining ring 179833 (fig. 93) and remove the damaged erecting lens from the cell. Note the position of the cemented elements of the lens.

(4) Assemble the new lens in reverse order of disassembly.

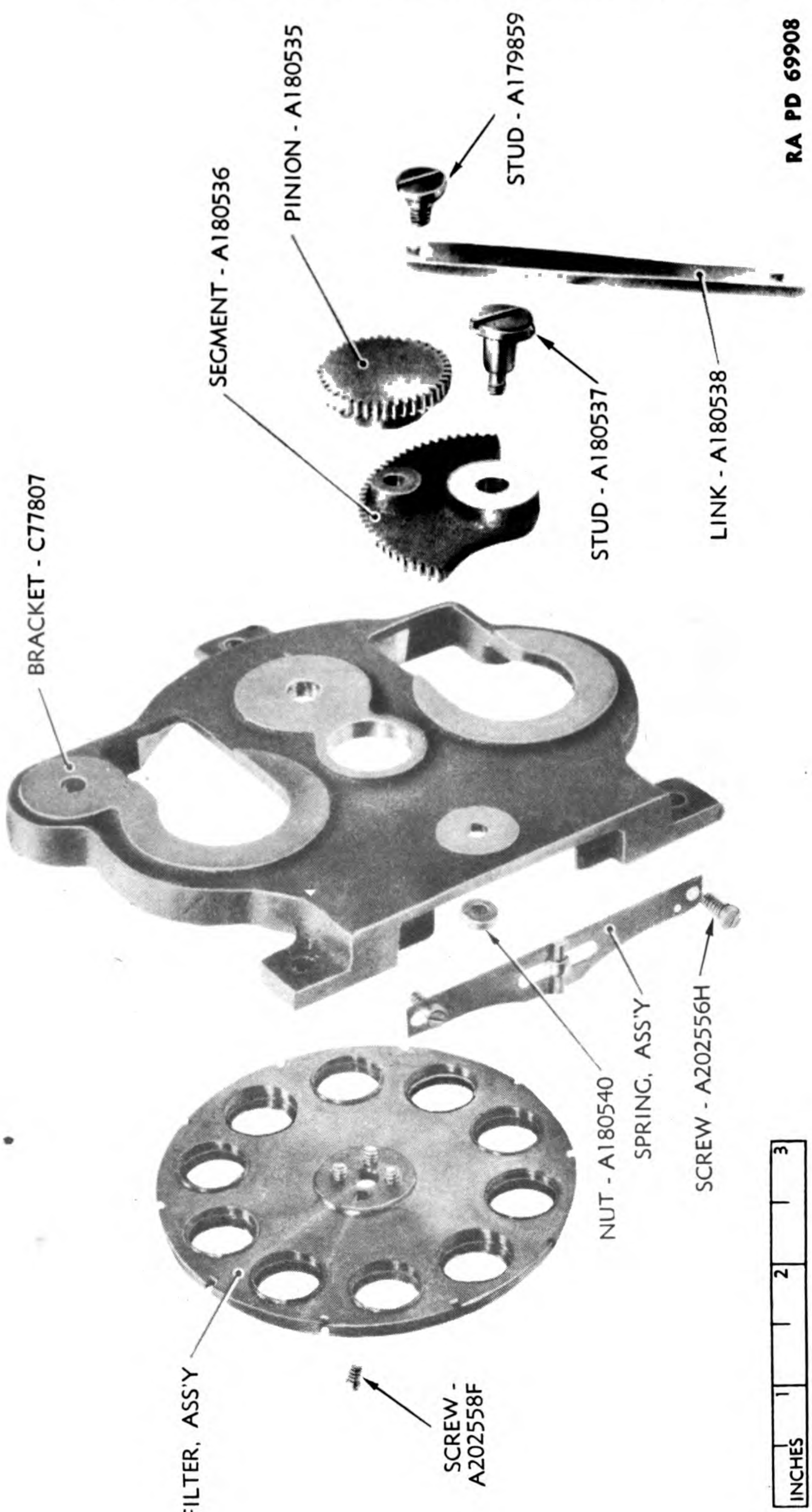


Figure 101 — Disassembly of the Filter Mechanism

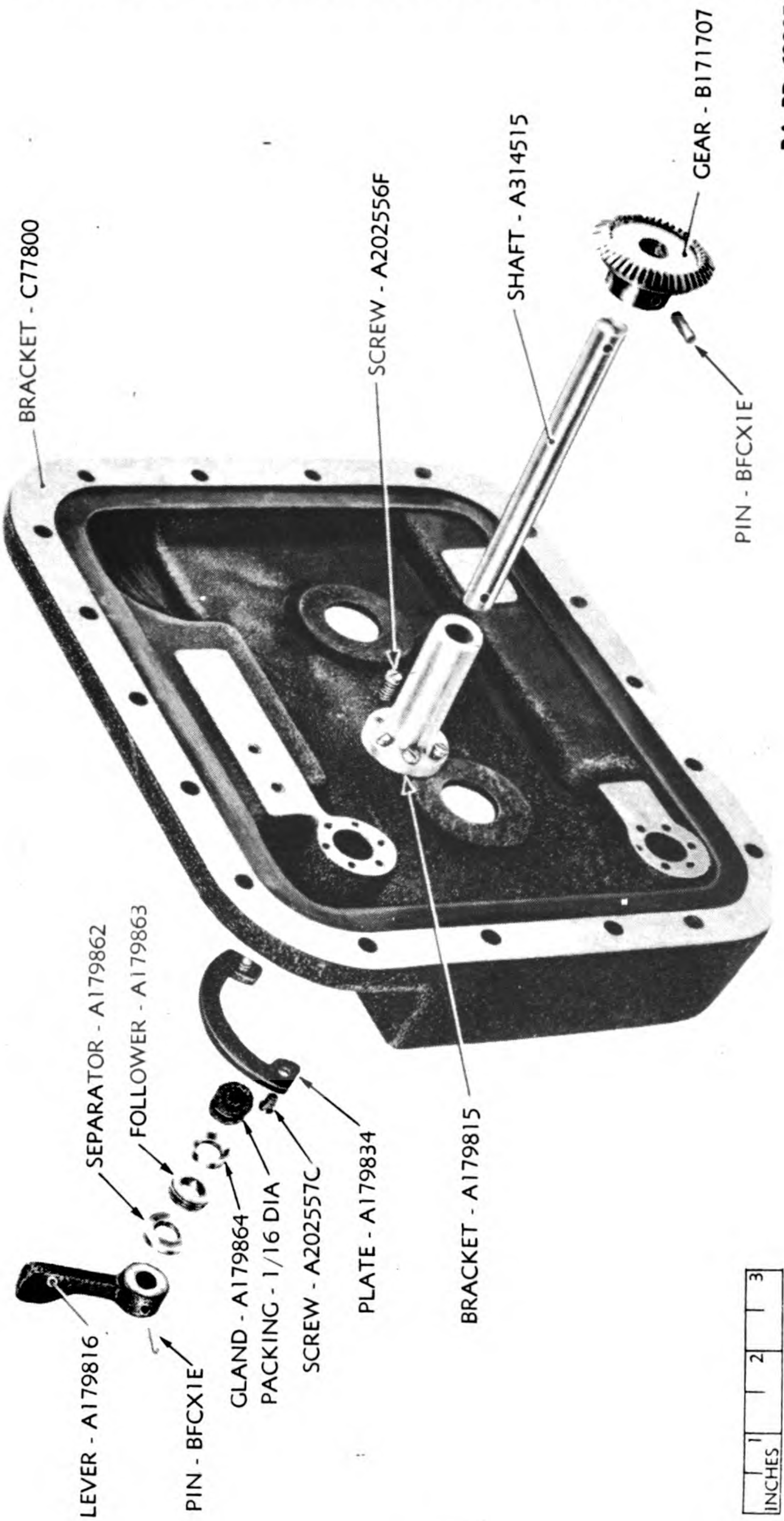


Figure 102 — Change-of-magnification Lever and Shaft Assembly — Exploded View

(5) Place the eyepiece assembly on the height finder and secure it in place temporarily with two screws.

NOTE: *It will be necessary to remove and replace the eyepiece a number of times while making the focus adjustment of the erector lens, and it is assumed that the maintenance man will understand this condition while reading these instructions.*

e. Shift the change-of-magnification lever to 12 power.

f. Place the collimating telescope over the eyepiece of the replaced erecting lens and focus to the height finder reticles.

g. Unless the focus of the reticles appears sharp when the diopter scale is set near zero, the erector lens will need shifting.

h. Shift the erecting lens up or down until the reticles at 12 power appear sharp, and the diopter scale reads very near zero diopter when the diopter scale has complete travel.

i. Shift the change-of-magnification lever to 24 power.

j. Check the focus of the reticles at 24 power with the collimating telescope (low-power telescope).

k. If the 12- and 24-power focus of the reticles are not in tolerance, refer to paragraph 100.

l. When the erecting lenses are focused within tolerance, mount the eyepiece assembly on the height finder.

m. Using a divergence tester, check lateral and up-and-down vergence in 24 and 12 power with the IPD set at 58, 65, and 72.

n. If the vergence is not within tolerance, refer to figures 56 and 58, and paragraphs 107 and 108.

o. After all adjustments are in tolerance, place a small spot of shellac varnish on retaining rings, screws, and pins to insure their remaining in place. When the shellac varnish is dry, clean the eyepiece.

p. Replace the eyepiece assembly on the height finder after making certain that the cork sealing gasket has not been damaged (par. 109).

106. EYEPIECE UNIT ADJUSTMENT — CHANGE-OF-MAGNIFICATION LEVER.

a. The change-of-magnification lever should snap into positive position when the lever is shifted to 12 or 24 power.

b. When the lever is shifted, there should be no binding of the erector lens rack B172258 (fig. 92) as it travels up and down on the rack guide post A180541. Sleeve A180543 and guide post A180542 must also be free from binding.

c. If the above conditions exist, the tension of the change-of-magnification spring A179825 (fig. 99) will force the erector lens rack to the proper positive position at 12 or 24 power when the change-of-magnification lever is shifted.

d. When the mesh of any of the gears of the change-of-magnification systems are to be disturbed they must be marked. NOTE: *The alining marks must be matched when assembling the gearing.*

e. After repairing or adjusting the erector system, apply a very light film of lubricating grease (special) on the guide posts A180542 and A180541 (fig. 92).

107. EYEPIECE UNIT ADJUSTMENT — LATERAL VERGENCE (DIVERGENCE AND CONVERGENCE).

a. Small errors of lateral vergence may be corrected by loosening the four screws which secure the eyepiece adapters B171702 and B171703 (fig. 94) to the eyepiece plate assembly, and moving the eyepieces as suggested in figures 56, 57, and 58. NOTE: *Vergence errors which cannot be adjusted to tolerance or closer, by shifting the eyepieces may be due to decentering of the eyepiece assembly to the height finder reticles.*

b. Before attempting to adjust an eyepiece assembly which is greatly out of adjustment, first check the entire eyepiece assembly for mechanical misalinement, and for loose or damaged lenses and prisms.

c. If lateral vergence, when changing magnification, does not remain the same for both powers, the eyepiece is decentered to the height finder reticles. To correct this condition proceed as follows:

(1) Set up divergence tester on the eyepiece and focus to the height finder reticles.

(2) Turn the change-of-magnification lever from 12 to 24 power and note that the eyepiece does not shift off center.

(3) Both eyepieces must be checked at the two powers with the center reticle of the divergence tester superimposed on the height finder reticles.

(4) Check first at high power, then, without moving the divergence tester, shift the change-of-magnification lever to low power and note the position of the 12-power reticle. There should not be more than 5 minutes difference.

d. To correct centering errors illustrated by figure 62, it will be necessary to remove the eyepiece bracket assembly from the height finder as described in paragraph 109.

e. Place the eyepiece plate assembly on the eyepiece bracket assembly.

f. Remove the guide pins in the off-center eyepiece auxiliary lens support A180547 (fig. 93). Have the screws loose enough so that the support will shift and gently tap the base of the support *in* on a *parallel line* with the opposite tube.

g. If the support was tapped properly, the 12- and 24-power reticles should now read zero ("A" of fig. 62) on the divergence tester scale. The 12-power reticle will have been moved in the converging direction 10 minutes, and the 24-power reticle 20 minutes. High power moves twice as fast as low power.

h. Remove the guide pins from the erector lens cell adapters A180545 and A180546 (fig. 93), and tighten the screws just enough so that the adapter can be shifted. Shift the adapter until the divergence is about 15 minutes and dipvergence is zero.

i. It will be necessary to frequently remove and replace the eyepiece assembly on the height finder to check progress of adjustment with the divergence tester while making the above adjustments.

j. In "B", figure 62, is shown a condition where the 12-power reticle divergence error is greater than 24 power.

(1) In this case the low-power reticle is first moved out of adjustment 10 minutes more, to the left, by moving the objective support tube away from the opposite tube.

(2) This will cause the 12- and 24-power reticles to read 30 minutes more divergence out of adjustment.

(3) To bring both reticles back into adjustment it is necessary to remove the guide pins in the erector cell adapters A180545 and A180546 (fig. 93).

(4) Loosen the screws and shift the adapter in or out toward the opposite erector cell adapter. Movement must be kept parallel with the opposite adapter.

(5) Tighten screws and repin the adapter.

NOTE: *The errors and correcting adjustment concerning lateral vergence and dipvergence are described separately for convenience, whereas the eyepiece may contain a combination of the above errors at the time of repair and adjustment.*

k. When guide pins are removed to make an adjustment, it is suggested that they not be returned until the eyepiece assembly is completely adjusted.

l. All cleaning of the optical elements of the eyepiece assembly should, wherever possible, be done when the eyepiece is adjusted and pinned and ready for final assembly to the height finder.

m. Assemble the eyepiece to the height finder and make final check with divergence tester and collimating telescope. Refer to paragraph 109 for assembly of the eyepiece assembly to the height finder.

108. EYEPIECE UNIT ADJUSTMENT — UP-AND-DOWN DIVERGENCE (DIPVERGENCE).

a. Dipvergence is dependent upon the positioning of the eyepiece unit in relation to the optical tube. A slight shift of the eyepiece plate assembly in relation to the eyepiece housing will change the amount of up-and-down divergence present. Every time, therefore, that the eyepiece unit has been removed, it will be necessary to recheck the dipvergence and to make the necessary adjustments as outlined below:

(1) Remove the eight screws and two guide pins (par. 109) holding the eyepiece plate assembly to the eyepiece bracket assembly (fig 89). Replace the eyepiece plate assembly and hold it in place temporarily with two screws at diagonal corners (do not set them up tight).

(2) Set the interpupillary distance at 65 mm.

(3) Turn the change-of-magnification lever to 24 power.

(4) Mount the divergence tester above the eyepieces so that the central lines of the right grid coincide with the central reticle mark of the right eyepiece.

(5) Note the relative position of the center height finder reticle lines in the right and left eyepieces (fig. 56).

(6) If necessary, shift the eyepiece plate by lightly tapping the corners.

(7) Recheck the dipvergence until it is within tolerance.

(8) Tighten all of the eyepiece plate screws and replace the filter nameplate and lever.

(9) Redowel with larger locating pins.

(10) Recheck the up-and-down divergence.

b. If it is impossible to bring the dipvergence within tolerance by this method, do one of the following:

(1) Loosen the screws in the eyepiece adapters B171702 and B171703 (fig. 94), and shift the eyepiece on the plate assembly (fig. 56).

(2) Shift the eyepiece plate assembly slightly by loosening the holding screws (par. 109) and tapping the proper corner.

(3) If this (steps (1) and (2), above) will not correct dipvergence, check for a dipvergence change between high and low power.

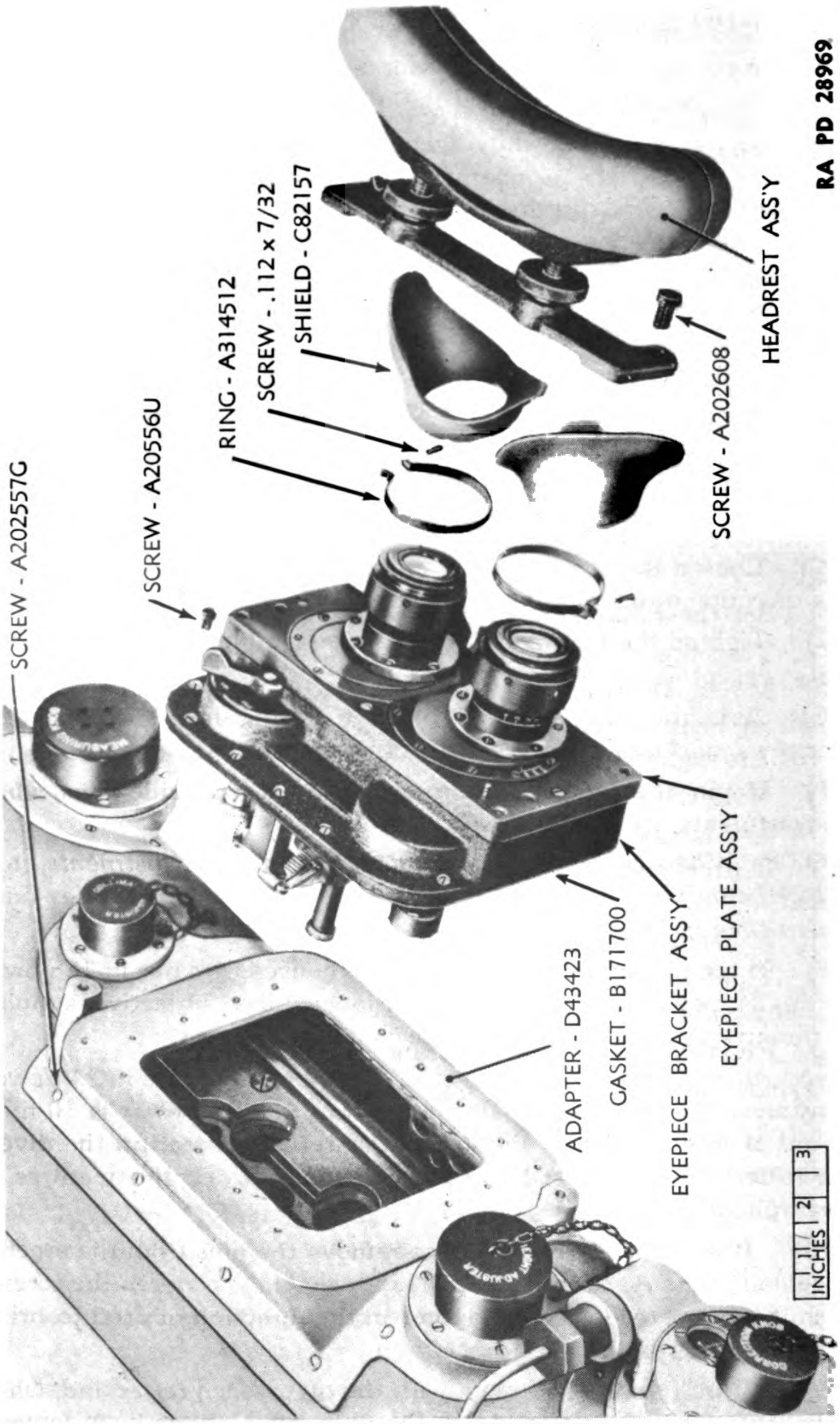


Figure 103 — Removal of Eyepiece Assembly

If a great deal of change is noticed, the eyepiece is decentered to the reticles.

(4) This condition is corrected by shifting the eyepiece objective lens supports A180547 (fig. 93) in a plane perpendicular to the axis of the height finder (toward the maintenance man or away).

c. When the shift of dipvergence is greater in 24 power than it is in 12 power, the adjustment below will cause the 24-power reticle seen through the divergence tester to move twice as fast as the 12-power reticle.

(1) Remove the eyepiece unit as described in paragraph 109.

(2) Remove the 18 screws holding the eyepiece bracket assembly to the height finder. Break the seal and remove the eyepiece bracket from the height finder, taking care not to damage the cork gasket which seals the eyepiece assembly to the height finder.

(3) It will be necessary to remove the guide pins in the eyepiece auxiliary objective support assembly before adjustments can be made (fig. 92).

(4) Loosen the screws in the support and gently tap the support in the direction desired, to correct the excessive up-and-down vergence.

(5) Tighten the loosened screws, and assemble the eyepiece completely, except for the guide pins.

(6) Assemble the eyepiece bracket to the height finder with two screws, and check progress of adjustments.

(7) Repin the objective supports with larger guide pins when all adjustments are complete.

NOTE: *When guide pins are removed to make adjustments, it is suggested that they not be returned to the eyepiece assemblies until all adjustments have been satisfactorily completed.*

(8) If the up-and-down shift of dipvergence is greater in 12 power than in 24 power, shifting of both the eyepiece objective support and the erector lens mounts will be necessary.

(9) If the 12-power dipvergence is greater than it is in 24 power, for instance, the 12 power is 20 minutes and the 24 power is 10 minutes out of tolerance, then the low power reticle as seen in the diverfence tester must be shifted 10 minutes more out of adjustment as in paragraph 107 **j** and **m**.

(10) It will then be necessary to remove the pins from the erector lens cell adapters A180545 and A180546 (fig. 93). Loosen the screws and shift the erector lens cell adapter in the direction desired to bring the dipvergence within tolerance.

(11) Check final adjustment with the divergence tester and, when adjustments are satisfactory, repin the units which have been moved.

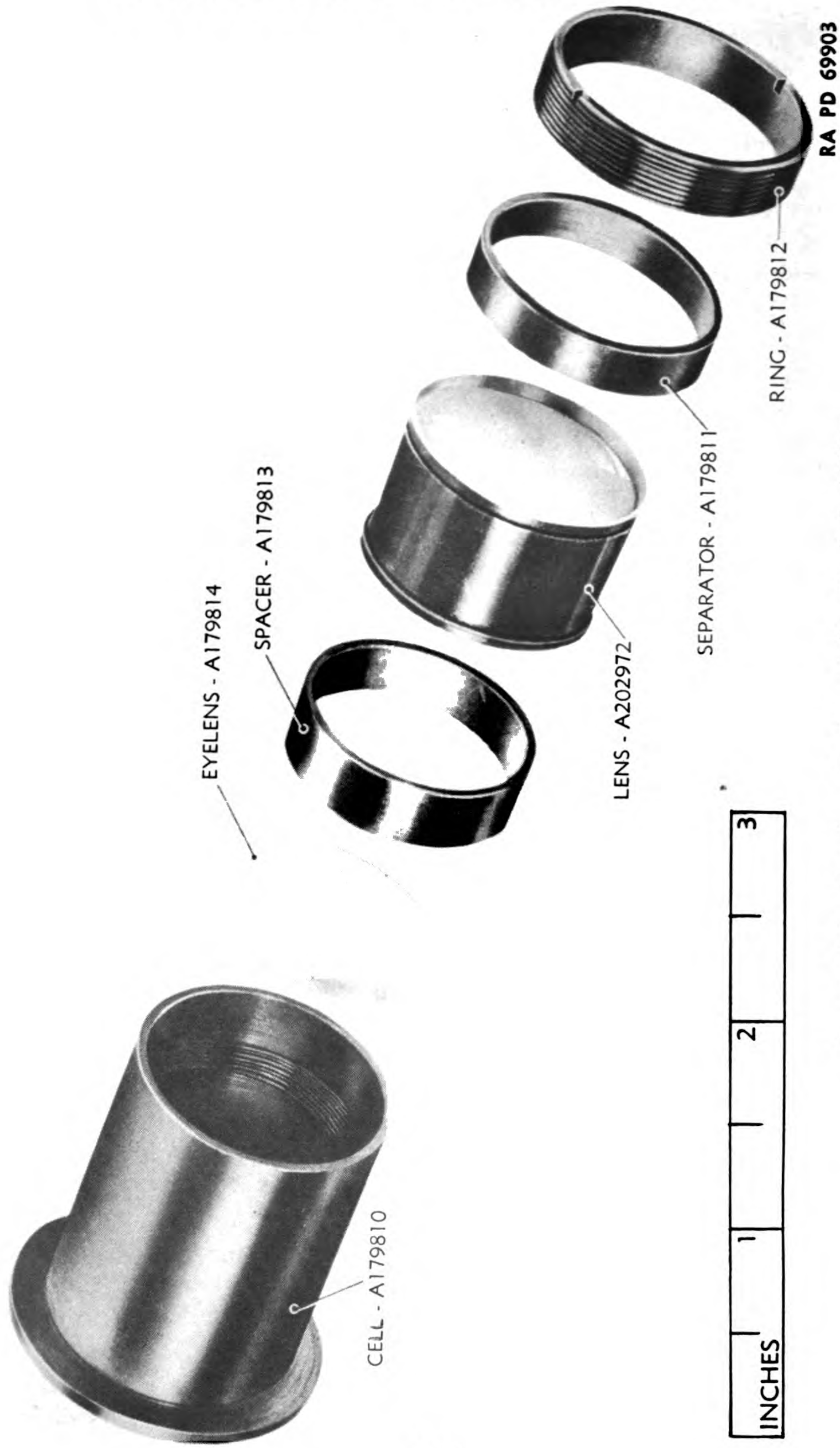


Figure 104 — Eyepiece Eyelens Cell — Exploded View

Apply shellac varnish to all pins, screw heads, and cells that have been moved.

(12) Clean the eyepiece and assemble to the height finder.

109. EYEPIECE UNIT — REMOVAL AND REPLACEMENT.

a. The eyepiece plate assembly must be removed for adjustment or repairs to the rhomboid prisms. It must also be removed, together with the eyepiece bracket assembly, for operations which require access to the filter and erecting lens assemblies, and the interior of the instrument at the center.

b. Remove the eyepiece unit (fig. 89) as follows:

(1) Drive out the taper pin from the filter shift lever A179826 (fig. 89) and remove the lever from the shaft.

(2) Remove the screws from the filter nameplate A179808 (fig. 105) and remove the plate.

(3) Loosen the screws in the eye shield clamp rings A314512 and remove the eye shields C82157 (fig. 103).

(4) Loosen set screw in retainer A314513 (fig. 94), and remove retainer and ring A314514. The removal of these rings will be necessary only when using a pupil loupe or low-power telescope equipped with an adapter which fits on the eyepiece lens cell assembly centering shoulder.

(5) Remove the two screws holding the headrest adapter A171701 (fig. 91) to the eyepiece plate assembly, and remove the headrest assembly.

(6) Remove the eight screws holding the eyepiece plate assembly, and gently pry the plate assembly up. The two guide pins should be removed from the plate assembly at this time.

NOTE: *On some instruments it will be necessary to loosen the screw A202604B ("W," fig. 100) holding the interpupillary knob and ring before removing the eyepiece plate assembly.*

(7) Remove the 18 screws around the edge of the eyepiece bracket assembly. Six of these screws are located inside the bracket.

(8) Insert a sharp blade between the bracket assembly and height finder eyepiece shim and break the seal. Take care to avoid marring the mating surfaces.

c. The eyepiece bracket assembly should not be disturbed except when it is necessary to gain access to the interior of the instrument. When this is necessary, remove the 18 screws, break the seal, and lift the bracket assembly off the height finder, taking care not to strike the erector lens or auxiliary support tubes on the optical and inner tubes.

d. When replacing the eyepiece bracket assembly or eyepiece plate assembly, clean the mating surfaces, apply the proper sealing compound, set the unit in place, and replace the mounting screws.

e. Before finally tightening the screws, center the reticle and eyepiece fields (par. 100) and check and adjust for dipvergence as described in paragraph 108.

f. After all the screws are tight, recheck the divergence and dipvergence.

110. DISASSEMBLY OF EYEPIECE LENSES.

a. If an eyelens or field lens is damaged or in need of cleaning, remove and disassemble the eyepiece cell (fig. 104) as follows:

b. Check up-and-down and lateral divergence with the divergence tester, before disassembling the eyepiece cell assembly, or focusing mechanism. This will aid the maintenance man when divergence check is made after assembly, because rotation of the eyepiece cell lenses *will* change vergence if they are not perfectly centered when assembled.

NOTE: *The eyepiece eyelens tube assemblies (fig. 94) are interchangeable so they must be marked "left" and "right," if both are removed from the eyepiece plate assembly. If they are not marked, and replaced wrong, changes in vergence, centering, and focus will result, and the position of the scale readings will be reversed.*

c. Loosen headless screw BCUX1CD in the eyepiece adapters B171702 and B171703, and unscrew the eyepiece tube B171704 (fig. 94) and cover the opening in the adapter to keep dirt and moisture from collecting on the rhomboid prism.

d. Remove retaining ring A179812 (fig. 104).

e. Remove the eyepiece separator A179811, lenses A202972 and A179814, and spacer ring A179813. Place a pencil mark on the edge of the lens cell A179810 and on the edge of the lenses and rings, as an aid in reassembly. NOTE: *Do not remove the marks while cleaning the lenses.*

f. When reassembling, observe the following precautions:

(1) Seal the eyelens with sealing compound (for optical lenses).

(2) Make sure that the lenses and separators are properly oriented.

(3) The retaining ring should be screwed in tight enough to hold the lenses snugly, but not enough to cause strain.

NOTE: *If possible, check the lens assembly with polarized light, which should show minimum strain.*

(4) After the cell has been replaced, check lateral divergence. If outside of tolerance, loosen the retaining ring and turn the field lens. Recheck divergence.

(5) Check the diopter setting and, if necessary, adjust the scale, as in paragraph 103.

111. EYEPIECE UNIT—DISASSEMBLY OF FOCUSING MECHANISM.

a. If the position of sharp focus of the height finder reticle will not register at the same position on the diopter scale when the focusing ring is rotated from +3 to zero, and from –4 to zero, then the error will be due to backlash or shake.

b. Wear or damage caused by forcing the shoes A179803 against the ends of the spiral in the eyepiece tube, or the shoes A179806 in the tube B171704 slots (fig. 94), will result in backlash or shake.

c. The small shoes should fit snugly along the complete length of the spiral and in the slots in the tubes. The screws in the shoes should be tight.

d. The shoes have guide pins in them which extend into the cell assembly and, if the eyepiece is disassembled, these shoes should be marked so that they will be reassembled in their proper place.

e. The eyepieces are mechanically (but not optically) interchangeable, so it is important that they be marked "right" and "left" if both are removed from the eyepiece plate.

f. Disassemble the eyepiece as in paragraph 110.

(1) Scribe a line across eyepiece tube shoulder B171705 and focusing ring A179805 (fig. 94).

(2) Remove three screws A202558C and focusing ring A179805 with diopter scales A179802 and A179801 (fig. 94) in place.

(3) Inspect for backlash and shake.

(4) Remove the two small shoes in the spiral.

(5) Mark the position of the cell assembly, both inner and outer tubes.

(6) Inspect for backlash by grasping the top part of the cell assembly and inner tube threaded area.

(7) Locate the set screw BCUX3AA which holds retaining ring A179804 (fig. 94) by rotating the outer tube and observing through one of the small holes on the outer tube shoulder.

(8) Mark its position on the retaining ring and outer tube shoulder.

(9) Remove and loosen the retaining ring.

(10) Remove the screws from the two shoes in the slides.

(11) Remove the cell assembly.

(12) Remove the shoes and separate the two tubes.

(13) Check the shoes, spiral, and slides for fit and rough spots.

(14) Lubricate lightly with lubricating grease (special) and assemble in reverse order of disassembly after all trouble has been corrected.

(15) After the eyepiece is assembled to the plate and all screws are tight, recheck for divergence and dipvergence.

112. EYEPIECE UNIT — REPLACEMENT OF FILTERS.

a. Should adjustment or replacement of filters be required, it is necessary that the correct filter be placed properly in front of each eyepiece at each setting and that they correspond to each other as well as the color indicated on the filter nameplate. Replacement of the filters requires removal of the eyepiece bracket assembly from the height finder. This breaks the hermetic seal and should be done only in a room free from dirt and dust. A divergence tester must be available for adjusting the eyepiece assembly after it is replaced. The procedure is as follows:

b. Remove the eyepiece unit as described in paragraph 109.

c. Disassemble the filter assembly as follows:

(1) Mark position of gear segment A180536 and pinion A180535 (fig. 101) when the filter lever is set in the *clear position.*

(2) Mark gear segment A180544 (fig. 99) and rack B172258 (fig. 92) with the change-of-magnification lever set at 24 power.

(3) Remove stud A179859, holding filter shift link A180538 to gear segment A180536 (fig. 101).

(4) Remove three screws and two guide pins holding lens and filter bracket C77807 to the eyepiece bracket adapter (figs. 89 and 101).

(5) Disengage filter holder from mating gears segment A180536.

(6) Mark position of filter assembly and pinion and remove four screws A202558F (fig. 101).

(7) Some filters have a slight wedge effect so, before the filters are removed, scribe on the filter holder the color of filter in each hole.

(8) Before each filter is removed from holder, scribe a small line on the filter holder and, opposite the line, mark the filter with a wax crayon.

(9) Remove the filter and then mark the edge of the filter so that it may be replaced in the same position from which it was removed.

NOTE: *Some filters have been marked on the edge which designates the base.*

d. Reassembly is done in the reverse order of disassembly taking care to match scribed lines of all mating gears, and of filters and holders.

e. Thoroughly clean the filters and other optical surfaces which will be covered when the eyepiece is assembled.

f. Assemble the eyepiece and check color calibration in each eyepiece and on index when the filter lever is moved into each position.

g. Clean all remaining optical surfaces which are dirty.

h. Check with a divergence tester and properly adjust the eyepiece.

i. When the filters are indexed with the shift lever, they should be held firmly in each position by the spring roller A179869 (fig. 98) engaging the detent on the filter holder.

j. If the roller does not engage the detent, firmly remove the spring A178971 and bend it for increased pressure.

113. EYEPIECE UNIT — HEADREST ASSEMBLY.

a. If the headrest assembly gives mechanical trouble, adjustments can be made as follows:

(1) Remove the two holding screws (fig. 103) and remove the headrest assembly.

(2) Place a drop of lubricating oil (for aircraft instruments and machine guns) on the base of the studs where they rotate in adapter B171701 (fig. 91).

(3) Equalize the height of the adapter by rotating the studs which are screwed into adapter B171716.

(4) Place a drop of oil on the threads where they enter the adapter.

(5) Reassemble the headrest to the eyepiece plate assembly.

114. EYEPIECE UNIT—RHOMBOID PRISM REPLACEMENT.

a. A rhomboid prism that has been damaged or does not adjust properly for lateral or up-and-down divergence can be replaced as follows:

(1) Remove the eyepiece plate assembly as in paragraph 109.

(2) Remove four screws A202556K (fig. 100) and gently pry the prism mount C77803 from the eyepiece plate C77804.

(3) Remove plate A179843 (fig. 100).

(4) The rhomboid prism is held in position with the two flat springs A179868 and A179841 (fig. 100). Note the position of these springs and the rhomboid prism in the mount.

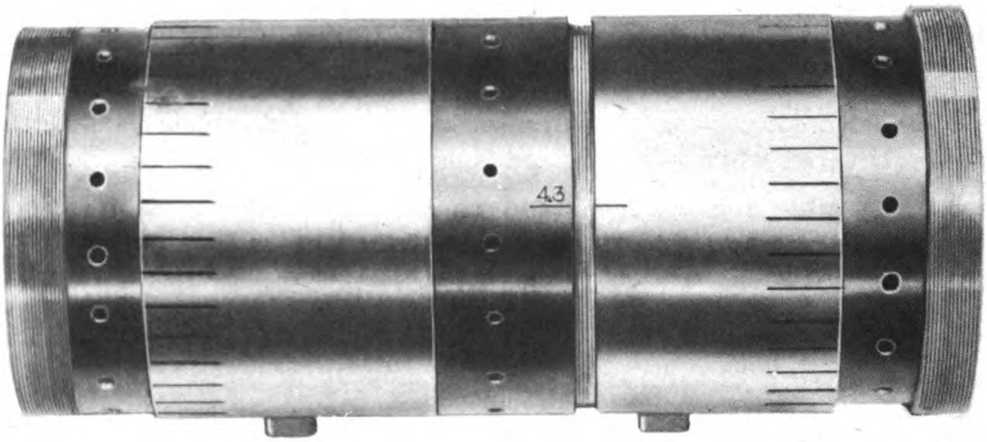


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Figure 105 — Objective Cell Assembly — Left Side

(5) Force the springs out of the mount with a thin cleaning stick.

(6) Clean the mount and rhomboid prism before reassembly, and reassemble the rhomboid prism to the mount.

(7) Reassemble the mount to plate C77804. The four screws should not be tightened until the two guide pins are in position.

(8) Assemble the eyepiece plate assembly to the eyepiece bracket assembly.

(9) Check and adjust for up-and-down divergence.

115. OBJECTIVES — GENERAL.

a. The objective lenses are mounted in cells which are clamped in the ends of the optical tube between two adjusting rings, in order to minimize any possible movement with respect to the reticles. The cells are prevented from rotating by two small shoes that fit into slots in the optical tube (fig. 105). The objectives are mounted so that their optical centers are alined as closely as possible with the mechanical axis of the optical tube, so that they give the best possible image of the target. Each of the individual components is held securely without strain.

b. The objectives must be so focused that the images of a distant target are formed in the planes of the reticles, so that the range and height readings will not be affected by movement of the observer's head with respect to the eyepieces. The focus can be checked roughly by noting whether the sharpest image of a distant target is obtained at the same eyepiece diopter setting which gives the sharpest image of the reticle marks. A more critical check is obtained by placing a collimating telescope over the eyepiece, and focusing the eyepiece to bring, first, the height finder reticle and, then, the target image into

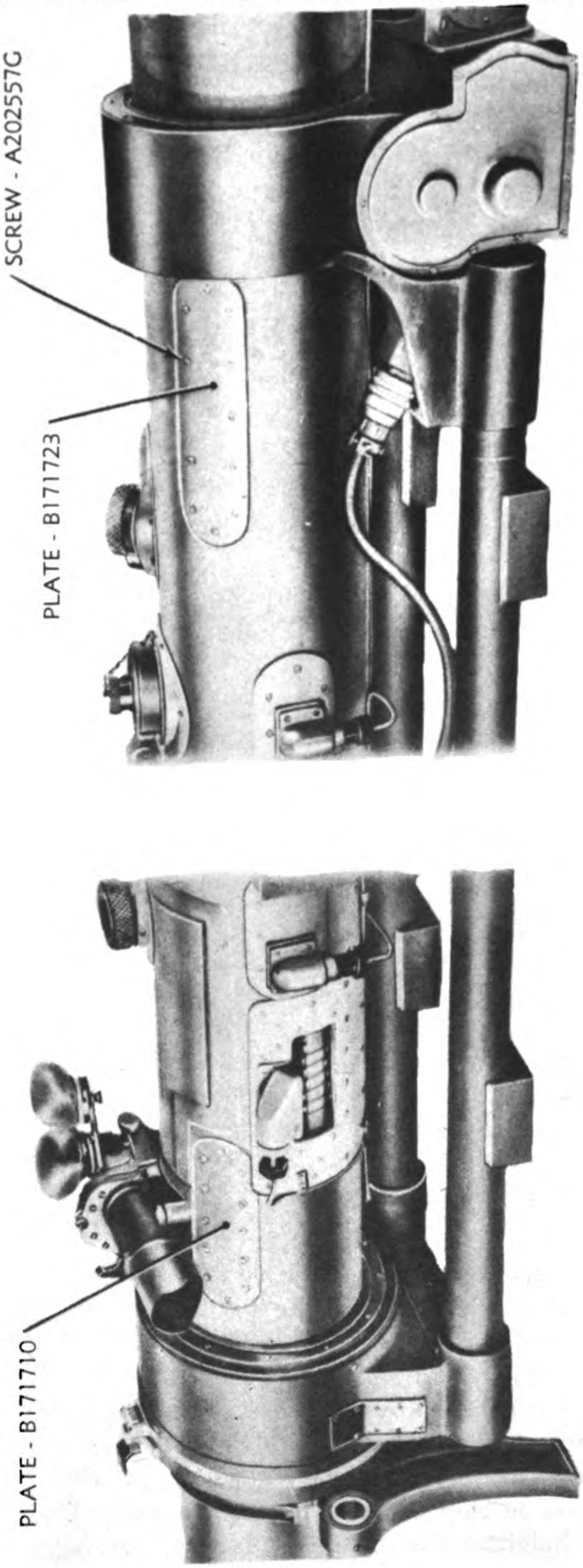

Figure 106 — Height Finder Telescope — Showing Objective Adjusting Cover Plates — Front View

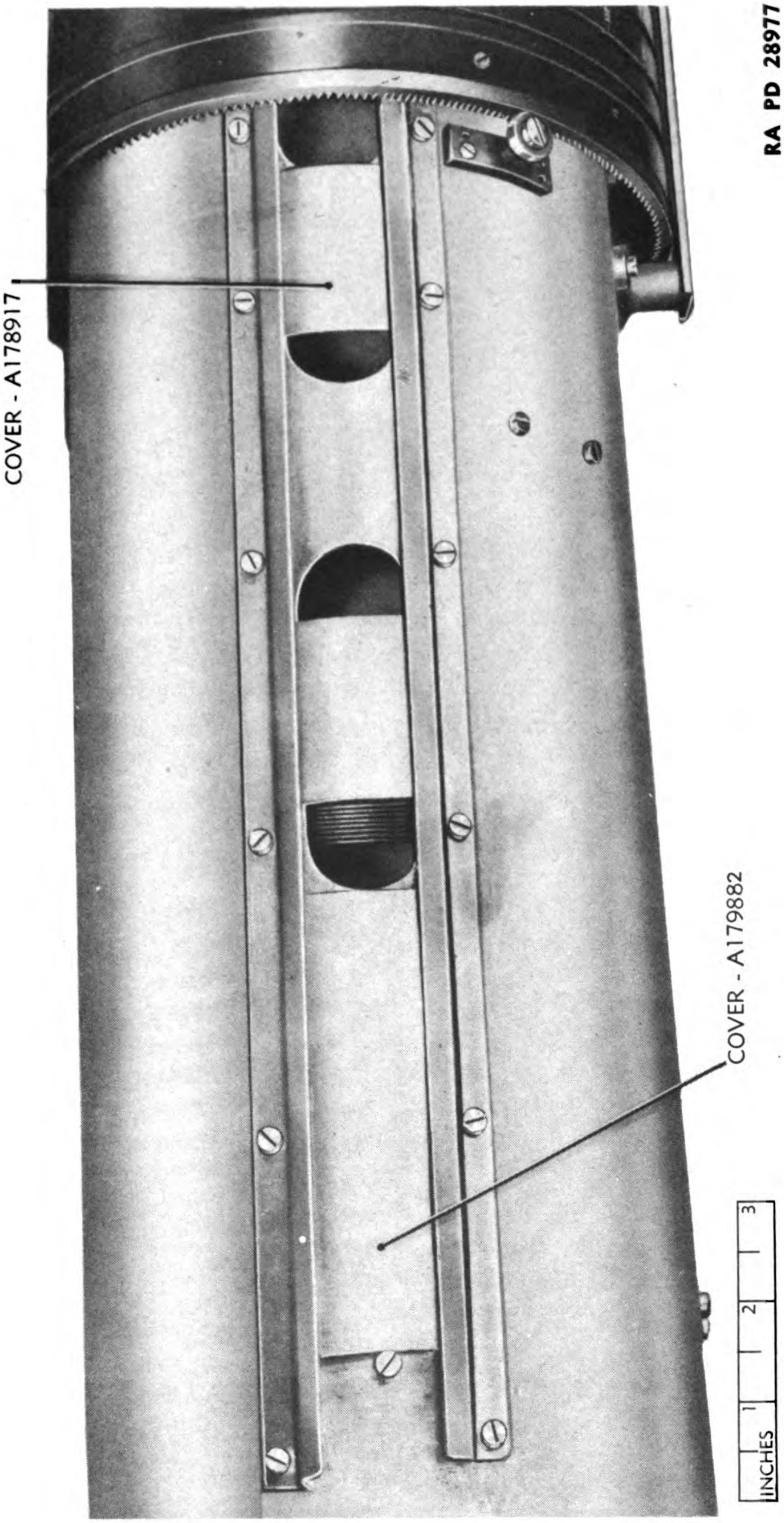

Figure 107 — Inner Tube Showing Objective Adjusting Openings

sharp focus with the collimating telescope reticle. Another critical check for focus is obtained by noting whether there is any relative movement, due to parallax, between the target image and the reticle marks when the eye is moved from side to side above the eyepiece. Presence of even a slight amount of parallax is serious.

c. Since the refractive index of helium differs slightly from that of air, a parallax correction must be made when the instrument is to be charged with helium. The objective must be moved *in* or toward the reticles by rotating the adjuster rings 9¼ holes, to correct for helium parallax.

d. The effective focal length of the two objectives should be so matched that the two images of the target are formed at exactly the same magnification; otherwise, the range readings will vary at different positions in the reticle field. This does not necessarily mean that the focal lengths of the objective lenses themselves must be exactly equal, since there may be slight optical power on the part of the other optical units, such as end reflectors, compensator wedges, etc., which changes the effective magnification. Tests for parallax are used to determine the best focus of the objectives, and across-field tests are made to determine the match of the optics on the two sides of the instrument.

116. OBJECTIVES—REQUIREMENTS.

a. Any operations on the objectives will require breaking the hermetic seal of the instrument. Access to the objective adjusting and locking rings may be obtained by removing cover plates B171710 and B171723 (fig. 106). An off-set screwdriver will assist in removing the plate screw directly under the azimuth telescope sunshade. After the plates are removed, the covers on the inner tube (fig. 107) must be slid out of position to expose the adjusting ring holes. An external target, at a distance of approximately 5,000 yards, is needed for checking the adjustments. An adjusting pin (fig. 76) will be necessary to move the objective adjusting rings.

117. FOCUSING OBJECTIVES TO ELIMINATE PARALLAX.

a. If the parallax observed through either eyepiece is outside tolerance, or if there is any detectable fore and aft movement, note the direction of movement of the target image with respect to the reticle marks, and focus the objectives.

(1) Set the interpupillary distance to suit the eyes, and check the eyepiece diopter setting for best focus on the reticles.

(2) Set the height-range lever in "RANGE" position and the correction knob scale at or near 60.

(3) Sight on an external target, at a distance of approximately

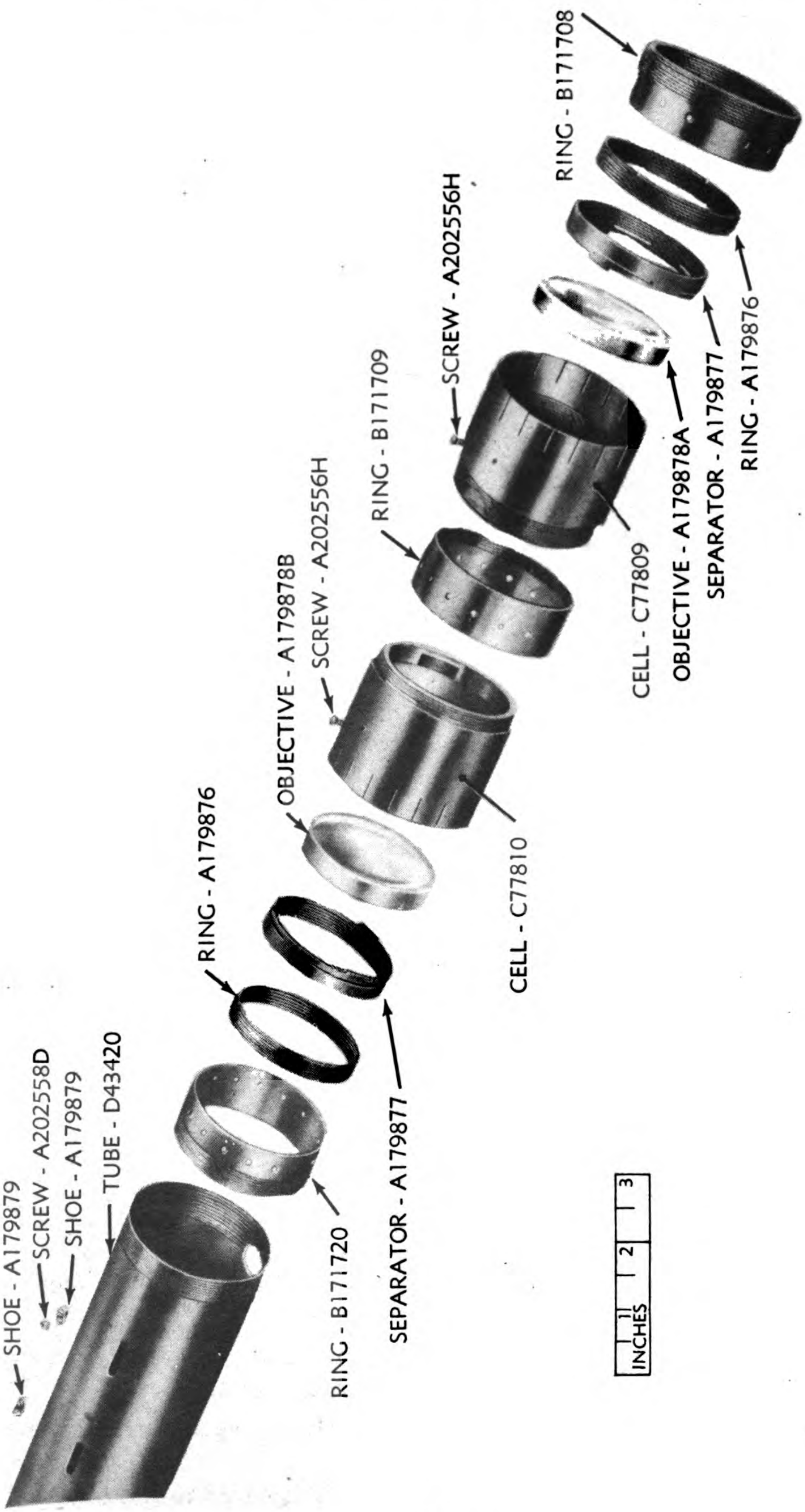

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Figure 108 — Main Objectives — Exploded View

5,000 yards, and turn the measuring knob until approximate stereo contact is made with the reticles and the target.

b. Place the low power telescope on the right eyepiece, and rotate the focusing ring until the reticle is sharply focused. The reading on the diopter scale should be zero, if not, refer to paragraph 103.

c. Focus the right objective as follows:

d. Rotate the focusing ring until the target is in sharp focus. If the reading on the diopter scale of the focus to the target is not zero, then the right objective must be moved toward or away from the stereoscopic reticle, depending on whether the reading is positive (plus) or negative (minus). A minus reading requires that the objective be moved *toward* the reticle, and plus reading requires a movement *away* from the reticle.

(1) Remove the screws from the plate covering the objective opening (fig. 106), using an offset screwdriver to remove the screw directly under the azimuth tracking telescope sunshade.

(2) Remove the plate, which will break the hermetic seal of the height finder.

(3) Slide the small covers on the inner tube (fig. 107) out of the way to expose the adjusting rings at each end of the objective assembly. CAUTION: *The center adjusting ring must not be rotated when making adjustments for parallax at this time.*

e. Movement of the objective is accomplished by rotating the adjusting rings B171720 and B171708 (fig. 108). Using the objective adjusting pin (fig. 76), loosen one ring and tighten the other. The objective will move toward the loosened ring.

CAUTION: *Do not force the adjusting pin against the side of the range drum when moving the inside adjusting ring of the right objective.* If the reading on the diopter scale is minus, loosen the inner adjusting ring with the adjusting pin and then tighten the outer ring. A plus diopter scale reading requires the opposite operation.

f. The focusing may be considered satisfactory if no relative motion or parallax occurs when the reticle and target images are observed when the observer's eye is moved up and down or right and left over the eyepiece, and the reading on the diopter scale is the same for both reticles and target. NOTE: *Motion of the target due to atmospheric conditions should not be confused with parallax.*

g. Replace the cover plate with one screw and check the focus of reticle and target with both the low-power telescope and the eye. If target moves *with* the eye, minus parallax is present and the objectives should be moved *toward* the reticle (or *in*). If the target moves *against* the eye, plus parallax is present and the objective should be moved away from the reticle (or *out*). It is important to note that, each time adjustments are made, the objective *must be firmly secured by the adjusting rings.*

h. Repeat the above operation for the left objective.

i. When both the right and left objectives are adjusted to the conditions under subparagraph f, above, then make across-the-field check as described below. If the across-the-field readings taken are not within tolerance proceed as directed in paragraph 118.

118. OBJECTIVES—CHANGING THE FOCAL LENGTH.

a. The field error is caused by a difference in effective focal length between the right and left main systems. The focal lengths may be equalized by varying the thickness of the air space between the elements of the objective lenses.

b. The field error may be considered satisfactory when the range readings made with the target at different positions in the field of view show little or no tendency to increase or decrease as the target is moved across the field. Due to various factors, perfect correction is not possible.

c. The field error may be determined as follows:

(1) Select a target at a known range of approximately 5,000 yards.

(2) Set the range-height lock lever over the range locking bracket.

(3) Set the correction scale to 60 and the magnification lever at 24 power, and take five range readings with the target at the central reticle measuring mark. NOTE: *If the instrument has not been disassembled and the internal system is in proper adjustment set the correction scale to the mean adjuster reading.*

(4) If the observed range differs from the true range by more than 2.5 units of error, then the end windows should be adjusted (par. 160).

(5) Prepare a table similar to the one on sheet 12 of the inspection report prepared by the manufacturer and carried with the instrument. Record the five range readings under "CENTER" on the chart.

(6) Rotate the instrument in azimuth until the target is at the last reference mark on the left. Make and record five range readings with the target in this position.

(7) Continue in the same manner with the target at the left midway, right midway, and right reference marks (fig. 60). The mean range of each group of five readings should not differ from the true range by more than 2½ units of error.

(8) If the error is exceeded, then the focal length of one of the

main objectives must be varied by rotating the lens spacing ring B171709 (fig. 108). EXAMPLE: Assume that the field error of the instrument under consideration is from left to right: 4,510; 4,530; 4,560; 4,570; and 4,600.

(a) The low reading on the left indicates that the focal length of the left objective is too short, and must be increased by decreasing the thickness of the air space between the two elements of the objectives lenses. If the focal length of the objective is increased, no appreciable change in its position takes place and, therefore, its focal plane and the plane of the stereoscopic reticle marks are no longer coincident. The objective as a whole must be moved away from the reticle to reestablish coincidence; in other words, the objective must be refocused.

(b) As an alternative procedure, the opposite operations may be performed on the right objective.

(c) To correct the field error in the above example:

1. Remove the left objective adjusting cover plate (fig. 106). Turn the outer adjusting ring about five holes, and turn the lens spacing ring in the direction which decreases the distance between the objective elements (adjusting holes move down). NOTE: *This is a sensitive adjustment and the lens spacing ring should not be turned more than one hole at a time.*

2. Turn the inner adjusting ring about six holes in the direction which moves the objective away from the reticle.

3. The outer adjusting ring *must* now be tightened.

4. Place the cover on the outer body tube and check the focus of the left objective. Make the necessary corrections.

5. Determine the field error. If it is not within the tolerance, repeat the procedure.

(d) When all adjustments are correct, close the inner covers, seal, and secure the outer cover plates.

119. REMOVING THE OBJECTIVES.

a. If the main objectives have been damaged or require cleaning, it will be necessary to partially disassemble the height finder and remove the optical tube (pars. 83 and 171).

b. Special tools shown in figure 78 are necessary to remove the objective mount cells and rings and, if not available, can be made by a good instrument repairman.

c. Both right and left objectives are constructed and assembled the same, except that the air space distance may not be the same between the crown and flint lenses on the right side as it is on the left. NOTE: *Air space distance is measured between the lenses at*

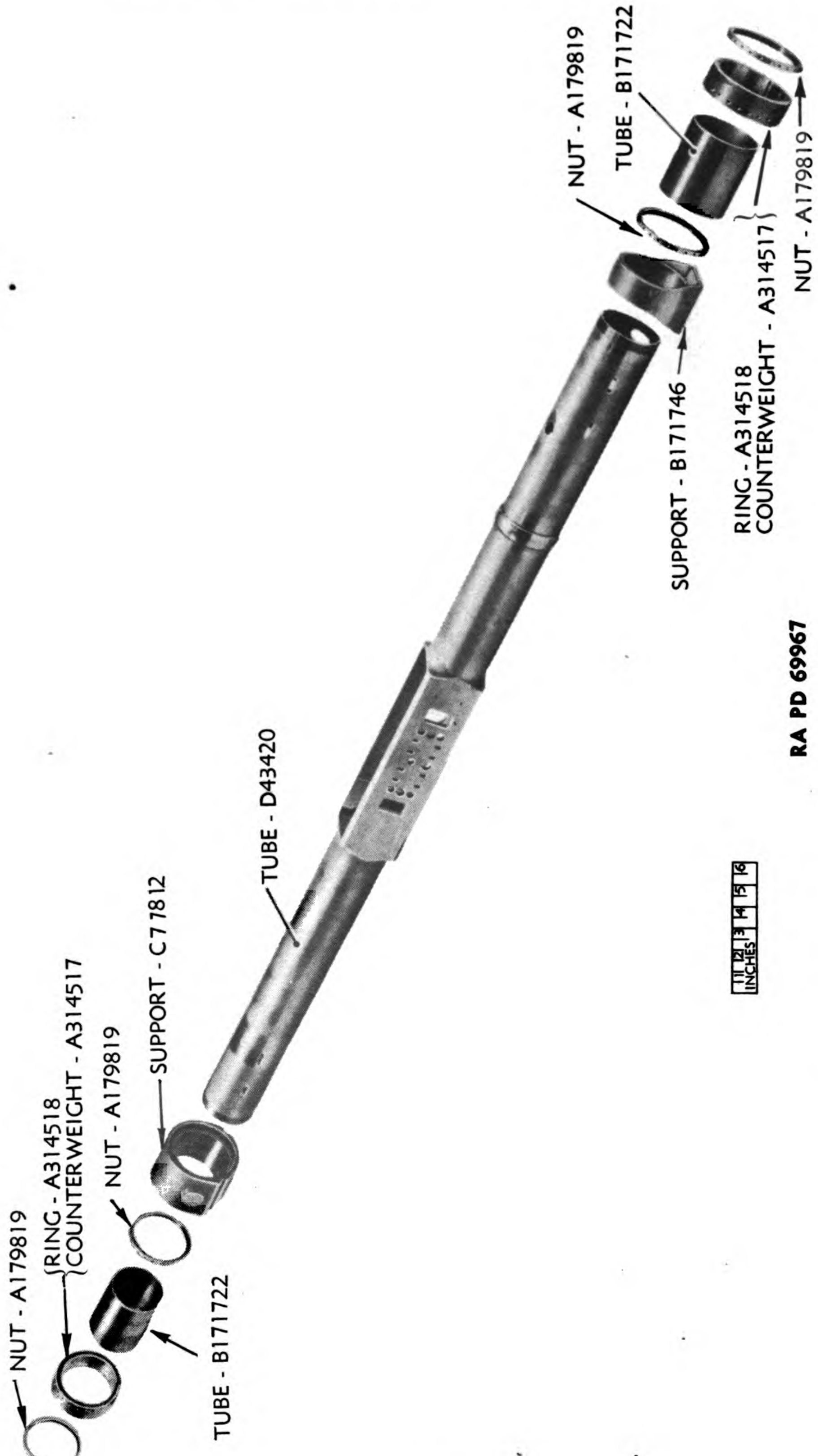

Figure 109 — Optical Tube Assembly — Exploded View

the center and must be maintained at all times, because it controls the focal length of the objectives.

d. The lens air space is controlled by the center adjusting ring B171709 (fig. 108). On the side of this ring which is screwed to the threaded section of the outside lens cell C77809 or C77810 will be found numbers (such as 4.3) and a scribed line (fig. 105). These numbers indicate the distance, measured in millimeters, that the adjusting ring shoulder is separated from the lens cell shoulder, and correspond to the proper air spacing between the crown and flint element of the objective when the optical tube is first assembled prior to the final adjustment in the instrument.

e. A scribed line on the adjusting ring is also made opposite a scribed line on the lens cell when the objectives are assembled at the factory. The adjusting ring may have been moved slightly when the instrument was finally adjusted, so that the lines may be found separated and the distance between the lenses slightly changed when the cell mounts are examined after removal from the optical tube. NOTE: *When the lens cell is being removed from the tube, do not rotate the spacing ring until you measure and record the separation of the adjusting ring and cell. Mark the position of the ring and cell with scribed lines.*

f. To remove the objective cells, proceed as follows:

(1) Scribe a line on the three adjusting rings B171720, B171709, and B171708 (fig. 108) next to the shoulder of the openings in the optical tube, so that, when the rings and cells are reassembled, they can be returned to their proper places, which will make refocusing much easier.

(2) Unscrew and remove counterweight tube B171722 (figs. 67 and 109) with the weight in place on the tube. NOTE: *Do not disturb lock nuts A179819 (fig. 109).*

(3) Using special objective cell puller (No. 1, fig. 78), screw the threaded end into the antireflection thread section of adjusting ring B171708 (fig. 108). A pin inserted into one of the adjusting holes will serve to keep it from turning until the puller is fitted tight enough to unscrew the ring out of the optical tube. NOTE: *Antireflection threads on some rings are 48 per inch, and in others are 36 per inch.*

(4) Mark position and remove the small guide shoes A179879 (fig. 118).

(5) Using the cell puller (No. 2, fig. 78) screw threaded end into crown lens cell C77809 (fig. 108).

(6) Pull the cell straight out. Adjusting ring B171709 will come out with the cell. CAUTION: *Be careful not to rotate this adjusting ring.*

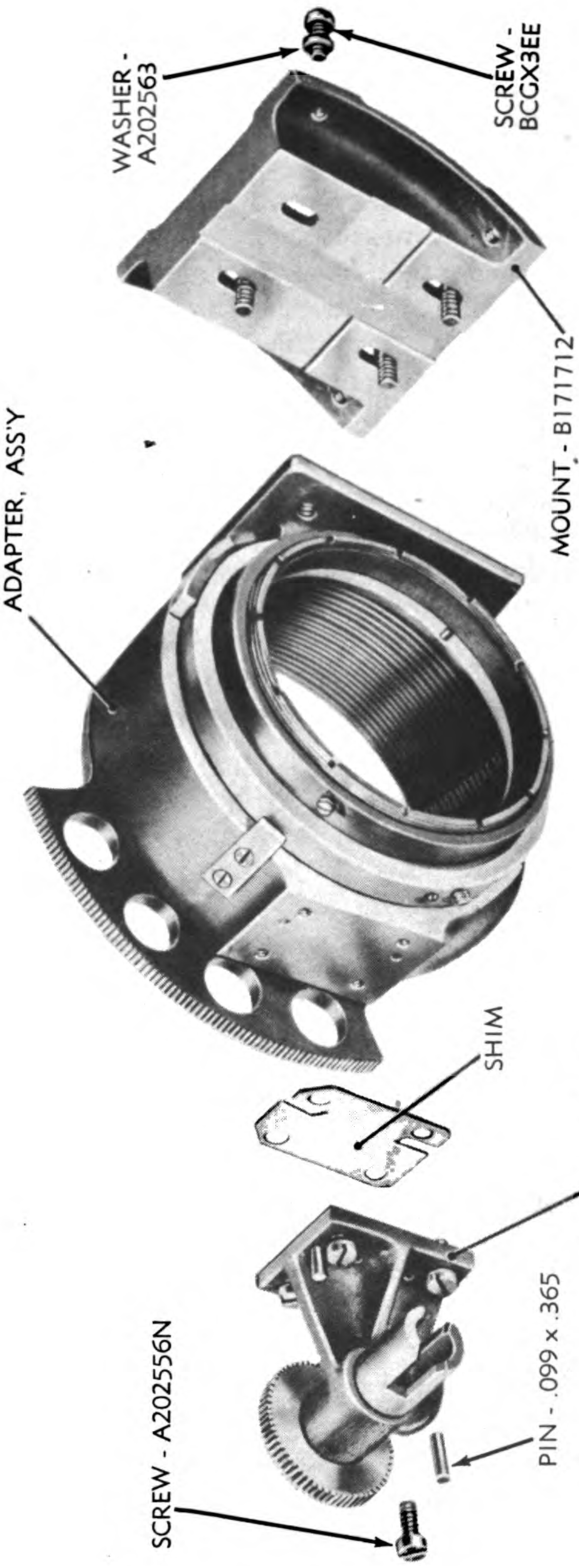

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Figure 110 — Correction Wedge Assembly — Partly Exploded

(7) Accurately measure the distance between the shoulder of the cell and rings, and scribe a line across the cell and rings B171709 as reference marks.

(8) Mark position and remove the small guide shoe A179879.

(9) Using cell puller (No. 3, fig. 78) screw it into the threaded shoulder on the flint lens cell C77810. Remove the cell by pulling straight out.

(10) Using wrench, remove adjusting ring B171720 in the same manner as the first adjusting ring B171708.

(11) If it is necessary to remove the crown or flint lens from its cell, first remove the screw A202556H in the separator that can be reached through hole in the lens cell.

(12) Remove the retaining ring A17-9876 and the separator A179877.

(13) Remove the lens, and mark edge of lens and cell so they may be reassembled *exactly* as removed (fig. 108). NOTE: *This is most necessary because the lens is positioned in the cell to give best image possible. Normally the figures scratched on the edge of lens are mounted in line with the small guide shoe screw holes.*

(14) Reassembly of the objectives is done in reverse order of disassembly, after the lenses have been carefully cleaned.

(15) The approximate focal position is reached when the scribed lines on the adjusting rings are placed as described in paragraph 119 e, and aline with the marks on the guide shoes.

NOTE: *After the height finder is completely assembled, it will be necessary to make focus and across-the-field adjustments as directed in paragraphs 117 and 118.*

120. CORRECTION WEDGE—REQUIREMENTS.

a. Explanation. In order to allow use of the full range of the adjuster scale, which may be necessary under extreme temperature conditions, the internal adjuster correction wedge should be mounted so that it is in a central "image-down" position when the adjuster scale is set at "60." Its deviating power should be such that the scale graduations are within 10 percent of the arbitrary unit of error for the instrument at high magnification. Both the orientation of the wedge and its deviation power are checked by determining the value of the adjuster scale graduations as described in paragraph 50.

b. Requirements. Removal of the correction wedge will require major disassembly of the height finder telescope (par. 171).

121. ADJUSTMENT OF CORRECTION WEDGE.

a. After disassembly and assembly of the height finder telescope, the correction wedge assembly position must be checked for proper location in the inner tube.

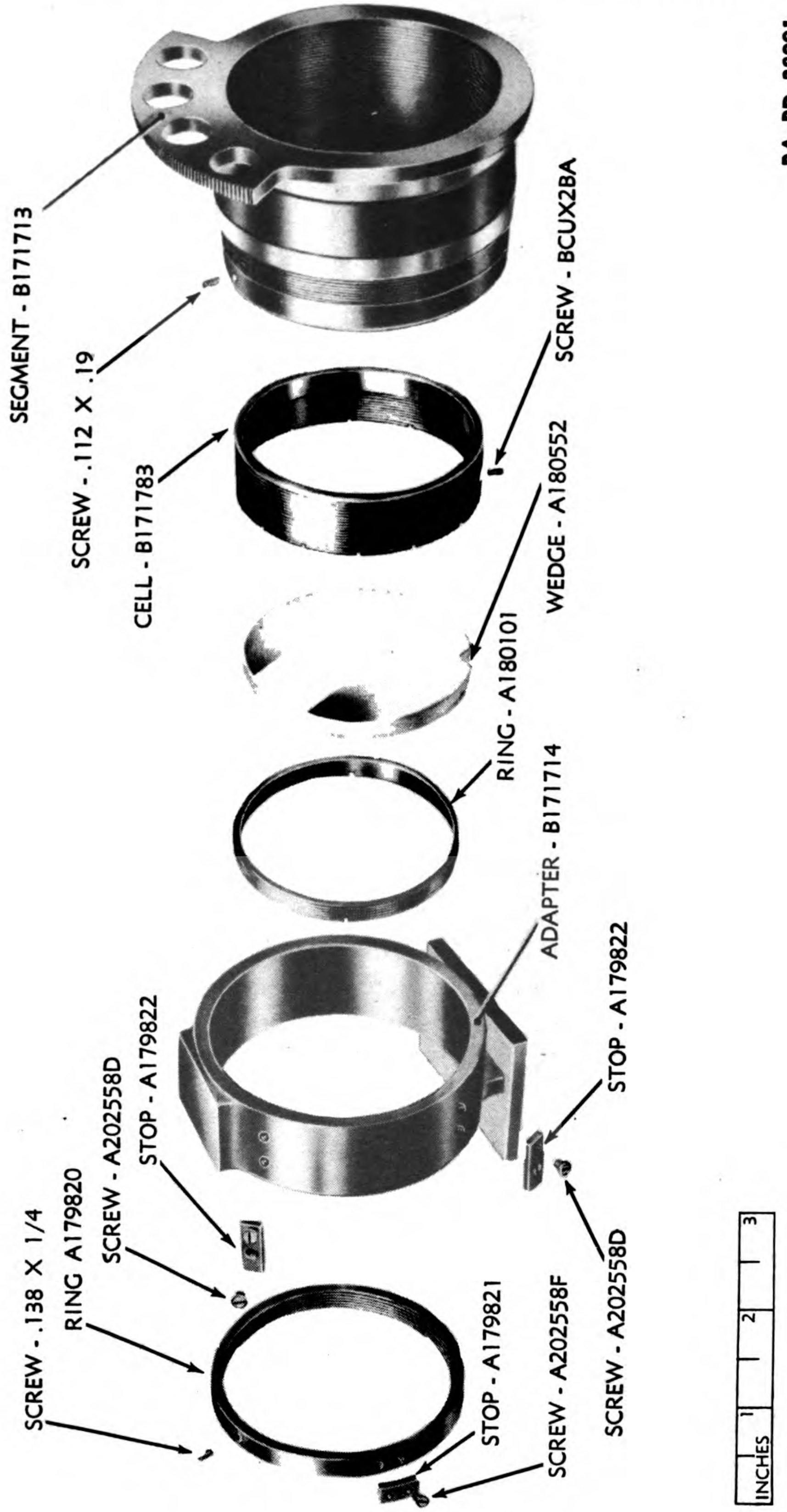

Figure 111 — Correction Wedge Adapter Assembly — Exploded View

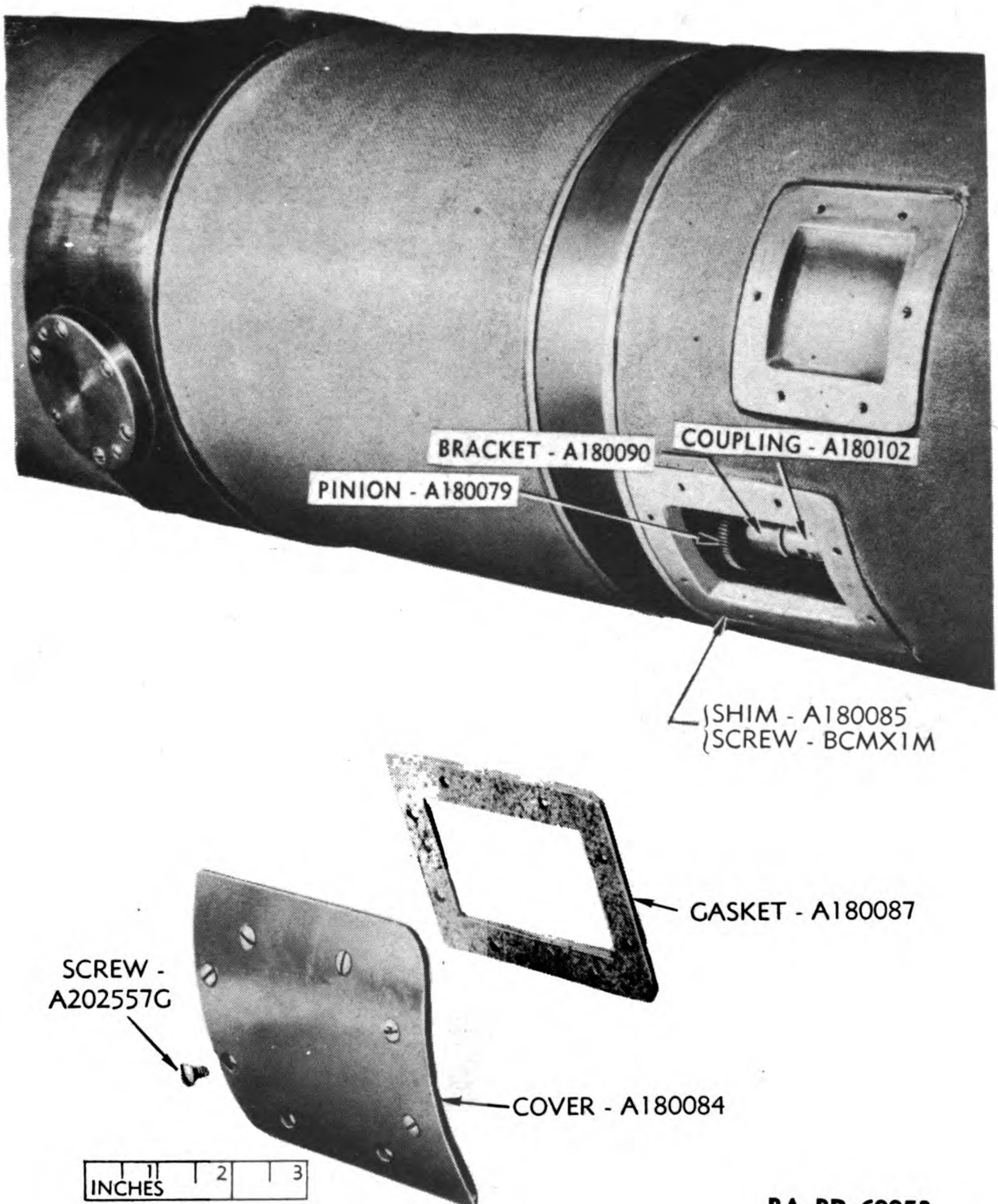

Figure 112 — Correction Wedge Pinion Bracket Cover

b. Dislocation of the correction wedge line-up in the inner tube will result when the correction wedge adapter assembly is separated from the correction wedge mount B171712 (fig. 111).

c. Slotted screw holes in the correction wedge mount allow the correction wedge adapter assembly to be shifted back and forth to eliminate cut-off of the pupils caused by the correction wedge. To check the pupils proceed as follows:

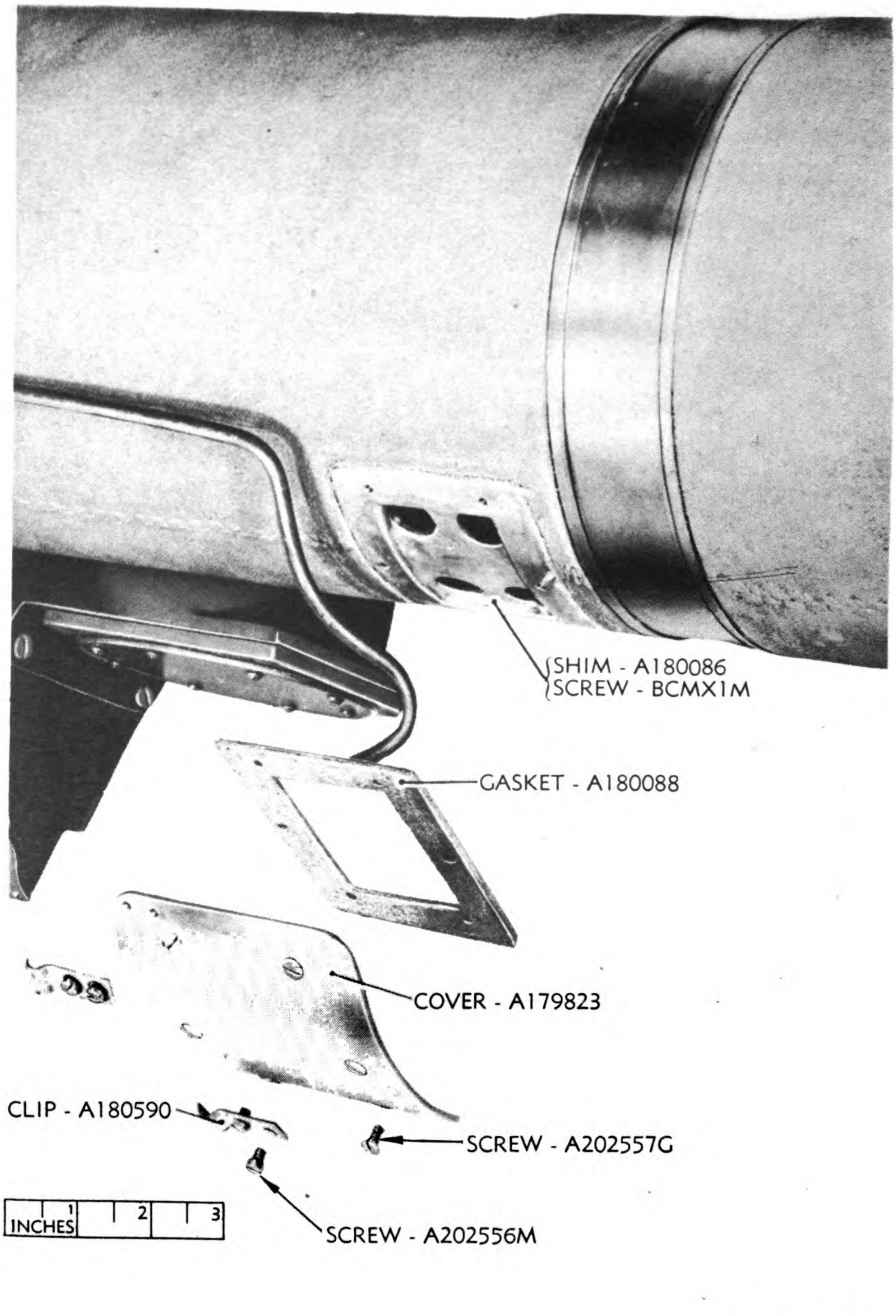

Figure 113 — Correction Wedge Adjusting Openings

(1) Shift the change-of-magnification lever to 24 power.

(2) Place a pupil loupe on the left eyepiece centering shoulder. Focus to the pupils (or apertures) formed by the end window, correction wedge, and objective.

(3) The pupils should be concentric with no cut-off of one field in another.

(4) If the pupil formed by the correction wedge cuts into other pupils of the left side of the height finder, proceed as follows:

(a) Remove cover A179823 (fig. 113).

(b) Observe four screws through the opening in the inner tube.

(c) Loosen the screws just enough to allow the correction wedge to shift.

(d) Shift the correction wedge assembly until the aperture that is observed through the pupil loupe is concentric, and there is no cutting off of the field by the correction wedge.

(e) Tighten the four screws that hold the adapter assembly to the mount.

(f) Replace the cover to the outer tube.

NOTE: *When the correction wedge is properly mounted "image down," the set screw in the wedge cell B171783 (fig. 111) is positioned in the 90-degree notch in the wedge base, and the position of the wedge base is down.*

122. REPLACING NEW CORRECTION WEDGE.

a. If due to damage, the correction wedge must be replaced as follows:

b. Disassemble the height finder as directed in paragraph 171.

c. Mark the relative location of the correction wedge adapter B171714 (fig. 111) to the mount B171712 (fig. 110), and separate the mount from the adapter.

d. Mark the position of all set screws in relation to the cells and rings they hold in adjustment, and mark the relation of rings to cells.

e. Remove set screw 0.112 x 0.19 in segment B171713 (fig. 111). Remove two set screws 0.138 x ¼ in ring A179820, stop A179821, and stop ring A179820.

f. Unscrew wedge cell B171783 from the segment adapter B171713 far enough to remove set screw BCUX2BA from the 90-degree notch in the wedge cell (fig. 111).

g. Unscrew retaining ring A180101 and remove the defective wedge.

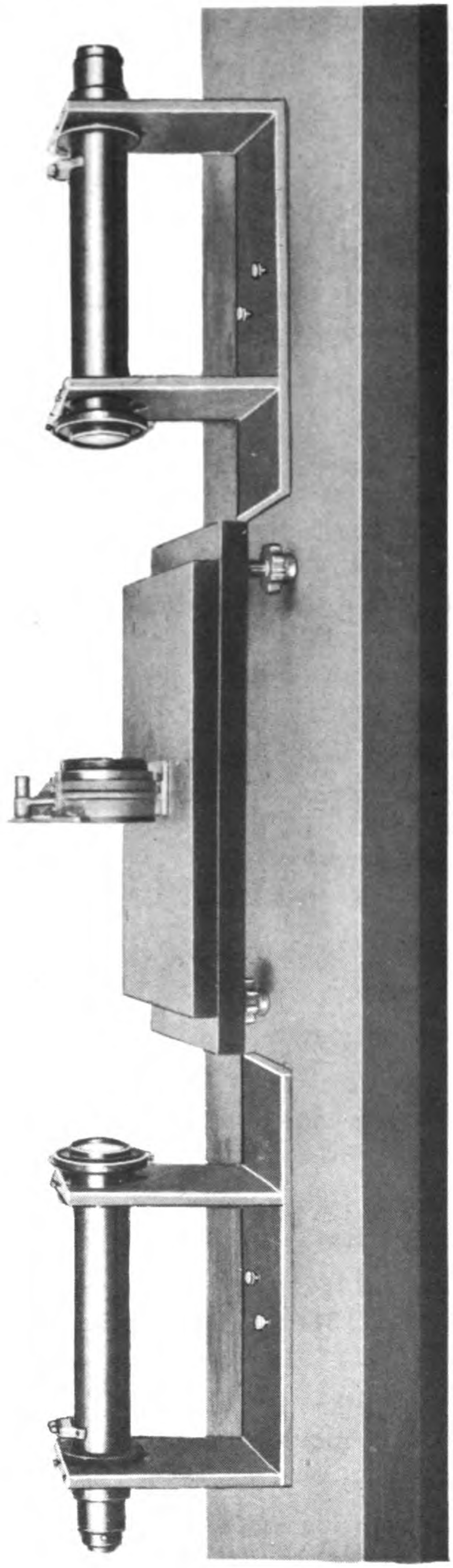

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Figure 114 — Adjusting Collimators Used To Check Correction Wedge

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT

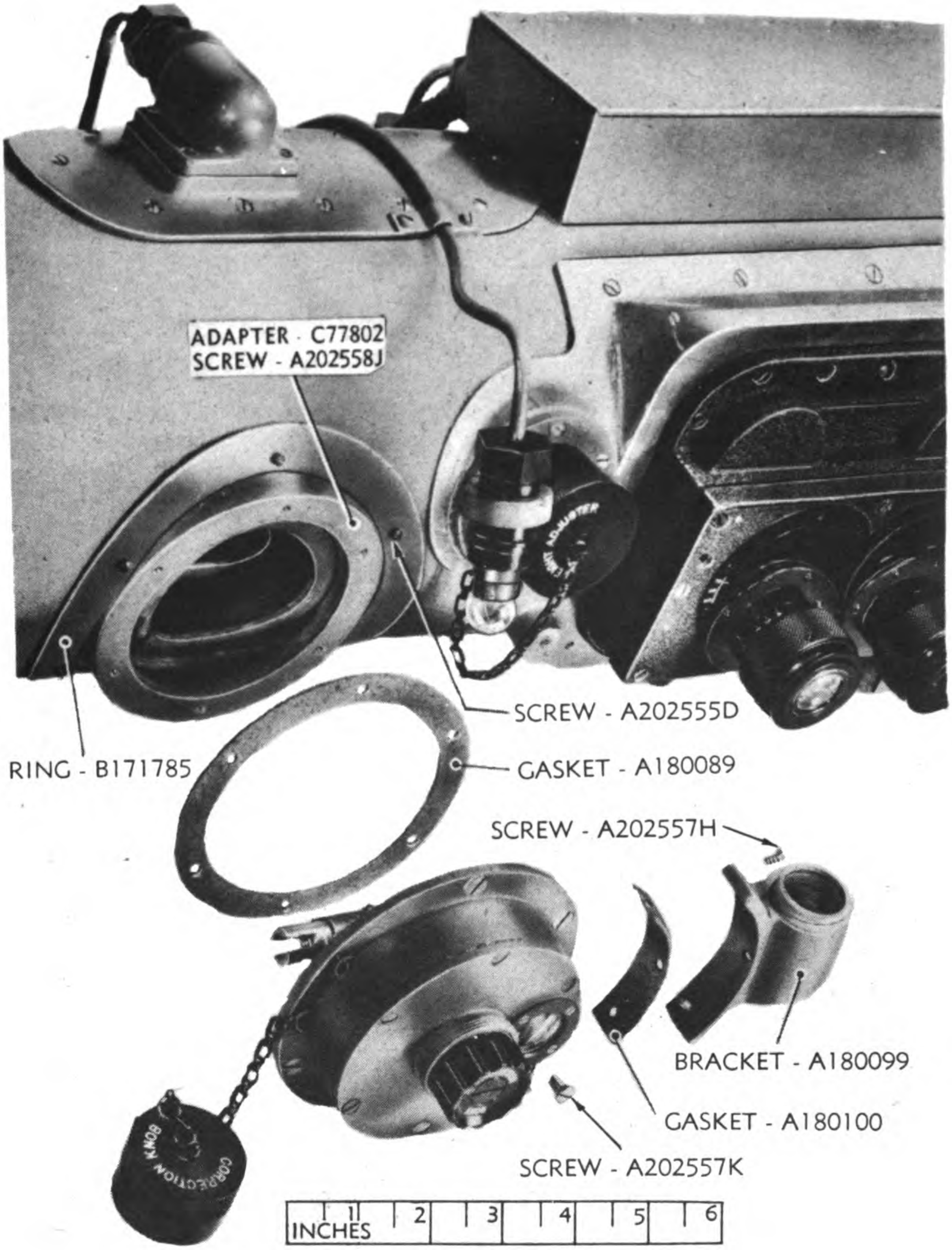

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Figure 115 — Removing the Correction Knob Scale Assembly

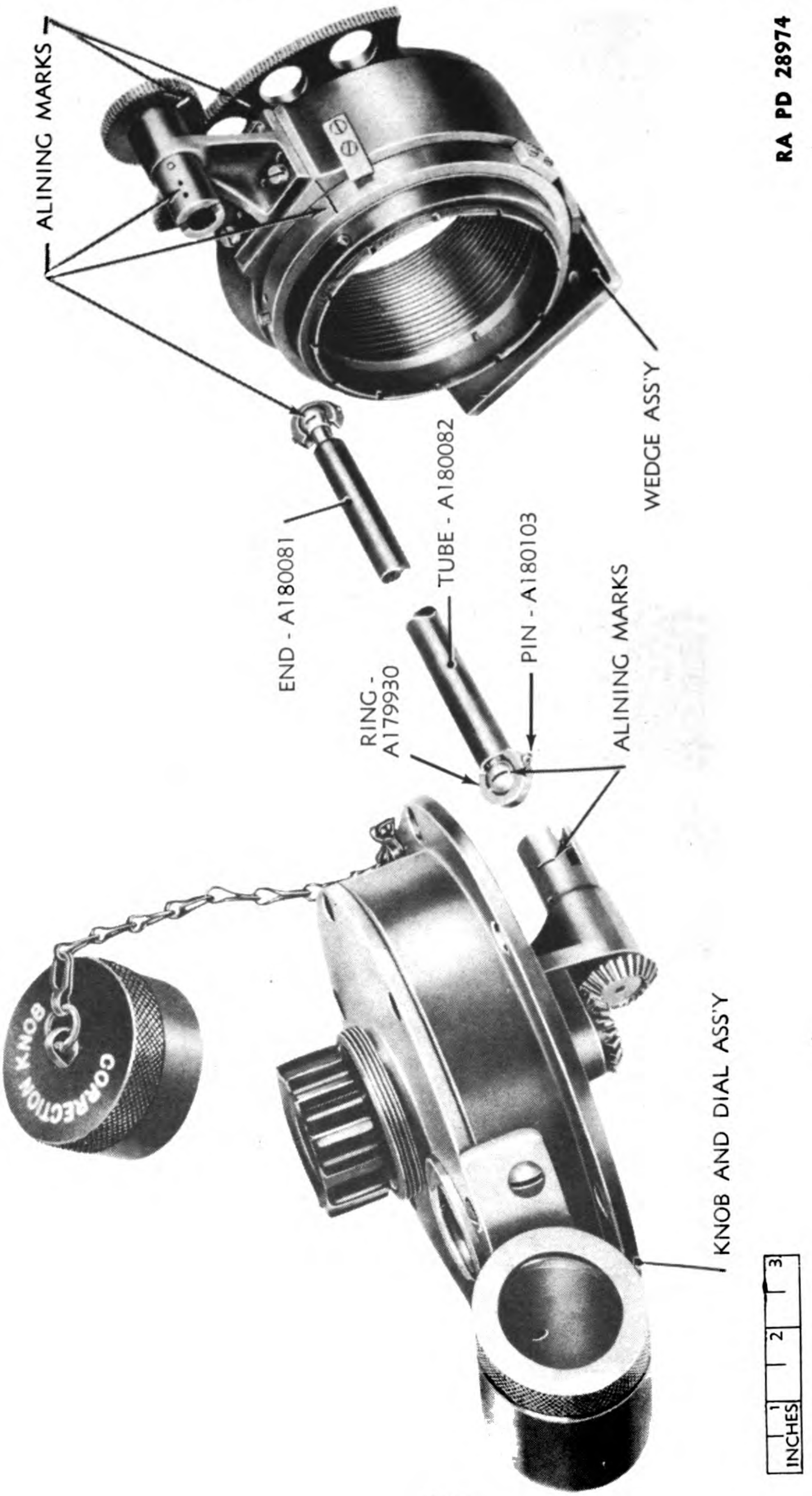


Figure 116 — Correction Knob Scale and Measuring Wedge Assembly — Functional View

h. Clean and place the new wedge in the cell with the beveled edge toward the retaining ring.

i. Replace set screw BCUX2BA in the 90-degree notch, screw the set screw in notch until it touches the glass, then back it off a half turn, and place a small spot of varnish shellac on the screw head.

j. Screw the retaining ring into place and seal with a drop of varnish shellac.

k. Screw the wedge cell into the segment adapter to the exact position it was removed from, and reassemble the remaining units in the reverse order of disassembly.

123. CORRECTION WEDGE—ADJUSTING "IMAGE-DOWN" POSITION.

a. Place the correction wedge adapter assembly on a leveled plate between the optical tube collimators arranged as shown in figure 114 (NOTE, subpar. f, below).

b. Set the correction wedge gear segment B171713 (fig. 111) in the center of its motion. This position has been indicated by a mark on the adapter assembly, and another on the mount retainer ring A179820 (figs. 111 and 116).

c. If the adjustment is correct, the image of the collimator horizontal cross line should appear below, and parallel to, the horizontal cross line in the telescope and both the vertical lines should be superimposed. If this condition is not realized, loosen the set screw in the retainer ring A179820 (fig. 111), and rotate the wedge cell B171783 until the condition is corrected.

d. Check the wedge for dirt, and clean if necessary. Shellac all set screws.

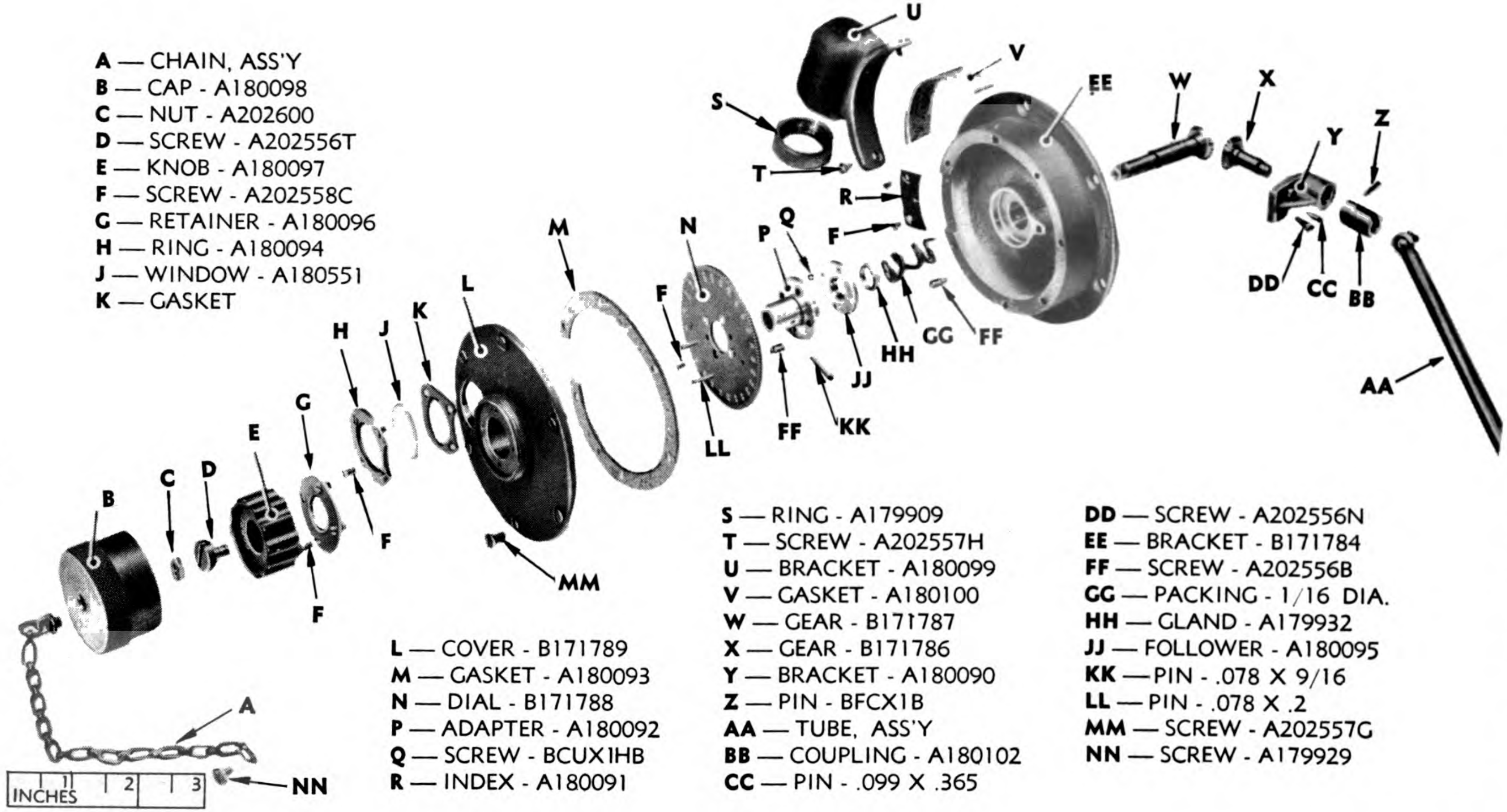
e. Mount the correction wedge adapter assembly to the correction wedge mount in as near the same location as that from which it was removed.

f. Assemble the correction wedge to the height finder as described in paragraph 181.

NOTE: *When engineer's telescopes, such as Y levels, which have an erecting system, are used to check the image position of the correction wedge, the image position will be opposite to that seen when using collimators (fig. 114).*

124. ADJUSTER KNOB AND SCALE ASSEMBLY—REMOVAL AND REPLACEMENT.

a. General. Rotation of correction scale knob operates correction wedge through bevel gears and a coupling rod. The correction



A — CHAIN, ASS'Y
B — CAP - A180098
C — NUT - A202600
D — SCREW - A202556T
E — KNOB - A180097
F — SCREW - A202558C
G — RETAINER - A180096
H — RING - A180094
J — WINDOW - A180551
K — GASKET
L — COVER - B171789
M — GASKET - A180093
N — DIAL - B171788
P — ADAPTER - A180092
Q — SCREW - BCUX1HB
R — INDEX - A180091
S — RING - A179909
T — SCREW - A202557H
U — BRACKET - A180099
V — GASKET - A180100
W — GEAR - B171787
X — GEAR - B171786
Y — BRACKET - A180090
Z — PIN - BFCX1B
AA — TUBE, ASS'Y
BB — COUPLING - A180102
CC — PIN - .099 X .365
DD — SCREW - A202556N
EE — BRACKET - B171784
FF — SCREW - A202556B
GG — PACKING - 1/16 DIA.
HH — GLAND - A179932
JJ — FOLLOWER - A180095
KK — PIN - .078 X 9/16
LL — PIN - .078 X .2
MM — SCREW - A202557G
NN — SCREW - A179929

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Figure 117 — Correction Knob Scale Assembly — Exploded View

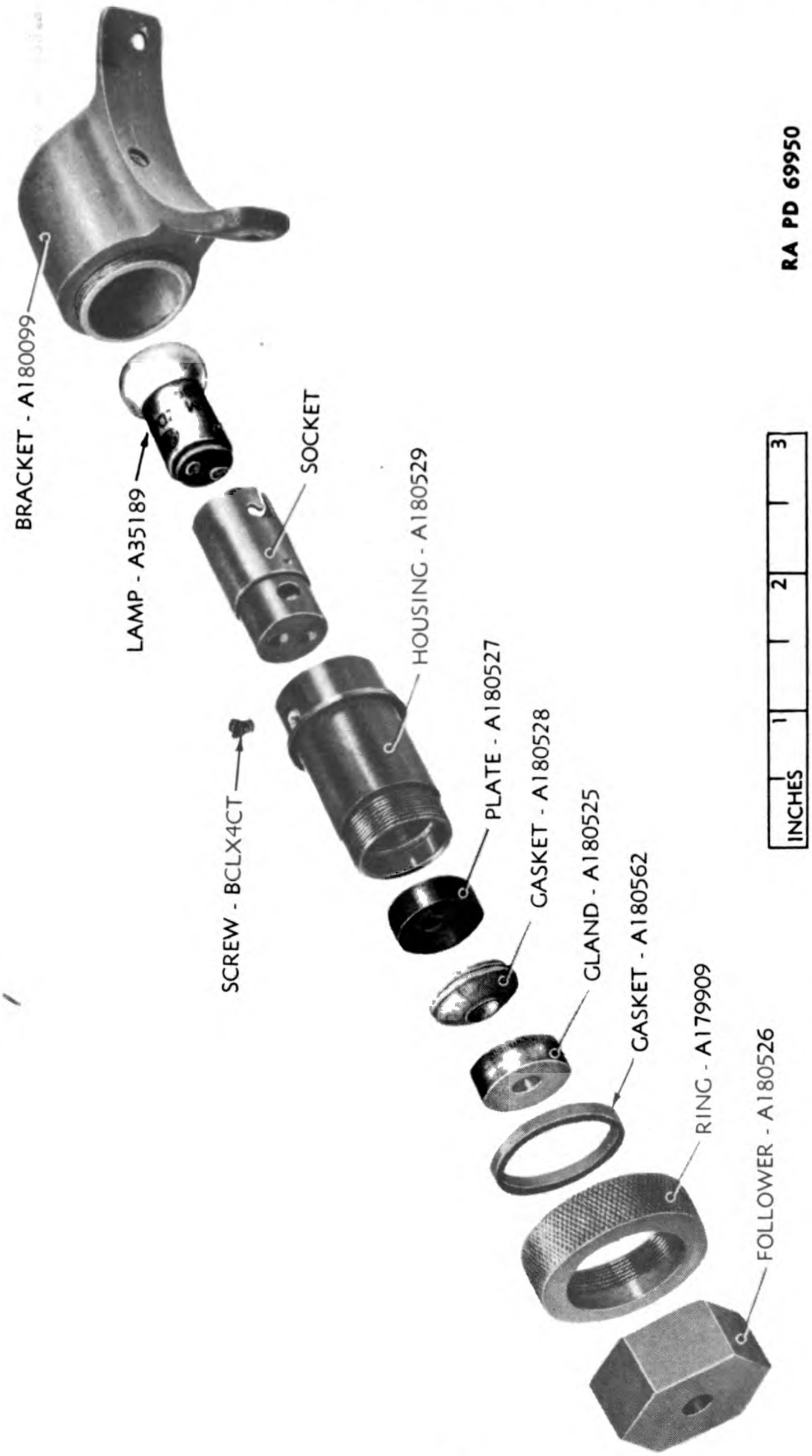


Figure 118 — Correction Knob Scale Lamp Bracket — Exploded View

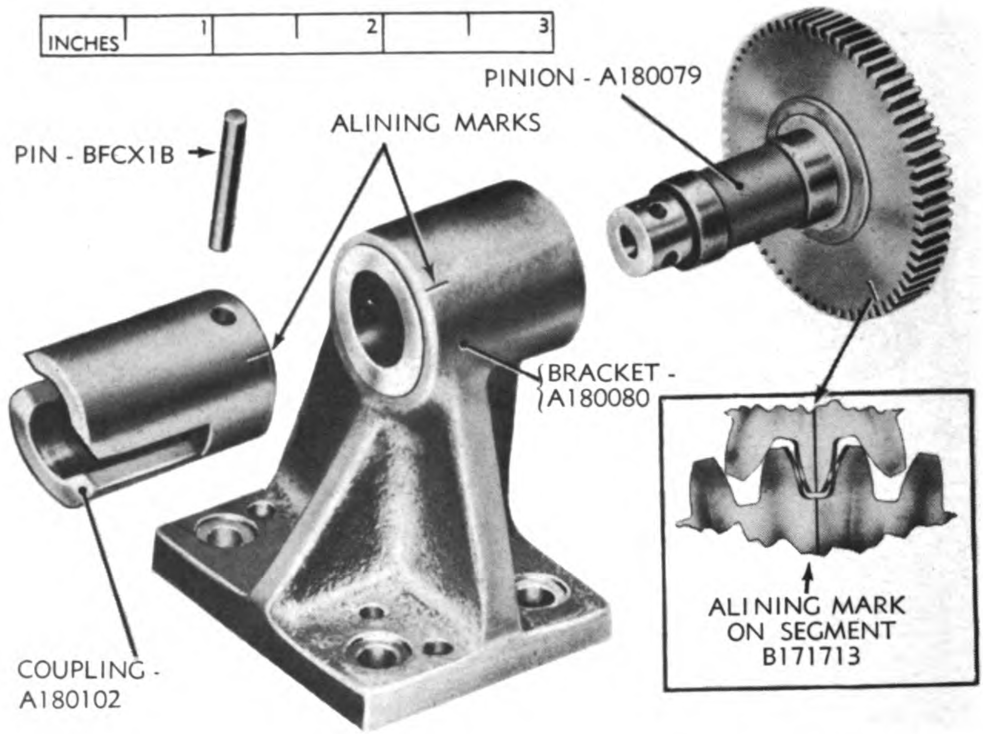


Figure 119 — Correction Wedge Pinion Bracket Assembly — Exploded View

knob and scale assembly should need no attention except in case of actual physical damage or when adjusting packing. In case of disassembly of the height finder telescope, however. it must be removed to permit removal of the inner tube. This requires breaking the hermetic seal of the instrument. The correction wedge pinion bracket assembly should first be removed from the instrument before disassembly of the main bearings.

b. Removal and Replacement.

(1) Remove the two screws and lift the lamp bracket assembly (fig. 118) out of the way, taking care not to damage the cork gasket.

(2) Set the correction knob scale to "60."

(3) Remove the elevation tracking telescope.

(4) Remove the elevation tracking telescope adapter.

(5) Remove cover A180084 (fig. 112) which will expose the correction wedge pinion bracket assembly.

(6) When the correction wedge scale is set at "60," the alining marks on the correction wedge segment gear, and the mark on the correction wedge pinion gear should match (fig. 119). It will be necessary to rotate the correction knob and look for the joining

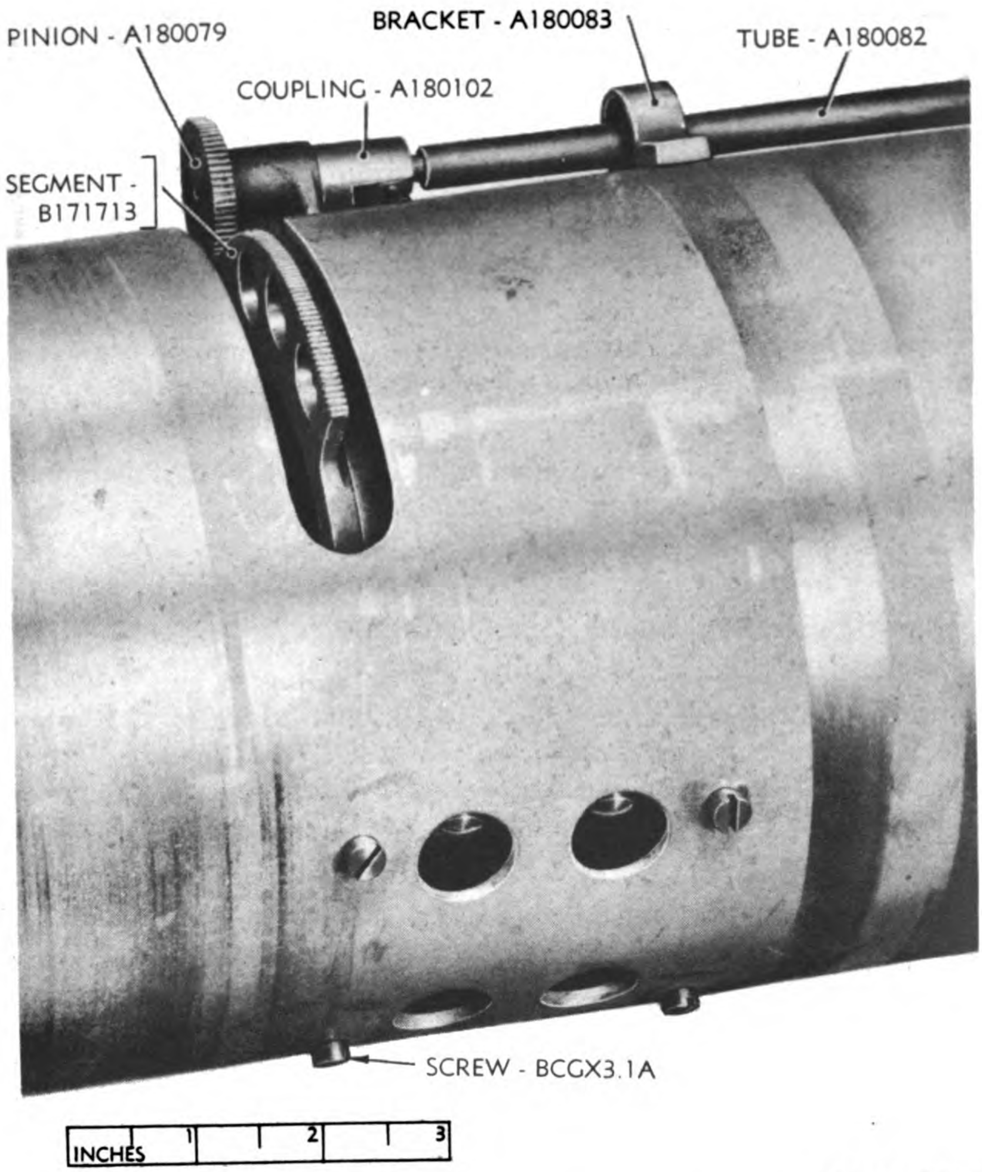


Figure 120 — Correction Wedge Drive

marks of the gears, as they are partly concealed by the pinion gear adapter when they are in their proper position.

(7) The line on the pinion gear adapter and the line on the coupling should match as shown in figure 119. If the coupling and bracket do not have the alining marks mentioned above, check the segment and pinion gear marks, set the correction scale on "60," and scribe joining lines on the coupling and bracket. This will assist in assembly.

(8) Remove the flat-head screws holding bracket B171784 (fig. 117) to the adapter C77802 (fig. 115).

(9) Gently pry the bracket from the adapter, taking care not to damage the gasket.

(10) Slide the knob and dial assembly toward the eyepiece while holding the drive tube at the pinion gear from disengaging, and remove the correction knob assembly from the height finder.

(11) Disconnect the correction wedge drive tube from the pinion gear coupling and tape both ends to the inner tube.

(12) Remove four screws holding pinion bracket assembly, and gently move the assembly back and forth until the pinion bracket assembly is separated from the wedge assembly, taking care not to bend the two guide pins.

(13) Disassemble the pinion bracket assembly as illustrated in figure 119, and place a light coat of grease on the pinion shaft and reassemble.

(14) If necessary to disassemble the correction knob and scale assembly proceed as illustrated in figure 117.

(15) Reassemble the correction knob and scale and drive tube assembly in the reverse order of disassembly. Make sure the pinion gear and segment gears are joined with the scribed lines, or beveled teeth matched. When the segment gear is rotated by hand, make sure that the movement is free from binding.

(16) Rotate the segment gear to its central position, match the scribed lines on the pinion bracket and coupling.

(17) Set the correction knob scale to "60."

(18) Untape the drive tube, and place a piece of string around the ball end, to assist in joining the ball tube to the knob assembly coupling, taking care to match the filed marks on the tube ball and knob coupling.

(19) Place the knob and scale assembly on the height finder, and use a wire with hook to join the drive tube to the pinion coupling, matching the scribed lines and punch marks.

(20) Secure the correction knob and scale assembly to the height finder and move the scale from zero to 120. The scale should move freely from stop to stop if everything has been assembled as directed above. If the knob does not turn freely, the packing around the gear shaft B171787 (fig. 117) may be too tight.

(21) Assemble the lamp bracket, pinion gear cover, tracking telescope adapter, and tracking telescope in the reverse order of disassembly.

(22) Aline the tracking telescope as described in paragraph 189.

125. ADJUSTER KNOB AND SCALE ASSEMBLY—ADJUSTING THE PACKING.

a. Due to the enclosed position of the packing around the gear shaft B171787 (fig. 117), it will be hard to locate helium leaks caused by the packing around the gear shaft, the packing being too loosely compressed. The packing must be compressed enough to retain helium pressure but not too tight. If the packing is too tight, extra effort will be required to rotate the correction knob, and stereo contact of the reticle and target will be hard to make accurately.

b. Method of Adjusting the Packing (letters in parentheses refer to figure 117).

(1) Set the scale dial B171788 (N) to zero or 120.

(2) Remove knob A180097 (E).

(3) Remove cover B171789 (L), taking care not to damage the cork gasket.

(4) Mark top of gear shaft B171789 (W) and adapter A180092 (P).

(5) Remove taper pin (KK) and gently pry adapter A180092 (P) off of the bevel gear shaft.

(6) Loosen set screw BCUX1HB (Q).

(7) Use two pins and rotate follower A180095 (JJ).

(8) Apply soap solution around bevel gear shaft and follower, and tighten follower until no bubbles appear.

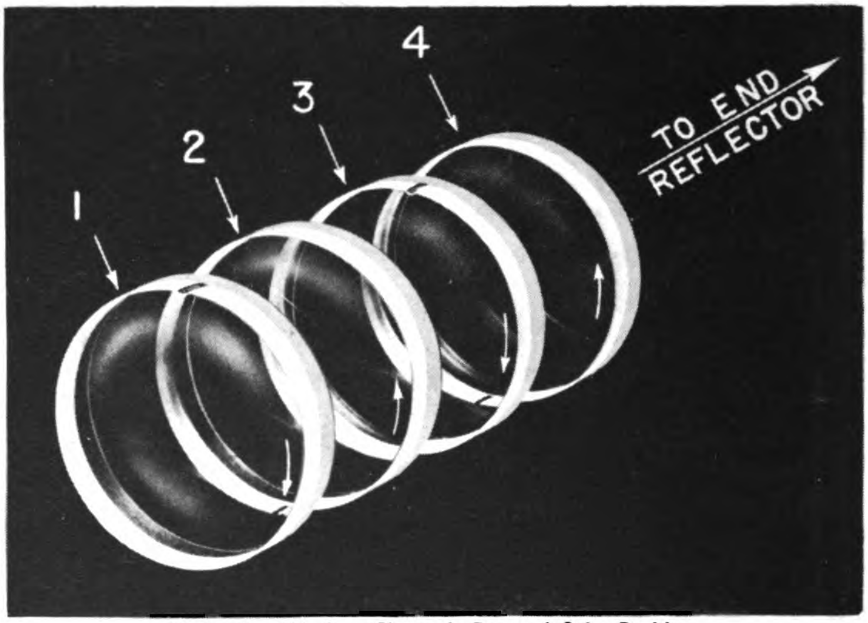
c. Assemble in the reverse order of disassembly. After assembling the dial, place the knob on the bevel gear shaft temporarily, and rotate the dial from stop to stop a number of times. Fill the bracket well with clean water, and check for leaks. If no leaks appear, drain the water from the well, clean the dial, and complete assembly.

126. COMPENSATOR ASSEMBLY—REQUIREMENTS.

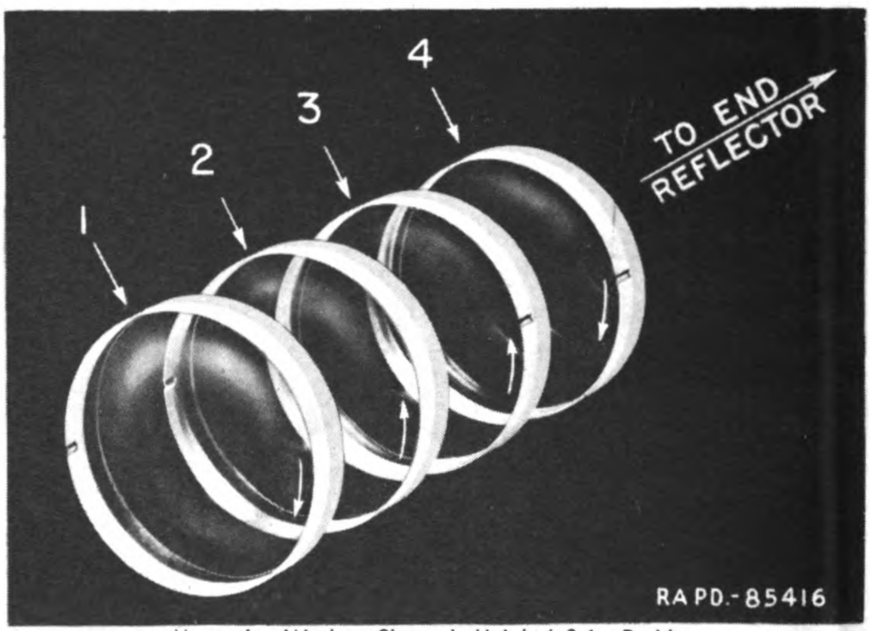
a. When the height finder is level, height range is set for "**RANGE**" and the measuring drum reads infinity, and the compensator assembly should be in a position for zero deviation, with the bases of wedges 1 and 3 opposed to the bases of wedges 2 and 4.

b. When the height-range lever is set for "HEIGHT" and the instrument is level, each pair of wedges should be set for zero deviation, with wedge 1 opposed to 3, and 2 opposed to 4, for any position of the measuring drum.

c. Under these conditions, the same internal target readings should be obtained for range-infinity and for any height setting (usually checked at height-infinity and height-900). If the readings for these



Measuring Wedges Shown In Range Infinity Position.
Arrows Show Direction of Rotation
Due to Range Drive
(Decreasing Range)



Measuring Wedges Shown In Height Infinity Position.
Arrows Show Direction of Rotation
Due to Height Conversion Drive
(Decreasing Height)

Figure 121 — Measuring Wedges

different settings do not agree within the specified tolerance, the compensator is out of adjustment and must be corrected.

d. The range-infinity adjustment is made by setting the compensator for zero deviation when the measuring drum is set to read infinity. The height-infinity adjustment is made by turning the height conversion bevel gear with respect to its shaft, to bring the wedge pairs to zero deviation at zero elevation.

e. If the compensator is completely out of adjustment so that readings cannot be made on the correction knob scale, the compensator should be removed from the instrument, and the gears turned so that the scribed marks on the indexes at the range-infinity position line up, then replace the unit in the instrument. See paragraphs 129 to 138 for these operations.

f. Whenever the compensator is removed, the measuring drum should be set at infinity, and the conversion ring lock in place over the range locking bracket. Height finder telescope must be level.

g. The instrument should be at a stable temperature for at least 4 hours previous to, and during, the adjustment. All readings and adjustments must be made by an experienced observer. Range adjustment (range-infinity—height-infinity) will require the breaking of the hermetic seal. After any adjustment of wedges for range, the settings of the height conversion mechanism (height-infinity—height-900) must be checked.

127. COMPENSATOR ASSEMBLY—RANGE ADJUSTMENT (RANGE-INFINITY—HEIGHT-INFINITY).

a. If the internal target readings made at height-infinity and at range-infinity differ by more than the tolerance, adjust measuring drum adjuster as follows:

(1) Set the instrument for readings at zero elevation.

(2) Lock the fine elevation knob in center position.

(3) Carefully level the cradle and height finder telescope. Aline the elevation indexes. Check and use the optical tube level if the zero elevation indexes are damaged.

(4) Set the height-range lever at "HEIGHT."

(5) Set measuring drum at infinity.

(6) Set interpupillary distance and eyepiece diopter settings to suit observer's eyes.

(7) Take five internal target readings and set the correction knob scale to the median value obtained.

(8) Shift the height-range lever to the "RANGE" position.

(9) Take five internal readings at the range-infinity position.

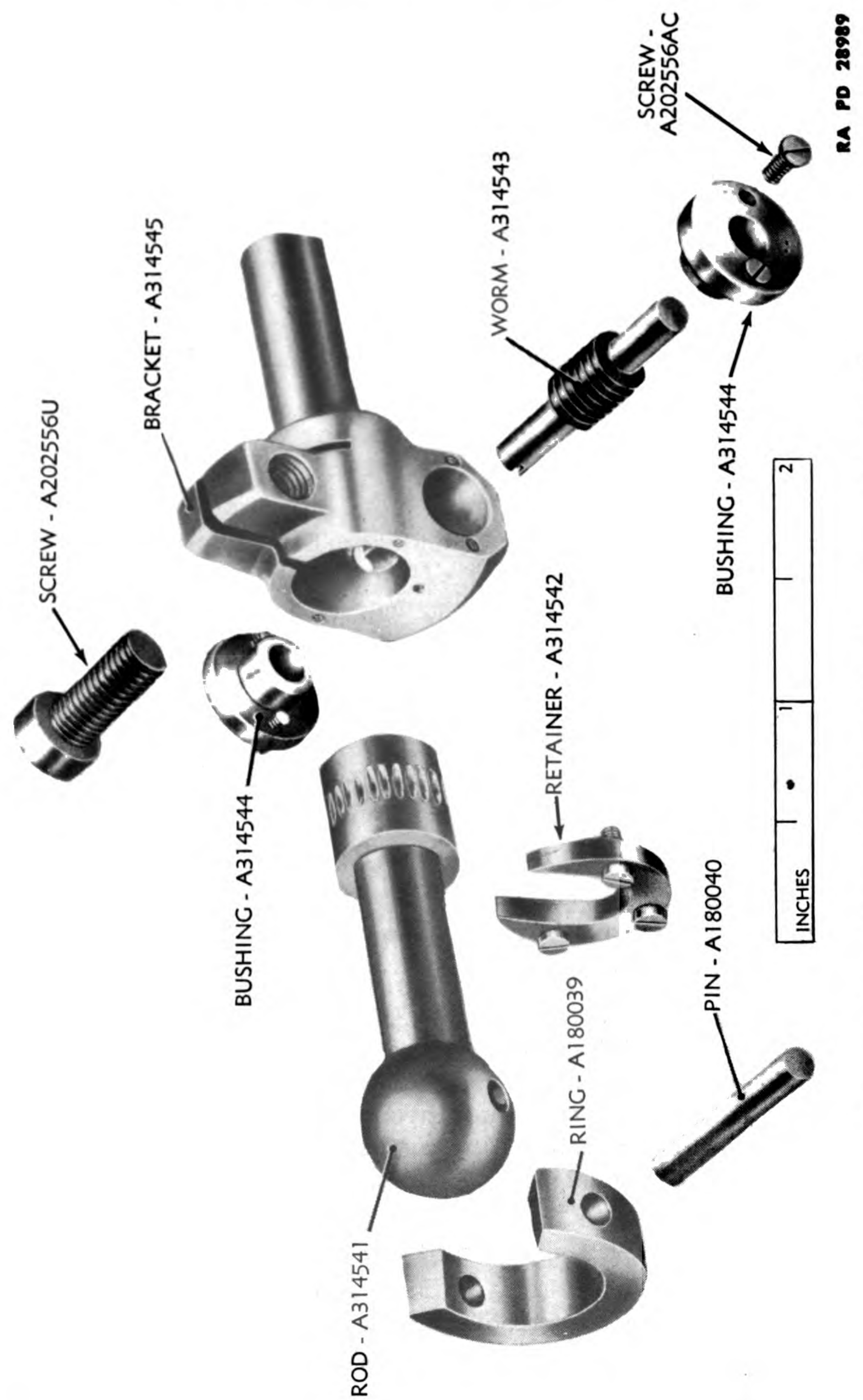


Figure 122 — Measuring Drum Adjuster — Exploded View

b. If the average of the readings taken in the range-infinity position do not come within the tolerance, the relative position of the compensator wedges and the measuring drum must be changed by rotating the worm on the drum adjuster assembly.

(1) Remove cover B171781 (fig. 123).

(2) Move the measuring knob until clamp screw A202556U and the slot on the adjusting worm (fig. 122) are observed.

(3) Loosen the clamp screw and rotate the worm.

NOTE: *If the readings taken in the range-infinity position are higher than those taken at height-infinity, rotate the worm in a clockwise direction.*

(4) Tighten the clamp screw.

(5) Set the measuring drum on infinity and repeat the above adjustment until the average of the readings taken at height-infinity and range-infinity agree within tolerance.

(6) When all adjustments are within tolerance, replace the measuring drum adjuster cover.

NOTE: *Figure 124 is an exploded view of a type of measuring drum adjuster used on low number instruments. To make adjustments as described above, one screw must be loosened, and the other tightened, to change the relative position of the measuring drum and compensator wedges.*

c. When the range adjustment has been brought within tolerance, check and, if necessary, adjust the height conversion mechanism as described in paragraph 128.

128. COMPENSATOR ASSEMBLY—HEIGHT CONVERSION ADJUSTMENT (HEIGHT-INFINITY—HEIGHT-900).

a. If the internal adjuster scale readings made at the two ends of the measuring drum scale (infinity and 900), with the height-range lever at "HEIGHT" and the instrument at zero elevation, do not agree within the tolerance, the height conversion locking bracket must be adjusted. It is important that the instrument be on its own cradle and that *both instrument and cradle be level* during this adjustment, and that the travel of the height conversion ring be exactly 90 degrees. Proceed as follows:

(1) Set the fine elevation knob in the central locked position.

(2) Set the measuring drum at "550" and the correction knob scale at the median of the five readings made at height-infinity.

(3) Remove the "HEIGHT" locking bracket and drive out the two guide pins.

(4) Assemble the bracket to the instrument with the four screws holding it snug but not tight.

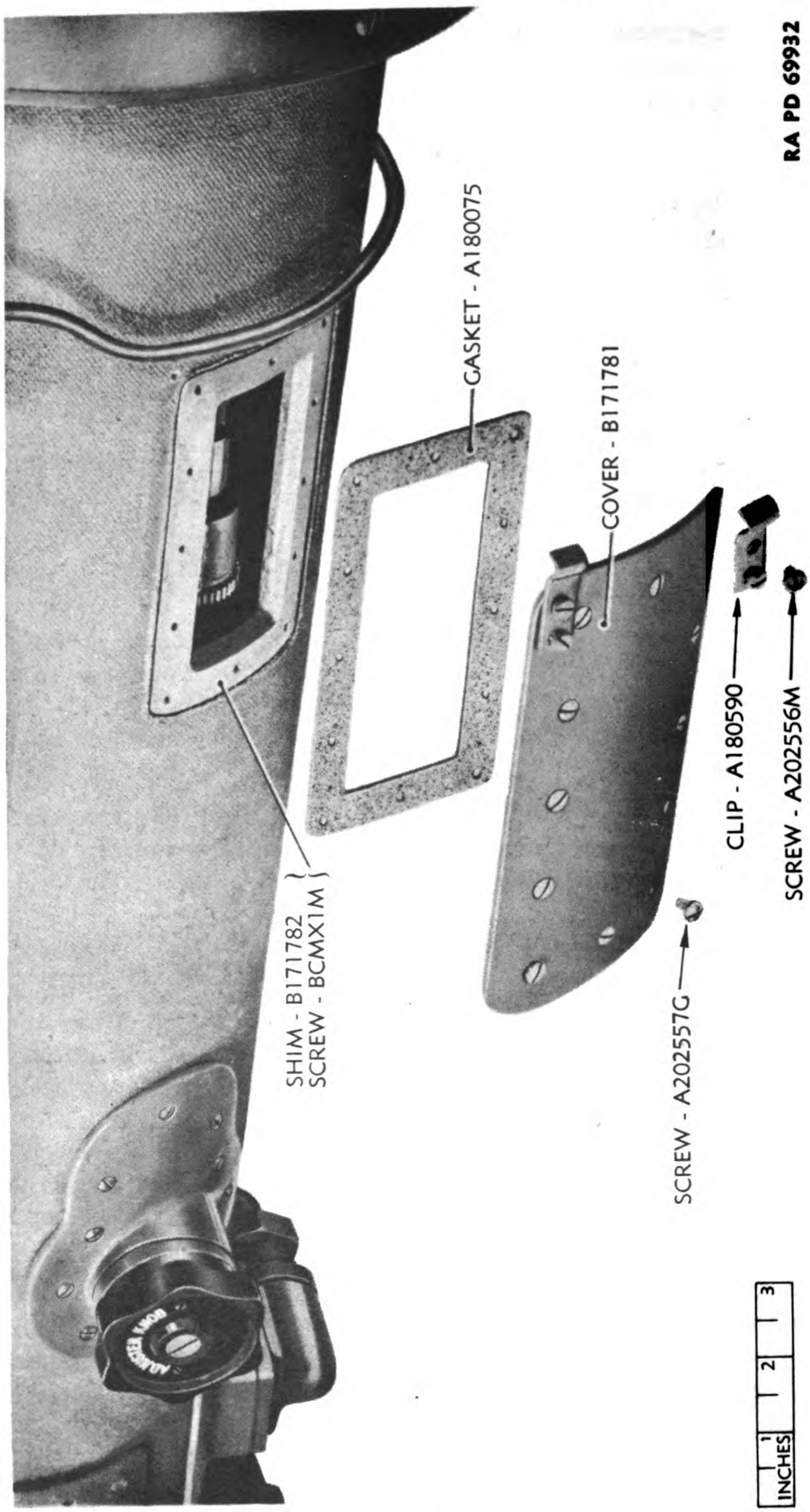


Figure 123 — Measuring Drum Adjuster Cover

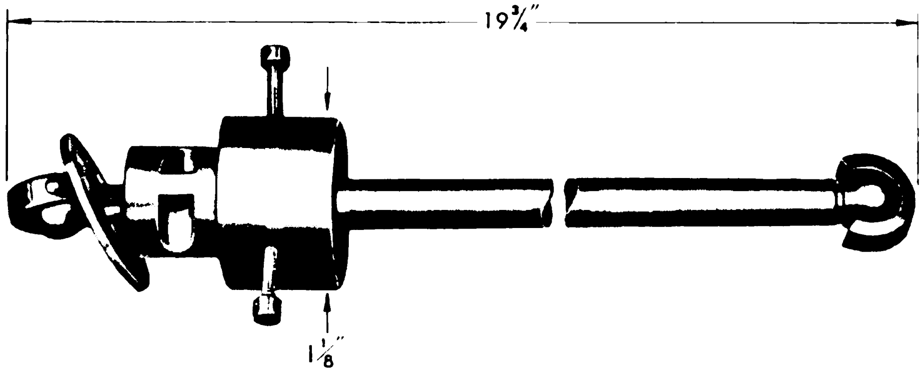


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Figure 124 — Range Drive Shaft Showing Adjuster

(5) Move the conversion ring up or down, observing the stereoscopic reticles. When a position is reached where stereo contact is made, shift the locking bracket to a position where the height-range lock lever will fit over the locking bracket without changing the stereo contact position (pars. 42 and 63).

(6) Tighten the screws in the locking bracket tight.

(7) Repeat range-infinity, height-infinity, and height-900 checks and adjustments as above until they agree within tolerance.

(8) When all adjustments are satisfactory, drill the locking bracket and housing for oversize pins and gently tap the pins into place.

NOTE: *When positioning the range drum at infinity and "550," approach the graduations on the drum to the index always in the same direction. When positioning the conversion ring lock, always come directly down and over the height locking bracket. This will keep backlash effect at a minimum.*

b. The distance between the height locking bracket and range locking bracket must be 90 degrees to obtain height readings (fictitious) within tolerances.

c. If the height locking bracket has been moved while making adjustments for range-infinity, height-infinity, and height-900, place the graduated arc and reading microscope on the instrument and adjust as described in paragraph 45 (fig. 66).

(1) Remove the range locking bracket and drive the guide pins out of the bracket.

(2) Replace the locking bracket on the instrument and replace the screws in the slotted holes.

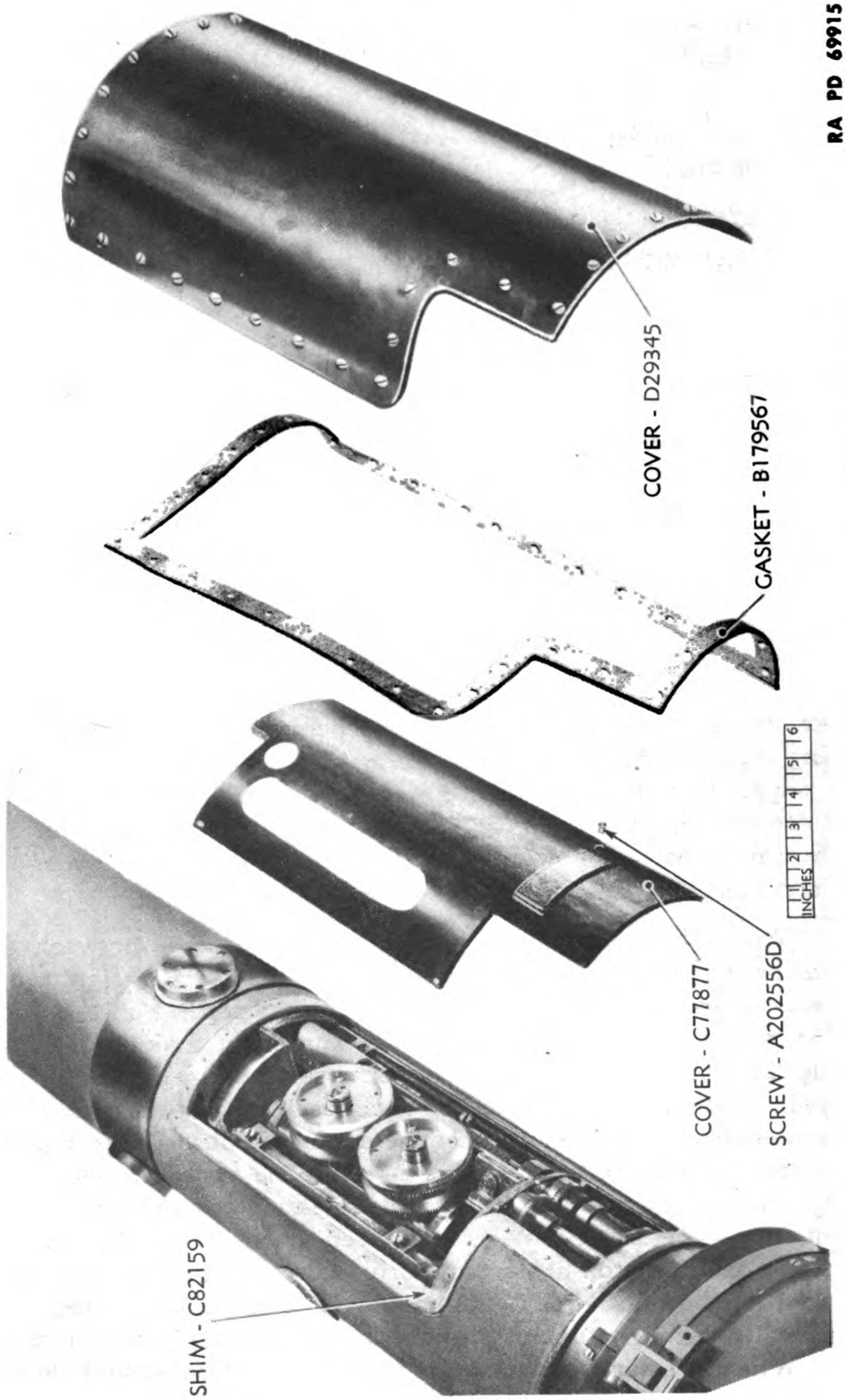


Figure 125 — Compensator Inner and Outer Covers — Exploded View

(3) Lock the height-range lock lever over the range locking bracket and tap the bracket with a hard rubber drift, until the 90-degree graduation is enclosed by the two cross hairs in the reading microscope (par. 45, fig. 66).

(4) Tighten the screws in the range locking bracket and repin with larger guide pins.

(5) Again check the following, preferably by two observers:

(a) Range-infinity, height-infinity, and height-900, making sure the telescope and cradle are level.

(b) Adjustment of end windows (pars. 161 and 162).

(c) Check the alinement of tracking telescopes (par. 189).

129. COMPENSATOR ASSEMBLY—REQUIREMENTS FOR REMOVAL AND DISASSEMBLY.

a. The compensator assembly has the combined function of range measurement and height conversion. It is the most complex assembly of the height finder and requires the highest mechanical precision in the fitting of its operating gear train. It is so constructed that it can be removed from the instrument and replaced as a unit, but it should never be disassembled, except in cases of absolute necessity. Unless proper equipment and trained personnel are available for making compensator repairs and alining the wedges, a complete new unit, supplied with its wedges adjusted and collimated, should be used for the replacement of a damaged or defective unit. Adjustments may be needed, however, and can be readily made, between the unit and the two controls which operate it.

b. There should not be any backlash or looseness between the four measuring wedges and the measuring drum or the height-range conversion gears; otherwise, the readings would depend on the direction in which the measuring knob was turned in making the final setting, and on whether the instrument was being elevated or depressed. Likewise, there should be no backlash in the measuring knob assembly, as this would inconvenience the observer in making rapid and accurate settings. Since it would be virtually impossible to eliminate all looseness in the complex gearing system required for height conversion, a backlash spring is used to urge the wedge mounts always in one direction against the drive gears so that any looseness is taken up and its effect eliminated. The backlash spring may occasionally become stuck or stretched, and need replacement or repair. When the backlash spring is in place, caution should be observed to avoid turning the shafts or gears of the compensator unit beyond the limits of the springs, which will stretch it and render it useless.

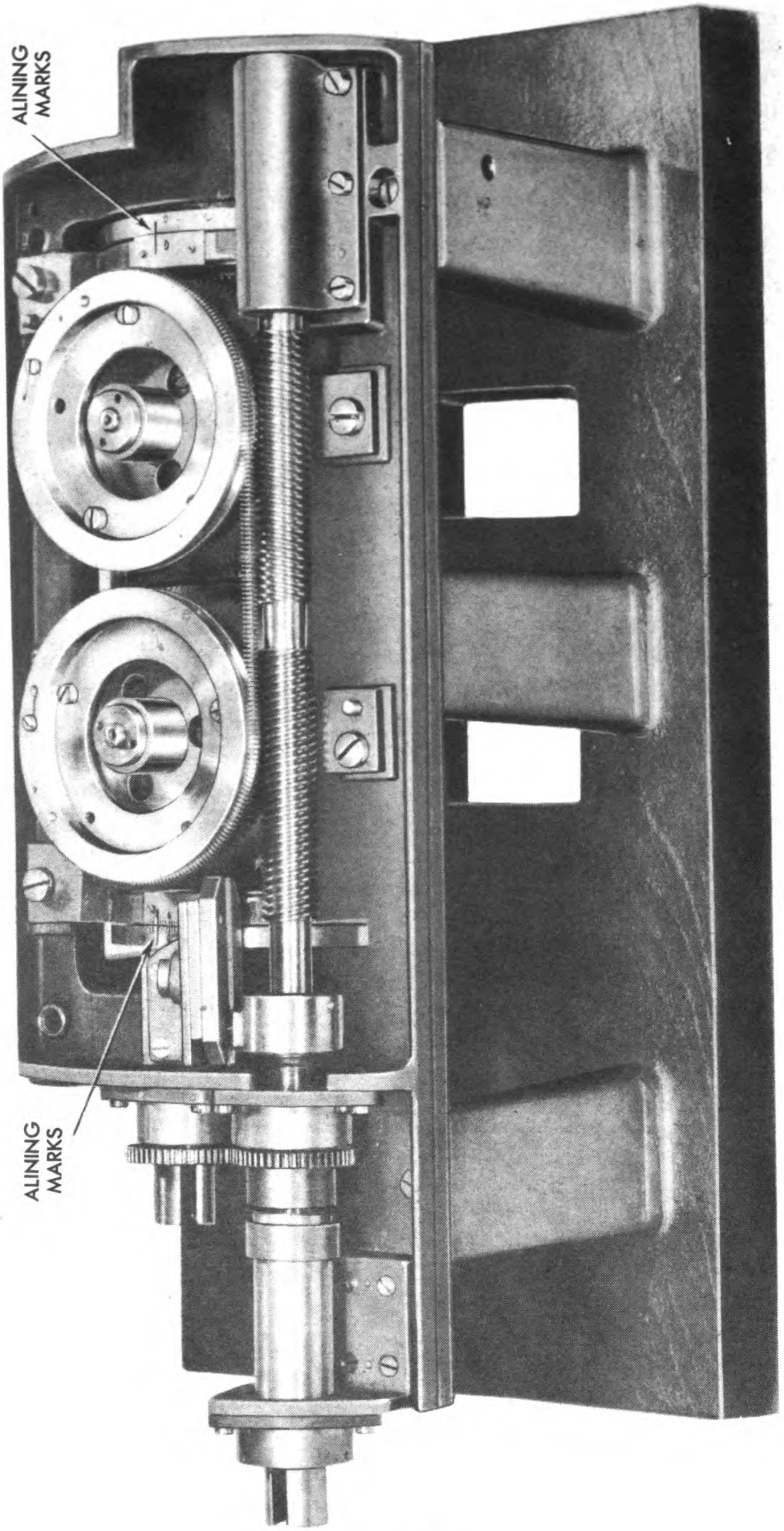


Figure 126 — Compensator Mounted on Assembly Plate

c. Removal of the compensator assembly involves breaking the hermetic seal of the instrument but, if proper precautions are taken, will not introduce undue difficulties. Disassembly and assembly, and replacement of wedges, will be done only at an authorized base shop having proper equipment and qualified personnel. If any one of the wedges requires replacement, all four wedges must be replaced by a new matched set of four. When new wedges are placed in an instrument, it usually is necessary to refocus the objectives. Adjustment of the wedges will require the use of an assembly plate and a mounting fixture as shown in figures 126 and 132.

130. COMPENSATOR ASSEMBLY—REMOVAL.

a. Removal of the compensator unit is necessary for removal of the inner tube. It will also permit the wedges to be cleaned. *Do not remove the wedges from their cells, nor the cells from the gear adapters, unless absolutely necessary.*

b. Remove the carrier handle assembly on the right side of the height finder telescope (par. 170).

c. Set the measuring drum to infinity and the height-range lock lever to the "RANGE" position.

d. Set the fine elevation knob in the central locked position.

e. Aline the zero elevation indexes.

f. Remove compensator cover D29345 (fig. 125). Be careful not to damage the cork gasket.

g. Take off dust cover C77877. NOTE: *Some of the later instruments do not have this cover.*

h. Scribe a fine line across both the index plate and the rotating scale of compensator, above or below the graduations on both right and left sides (fig. 126). NOTE: *This is the range-infinity position.*

i. Mark the engaging position of the measuring drum drive tube and the coupling (fig. 127) in which it fits, to make sure that they will be reassembled in the correct position. NOTE: *Both of the drive tubes are generally marked but, if not, be sure that this is done.*

j. Mark the engaging position of the ball ring on the elevation drive tube to coupling A179992 (fig. 129). Remove this tube when the compensator is taken out.

k. Remove the screws A202556V which secure the compensator frame D43426 to the adapter on the inner tube (fig. 127). Have an assistant remove the screws while the maintenance man holds the compensator in place, so it will not drop and spring the frame. CAUTION: *Do not remove the four screws which secure the compensator housing to the frame.*

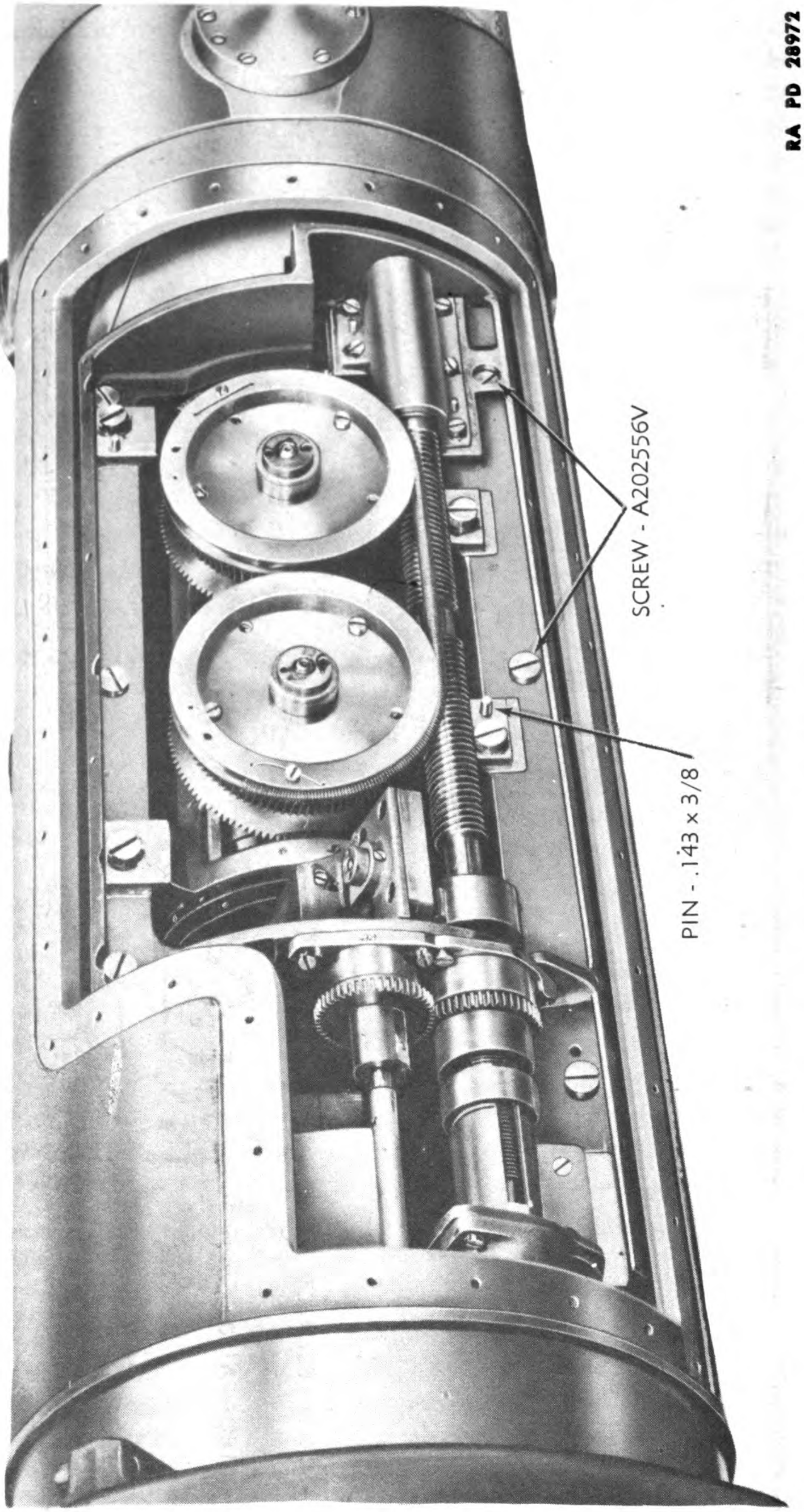


Figure 127 — Compensator Assembled in Height Finder Telescope

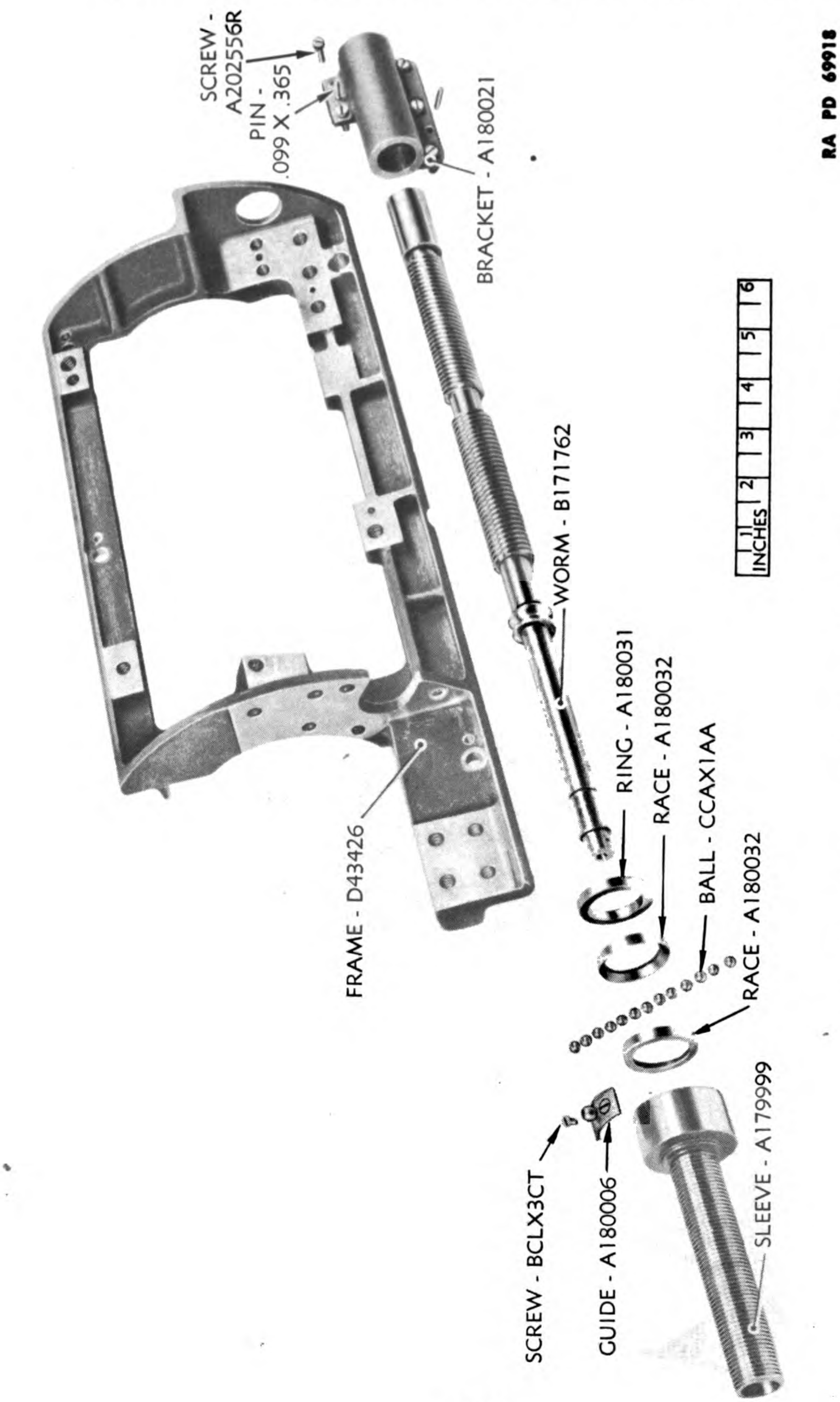
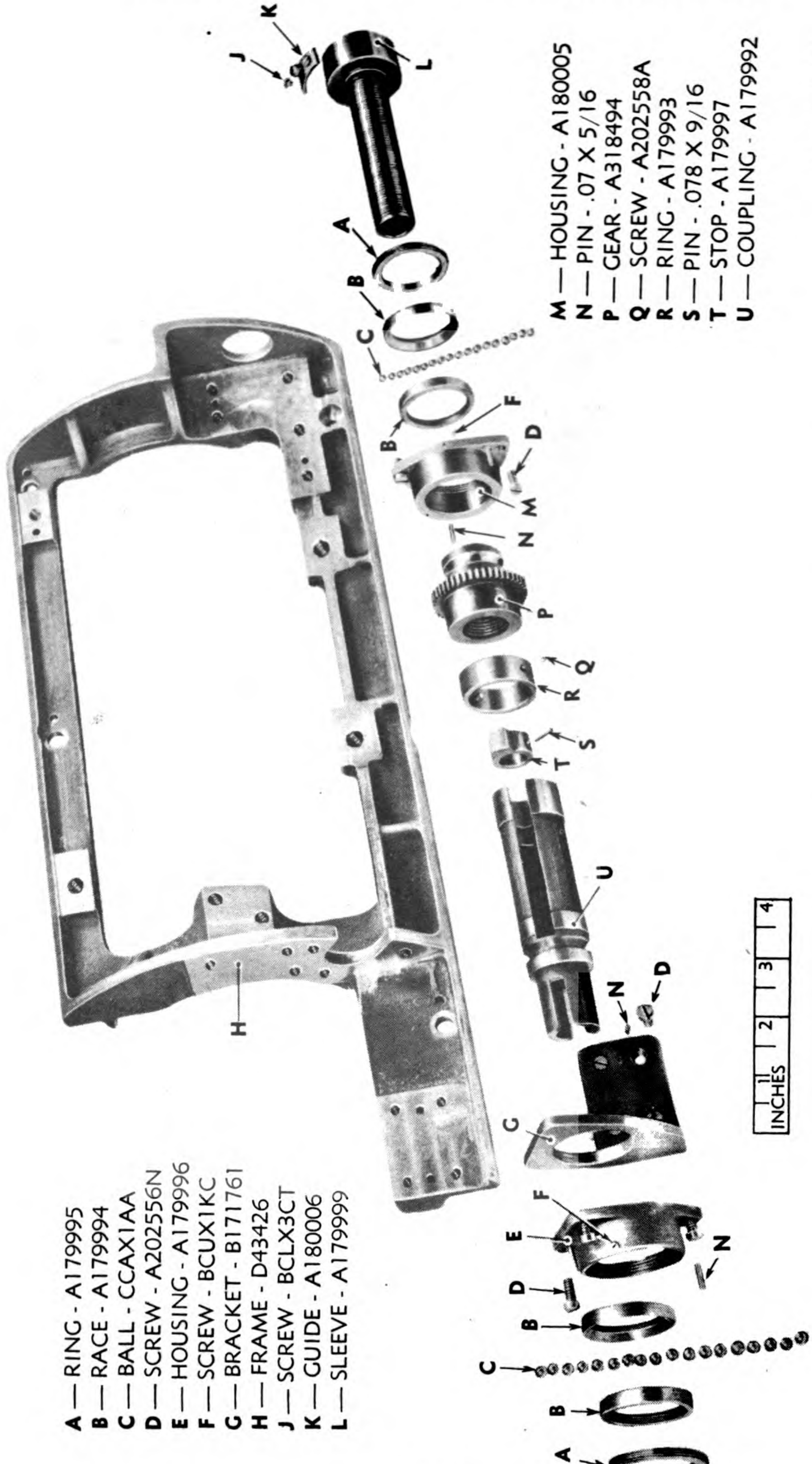


Figure 128 — Compensator Worm Shaft — Exploded View



A — RING - A179995
B — RACE - A179994
C — BALL - CCAX1AA
D — SCREW - A202556N
E — HOUSING - A179996
F — SCREW - BCUX1KC
G — BRACKET - B171761
H — FRAME - D43426
J — SCREW - BCLX3CT
K — GUIDE - A180006
L — SLEEVE - A179999

M — HOUSING - A180005
N — PIN - .07 X 5/16
P — GEAR - A318494
Q — SCREW - A202558A
R — RING - A179993
S — PIN - .078 X 9/16
T — STOP - A179997
U — COUPLING - A179992

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Figure 129 — Compensator Drive Mechanism — Exploded View

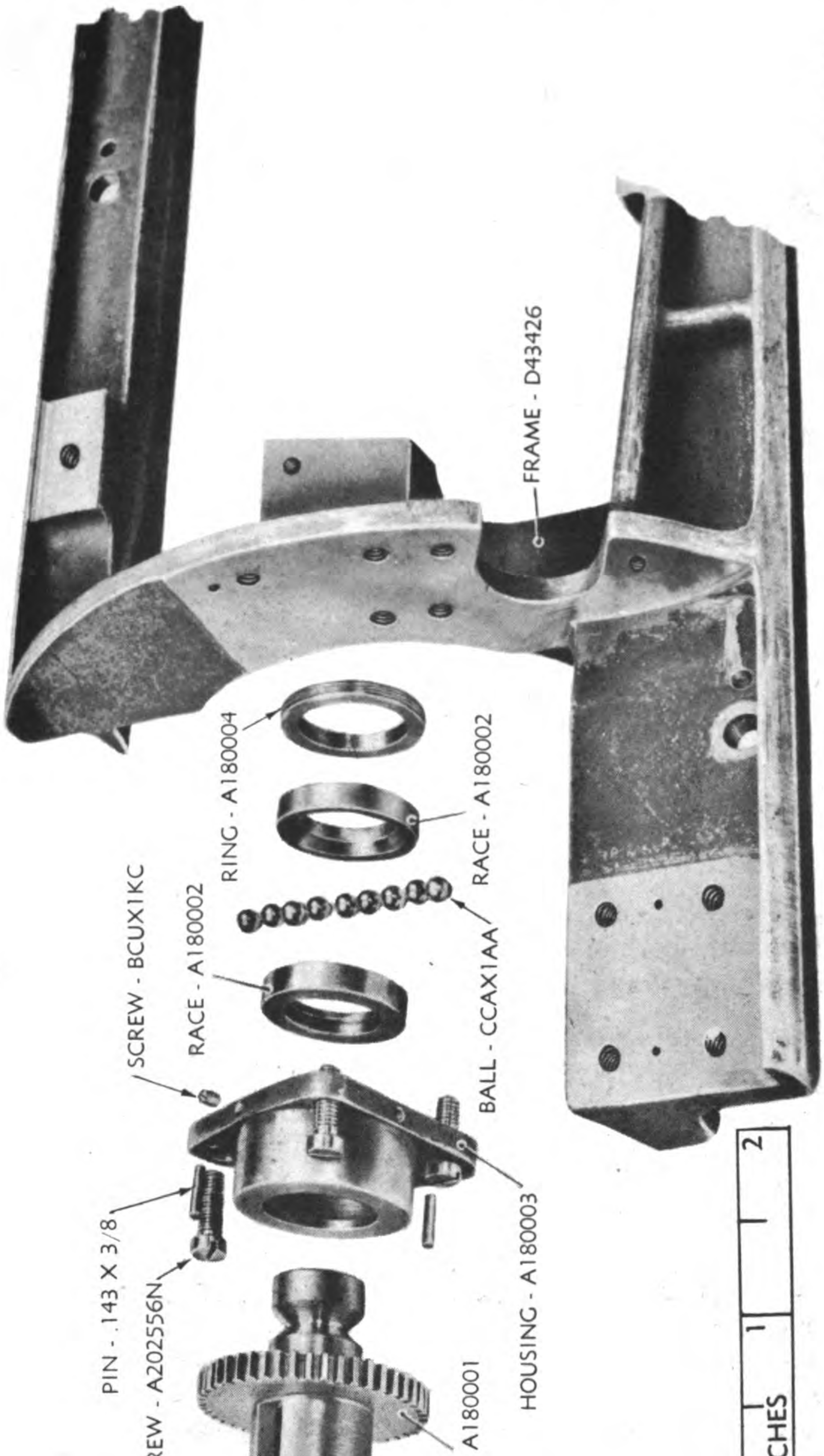

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Figure 130 — Compensator Drive Gear Assembly — Exploded View

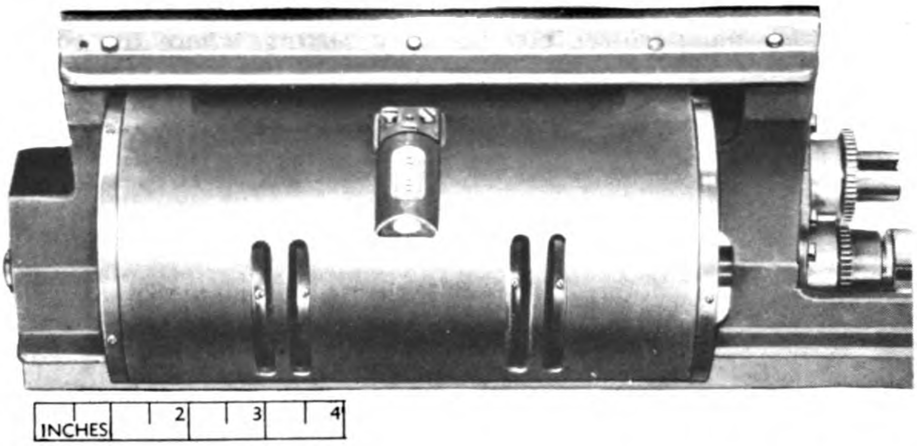

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Figure 131 – Bottom View of Compensator Showing Wedge Cell Locking Screws and Set Screws in Range-infinity Position

l. Remove the compensator assembly from its position in the inner tube. CAUTION: *Be sure to move compensator down before taking out, so as not to strike and damage the level.*

m. Secure the range drive tube near its free end to the inner tube with gummed tape.

131. COMPENSATOR ASSEMBLY REPLACEMENT.

a. For replacement of a damaged unit, a collimated compensator assembly, with wedges in place, is supplied as a single replacement component and should be installed as such.

b. Installation procedure follows, in general, the reverse order of removal, with the following additional steps:

(1) The range-height ball ring end must be fitted and adjusted to the range-height drive gear coupling A180001 (fig. 130).

(2) The height drive ball ring end must be fitted and adjusted to the height drive coupling A179992 (fig. 129). NOTE: *The ball rings should fit in the couplings with just a snug sliding fit.*

(3) The compensator must be assembled to the height finder to determine if the position of the ball ring ends of the connector tubes are oriented so it will not be necessary to move the range and height locking brackets. NOTE: *Range-infinity position of the compensator scales on all compensators received from spare parts will be marked by zeroes on both the scales on the compensator and the index on the frame scale.*

(4) Assemble the compensator to the height finder with the indexes alined at the range-infinity position. NOTE: *While alining*

the scales, check the cell set screws as shown in figure 131. Range-infinity is the only position, and the only setting, where the screws will be so alined.

(5) Assemble the connector tube from the conversion mechanism first. NOTE: *A bent wire will assist in locating the ball ring to the coupling.*

(6) Have an assistant assemble the range-height drive tube to the range-height gear coupling, move the compensator into place, and secure the compensator frame screws.

(7) If the tube connector is properly alined for the new compensator unit, the measuring drum can be adjusted to infinity, and the indexes on the compensator will be alined.

CAUTION: *Make certain the height finder is level, while performing the tests below.*

(8) Make height-infinity—range-infinity adjustment by adjusting the measuring drum adjuster (fig. 122). When the two position averages are within tolerance, make height-900 adjustment with the mean of range-infinity—height-infinity readings set on the correction knob scale.

(9) The height locking bracket should require but slight shifting.

(10) If, due to the pinned position of the height drive ball tube, stereo contact cannot be made by moving the conversion lever up or down slightly when near the approximate height locking position, the ball ring section of the height drive tube will have to be unpinned and shifted in the tube. Proceed as follows:

(a) Set the instrument for internal readings.

(b) Make height-infinity—range-infinity adjustment as described above.

(c) Set the measuring drum at "550," and move the conversion ring lock lever to the position where stereo contact is made with the internal target and reticles, when the averages of the readings taken at range-infinity and height-infinity are set on the correction knob scale.

(11) If the height locking bracket must be moved excessively, proceed as follows:

(a) Remove the compensator from the instrument.

(b) Remove the height drive tube, and remove the pins that hold the end section of the ball ring in the tube at the compensator coupling end.

(c) Remove the ball ring section from the tube, or be certain that the ball ring section will rotate in the tube with considerable tension.

(d) Assemble the compensator to the height finder with the drive tubes in place as above.

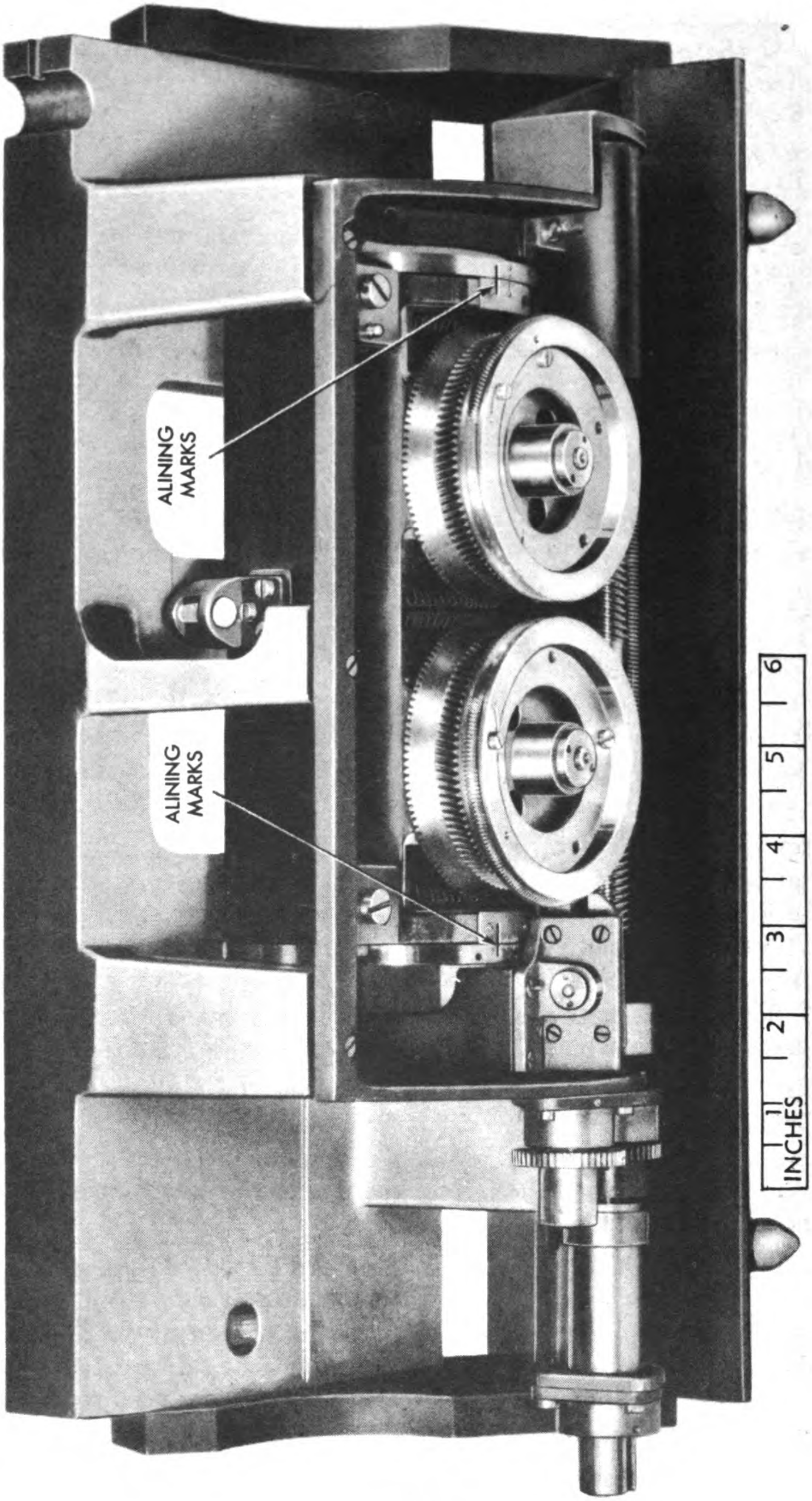

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Figure 132 — Compensator Mounted on Adjusting Fixture

(e) Make height-infinity and range-infinity adjustment.

(f) Set the measuring drum to "550."

(g) Position the conversion ring lock lever over the height locking bracket.

(h) Rotate the height drive coupling of the compensator by hand until stereoscopic contact is made with the internal adjuster target and reticles, when the correction knob scale is set at the average of the readings of the adjustment height-infinity—range-infinity.

(i) Mark the tube and ball ring end while in place, or place a clamp on the tube to hold the ball and in the tube without turning as the compensator is removed.

(j) Remove the compensator and repin the height drive tube.

(k) Assemble the compensator to the height finder and recheck all adjustments described above.

132. COMPENSATOR ASSEMBLY—REPLACEMENT AND ADJUSTMENT OF INDIVIDUAL WEDGES.

a. The optical portion of the compensator consists of four equal-angle wedges, 63-mm diameter × 14 mm, which can be so rotated that they neutralize the parallactic angle of a distant target. Each wedge consists of an "A" (Crown) and "B" (Flint) element in optical contact, forming an achromatized unit that has a deviation of 8 minutes 13.16 seconds.

b. A small 90-degree notch is cut into the "B" element of each of the wedges *opposite the base.* This is done to secure the wedge in the wedge cell with a small set screw, to prevent shifting. Two of these notches are seen opposite the other two when the compensator is level and the worm is near the left extremity of its lateral motion (range-infinity position) (fig. 121). Figure 121 shows the position of the wedges in relation to the notches when in the range-infinity position, and when in the height-infinity position.

c. The wedges are optically paired at the factory, so if any one of them has to be replaced, all four wedges must be replaced by a new matched set of four. NOTE: *When new wedges are replaced in an instrument, it usually is necessary to refocus the right objective and make across-the-field check (par. 116).*

d. Adjustment of the individual wedges, with the compensator unit removed from the instrument, is required only if the wedge cells or mounting gears have been disturbed or disassembly of the unit has to be made for cleaning. The adjustment should be performed only at a base shop or arsenal where qualified ordnance personnel and equipment are available.

e. A fixture, such as an adaptable angle plate and mount (fig. 132)

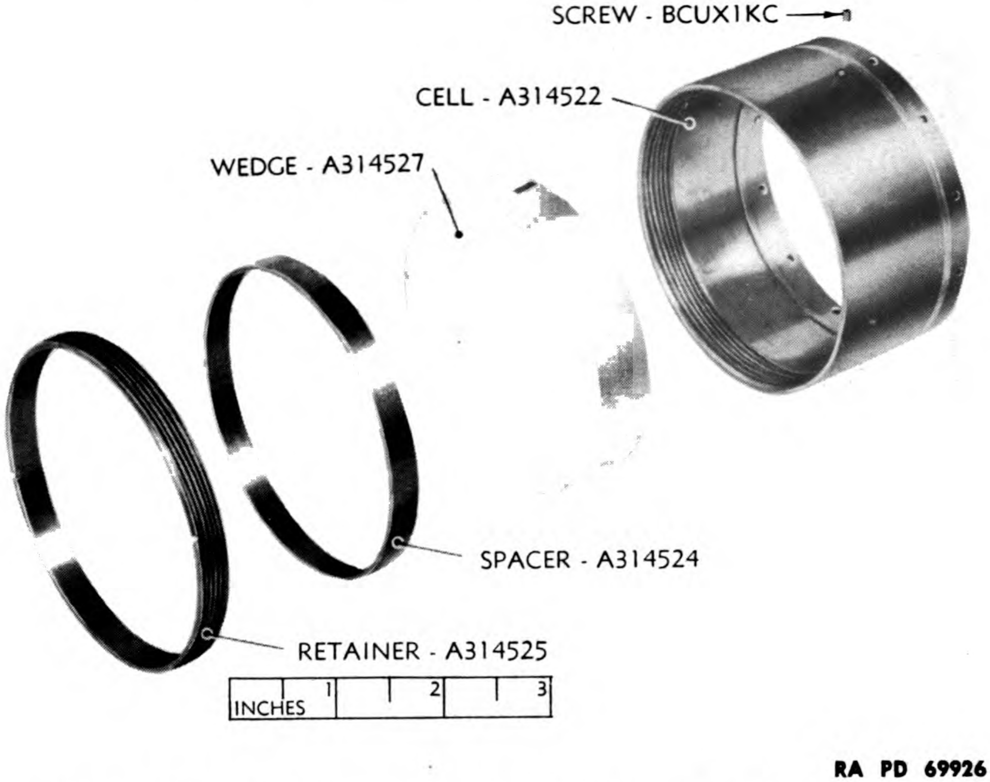


Figure 133 — Compensator Wedge (Outer) — Exploded From Cell

is needed to support the measuring wedge unit in the position it occupies in a leveled and horizontal height finder, with the mounting surface at 30 degrees from the horizontal. This angle can be set very accurately, and maintained by using the compensator level.

f. The compensator need not be completely disassembled to remove the measuring wedges. Proceed as follows:

(1) Make sure that the compensator is set at range-infinity position according to scribed lines, and as directed in step (3), below. NOTE: *When the compensator is inverted as shown in figure 131, the four set screws that secure the wedge cells are visible in the four openings as shown. Range-infinity is the only position of the wedge cells where these screws can be seen.*

(2) Loosen these set screws which have been shellacked to keep them from working free. Shellac also has been applied to each of the wedge cells, and must be softened by applying alcohol with a small brush and allowing to stand about a half hour before being removed.

(3) Remove the outer wedge cell assembly A314522 (fig. 133) from the left end of the compensator by engaging the special wedge cell puller (fig. 77) in the holes in the retainer A314525 (fig. 133)

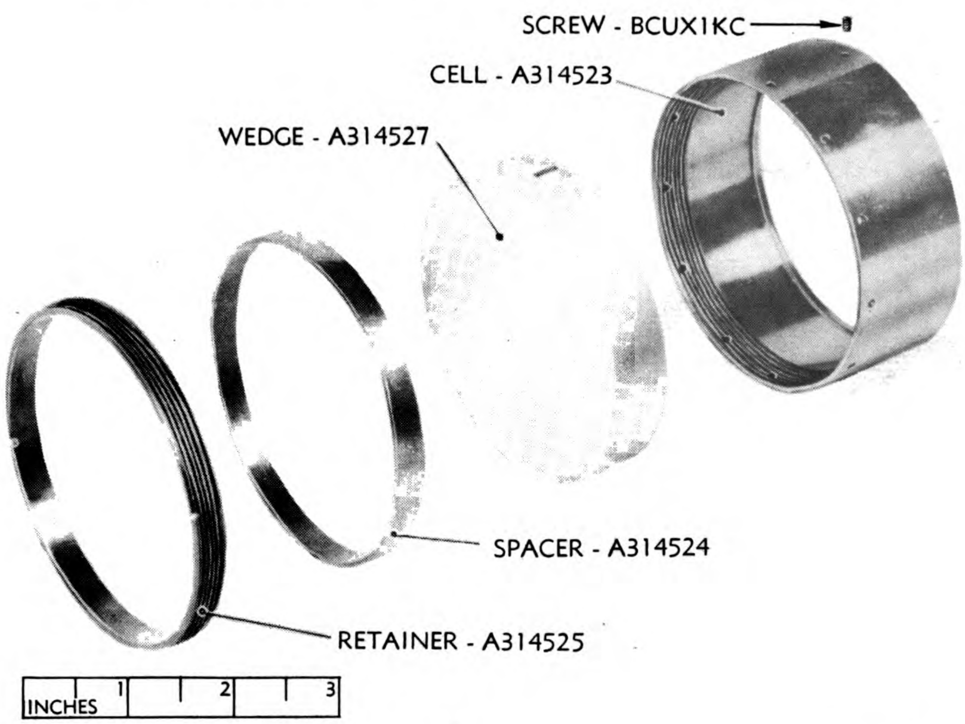


Figure 134 — Compensator Wedge (Inner) — Exploded From Cell

and pulling straight out. This cell contains wedge number 1 and should be so marked.

(4) Remove the inner wedge cell from the left end of the compensator and mark number 2.

(5) Remove the outer wedge cell assembly from the right side and mark number 4.

(6) The last wedge cell to be removed and marked, is number 3.

(7) The wedges can be removed from the cell by loosening the set screw BCUX1KC, unscrewing retainer ring A314525, and removing spacer A314524 (fig. 134).

NOTE: *When the wedge is reassembled in the wedge cell, the set screw should engage the slot and be screwed down with very light pressure until it first touches the glass, and then backed off a half turn so that no strain will be developed in the glass.*

133. COMPENSATOR ASSEMBLY—REMOVING THE BALL RACES AND ADAPTERS.

a. This will be necessary only after the instrument has been in service for a long period of time, has been used in tropical climates, or if the gears and balls and races have been injured in some way.

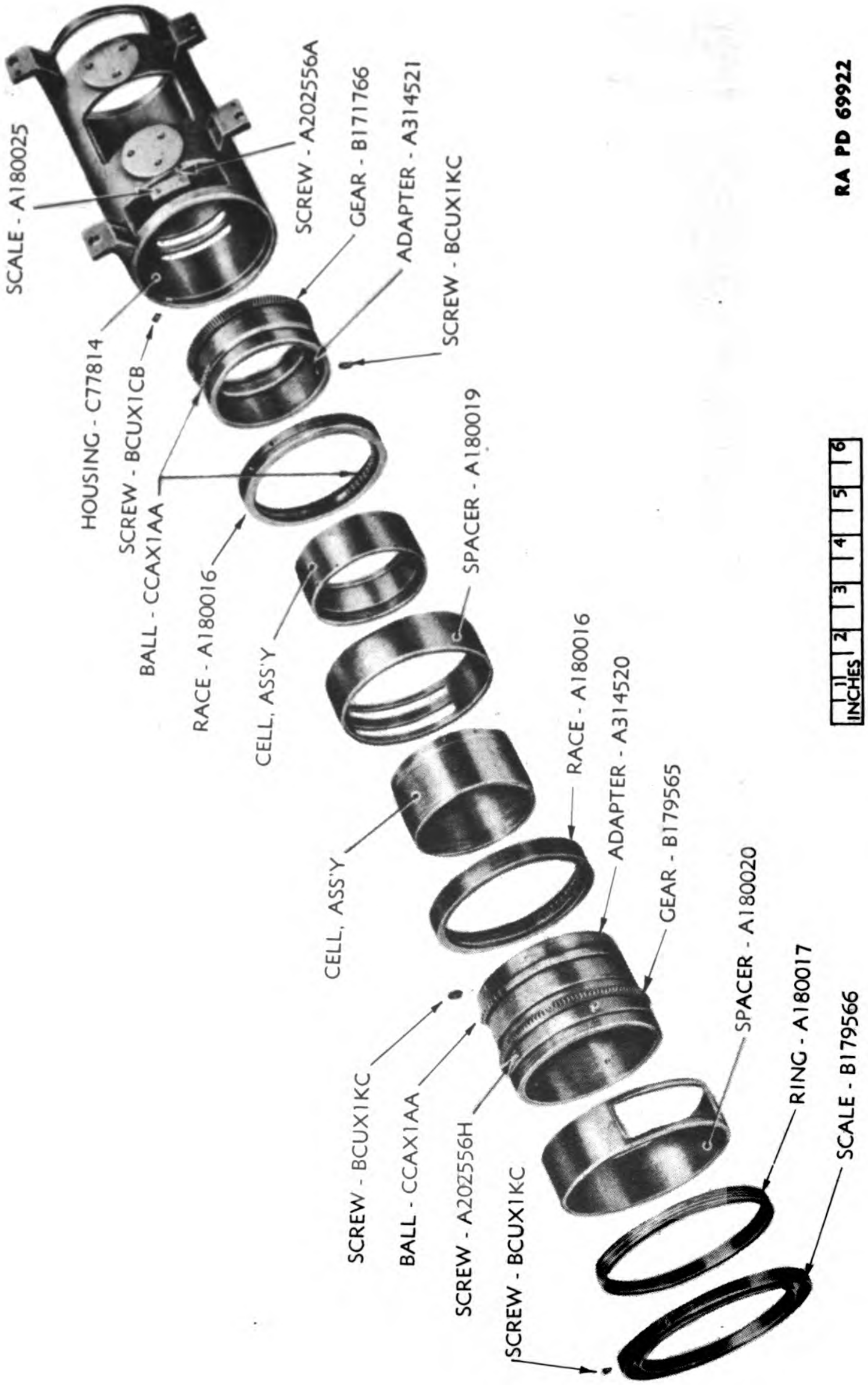


Figure 135 — Compensator Wedge Cell Gears and Adapter — Exploded View

b. Mark *each* and *every part* of the *assembly* before it is *removed,* so they may be reassembled in the *exact reverse* order.

c. Loosen the three set screws and remove the scale ring B179566 (fig. 135).

NOTE: *There are three scales on each scale ring. One scale on each is used to set and check the compensator in the range-infinity position, and the other two are used at the factory to assist in manufacture. It is important that the range-infinity scale used, be marked for identification and for position on the cell to which it is attached.*

d. Loosen set screw on under side of compensator housing which secures lock ring A180017 (fig. 135), mark lock ring for position, unscrew, and remove.

e. Remove the brass spacer A180020.

f. When the bevel gear adapter A314520 is withdrawn, one section of the ball race A180016 and the balls will come with it. (Do *not* remove the bevel gear B179565 from the adapter.)

g. Remove the other section of the ball race and the spacer A180019.

h. Withdraw the next gear adapter which will bring out one section of the ball race and balls.

i. Remove the other section of the ball race.

j. Repeat the same procedure on the opposite end of the housing.

k. Each ball race holds 61 steel balls. A small can perforated with many small holes, bur to the outside, may be used to wash grease off the balls by immersing the can and balls in grease-removing fluid. A small brass or copper spoon will assist in replacing the balls when reassembling.

l. Clean and examine all the parts removed.

m. Grease the ball races sparingly with a light grease.

n. Reassemble the ball races, adapters, spacers, and scale rings in the *exact reverse order* of disassembly.

134. COMPENSATOR ASSEMBLY—INSERTING AND ADJUSTING THE WEDGES.

a. The compensator scales must be set at zero in the range-infinity position, and the ball guide A180006 on sleeve A179999 (fig. 129) should be positioned approximately one turn from the compensator frame. This position is obtained by rotating the coupling sleeve gear. To properly assemble and adjust the measuring wedges, the assembly plate (fig. 126) should be mounted in an assembly fixture such as shown in figure 132. This holds the com-

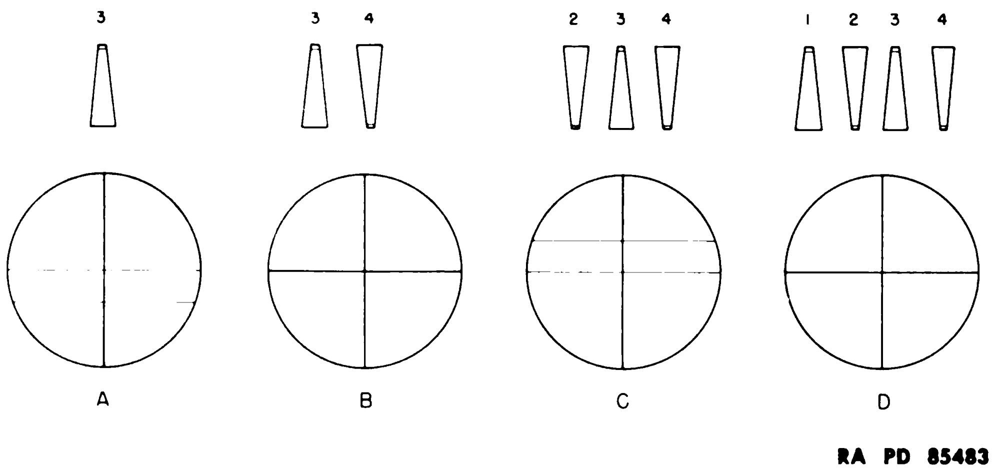


Figure 136 — Appearance of Collimator Cross Lines When Wedges Are Being Assembled

pensator with the level in such a position that it can be accurately leveled by means of adjusting screws in the base of the fixture.

b. The compensator mounted in the test fixture should be placed between two collimators, each with cross lines, one of which should have an eyepiece that will focus on both cross lines. The collimators should be adjusted so that the cross lines in one collimator are superimposed on the other as seen through the eyepiece.

c. If collimators are not available, two transits may be used, placed 6 to 8 feet apart then leveled and focused so the reticles are superimposed. The compensator should be placed about half way between them.

d. If only one transit is available, cross lines of fine black thread may be used on a background of white paper, placed 40 or 50 feet from the transit. Level the transit carefully, and adjust the cross lines on the paper until they are covered by the cross lines in the transit. Place the compensator in its fixture directly in front of the transit with the right end of the compensator about 3 feet away, and level the compensator.

e. If two collimators are used, proceed as follows:

(1) Mount the compensator in the adjusting fixture and place it between the two collimator telescopes as described above.

(2) By means of the leveling screws, adjust the fixture until the level bubble of the compensator is centered and the telescope is sighted directly through the center line of the compensator housing.

(3) Clean all four wedges very carefully.

NOTE: *The 90-degree notch cut into the flint element of the wedge is* opposite *the base of the wedge.*

(4) Place number 3 wedge cell into the right end of the compensator with the base down, and grooved end toward the right. Push into the inner adapter as far as it will go.

(5) Insert an adjusting pin in the adjusting holes of number 3 wedge cell, and rotate it until the collimator vertical cross line falls exactly on the telescope vertical cross line. The collimator horizontal cross line will then be parallel but below the telescope horizontal cross line. The appearance of the cross line images to an observer will be as shown in "A," figure 136.

(6) Secure the wedge cell by means of the set screw, firmly but not too tight. Apply varnish shellac around the end of the cell to secure it to the adapter.

(7) Place number 4 wedge cell in the right end of the compensator with the base up and the grooved end in first. Push the cell into the adapter until the groove lines up with the set screw hole.

(8) Rotate number 4 wedge cell until both cross lines of the collimator and the telescope are exactly superimposed, thus the upward deviation of wedge number 4 cancels the downward deviation of wedge number 3. The appearance through the eyepiece will then be as shown in "B," figure 136. Secure the wedge cell by means of the set screw and apply varnish shellac.

(9) Place number 2 wedge into the left end of the compensator with the base up and the grooved end to the left. Push into the adapter as far as it will go.

(10) Wedge cell number 2 should be rotated until the collimator vertical cross line falls exactly on the telescope vertical cross line. The collimator horizontal cross line will then be parallel but above the telescope horizontal cross line. The appearance of the cross line images to an observer will be as shown in "C," figure 136. Secure the wedge cell by means of the set screw and apply varnish shellac.

(11) Place number 1 wedge into the left end of the compensator with the base down and the grooved end in first. Push the cell into the adapter until the groove lines up with the set screw hole.

(12) Wedge cell number 1 must be rotated until the cross lines are superimposed, thus the downward deviation of wedge number 1 cancels the upward deviation of wedge number 2. The appearance of the cross line images to an observer will be as shown in "D," figure 136. Secure the wedge cell by means of the set screw and apply shellac.

(13) Apply a small spot of varnish shellac around each of the four set screws to prevent loosening in service.

NOTE: *If a transit or other engineering telescope with erecting system is used in place of the collimators. the horizontal cross line*

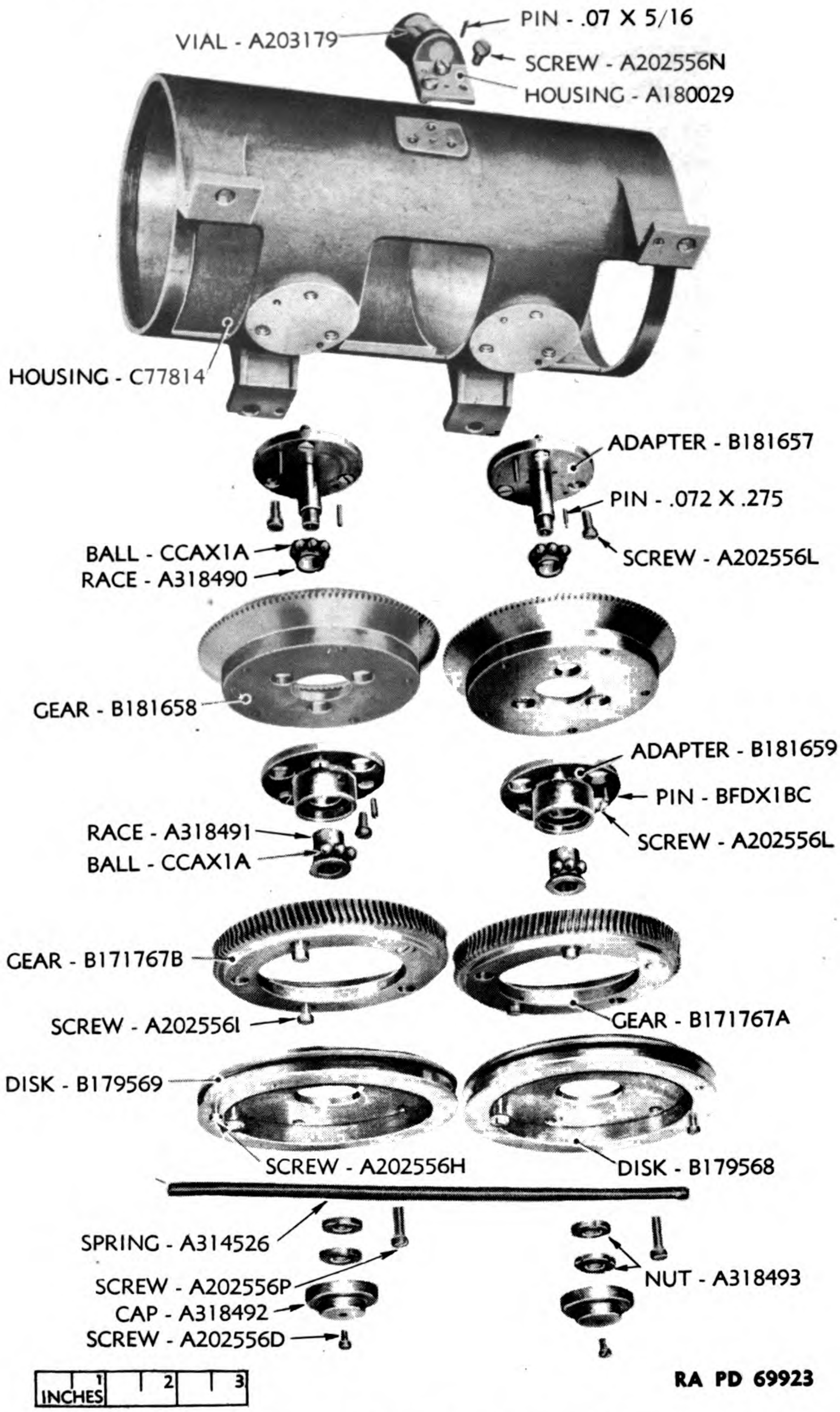


Figure 137 — Compensator Worm Wheel Assemblies (Ball-bearing Type) — Exploded View

image will be seen above the telescope horizontal cross line instead of below, and below instead of above.

(14) Check the adjustment of the four wedges by turning the range shaft clockwise and counterclockwise about six turns each way. The image of the target should travel back and forth horizontally with no changes in height. If the travel of the image is not horizontal, the wedges are not correctly adjusted.

135. COMPENSATOR ASSEMBLY—COMPLETE DISASSEMBLY.

a. If complete disassembly for repairs and adjustment is necessary, the following conditions must be fulfilled:

(1) Only an authorized highly skilled instrument repairman should be selected to do this work.

(2) The special assembly plate and adjusting fixture described in paragraph 132 **e**, will be required.

(3) Special tools such as described in paragraph 84 will be found very useful, in addition to the regular tools used by instrument makers and repairmen.

(4) The work should be done in a room where dust can be kept to a minimum.

(5) The meshing position of each of the spur gears, bevel gears, worms, and wheels must be marked so that they can be reassembled in exactly the same relation. All brackets, housings, etc. should also be marked to insure correct reassembly.

b. Remove the wedge cells as described in paragraph 134 **e** (3) to (12).

c. Disassemble the ball races and adapters as described in paragraph 133.

d. Remove coil spring A314526 (fig. 137) and spring disks B179568 and B179569 (fig. 137). (These were used on later instruments only.)

e. Remove three screws and take off gear housing assembly A180003 (fig. 130).

f. Remove three screws in coupling housing A179996 and loosen screws in coupling ring A179993 (fig. 129).

g. Pry coupling housing A179996 loose, and slide both housing and coupling A179992 (fig. 129) to the left. Coupling ring A179993 will be eased off and can be removed.

h. Remove screws in coupling bracket B171761 (fig. 129) and pry off this part.

i. Remove screws in sleeve gear housing A180005 (fig. 129) and

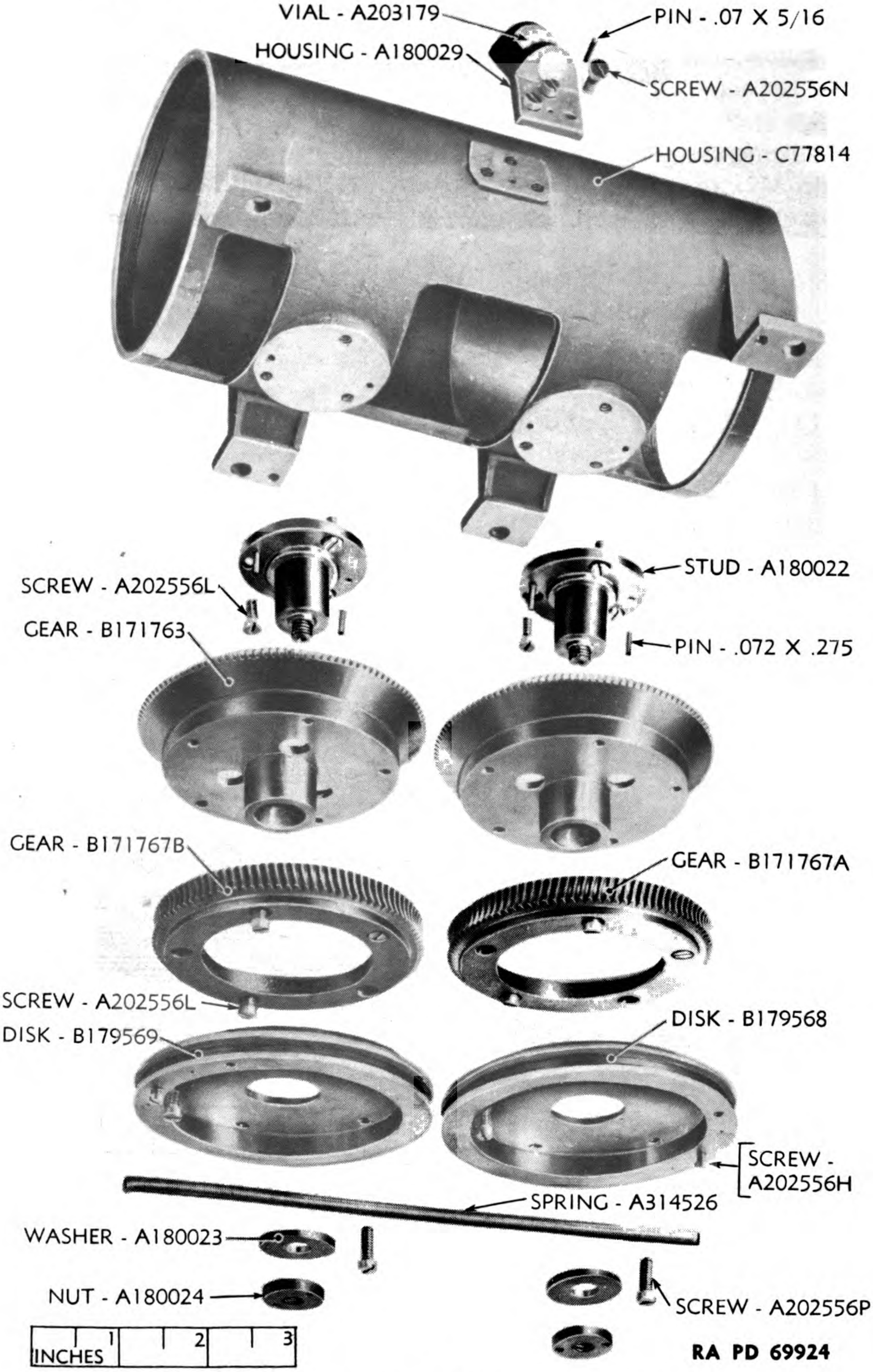
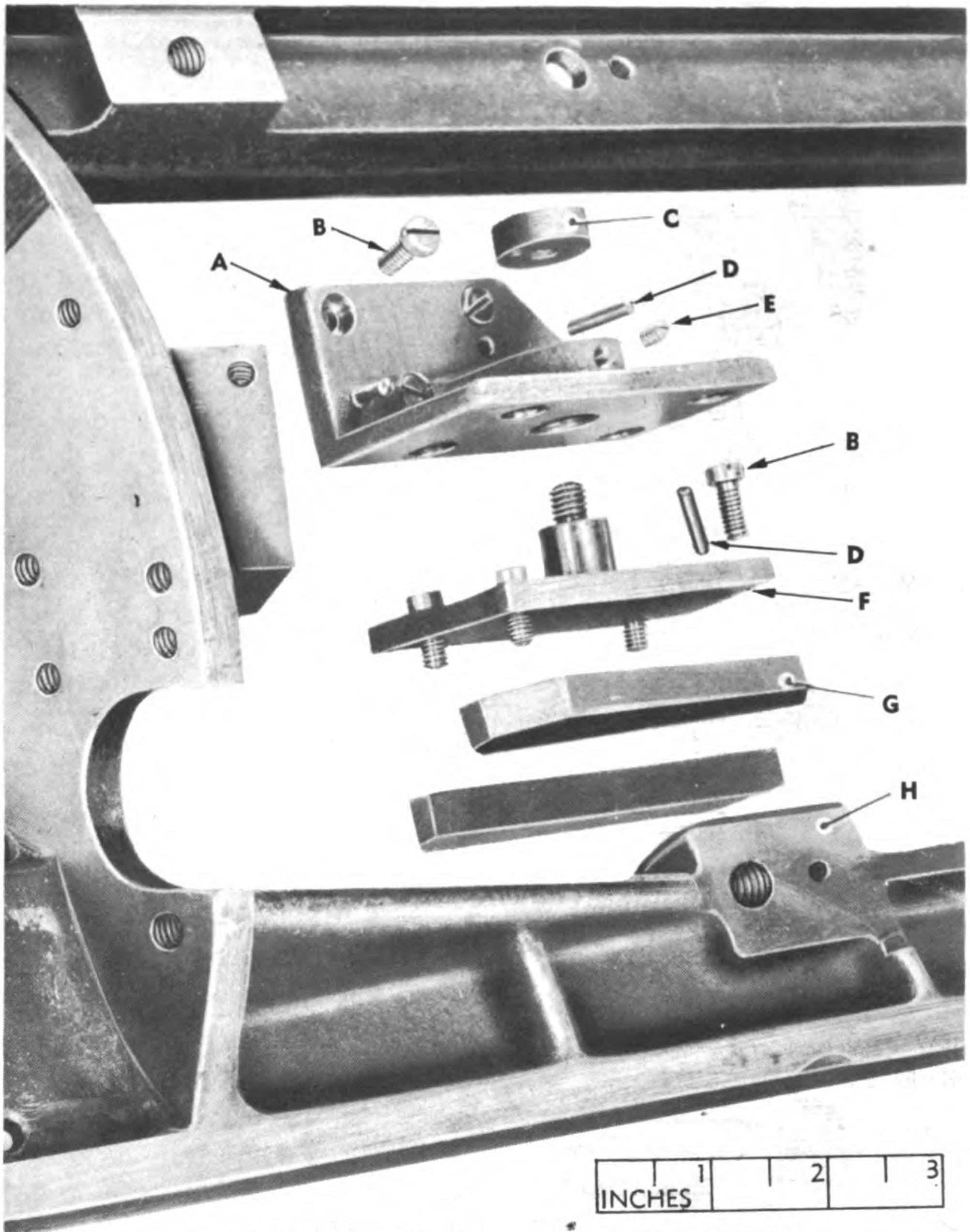


Figure 138 — Compensator Bevel Gear Assemblies (Plain-bearing Type) — Exploded View



A — BRACKET - A180007
B — SCREW - A202556K
C — NUT - A180030
D — PIN - .07 X 5/16
E — SCREW - BCUX1KC
F — PIVOT - A180009
G — RAIL - A180008
H — FRAME - D43426

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Figure 139 — Compensator Ball Guide Mechanism — Exploded View

those in worm bearing bracket A180021 (fig. 128) and pry both loose from the frame.

j. The worm shaft B171762 (fig. 128) together with housing A180005 and bracket A180021 can now be removed from the frame.

k. Remove three screws and take off correction guide rail bracket assembly A180007 (fig. 139).

CAUTION: *Do not remove nut A180030, or set screw BCUX1KC (fig. 139). These secure the correction guide rails A180008 which are positioned at the factory to increase or decrease the travel of the worm as the range scale is moved from infinity to low range. No adjustment is required unless the position of the guide rails has changed, due to accidental causes.*

l. Remove the two 0.143 x 3/8 pins and the four screws A202556V (fig. 127) that hold the compensator housing assembly to the main frame D43426. Slide the frame back to allow play between the worm B171762 and the worm wheels.

m. Remove nuts A180024 (fig. 138), or cap A318492 (fig. 137), and take off both worm and bevel gear assemblies. Check the lubrication between stud A180022 and bevel gear B171763 (fig. 138). Be sure that all of these parts are so marked so that they will be reassembled in the correct position.

n. Remove the screws in stud A180022 (fig. 138), for adapter B181657 (fig. 137), and carefully pry loose, taking care not to damage the guide pins. Figure 138 shows the plain bearing mount and figure 137 the later ball bearing mount.

o. Remove the compensator housing assembly C77814 (figs. 137 and 138) from the frame D43426 (fig. 139).

p. Check the frame to determine if it has been sprung.

(1) Remove the screws that hold the frame in the assembly plate (fig. 126).

(2) Tap the frame with one finger directly over each of the legs of the assembly plate where there is a bearing surface.

(3) If a tilt is detected, note where, and straighten the frame until it rests evenly on each leg of the assembly plate. NOTE: *Most compensator frames have six bearing surfaces; however, on the later types only three are provided.*

136. COMPENSATOR ASSEMBLY—ASSEMBLING THE COMPENSATOR.

a. Reassembly should be done in the exact reverse order of disassembly, and particular attention must be paid to alining reference marks.

b. The wedges should not be replaced until the rest of the compensator has been assembled.

c. The edge of ball sleeve A179999 (fig. 128) must be positioned approximately one turn of the thread to the right, to clear the compensator frame.

d. When the marks on the scale rings are alined with the marks on the infinity scale, the four set screws locking the wedge cells will then be seen through the openings in the bottom of the compensator in a direct line if the assemblies have been correctly made (fig. 131).

e. All gears should be carefully checked to insure smooth operation without backlash.

f. Make certain there is no binding or shake in any of the bearings. Any shake between the ball guide A180006 (fig. 137) and the guide rails A180008 (fig. 139) must be eliminated by loosening the screws in one rail, forcing it closer to the other, and then retightening the screws. Check for shake along the entire travel of the ball guide.

g. The guide rail adjusting pivot A180009 (fig. 139) is pinned at the factory and should never be disturbed unless the compensator has been seriously damaged and will not perform properly. If such is the case, proceed as follows:

(1) Loosen the pivot nut A180030 and the pivot set screw BCUX1KC (fig. 139).

(2) Force the right end of the guide rails A180008 down toward the housing, which will increase the travel of the worm.

(3) When the travel has been adjusted properly, lock the set screw BCUX1KC and tighten the pivot nut A180030.

h. There should be very little shake between the stop key A179997 and the sides of the coupling A179992 (fig. 129). If the stop key has become worn after constant use of the height finder over a period of time, it should be replaced or repaired to reduce shake in the coupling slot to the absolute minimum.

NOTE: *All threaded retainer rings and set screws should be lightly shellacked to prevent them from working loose.*

137. COMPENSATOR ASSEMBLY—EXPLANATION OF COMPENSATOR MECHANISM.

a. Refer to schematic diagram (fig. 41).

b. Range Drive (Conversion Lock Lever (5) Set in "RANGE" Position).

(1) Rotation of the measuring knob transmits motion through the bevel gears (12) to spur gears (14) and pinion, meshing with internal rack inside measuring drum (3). The range or height of

the target is indicated by an index (13) moving in a spiral slot on the measuring drum which is graduated in yards.

(2) Rotation of the measuring knob also transmits motion to the compensator through the shaft (16) and spur gear (17) to the sleeve gear (25) which has a threaded bore and turns on the screw sleeve (26).

(3) The sleeve gear is restrained from moving endwise and, when rotated, acts as a nut and causes the sleeve to move the worm shaft (27) to the right or left.

(4) The worm shaft is prevented from rotating by means of the stop lug (23) engaged in the slot in the coupling (24) and acts as a rack causing both the worm wheels (11) to rotate in the same direction. Bevel gears (10) secured to the worm wheels mesh with bevel gears (9) on the cell adapters and transmit rotation to the measuring wedges.

c. Elevation (Height) Drive (Conversion Lock Lever (5) Set in "HEIGHT" Position at (15)).

(1) The mechanism for converting the instrument from a range finder to a height finder is enclosed in the right bearing housing (8).

(2) The conversion ring bevel gear (7) is secured to the conversion lock ring (6) which can be turned and locked in either of the two positions ("RANGE" and "HEIGHT") and secured by the lock lever to either locking bracket at (4) or (15). The conversion pinion (20) meshing with bevel ring gear rotates the conversion bevel drive gears (21) which are mounted as a unit and attached to the outer tube (2).

(3) When the height finder is elevated or depressed, the conversion bevel ring gear moves relative to the bevel drive gears (21) and causes a rotation of the height drive shaft (22). This rotation is transmitted to the worm shaft through coupling (24) and stop lug (23).

(4) Since the worms are cut right and left, rotation of the worm shaft causes worm wheels (11) to rotate in opposite directions. Bevel gears (10), secured to the worm wheels mesh with bevel gears (9) on the cell adapters, transmit motion to the measuring wedges. The arrows in diagram (fig. 41) indicate the direction of rotation.

138. COMPENSATOR ASSEMBLY—BACKLASH.

a. If the readings for up-scale and down-scale settings of the measuring drum do not agree within one unit of error, there is backlash somewhere between the drum and the compensator wedge cells.

b. Backlash or looseness can occur between the drum engagement gear and the measuring drum, in the range shaft couplings, or in the

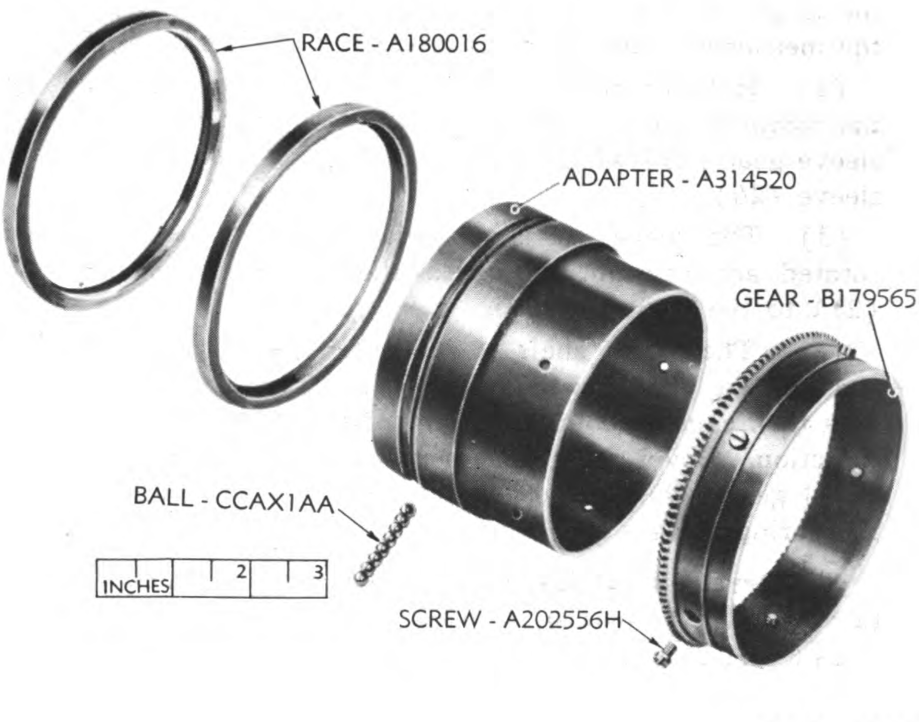

Figure 140 — Compensator Wedge Adapter (Outer Assembly) — Exploded View

gearing of the compensator assembly. If the backlash spring is stretched or sticking, even the necessary amount of backlash in the gears will cause trouble, and any excessive play will be aggravated.

c. Backlash between the drum engagement gear and the measuring drum can be eliminated by placing a shim of desired thickness under the measuring drum pinion and gear bracket (fig. 147).

d. To find and correct backlash in the height conversion gear unit, proceed as follows:

(1) Remove the compensator assembly as described in paragraph 130. Take all precautions noted.

(2) Hold the ball drive tube assembly and rotate the conversion ring to detect any looseness in the coupling or bevel gear assembly.

(3) If backlash is detected, refer to paragraphs 165 **b** and 166 **c** for instructions.

(4) Withdraw the drive tube from the instrument, and check the fit of the coupling pin or of the couplings on the shaft.

e. To find and correct backlash between the measuring knob and measuring drum drive assembly, proceed as follows:

(1) Remove the adjuster knob assembly and ball connector tube.

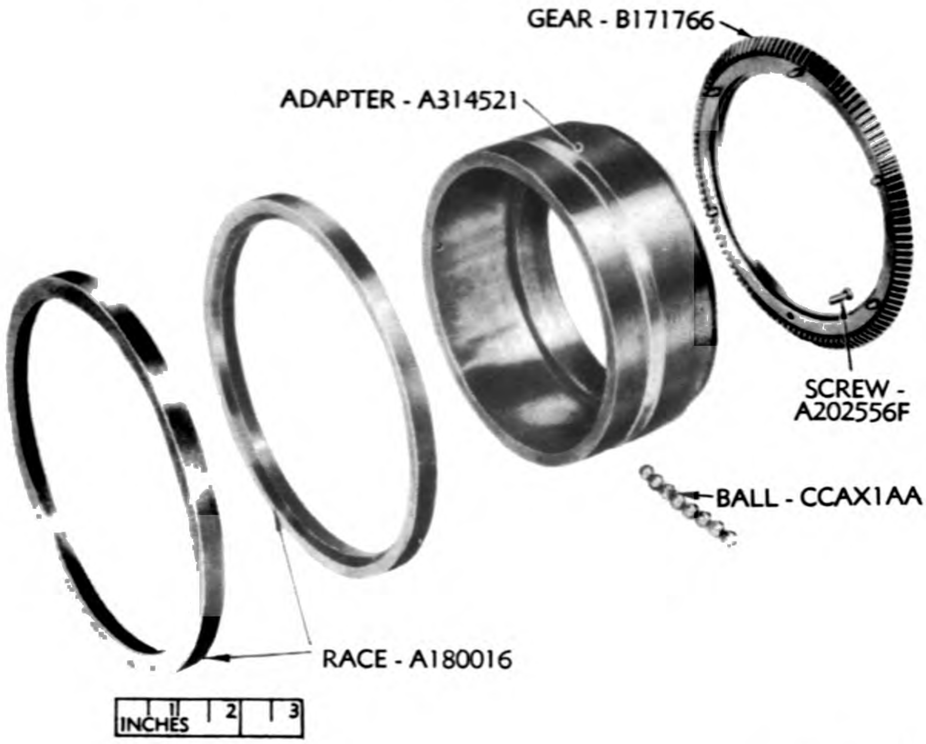

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Figure 141 — Compensator Wedge Adapter (Inner Assembly) — Exploded View

(2) Remove the screws from the height break roller shim and move out of the way.

(3) Hold pinion B171774 (fig. 152) and check for backlash from the measuring knob to the pinion gear. With a screwdriver, check tightness of the three screws in bracket B171775. Remove the bracket and gear assembly if it is necessary to replace gear B171773 or coupling A180043 (fig. 152).

(4) Assemble all parts removed in reverse order of disassembly.

f. Brass chips or looseness between gears B181658 (fig. 137) and B171763 (fig. 138), and gears B179565 (fig. 140) and gears B171766 (fig. 141), will cause up-and-down scale readings to read out of tolerance.

(1) Correct by inspecting all teeth of the above gears for burs and chips.

(2) Adjust the coil spring so there is a slight amount of tension on the spring when the compensator is adjusted for the height-infinity position.

g. To correct backlash between gears B171767A and B171767B (figs. 137 and 138) and worm B171762 (fig. 128):

(1) Remove pin 0.143 x 3/8 and loosen screws at the four corners of the compensator housing.

(2) Gently force the housing toward the worm gear and tighten the four corner screws while force is being applied. Redrill for oversize pins.

(3) Rotate the measuring drum through its entire travel and move the conversion lock ring from "RANGE" to "HEIGHT" positions to check binding.

h. When all adjustments are satisfactorily made, replace the compensator cover after sealing both sides of the cork gasket with sealing compound for height finders.

i. When replacing the compensator cover screws, it will help to eliminate stripping the cover screws if they are started in the center curved sides of the cover. Tighten these screws first and work out toward the two long straight sides, and then draw down all screws tightly a few turns at a time. Replace the carrying handles as directed in paragraph 170.

139. MEASURING KNOB ASSEMBLY.

a. General. The measuring knob bracket assembly (fig. 142) operates the measuring drum and compensator range-height drive. The measuring knob assembly (fig. 142) is connected to the measuring drum drive assembly (figs. 147 and 152) which is coupled to the measuring drum pinion and gear assembly (fig. 147) by a shaft and universal joint. The drum pinion and gear assembly is connected to the compensator by a drive tube and measuring drum adjuster assembly (figs. 122, 124, and 147). The knob adapter assembly must be removed for adjustment or repair, and for removal of the inner tube from the instrument, which breaks the hermetic seal of the instrument. Apparent tightness of the knob may be due to packing which has been forced too tightly against the knob shaft.

b. Removal and Disassembly.

(1) To remove the measuring knob adapter bracket assembly proceed as follows:

(a) Rotate the measuring knob counterclockwise as far as it will go. This should turn the measuring drum about one half inch past the infinity mark.

(b) Remove the eight screws that secure the adapter bracket to the shim B171772 (fig. 142) and take off the measuring knob adapter bracket assembly.

(c) Remove the ball tube connector A180045.

(2) To completely disassemble the measuring knob unit, proceed as follows:

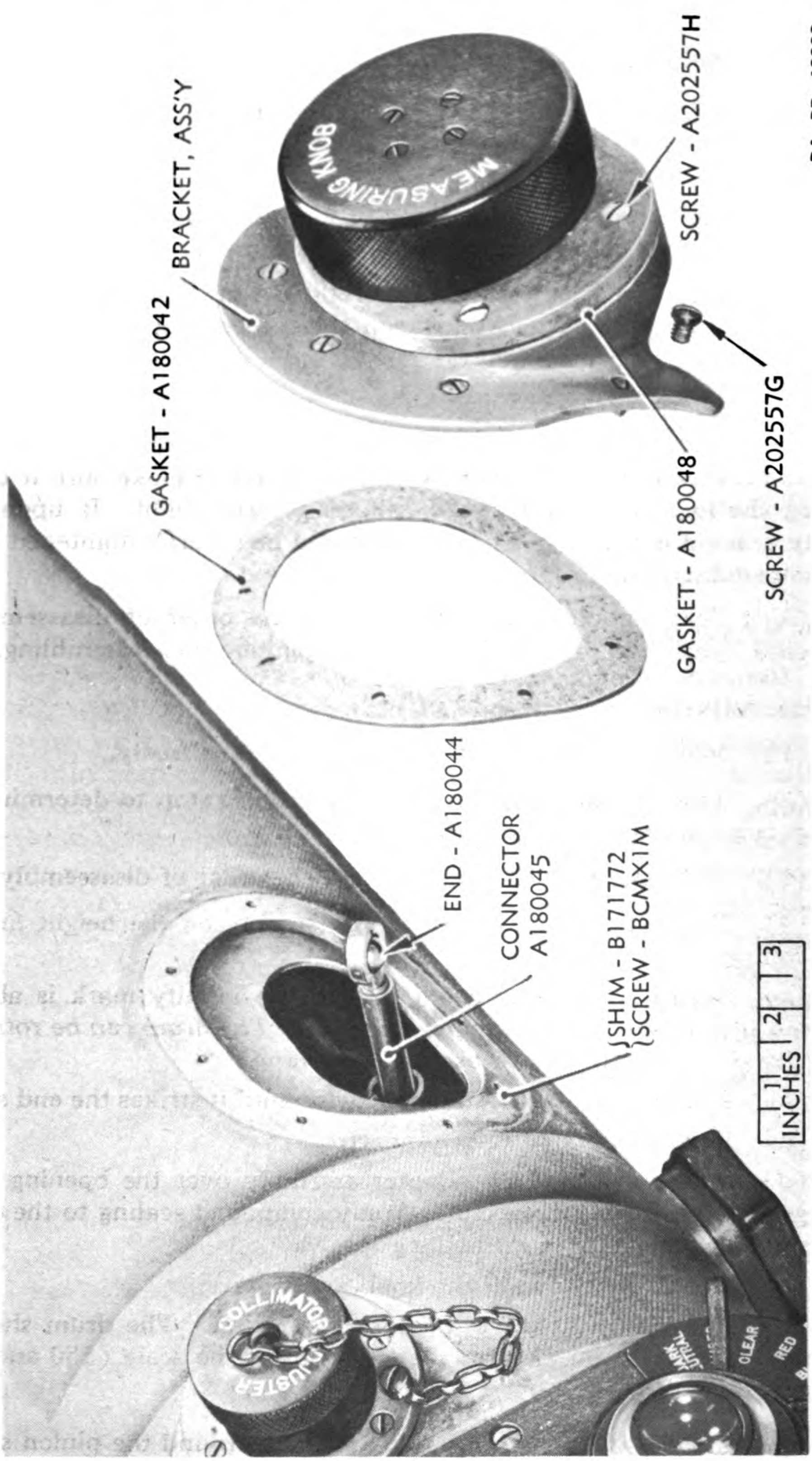

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Figure 142 — Removing the Measuring Knob Bracket Assembly

(a) Remove the four screws that secure the knob B17179 (fig. 143) to the adapter A180055.

(b) When knob is taken off, the taper pin that secures the adapter A180055 should be driven out, which allows this part to be removed.

(c) Mark the engaging position of teeth in pinion B171770 with the mating gear A180051, and remove the pinion.

(d) Drive out taper pin in ring A180050 and slide it off the shaft. Remove the 12 stop rings and keep these in consecutive order for ease of replacement.

(e) Remove gear A180051.

(f) Shaft A180049 is threaded tightly into the adapter B171777, secured with a set screw, and the end soldered to make sure it does not come loose, and to make the adapter pressure tight. If, upon examination, it is found to be loose, it should be securely tightened and resoldered, and the travel of the stops adjusted.

(3) To reassemble the unit, reverse the order of disassembly. Grease lightly the stop rings, gear, and pinion when assembling.

c. Adjustment.

(1) Make sure that the pinion and gear turn freely.

(2) Test the knob by rotating from stop to stop to determine if stop rings operate satisfactorily.

(3) To reassemble the unit, reverse the order of disassembly.

(4) Replace the measuring knob assembly on the height finder as follows:

(a) Set the measuring drum so that the infinity mark is about a half inch above the index pointer. NOTE: *The drum can be rotated by hand through the knob assembly opening.*

(b) Rotate the knob counterclockwise until it strikes the end stop.

(c) Replace the ball tube connector.

(d) Assemble the knob adapter assembly over the opening and engage the ball tube connector. Apply compound sealing to the cork gasket. Insert and secure holding screws.

(e) Check the action of the knob and drum.

(f) Check for full travel of the range drum. The drum should travel equal amounts beyond the two ends of the scale (550 and infinity).

d. Adjusting the Packing. The packing around the pinion shaft B171770 (fig. 143) will become worn, and will need adjusting more

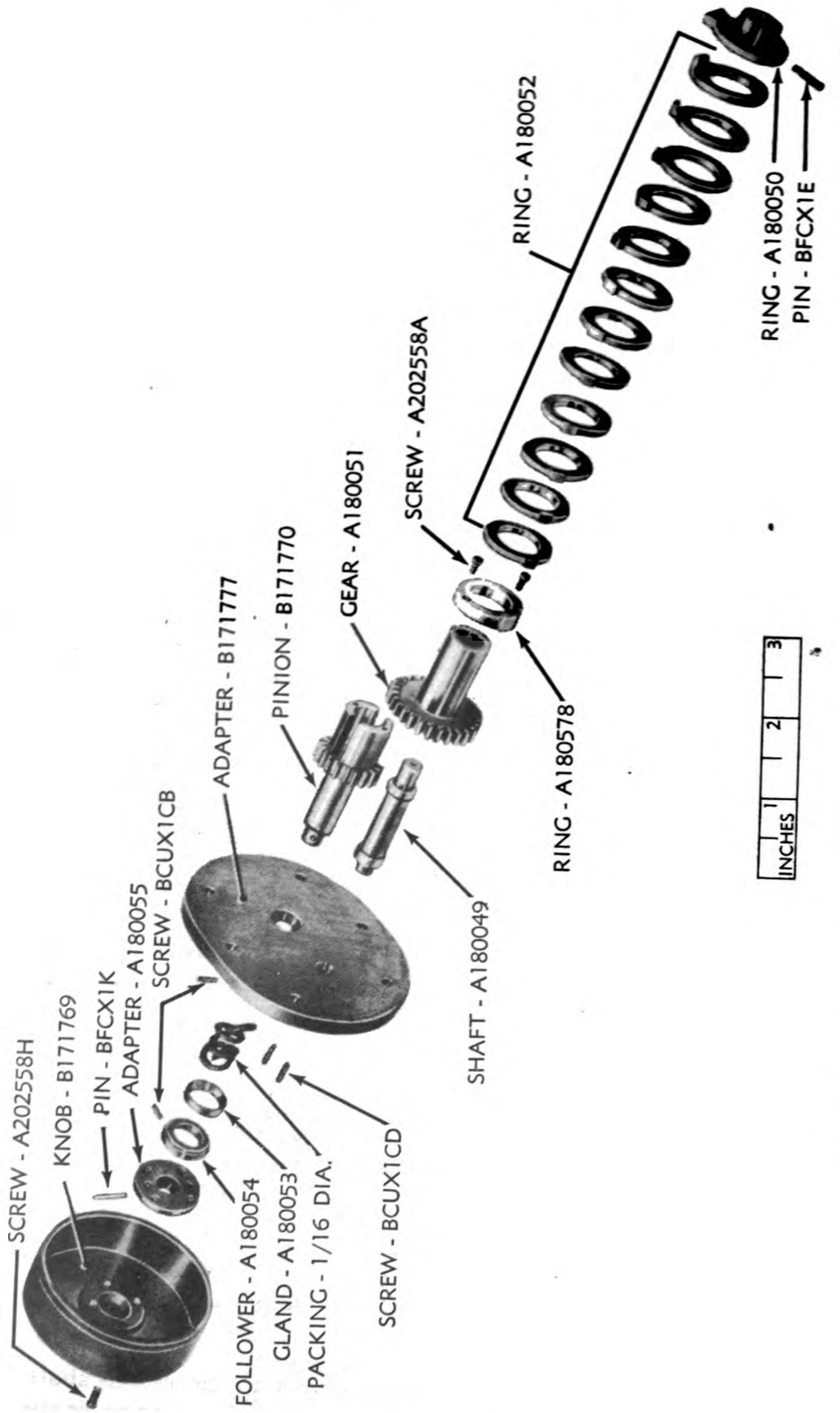
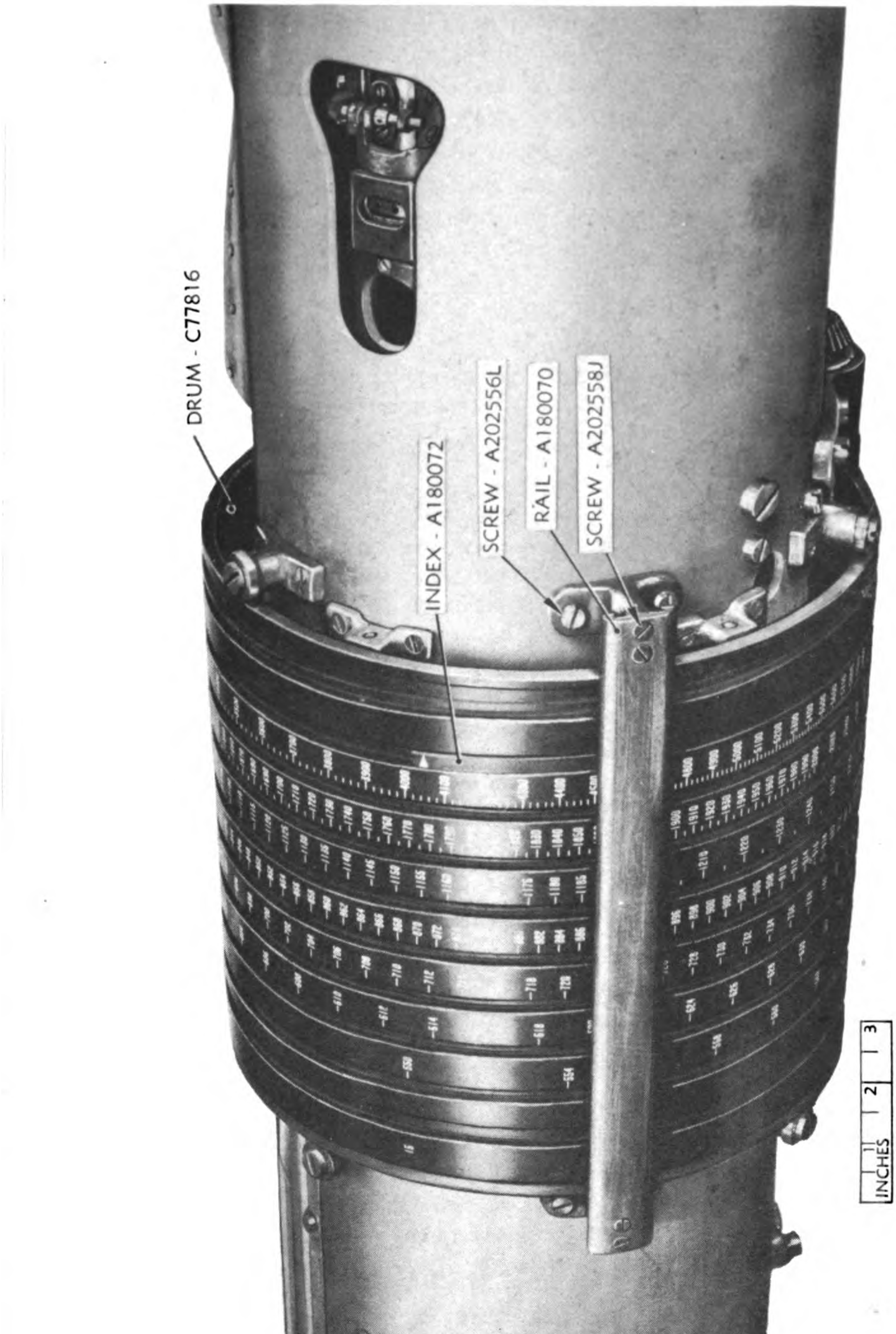
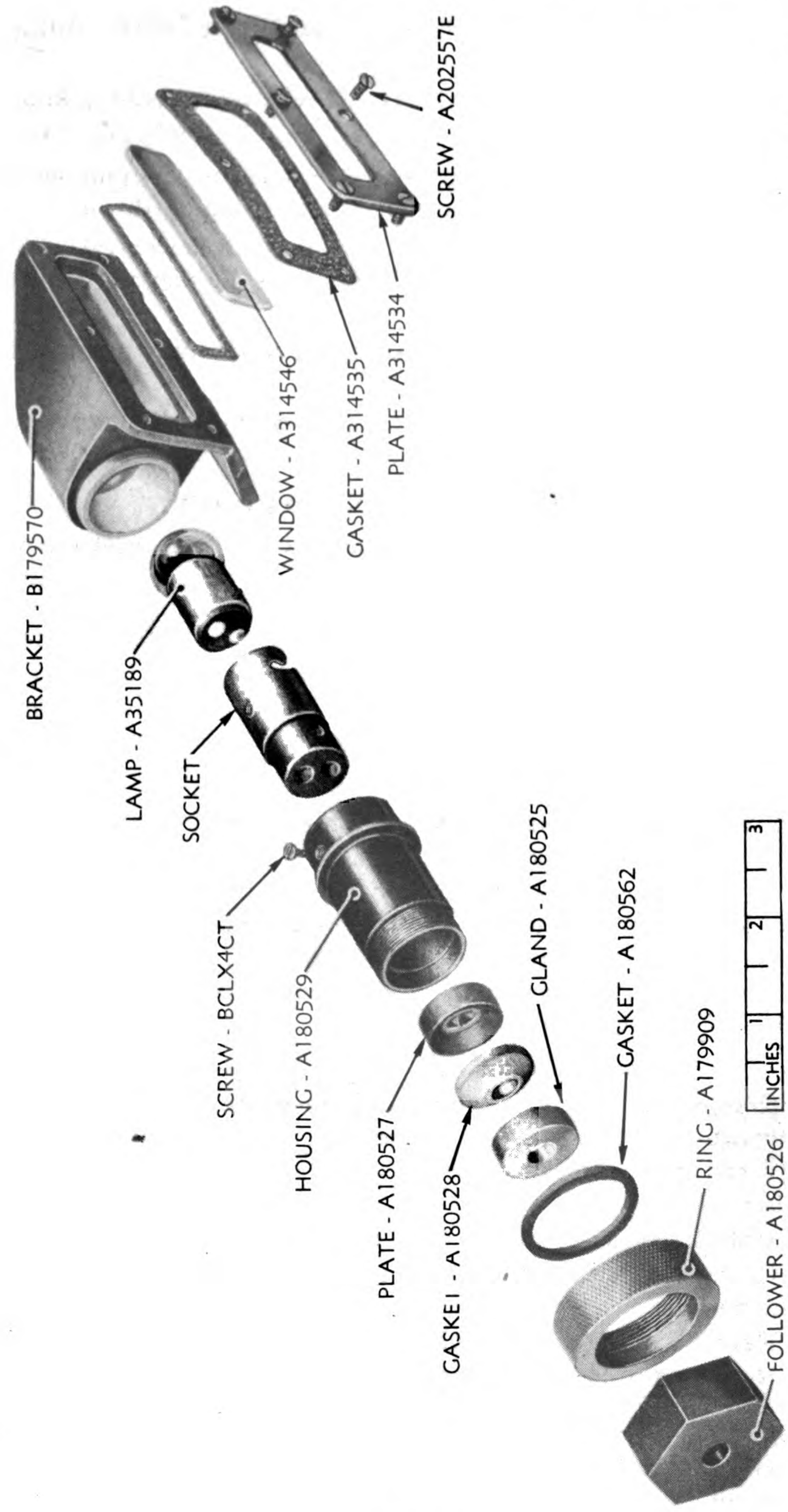


Figure 143 — Measuring Knob Adapter Assembly — Exploded View



RA PD 69936

Figure 144 — Measuring Drum Scale Showing Index and Rail



RA PD 69933

Figure 145 — Measuring Drum Scale Illuminator Bracket — Exploded View

frequently than any other shaft packing on the height finder. Adjust as follows:

(1) Remove four screws A202558H and take off measuring knob.

(2) Drive out pin BFCX1K; remove adapter A180055 (fig. 143).

(3) When the adapter is removed, place a pin in the pinhole in the pinion gear shaft and hold the shaft from dropping down.

(4) Loosen set screw BCUXICB, and screw follower A180054 down against gland A180053. This will compress the packing around the pinion shaft.

(5) Rotate the shaft a number of times and apply soap suds around the follower.

(6) When the packing is pressuretight, assemble the parts removed in the reverse order of disassembly.

140. MEASURING DRUM INDEX AND WINDOW.

a. General. The measuring drum index travels in a spiral groove in the measuring drum. A slide fixed to the back of the index rides in grooves in the rail, and the index rides in the spiral groove of the drum and moves back and forth as the drum is rotated (fig. 144). The index should not require attention unless it becomes jammed or otherwise damaged, possibly as a result of breakage of the window. When the instrument is disassembled, grease the rail grooves lightly.

b. Removal and Disassembly of Window.

(1) Remove the screws and tube clamps, and move the lamp bracket assembly out of the way (fig. 144).

(2) Remove the 26 screws around the outside of the window assembly, and lift the plate B171780 from the cork gasket, taking care not to damage the gasket.

(3) Remove the window and rubber gasket, taking care not to stretch the gasket (fig. 146).

c. Replacing Glass Window.

(1) Remove the damaged glass, and clean the index recess and measuring drum. Install rubber gasket and place a film of sealing compound for optical lenses in recess under rubber gasket to insure tight seal.

(2) Install the new window after it has been carefully cleaned.

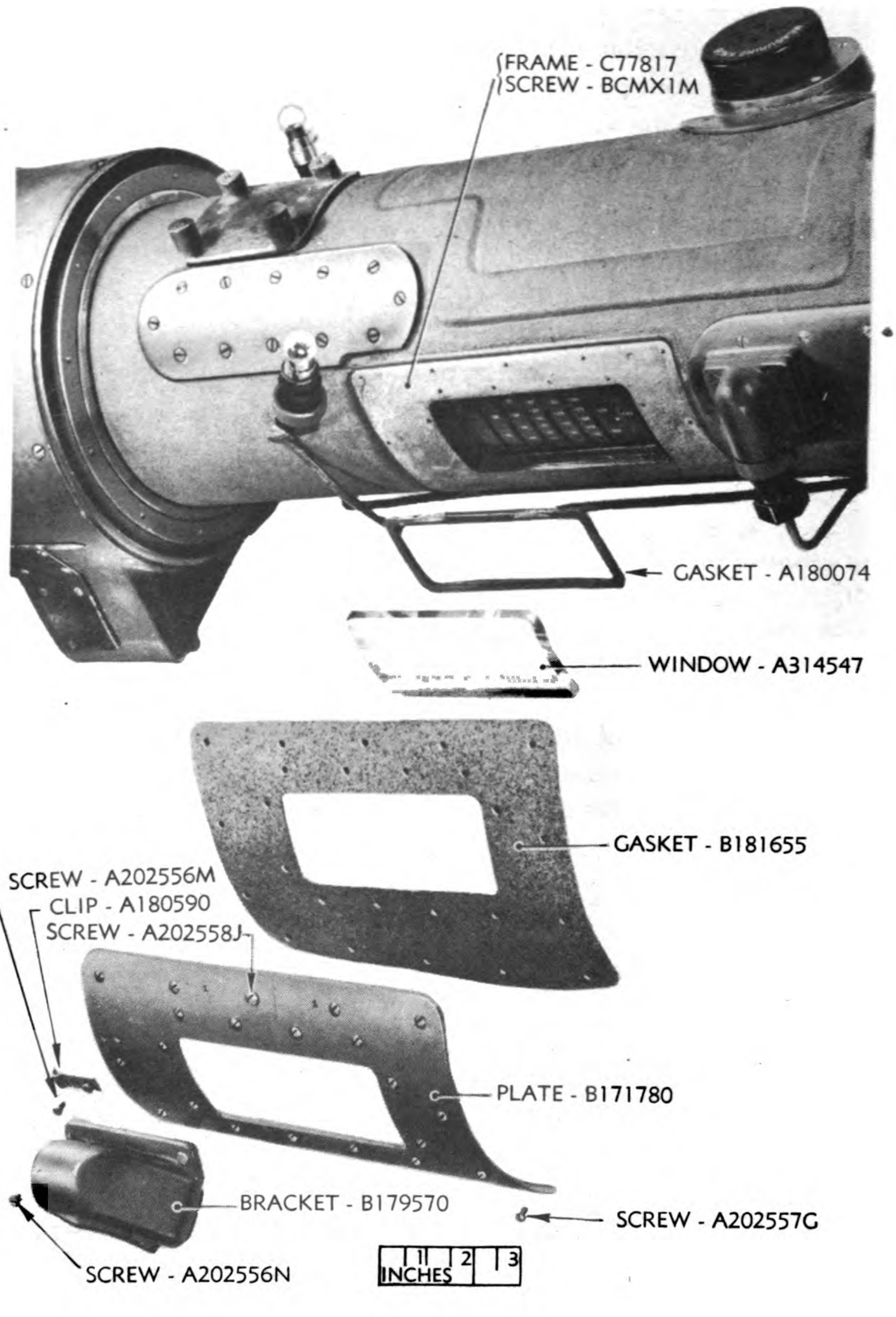
(3) Cover both sides of the cork gasket with sealing compound for height finders.

(4) Replace the plate and tighten all the screws uniformly.

(5) Replace the lamp bracket and tube clamps.

141. MEASURING DRUM.

a. General. The range drum rotates around the inner tube, just inside the outer tube of the instrument. It is supported at each end



RA PD 69931

Figure 146 — Measuring Drum Scale Window — Exploded View

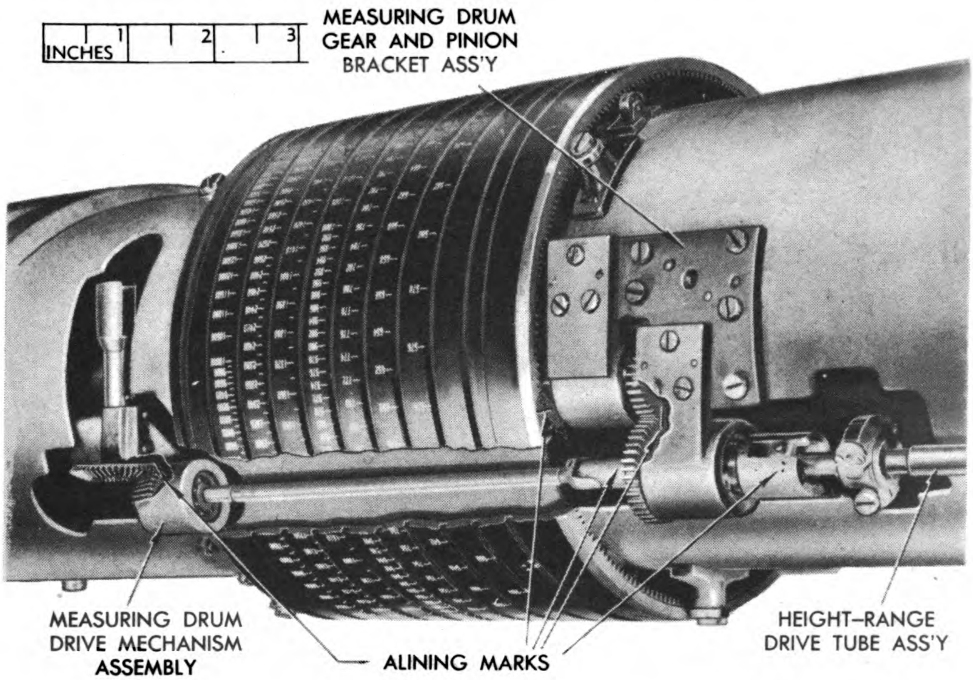


Figure 147 — Measuring Drum and Drive Mechanism Showing Alining Marks

by eight roller bearings attached to the inner tube, and is driven by a gear of the measuring drum drive unit. The drum can be withdrawn over the inner tube only after the inner tube has been removed from the outer tube. This should seldom be necessary and should be avoided if possible.

b. Removal of Drum. After the inner tube has been removed from the outer tube (par. 172), the range drum can be removed as follows:

(1) Remove the cardboard protective cover.

(2) Set the measuring drum to infinity.

(3) Mark the engaging position of all gears (fig. 147).

(4) Mark the engaging position of couplings.

(5) Mark and remove the index rail assembly by removing the four screws that hold the two supports A180069 (fig. 148) on the inner tube.

(6) Remove the six drum thrust roller assemblies (fig. 150).

(7) Remove counterweights, guide roller assembly, and studs A180185 (fig. 151) from the right end of the inner tube.

(8) Remove the range-height drive tube assembly (fig. 147).

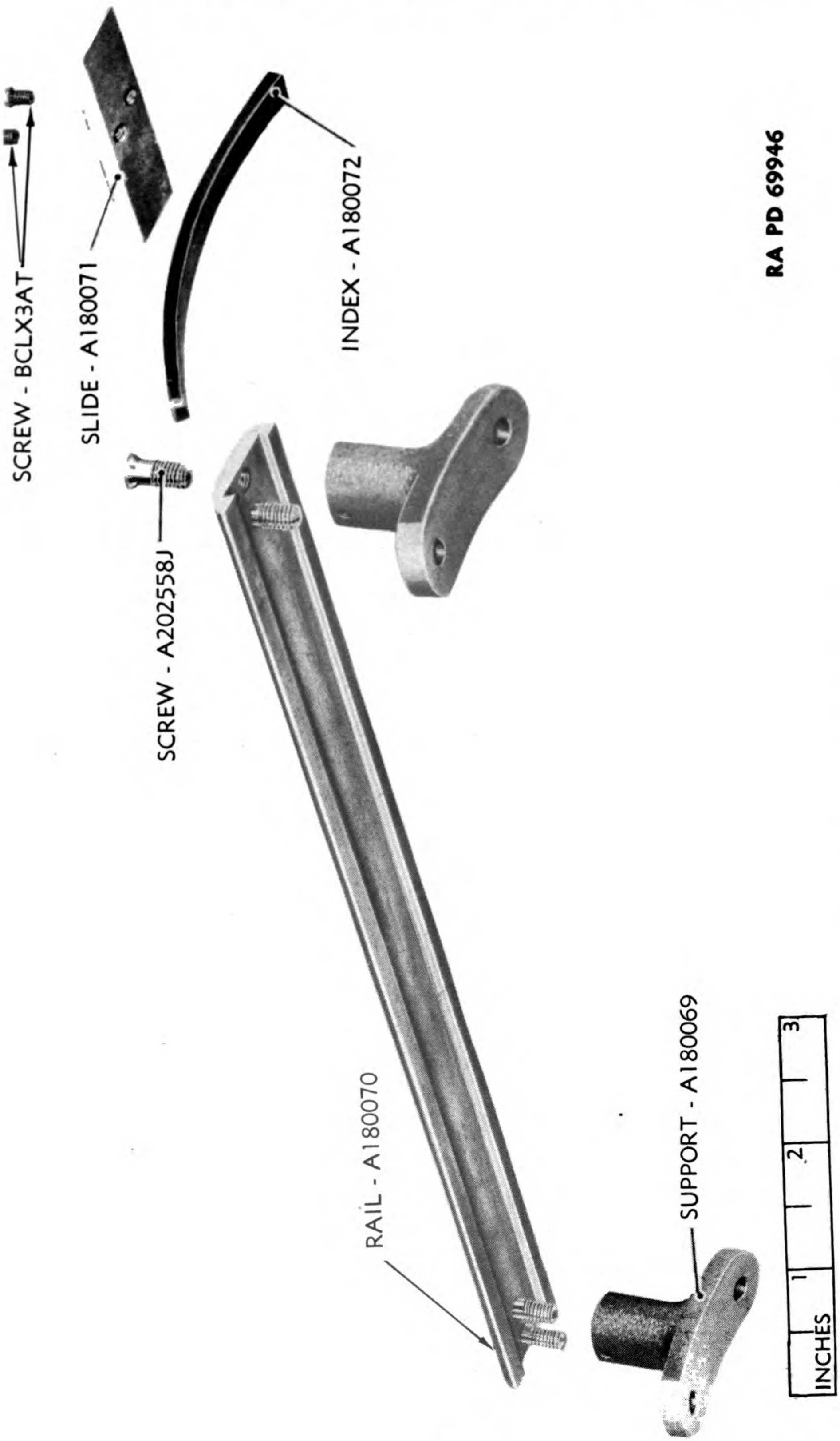
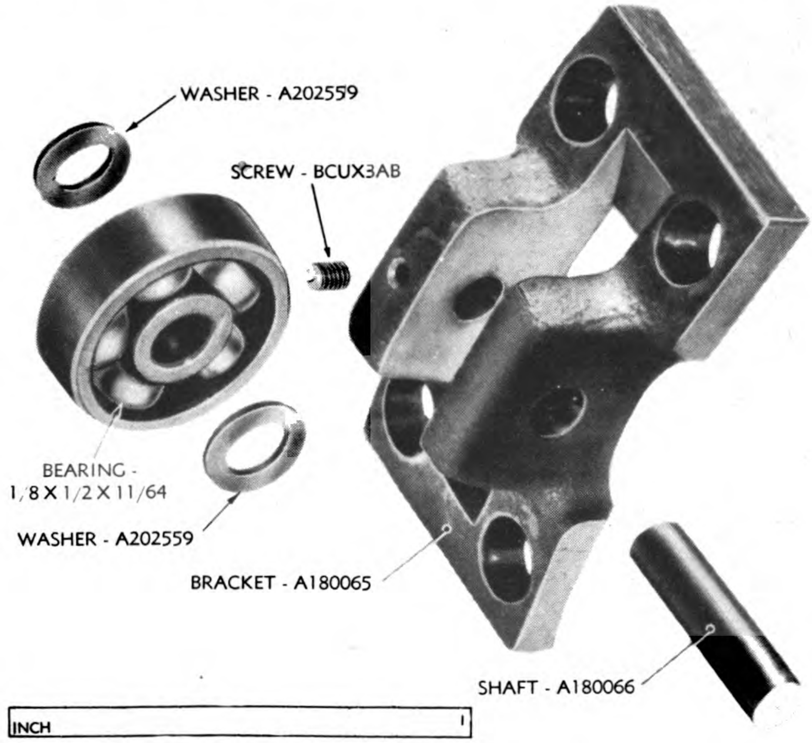


Figure 148 — Measuring Drum Index Guide Rail — Exploded View



RA PD 69945

Figure 149 — Measuring Drum Roller Bearing Assembly — Exploded View

(9) Remove the measuring drum pinion and gear bracket assembly (fig. 147).

(10) Rotate the measuring drum off the rollers toward the right, and remove carefully over the end of the inner tube. Do not *slide* the drum on the inner tube, as this will damage the gear teeth.

(11) Remove the eight measuring drum bearings (fig. 149). These should all be marked for positioning in reassembly.

(12) Remove the measuring drum drive assembly (figs. 147 and 152).

CAUTION: *Be sure to secure all loose shims to the parts on which they are used.*

NOTE: *On instruments that have inner tube reenforcing ribs, the measuring drum will have to be first moved to the right and then be removed from the left end of the inner tube.*

c. **Replacing and Mounting Drum.**

(1) Place the measuring drum over the end of the tube with the end of the drum carrying the teeth toward the right end of the tube, and move it just to the right of its mounting position.

(2) Mount each of the eight measuring drum bearing bracket

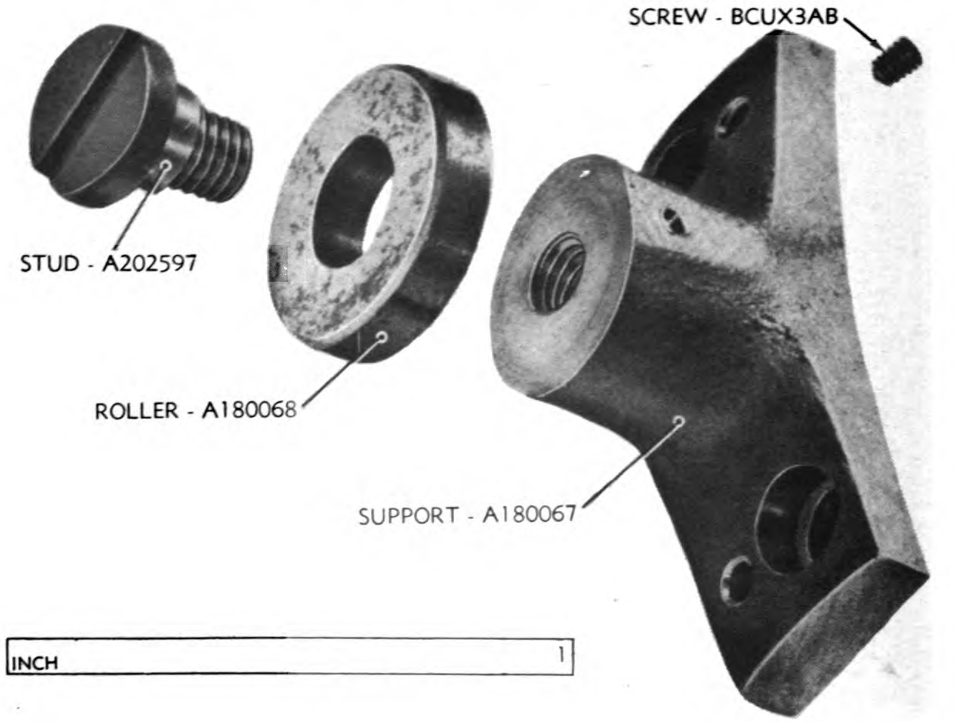


Figure 150 — Measuring Drum Guide Roller Assembly — Exploded View

assemblies (fig. 149) in its proper place as indicated by number stamped on one edge of the bracket and on the tube. Be sure the shims are replaced in proper place.

(3) Clean rollers and inside of drum. Grease the rollers.

(4) Place the measuring drum drive assembly into position on the inner tube.

(5) Rotate the drum into the correct operating position on the roller bearings.

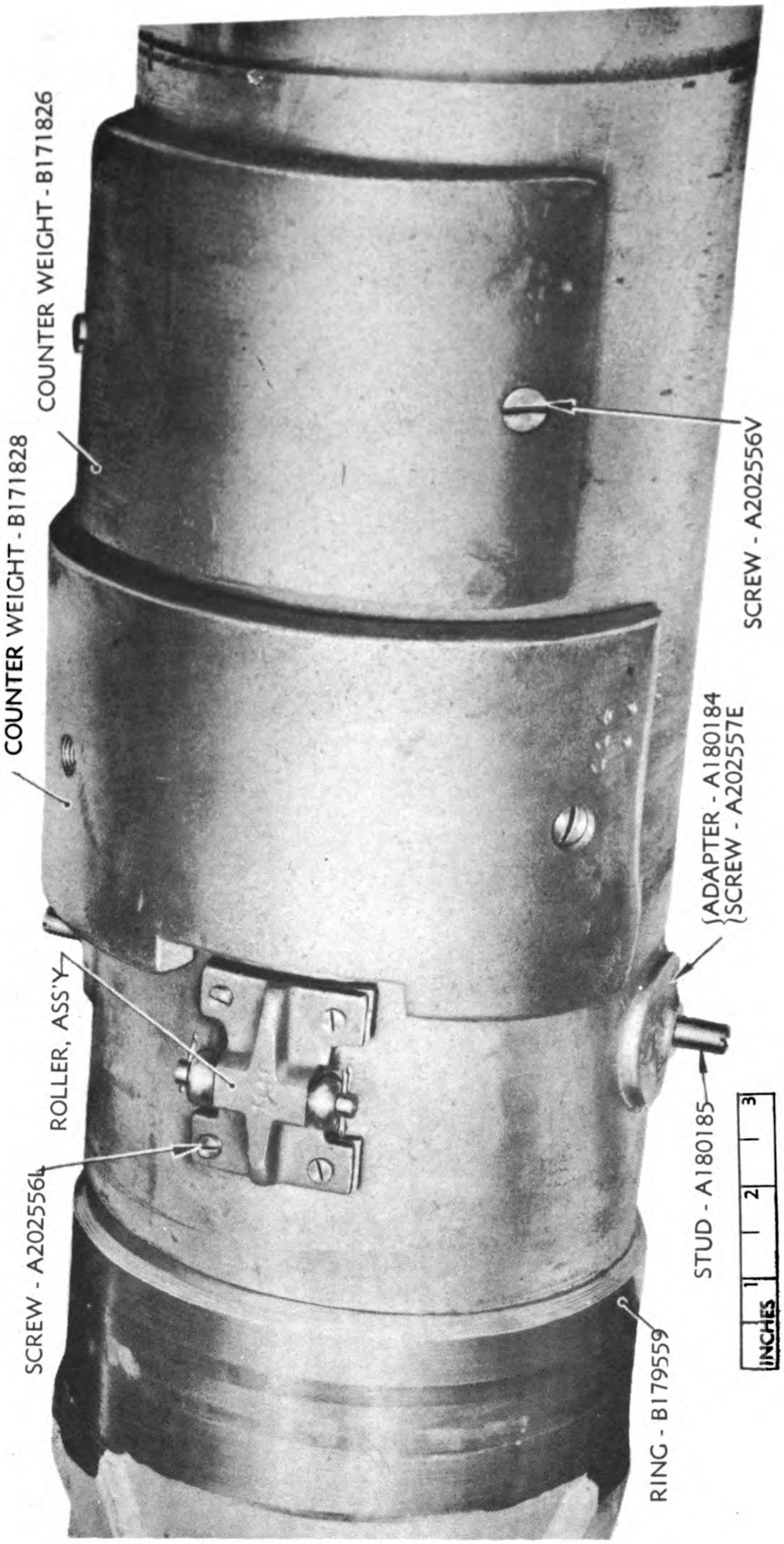
(6) Mount the six drum thrust roller assemblies (fig. 150) on the inner tube. These rollers should touch very lightly as the tube is rotated.

(7) Check the measuring drum for smoothness of rotation, and for play perpendicular to its axis.

NOTE: *Run-off to one side is caused by the bearings being too tight on that side.*

(8) Clean the bearing surfaces of the drum with lens-tissue paper wet with dry-cleaning solvent, if there is any dirt, or chips, that may cause the drum to rotate unevenly.

(9) Replace the index rail assembly (fig. 148) on the inner tube. Make sure the index travels smoothly on the rail.



RA PD 70047

Figure 151 — Inner Tube Guide Rollers and Counterweights

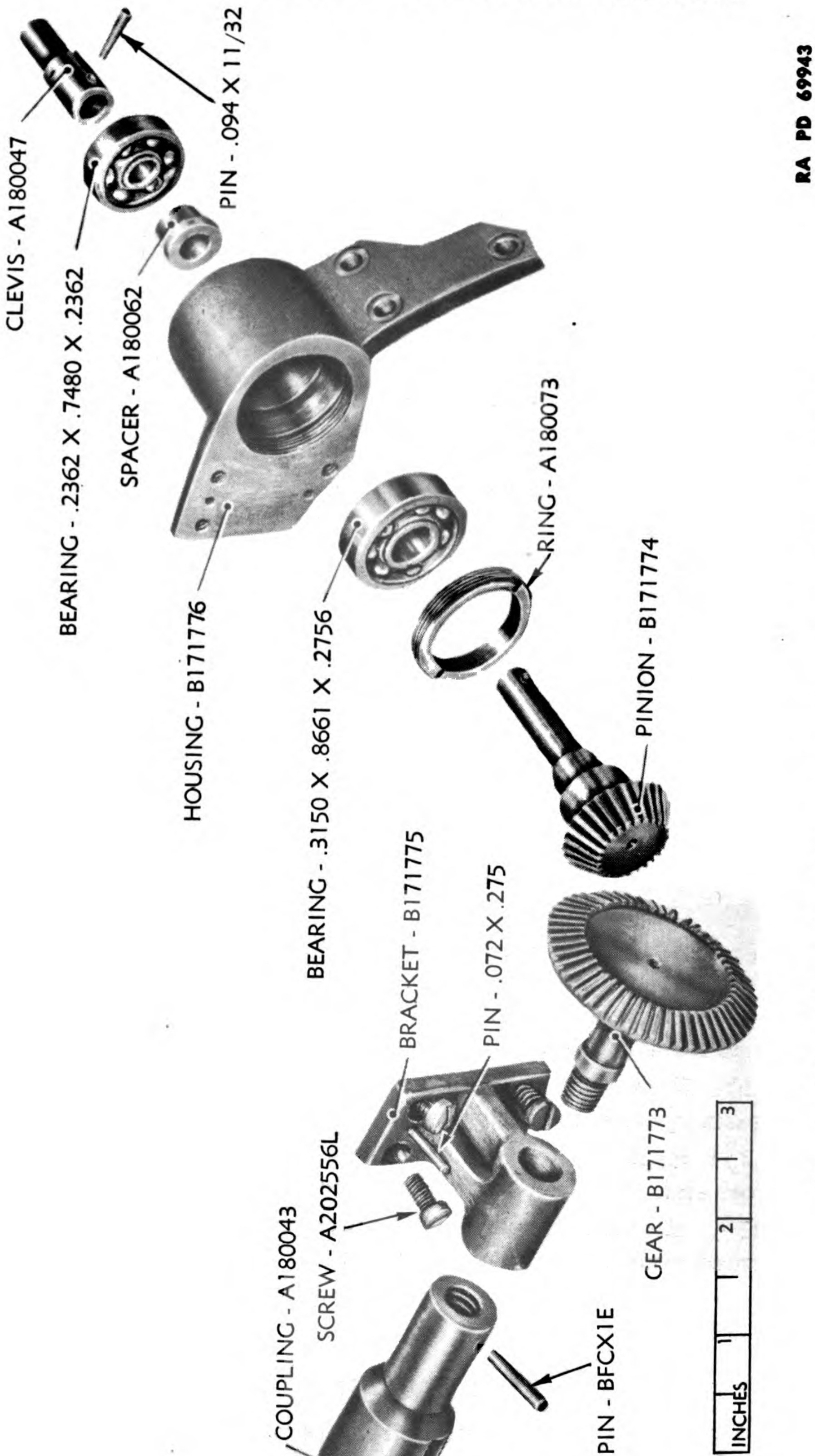
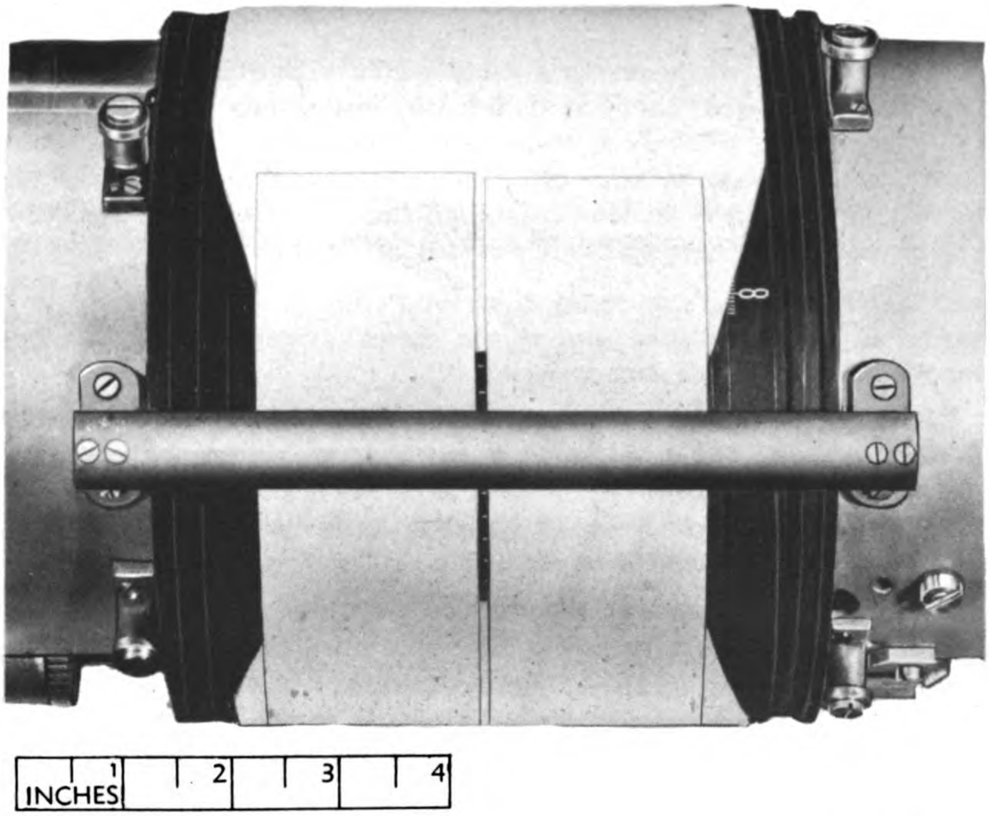


Figure 152 — Measuring Drum Drive Assembly — Exploded View



RA PD 85464

Figure 153 — Measuring Drum Showing Protective Cover

(10) Mount the measuring drum pinion and gear bracket assembly (fig. 147) in place on the inner tube, making sure that the reference lines on the gear teeth and on the couplings are alined when the index is set at infinity.

(11) Rotate the entire assembly several times to make sure that the gears operate freely and with minimum backlash.

(12) Replace the measuring drum drive tube assembly and tape the free end near the compensator opening to the inner tube.

(13) Replace the cardboard protection cover, noting position of the taped ends as shown in figure 153.

(14) Replace the counterweights, guide roller assembly, and studs (fig. 151).

142. RETICLES—EXPLANATION.

a. The right and left stereo reticles provide the reference marks with which the relative positions of the two images of the target are compared. They must be properly alined and located, therefore, in the optical system, and must match each other closely in size and design.

b. Since the reticle marks are etched on a thin plate of optical glass and cemented between two thick lenses, any dust, dirt, or scratches will not be sharply visible and will not interfere with stereo observation. Smears or large pieces of dirt on the lenses cemented to the reticle will cast a shadow; it is important, therefore, that the surface of these lenses be kept free from smears or dirt.

c. The reticles are mechanically mounted in such a way that they can be adjusted for alinement in the optical system. They can be removed and replaced if necessary.

CAUTION: *The reticles in the M2 Height Finder should never be removed, realined, or adjusted in any manner, unless the eyepiece unit and the ocular prisms are known to be in perfect adjustment. To a perfectly adjusted eyepiece and ocular prisms, the center mark of each reticle pattern should be located on a line which passes through the optical center of its erector lenses in both the 12- and 24-power positions.*

d. Besides being properly centered, the reticle should be positioned so that the pattern of marks is exactly parallel to the plane of sight of the instrument. This means, of course, that the reticles must not appear tilted in relation to any horizontal target. Also, they should not be tilted in relation to an index line in the image space which is parallel to the axis of the instrument. A reticle probably will not become tilted or off center unless it has been tampered with but, if such occurs, stereo observations may be difficult or perhaps impossible, and the fault must be corrected.

143. RETICLES—REQUIREMENTS.

a. Adjustment or cleaning of the reticles necessitates breaking the hermetic seal of the instrument.

b. Centering requires the use of a divergence tester, dioptometer, or a collimating telescope (low power telescope) with cross hairs.

c. Checking for tilt requires an external target, with well-defined detail, level with the height finder, or a transit placed in front of the end reflector.

d. It is also necessary that the end reflectors be in proper adjustment.

e. Cleaning must be done in a dust-free room, with a vacuum or compressed air line (used with valve assembly B138732 and a special nozzle), or by the careful use of lens-tissue paper and special cleaning tools as described in paragraphs 86 to 88.

f. The corresponding marks on the two reticles must be of exactly the same width; otherwise, it is extremely difficult to make stereo contact. The two reticles must also be matched for equal spacing of the lines; otherwise, range readings will vary at different points across the field. Because of the extreme delicacy of the measurements involved, and because it is unlikely that the repair station will have a sufficient assortment of reticles, it is not advised that any attempt be made to match a pair of reticles. If it becomes necessary to replace a damaged reticle, replace both right and left reticles with a *factory-matched* pair, and adjust as described in paragraphs 144 to 147. The adjustments must be made in the order given.

144. REPLACING RETICLES.

a. If a *factory-matched* pair of reticles is available, they can be substituted for a damaged pair in the height finder. Replace one reticle at a time, and complete the adjustment for tilt and the centering adjustment before replacing the other reticle.

b. If for any reason it becomes necessary to remove a reticle assembly from the optical tube in the height finder, it will not be necessary to disassemble the telescope to accomplish this. Proceed as follows:

(1) Shift the change-of-magnification lever to low power.

(2) Place the low power telescope on the right (or left) eyepiece of the height finder and focus on the stereoscopic reticle marks.

(3) Secure the telescope to the eyepiece so that it will not move. Carefully note the position of the center reticle mark with relation to the cross lines of the telescope. When a new reticle is assembled in place, it must assume the same relation to the cross lines, so it will be advisable to record this position by a sketch and a description.

(4) Remove reticle opening cover B171740 (fig. 154) and illuminator adapter plate B171735 (fig. 263). NOTE: *The illuminator rod holders are punch-marked for ease in location for assembly (figs. 262 and 263).*

(5) Mark position of reticle cells in relation to bracket and bottom plate as shown in figure 155.

(6) Remove two screws (3, fig. 156) that can be reached through opening in outer tube.

(7) Loosen screws in gib A179904 or A179905 (fig. 155), slide out the reticle cell and bracket assembly, and remove through the opening in outer tube.

(8) Before removing the reticle from the cell, mount or clamp the bracket on a parallel block on a surface plate.

(9) Focus the cross lines of a microscope (low-power telescope or transit) on the reticle marks.

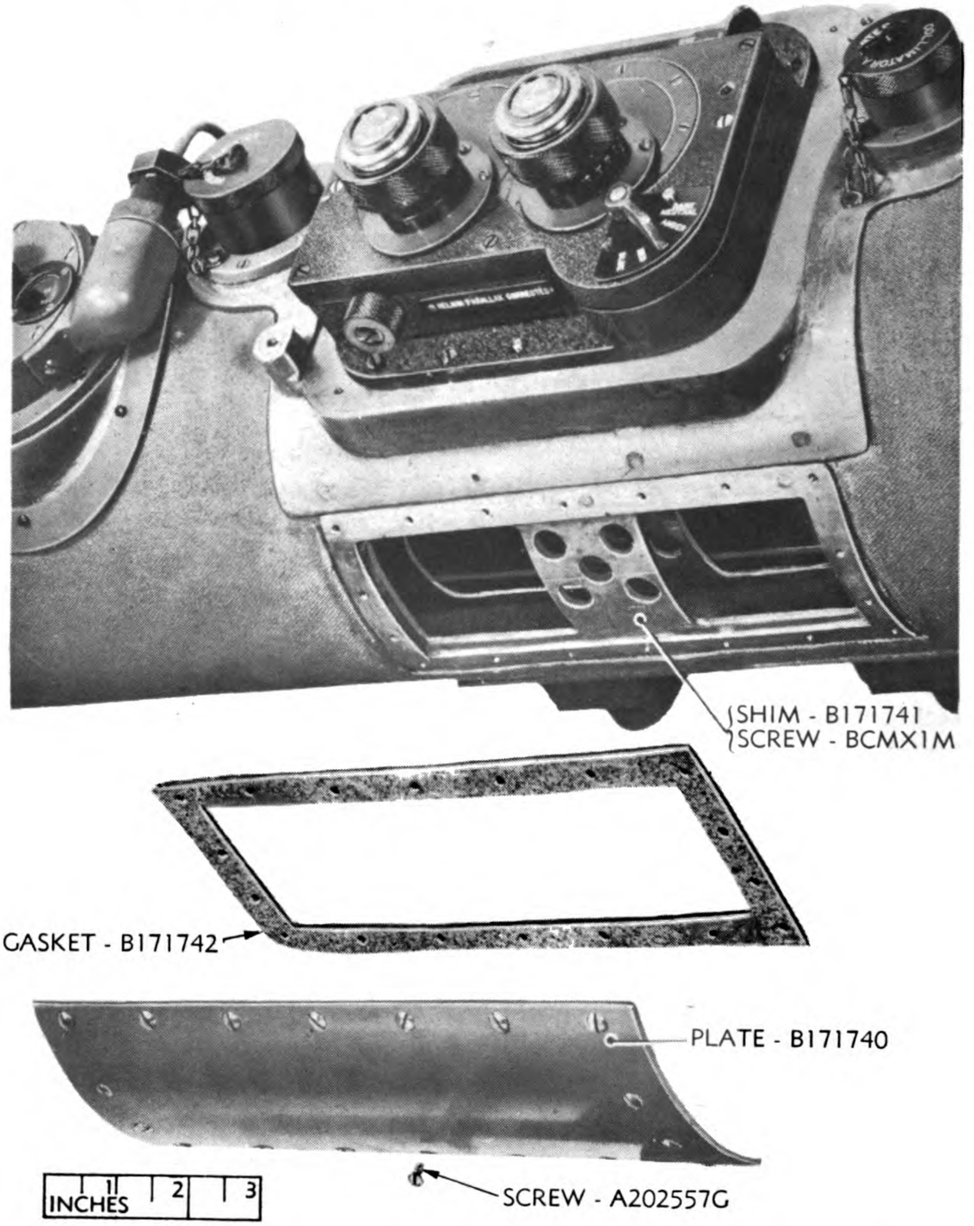


Figure 154 — Removing the Reticle

(10) Aline the horizontal cross hair (in whichever instrument is used) to the horizontal axis of the reticle lines so that the replaced reticle may be alined in the exact position of the reticle which was removed.

(11) When replacing new reticle in reticle cell, apply three small spots of warm turpentine on outer edge of reticle in contact with inner surface of cell A179891 or A179892 (fig. 158).

RA PD 85459

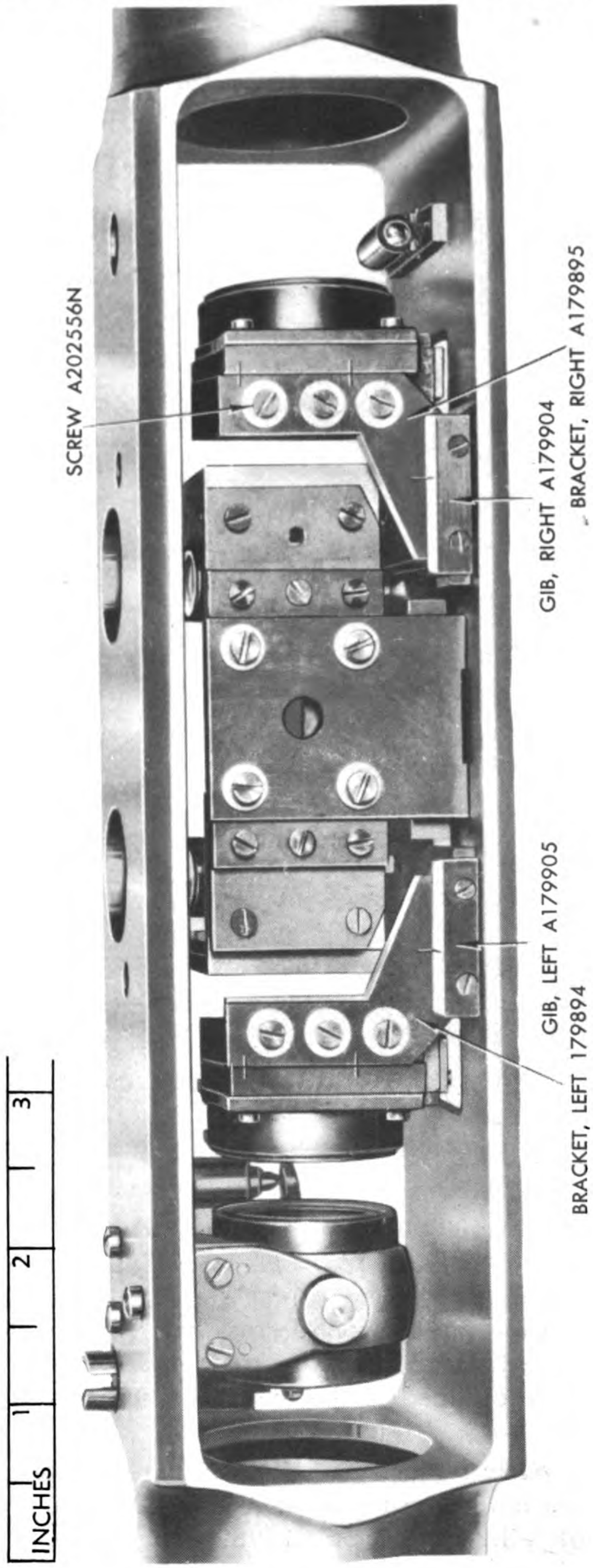


Figure 155 — Center Portion of the Optical Tube — Rear View

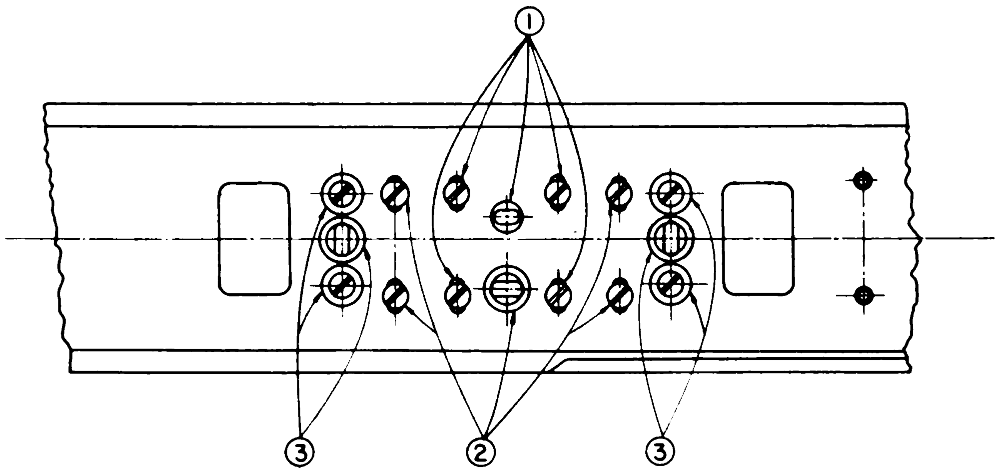


Figure 156 – Reticle and Ocular Prism Adjusting Diagram

(12) The reticle can be rotated slightly for alinement when the four screws are removed and cell A179891 or A179892 is taken out.

(13) Tighten retaining ring A179893 and secure with set screw.

(14) Reassemble the reticle cell and bracket in the height finder in reverse order of disassembly, paying particular attention to alining marks (fig. 155).

145. FOCUSING RETICLE.

a. Tighten the two screws in the bracket assembly (fig. 155) just tight enough to allow the bracket to be shifted with the eccentric adjusting wrench (par. 84) (fig. 77).

b. Observe the reticle through the low-power telescope (fig. 74) at 12 power, with the eyepiece diopter scale set at zero.

c. With the eccentric adjusting wrench inserted through the adjusting hole (3, fig. 156), move the reticle until it is sharply focused to the cross hair in the low-power telescope.

d. Shift the change-of-magnification lever to 24 power.

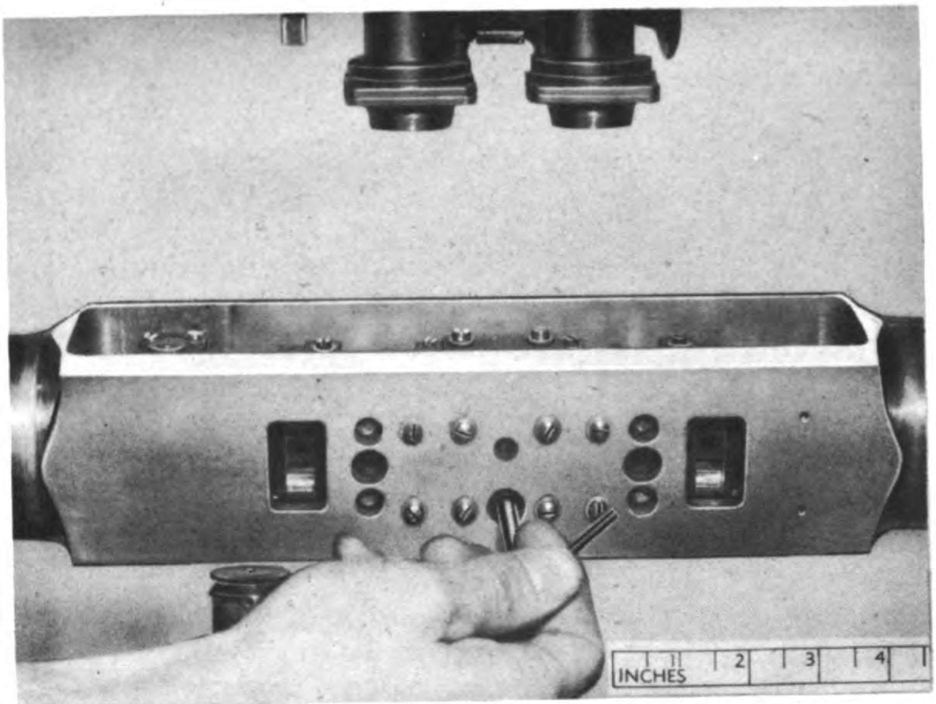
e. The reticles should be sharply focused to the cross hair in the low-power telescope.

f. Tighten the two screws (3, fig. 156) when the reticle has been positioned at the best focus position.

146. ADJUSTING RETICLE FOR TILT AND CENTERING THE RETICLE.

a. Adjusting for Tilt.

(1) The reticle should not be tilted if the instructions in paragraph 144 have been carefully followed.



RA PD 85432

Figure 157 — Adjusting the Ocular Prism Mounts

(2) Check and correct tilt as follows:

(a) Carefully level the cradle and aline the height finder on a distant target at approximately the same height as the instrument.

(b) View the target through the eyepiece and traverse the height finder so that the target image moves across the reticle field, noting its relative position at both ends of the field. The target image should fall at the same height at both ends of the field within about one-half the width of a reticle line.

(3) If the amount of tilt is excessive, adjust the reticle as follows:

(a) Remove four screws in reticle cell A179891 or A179892 (fig. 158).

(b) Remove the cell.

(c) Using a small suction cup or clean eraser, rotate the reticle until tilt is eliminated.

(d) Replace the cell and screws.

(e) Check the adjustments to see that the position of the reticle has not shifted.

b. Centering Reticle.

(1) If a reticle is not centered with respect to the erector lens

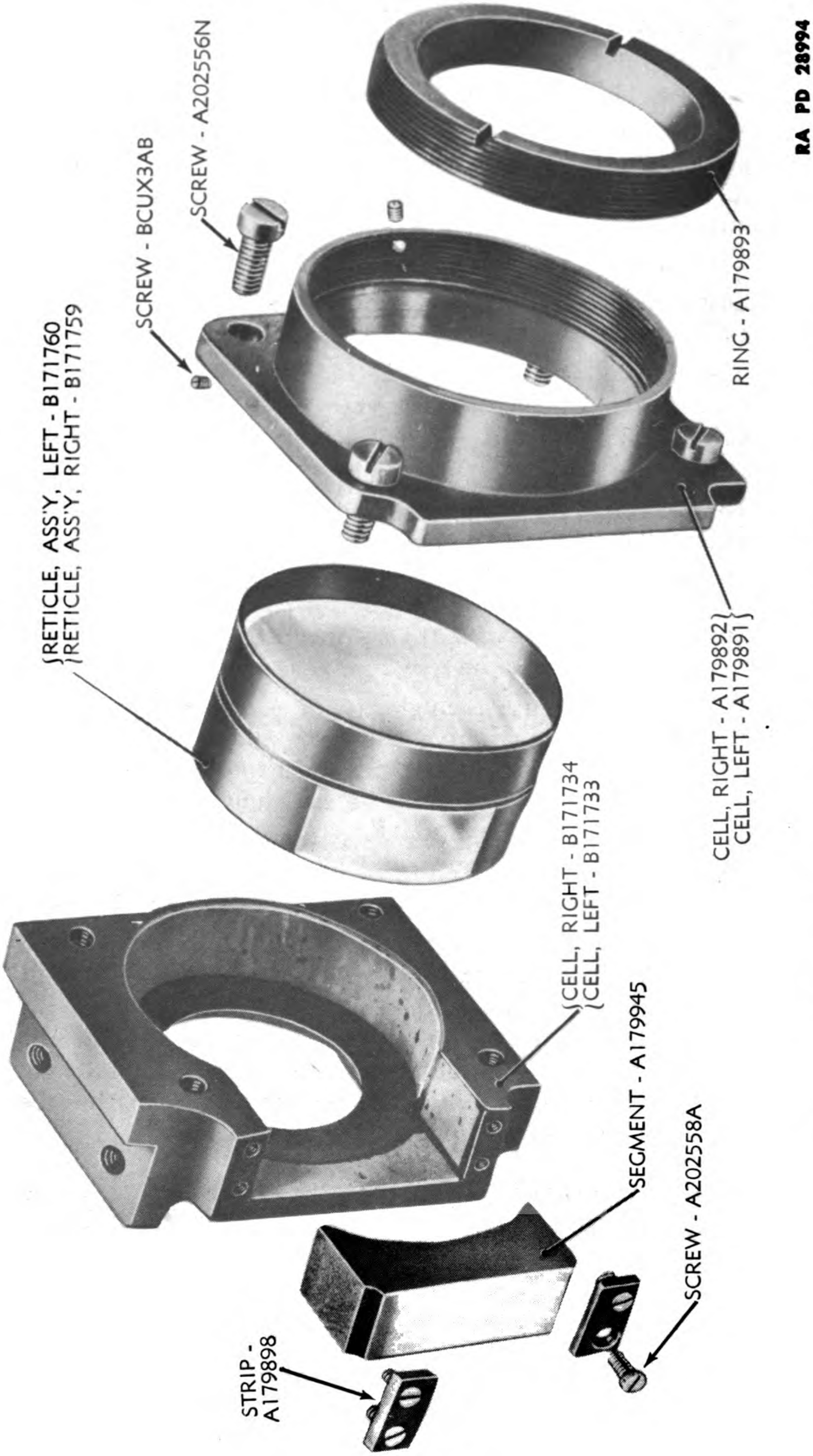


Figure 158 — Reticle and Mount Assembly — Exploded View

movement, stereo readings will be difficult, and considerable eyestrain may result.

(2) Set up the height finder with a divergence tester on the eyepiece. Focus for a sharp image of the reticle.

(3) Turn the change-of-magnification crank from 12 to 24 power and note the movement of the center reticle mark in relation to the divergence tester grid line. NOTE: *At 24 power, the height finder reticle mark is about 5 minutes wide in the divergence tester field.*

(4) If adjustment is necessary, the reticle cell can be shifted up and down by loosening the three screws A202556N (fig. 155).

(5) If it is necessary to move the cell toward or away from the rear of the instrument, it will be necessary to either file the cell contacting surface of the bracket A179894 and A179895 (fig. 155), or to place shims of the desired thickness between two surfaces.

(6) Move the reticle cell slightly to produce the necessary correction, so that, when the erector lenses are shifted from 12 to 24 power, the combined movement of both the center mark of the left reticle and the center mark of the right reticle is not more than 5 minutes, up and down or sideways, as measured by means of a divergence tester placed over the eyepiece (par. 102).

EXAMPLE. The left reticle might jump 4 minutes when the erectors are shifted, and the right one only 1 minute (in opposite directions). The combined movement in respect to each other would be 1 plus 4, or 5 minutes. This would be sufficiently close.

(7) Tighten the three holding screws on the bracket and apply a spot of varnish shellac where each screw head contacts the surface of the bracket.

(8) Adjust the left reticle as described in paragraphs 144 and 145. Tilt of the reticle should fall at the same height at both ends of the field within one-half the width of a reticle line. If the right side was not set exactly level to the external target, set the left one an equal amount off level. The object of this adjustment is to get both reticles parallel to the field. Both end reflectors can then be corrected for tilt of field as outlined in paragraph 93.

147. PREPARATION FOR CLEANING RETICLES.

a. Of all the optical elements, the reticle is the most difficult one to clean, and requires the utmost patience and care. Do the cleaning in a dust-free room; otherwise, the condition may be aggravated instead of improved. Prepare for cleaning as follows:

(1) Place a strong light, diffused by a clean, white paper, in front of the end windows.

(2) Observe the reticles through the eyepieces.

(3) Shift the change-of-power lever out of normal focus, and locate dirt or smear on the reticle.

b. Do not remove the reticle from the instrument unless there is oil, grease, or other dirt which requires the use of a solvent. Small dust specks or lint should be removed by using a vacuum system as described in paragraph 87.

c. To remove oil or grease, remove the reticle mount as described in paragraph 144, and clean the reticle as described in paragraph 87.

d. Seal and replace plate, illuminator holders, and lamp brackets.

148. HEIGHT ADJUSTER DISK (HEIGHT-OF-IMAGE ADJUSTMENT).

a. Explanation.

(1) The height adjuster disk is a plane parallel disk of glass about 1¼ inches thick. In order to make accurate stereoscopic settings, the target images formed by the right and left systems must appear on the same level. Vertical displacement of the images is corrected by rotating the height adjuster disk on an axis which is perpendicular to the optical axis and coincides with the plane of triangulation.

(2) The height adjuster mechanism is mounted in the optical tube immediately in front of the left stereoscopic reticle and is actuated by the height adjuster knob. Turning the knob causes a vertical movement of the screw A179913 which imparts a rotational movement to the lever A179915, and to the cell A179916 in which the disk is mounted (fig. 160). The spring plunger A179926 on the opposite end of the lever keeps the lever in contact with the height adjuster screw. From stop to stop, the height adjuster knob will turn approximately 8.8. turns, causing the disk to turn through an angle that corresponds to 14 minutes of true field.

b. Requirements. Squaring of the height adjuster disk assembly involves breaking the hermetic seal of the instrument. Checking of the adjustment requires that the internal target line be free from any tilt or lean (pars. 152 and 153). The face of the height adjuster disk must be set perpendicular to the longitudinal axis of the optical tube when the height adjuster tube is set at its center of travel.

c. Adjustment.

(1) The height adjuster disk assembly is so constructed that it will need very little adjustment and should *never* be removed from the optical tube unless it has been damaged by shell fire, or by extremely rough handling during transportation.

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT

RA PD 69983

Figure 159 — Height Adjuster Disk and Knob Assemblies — Functional View

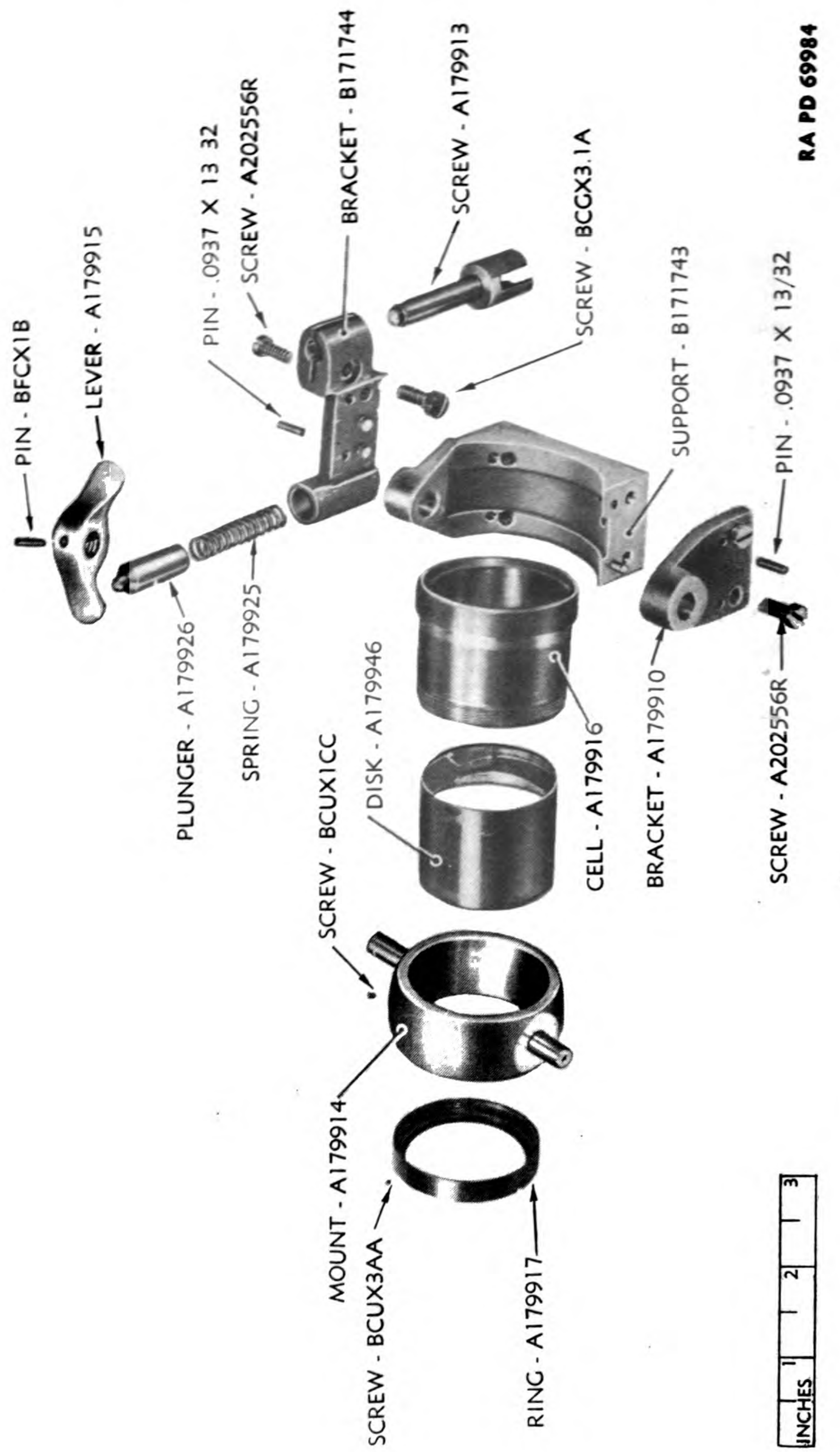


Figure 160 — Height Adjuster Disk Assembly — Exploded View

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT

(2) Check and adjust the disk for perpendicular position in the following manner:

(a) Remove the reticle cover plate B171740 (fig. 154).

(b) Rotate the height adjuster knob until the face of the adjuster disk is parallel to the blade of a small steel square, when the base of the square is resting on the ground inside surface of the optical tube.

(c) Place a parallel bar against the back surface of the optical tube, adjust the steel square to the parallel and the face of the adjuster disk. The face of the disk should be perpendicular to the longitudinal axis of the optical tube.

(3) Repositioning the cell assembly will be possible only when the optical tube is removed from the inner tube and should not be attempted then, unless all other adjustments fail to cause the height finder to read true ranges.

(4) When the height adjuster disk is set perpendicular to the longitudinal axis of the optical tube, the height adjuster knob should be set in the center of its travel from stop to stop. This can be corrected as follows:

(a) Remove screws holding adjuster knob adapter assembly (fig. 159) to the height finder.

(b) Remove the knob adapter assembly from the height finder, taking care not to damage the cork gasket. NOTE: *Do not remove the connecting rod from the adjuster disk coupling.*

(c) Hold the knob assembly in the position in which it was removed from the height finder, and rotate the knob to the stop at one end.

(d) Rotate the knob from stop to stop, counting the number of turns.

(e) Rotate the knob back half the total number of turns from stop to stop.

(f) Place the knob assembly shaft coupling A179919 (fig. 161) over the connector rod ring, and return the screws to the adapter on the height finder.

(g) Rotate the adapter slightly while holding the knob, if the screw holes do not line up in the adapter on the height finder.

(h) Mark the knob and adapter with an adjoining line and check the number of turns each way from the marked center position. A quarter turn more one way or the other will not be detrimental.

(i) Set the height finder for internal readings and elevate the height finder telescope to 90 degrees.

(j) Observe the reticles and target line, and rotate the height adjuster knob from stop to stop. If the reticles appear to jump away from the target line when the knob is rotated near one end

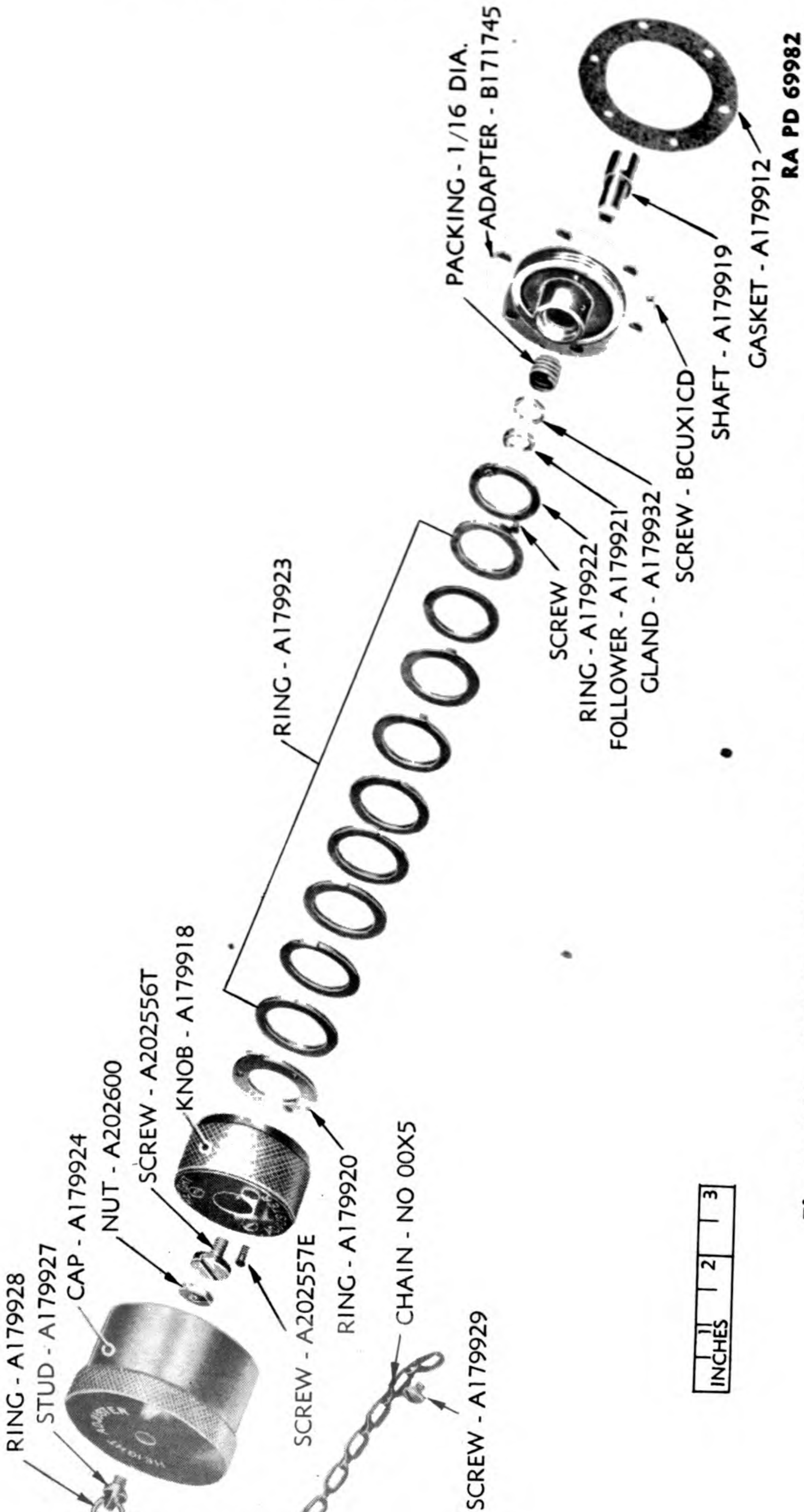


Figure 161 — Height Adjuster Knob Assembly — Exploded View

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT

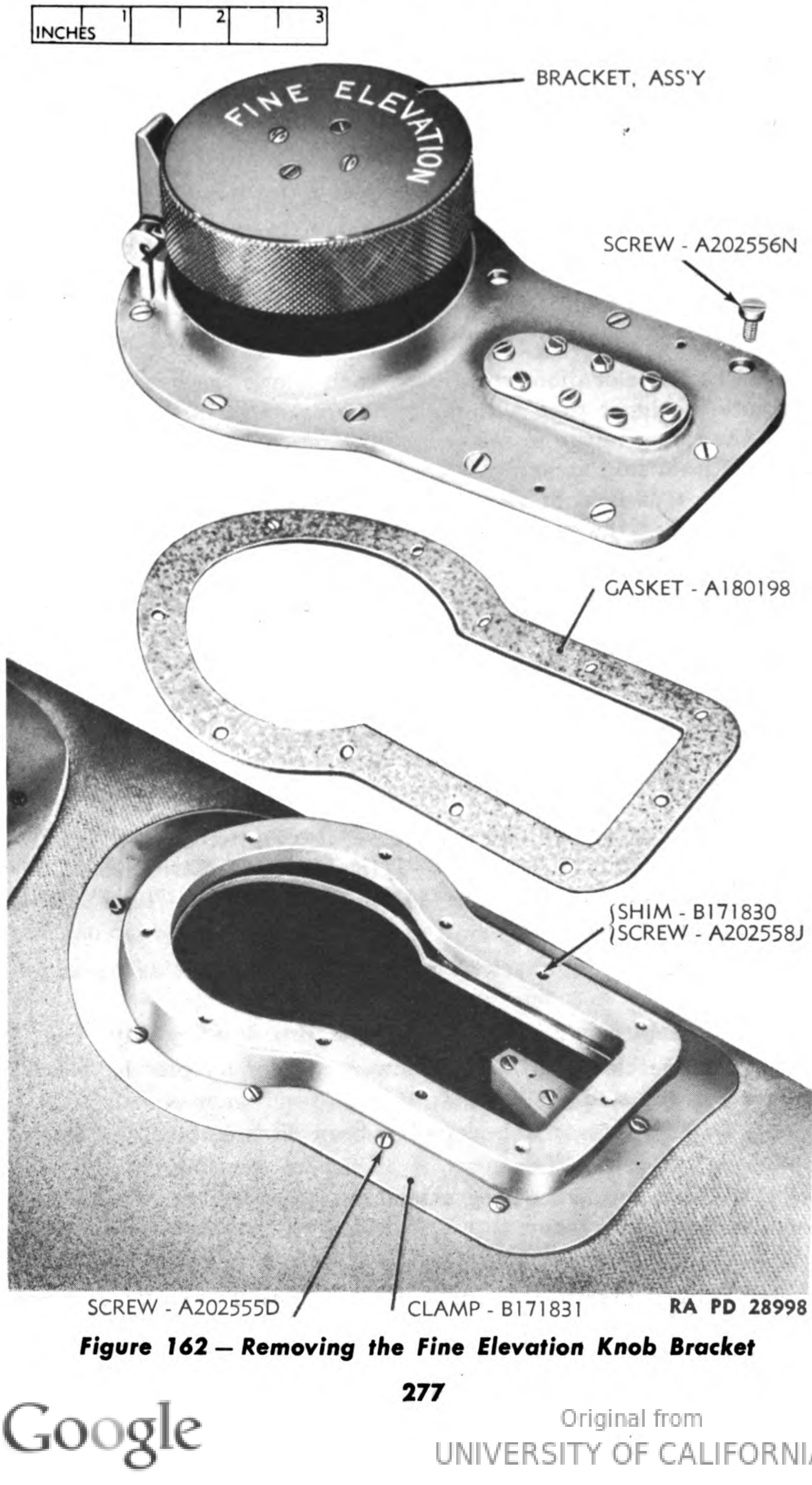


Figure 162 — Removing the Fine Elevation Knob Bracket

of its travel, either there are too many turns of the knob one way or the connecting rod A179911 (fig. 159) is too long.

(k) A connecting rod that is too long will show burs on the connector ring. To correct this condition, file the connector ring where burs appear.

(5) If necessary, repeat all adjustments described above.

(6) Replace and seal the knob adapter to the outer tube shim when all adjustments are satisfactory.

149. FINE ELEVATION ADJUSTMENT KNOB—REQUIREMENTS.

a. The fine elevation adjustment knob allows the stereo observer to rotate the inner tube within the outer tube in order to raise or lower the target image in relation to the reticle marks. Rotation of the knob from stop to stop rotates the tube through an angle of 1 degree of the true field of view. A locking mechanism is provided to lock the knob in the center of its travel. Release is accomplished by pushing a lever adjacent to the knob.

b. The fine elevation knob must be adjusted so that, when it is locked in the center position, the reticle field and the eyepiece field of view at 12 and 24 power will be concentric, and the center row of reticle marks will be adjusted to the center of the eyepiece field of view.

c. The fine elevation knob must also be locked in the center position when the height finder telescope is adjusted to the line of sight.

150. FINE ELEVATION ADJUSTMENT KNOB—PRELIMINARY CENTERING OF THE HEIGHT FINDER RETICLES WITH CENTER (LOCKED) POSITION OF FINE ELEVATION KNOB.

a. The reasons for check of reticle and eyepiece fields are as follows:

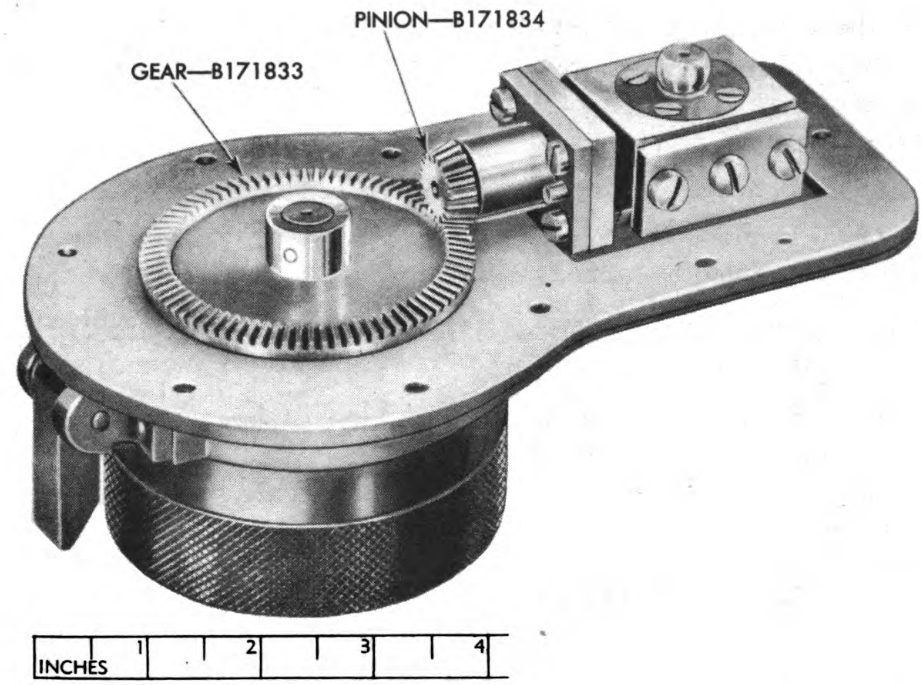
(1) If eyepiece alinement has been disturbed in any way.

(2) If fine elevation knob, follower, cam, or adapter have been replaced or adjusted.

(3) If height finder telescope has been disassembled and assembled.

(4) If inner tube bearing assemblies (figs. 217 and 218) have been changed in any way.

b. Centering. Two methods of centering the reticle may be used: The one described in paragraph 100 is used when the eyepiece has been damaged. When the eyepiece is in adjustment, use the following method:



RA PD 85435

Figure 163 — Fine Elevation Bracket Assembly — Bottom View

(1) Shift the change-of-magnification lever to low power.

(2) Adjust the height finder for outside readings, or direct diffused light into both end windows.

(3) Place a low-power telescope on the centering shoulder of one of the height finder eyepieces.

(4) Rotate the low-power telescope and check to determine if the mechanical axis of the telescope is centered to its optical axis.

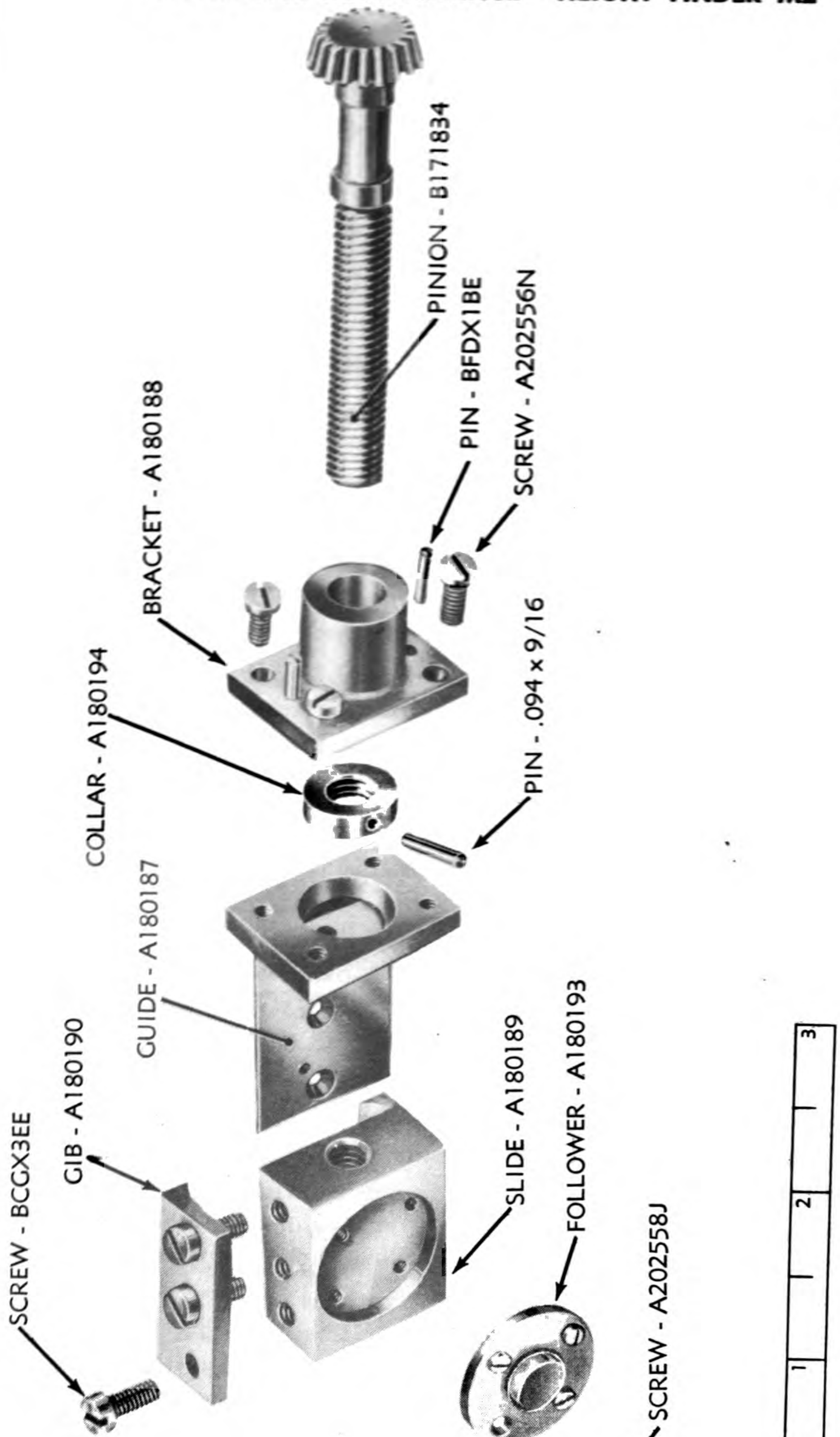
(5) Observe the height finder reticles when the fine elevation knob is locked in the center (locked) position.

(6) Perfectly adjusted reticle fields appear as illustrated ("A," fig. 90).

c. Alinement of Eyepieces With Reticles.

(1) It may not be possible to adjust the inner tube to a position where both eyepieces are alined to the reticles as at "A," figure 90. In such a case as where they cannot be alined as illustrated, the difference in alinement may be adjusted to appear as "B," figure 90.

(2) Differences greater than one ball thickness are an indication that there is dirt on the centering shoulder of the eyepiece or adapter of the low-power telescope, or that the eyepiece is not properly adjusted (par. 101).



RA PD 28997

Figure 164 — *Fine Elevation Slide Assembly — Exploded View*

151. FINE ELEVATION ADJUSTMENT KNOB—ADJUSTMENT OF HIGH OR LOW RETICLE.

a. **New Type of Knob.** If the reticles are high or low in the eyepiece field when observed through the low-power telescope proceed as follows:

(1) Rotate the fine elevation knob until they are centered to the low-power telescope cross hair as shown in figure 90.

(2) Mark the position of the fine elevation knob with a wax crayon line on the knob and bracket.

(3) Remove the 11 screws holding the fine elevation knob bracket assembly to the height finder. Gently pry the assembly up off the two guide pins, taking care not to damage the cork gasket or to rotate the knob.

(4) Remove the fine elevation assembly, and mark the position of the pinion B171834 tooth that engages the bevel gear B171833 (fig. 163) when the crayon lines are opposite each other.

(5) Rotate the knob to the locked position and watch the direction the mark on the pinion gear is rotated.

(6) Remove the small screws from the small cover plate A314528 (fig. 165). NOTE: *Low-numbered instruments do not have this cover.*

(7) Under the plate are three screws A202556N (fig. 165). Loosen them enough to allow the bevel pinion B171834 to be lifted and disengaged from the bevel gear B171833 (fig. 165).

(8) Lift and rotate the bevel pinion gear back to the position in which it was marked.

(9) Tighten the three screws A202556N.

(10) Replace the small gasket and cover.

(11) Position the fine elevation knob assembly on the height finder with all the holding screws in place.

(12) Check center position of the height finder reticles with the low-power telescope.

NOTE: *Very small adjustments may be made by shifting the fine elevation knob assembly around the "screws in the bracket." To prevent binding of the fine elevation knob assembly, all screws must be drawn down equally tight.*

b. **Old Type of Knob.** On instruments which have the older type of fine elevation knob (fig. 166), the center position of the optical bar reticles and center position of the fine elevation knob is adjusted in the manner described below.

(1) Position the reticles and fine elevation knob as described in subparagraph **a**, above.

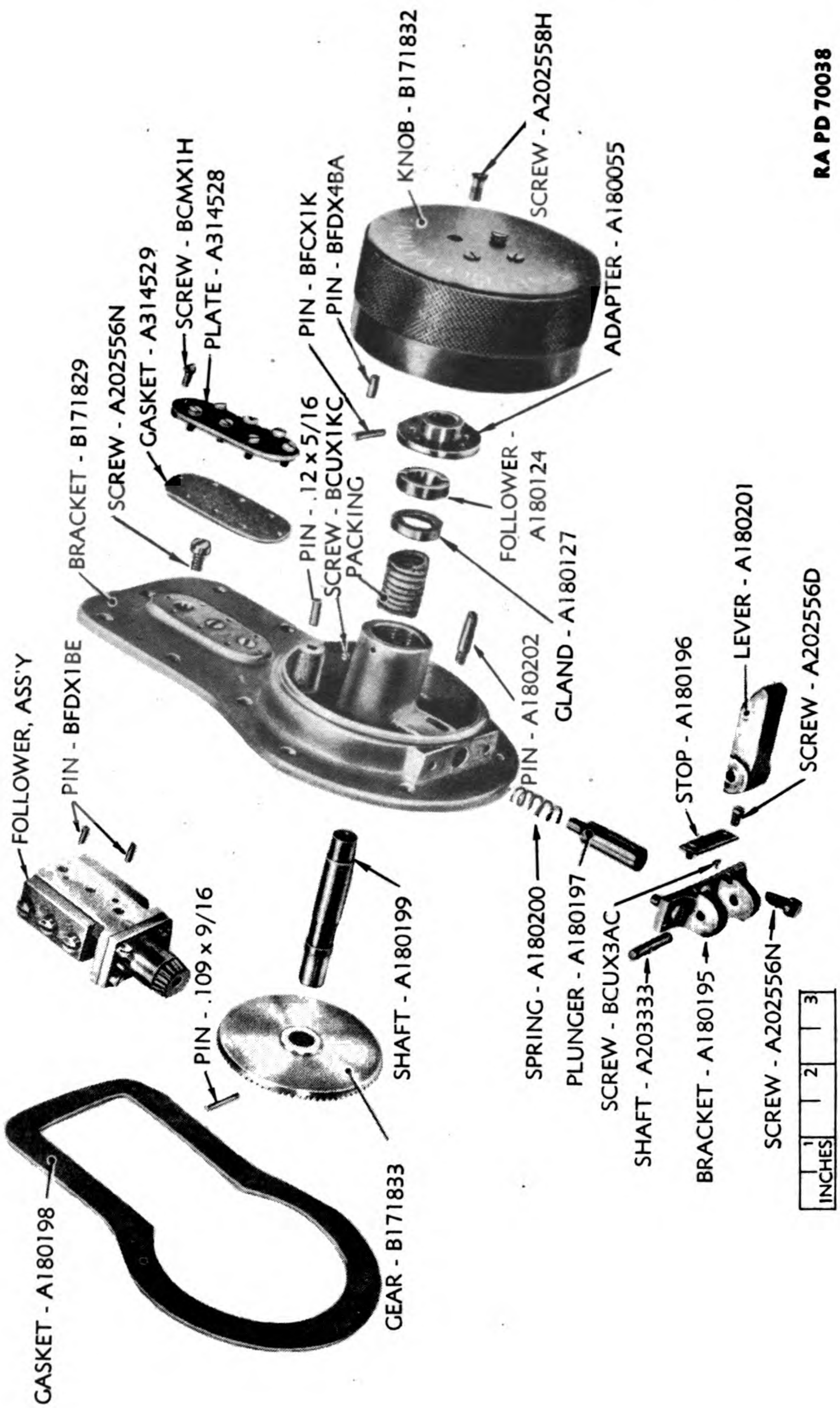
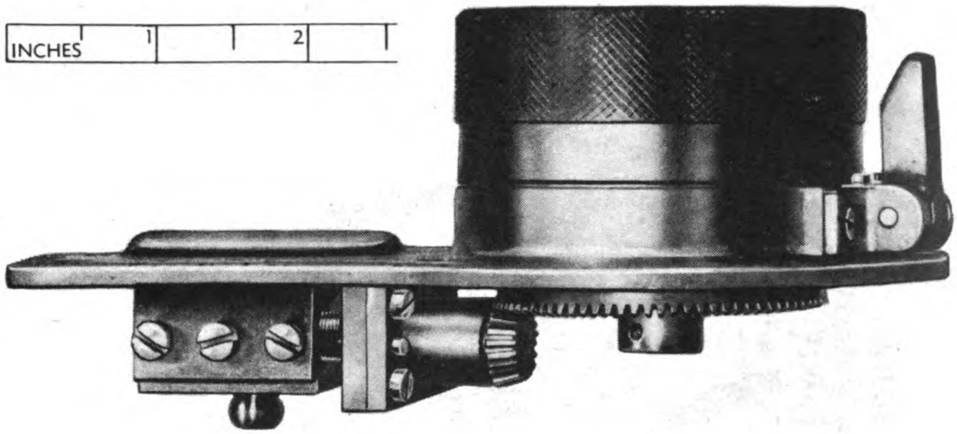


Figure 165 — Fine Elevation Knob Assembly — Exploded View



RA PD 85444

Figure 166 — Fine Elevation Knob Bracket Assembly (Used on Low-number Instruments)

(2) Mark bevel pinion where it engages the bevel gear.

(3) Watch the rotation of the pinion gear mark while rotating the knob to the locked position.

(4) Scribe a line half way across the bevel gear and shaft A180199.

(5) Remove the taper pin holding the bevel gear to the shaft, unlock the knob, and slide the bevel gear shaft off the bevel gear until they are disengaged.

(6) Disengage the bevel pinion and bevel gear.

(7) Rotate the pinion gear around to the position in which it was marked.

(8) Engage the bevel pinion and bevel gear. Assemble the bevel gear shaft and taper pin.

(9) Lock the knob in center position and check the position of the mark on the bevel pinion.

(10) Place the knob bracket assembly on the height finder as directed above, and check the adjustment.

(11) Seal the cork gasket and replace all holding screws. NOTE: *Binding and uneven operation of the knob will result unless all holding screws are drawn down equally tight.*

c. **Lost Motion.** Lost motion is evident when the reticles will not aline at the same position while observing through the low-power glass and rotating the fine elevation knob from a stop to the locked

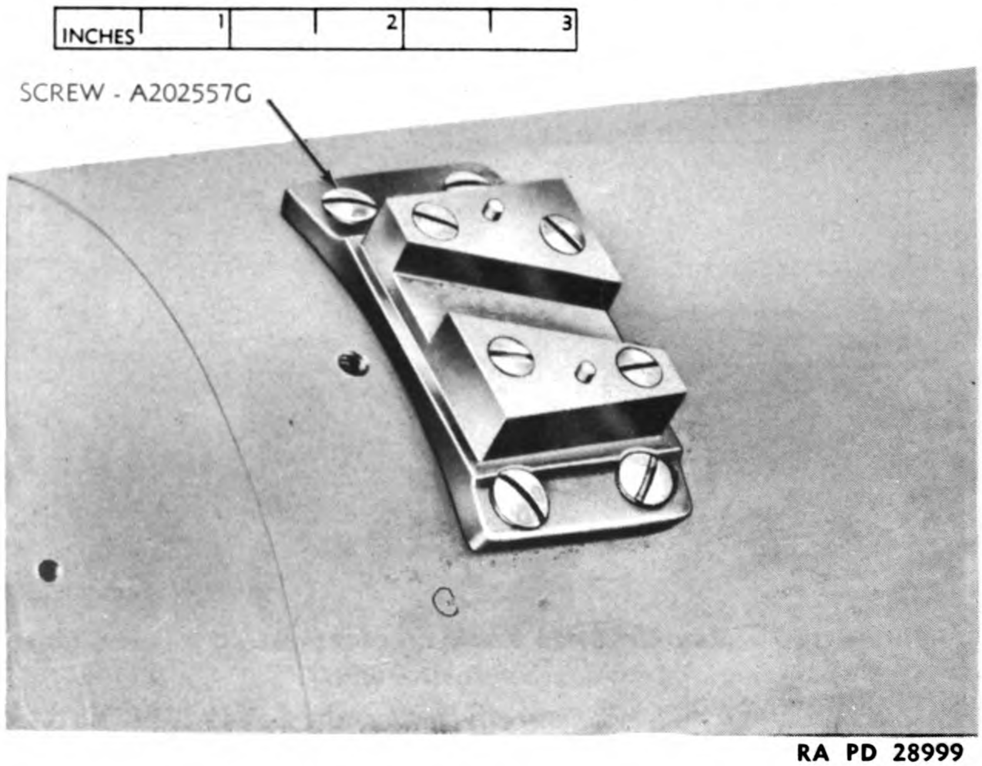


Figure 167 — Fine Elevation Cam Assembly

position a number of times. Determine the cause and eliminate as directed below.

(1) Remove the fine elevation bracket assembly from the height finder as described in subparagraph a, above.

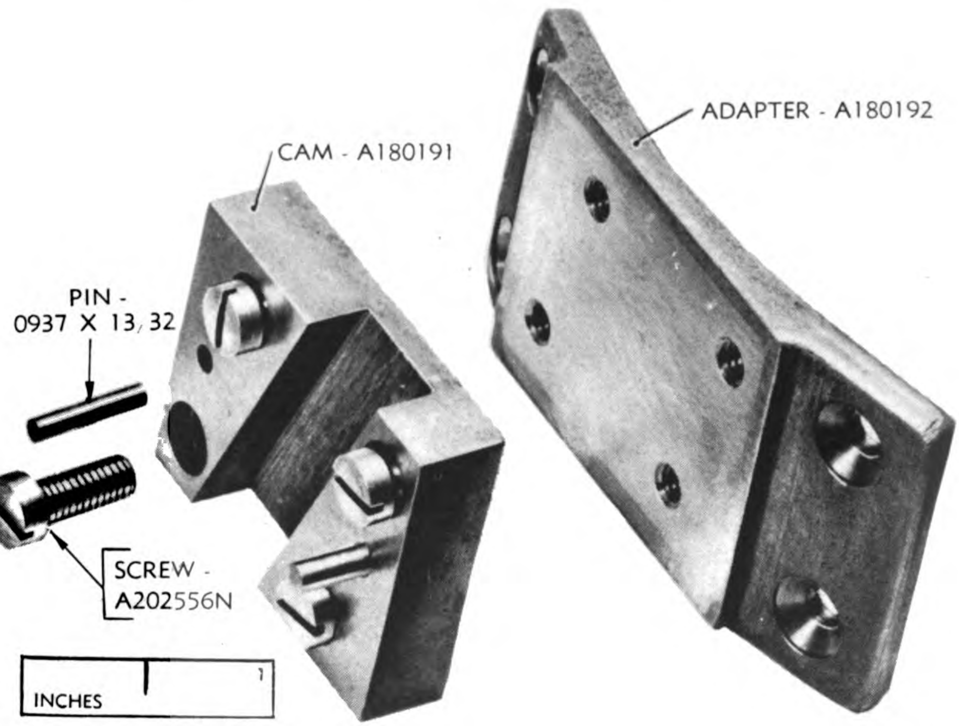
(2) Inspect the screws in the inner tube cam adapter A180192 (fig. 168). They must be tight and hold the adapter securely to the tube.

(3) Inspect the screws holding cam A180191 (fig. 168) to the adapter. These screws must be tight and not bottom on the inner tube.

(4) Two pins 0.0937 x $^{13}/_{32}$ should be tightly in place through the cam and adapter.

(5) Remove follower A180193 from slide A180189 (fig. 164) and inspect the fit between follower and cam slot, by placing the follower in the slot and checking the fit. This should be just snug enough to be moved by hand.

(6) Shake between the cam and follower can be eliminated by placing small shims between the cam and inner tube adapter, either at the top or lower area of the cam, just outside of the holding screws.



RA PD 70041

Figure 168 — Fine Elevation Cam Assembly — Exploded View

(7) When a cam or follower is damaged by Brinelling, they should be replaced by spare parts (SNL F-189).

(8) If only the follower is damaged, it may be rotated in the slide recess until sides that are not Brinelled contact the sides of the cam.

(9) Return the fine elevation knob bracket assembly to the height finder after the gasket is properly prepared to eliminate leaks.

(10) Check all adjustments described above.

152. INTERNAL TARGET SYSTEM—COMPLETE ADJUSTMENT REQUIREMENTS.

a. The internal target system is largely self-compensating, and normally should not require any adjustments unless one or more of the optics have been damaged or have shifted in their mounts. Large temperature changes will cause considerable changes in the adjuster scale setting, but these need not be compensated for, so long as the setting remains on the scale.

b. Before any corrections are made on the internal target system, the main optical system of the height finder must be in proper adjustment. If the basic inspection indicates that the main optical system is not in adjustment, the necessary corrections must be made as described in the appropriate paragraphs. The adjustments which involve stereoscopic observation of the internal target line should be made by an experienced stereo observer. Adjustments or repairs to any units of the internal target system will require breaking the hermetic seal of the height finder tube.

153. OUTLINE OF ADJUSTMENT OF INTERNAL TARGET SYSTEM.

a. Preparation (Height Finder Main Optical System Must Be in Adjustment).

(1) Set height-range lever at "RANGE," and measuring drum at infinity.

(a) Adjust height adjuster for halving on an external target.

(b) Set adjuster scale at "60."

(2) Turn the adjuster knob to bring the penta prisms into position for internal readings.

(3) Set the light switch at "2" and the transformer-battery switch at "TRANS." if the 110-volt source of power is used (fig. 48).

(4) Set internal target at desired position for readings by turning the correction knob (fig. 115) and collimator knob (fig. 175).

(5) The internal target collimator is properly adjusted when:

(a) The best focus setting for both target lines and reticles is zero diopter on both eyepieces as observed with the collimating telescope.

(b) The collimator target lines are parallel to the central measuring marks and to each other.

(6) Before proceeding with the adjustment, the penta prisms should be checked for centering, pupil size, and illumination, as directed in paragraph 155.

b. Focus.

(1) Place the low-power telescope on the *right* eyepiece, and determine the position of best focus of the target line. If the reading is not zero, then the distance between the collimator objectives must be varied. This is accomplished by shifting the objectives in a manner similar to that used in adjusting the optical tube objectives.

(2) If the reading is plus "+," remove the left illuminator adapter cover B171749 (fig. 169) and increase the distance between the objectives by means of adjusting rings A179970 and A179955 (fig. 172). Use adjusting pin for this purpose (fig. 76). Secure the objective by means of the adjusting rings, replace the cover and lamp bracket temporarily, and check the focus.

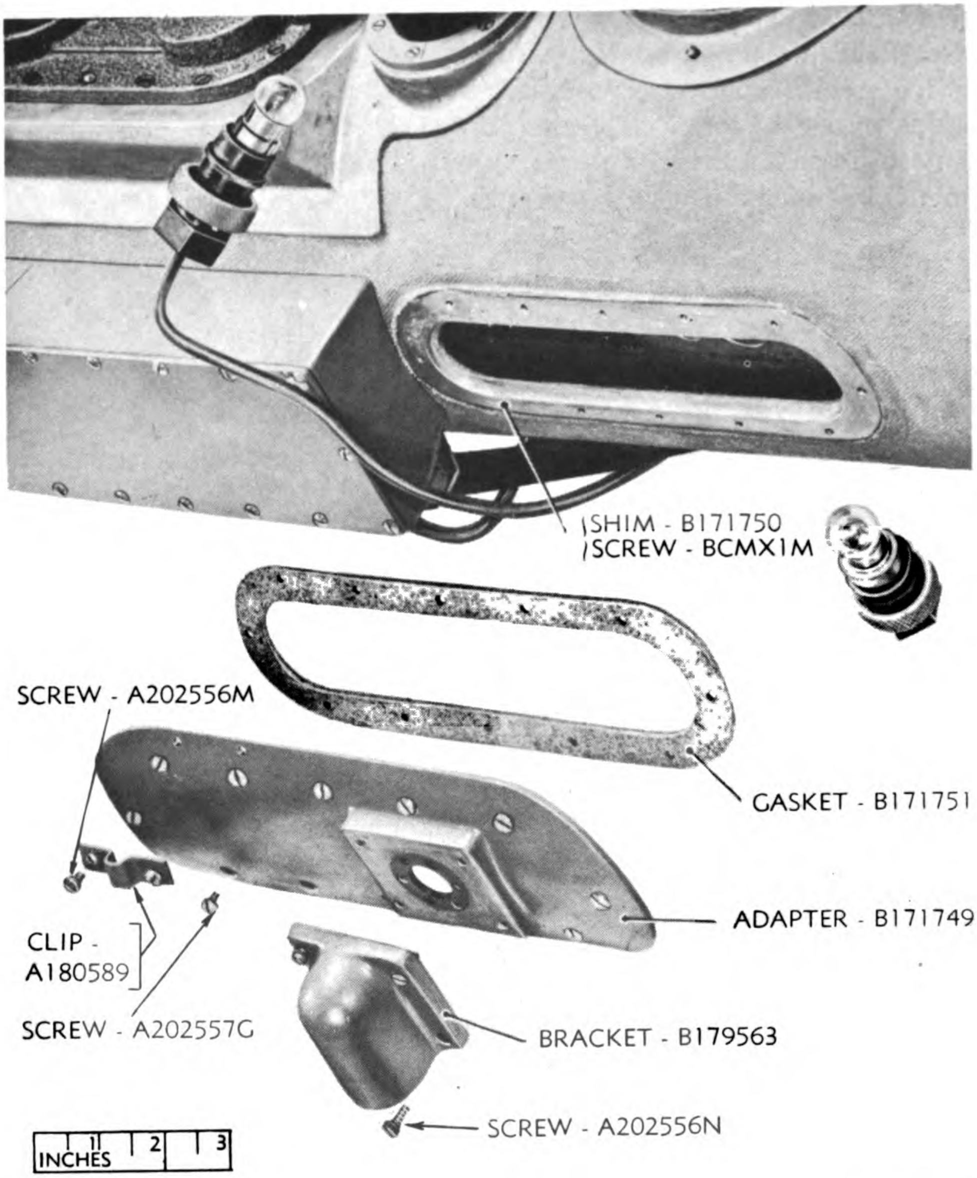


Figure 169 — Removing the Internal Target Illuminator and Adapter

(3) The focus for the *left* eyepiece is varied by changing the thickness of the air space between the elements of the left collimator objective. This is accomplished by rotating the lens spacing ring A179948 (fig. 172).

(4) Place the low-power telescope on the left eyepiece and determine the position of best focus. If the diopter scale reading is plus "+," proceed as follows:

(a) Remove the *left* illuminator cover (fig. 169).

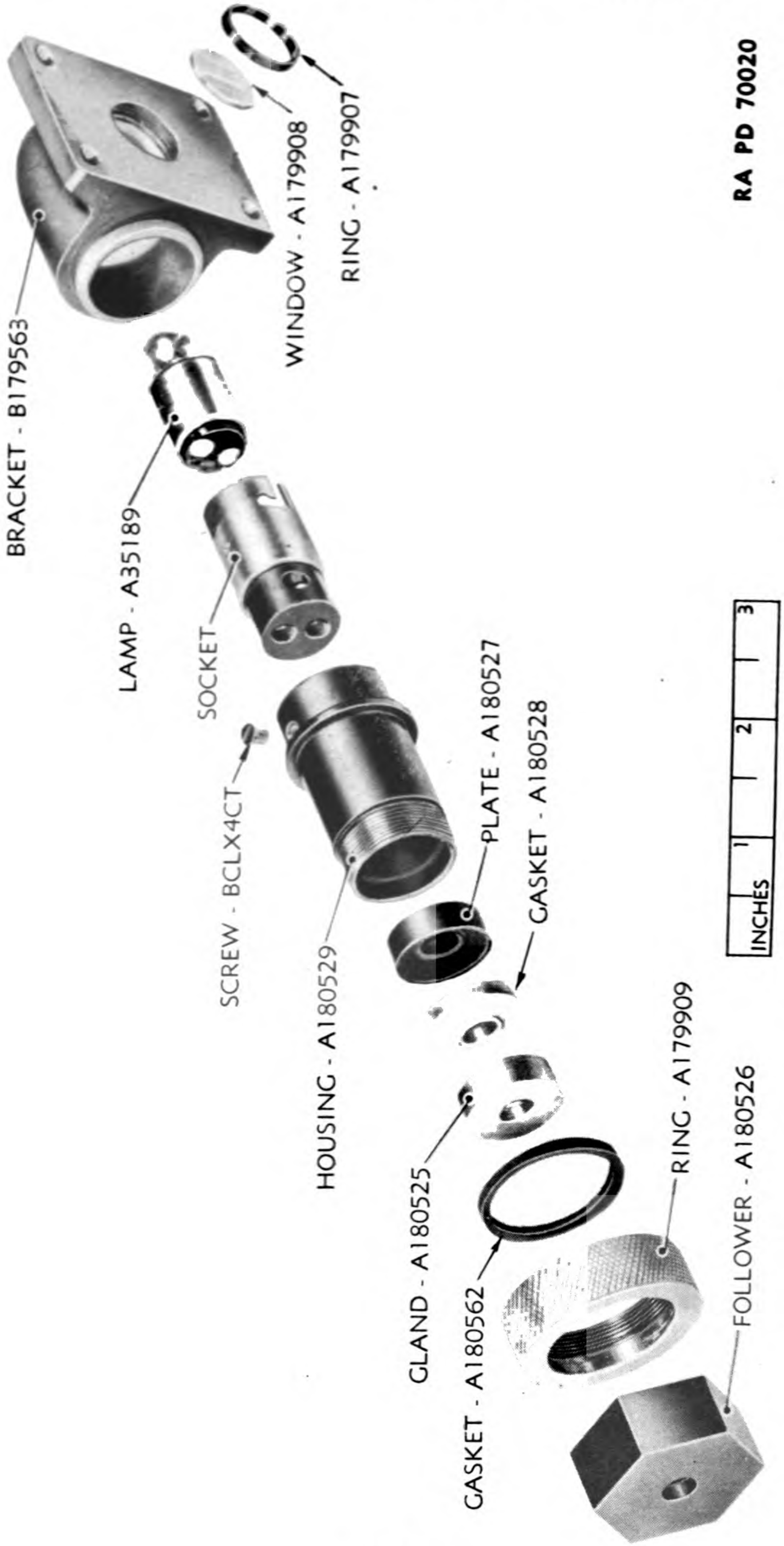


Figure 170 — Internal Target Illuminator Assembly — Exploded View

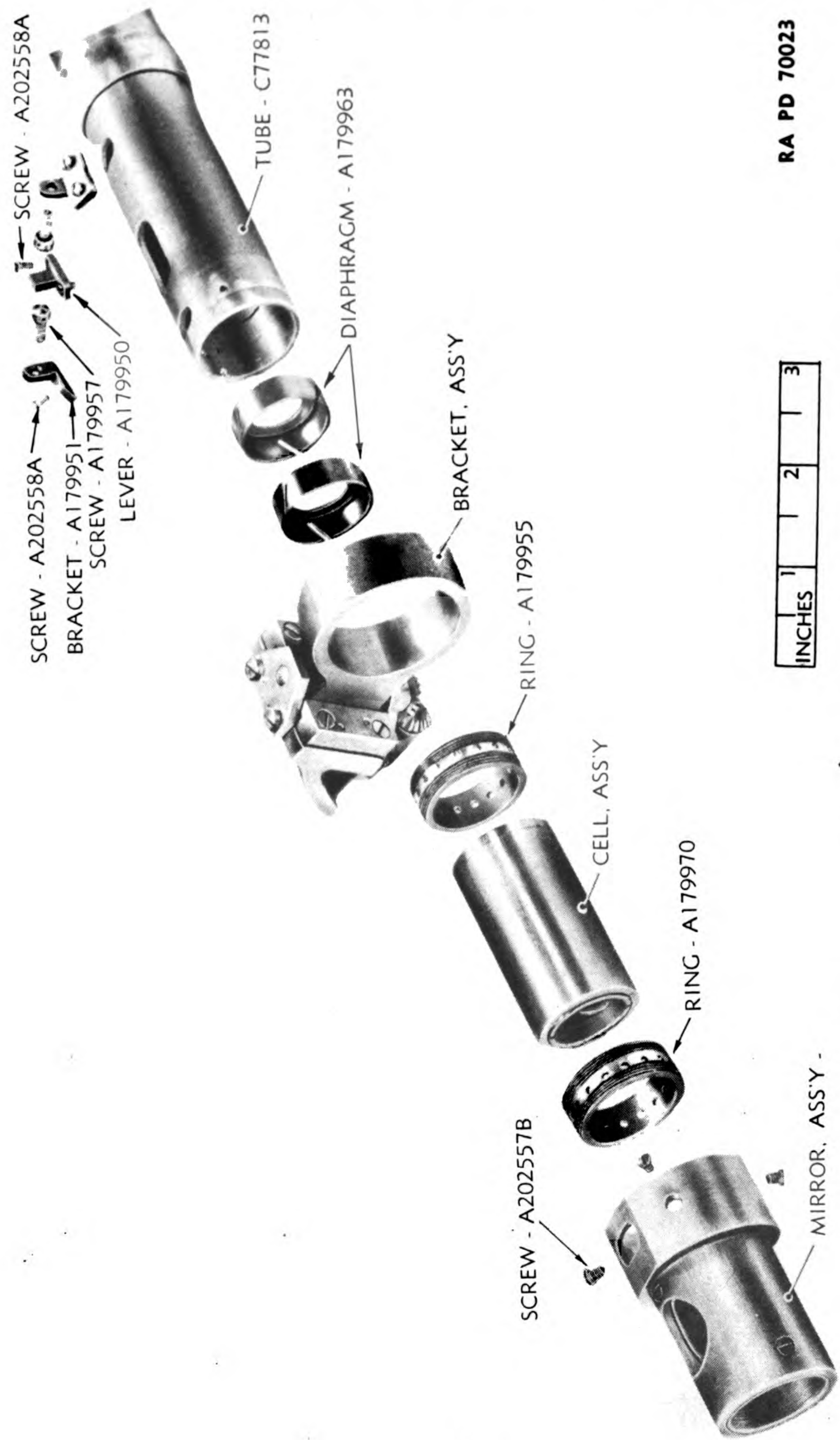


Figure 171 — Internal Target Collimator Assembly (Right End) — Exploded View

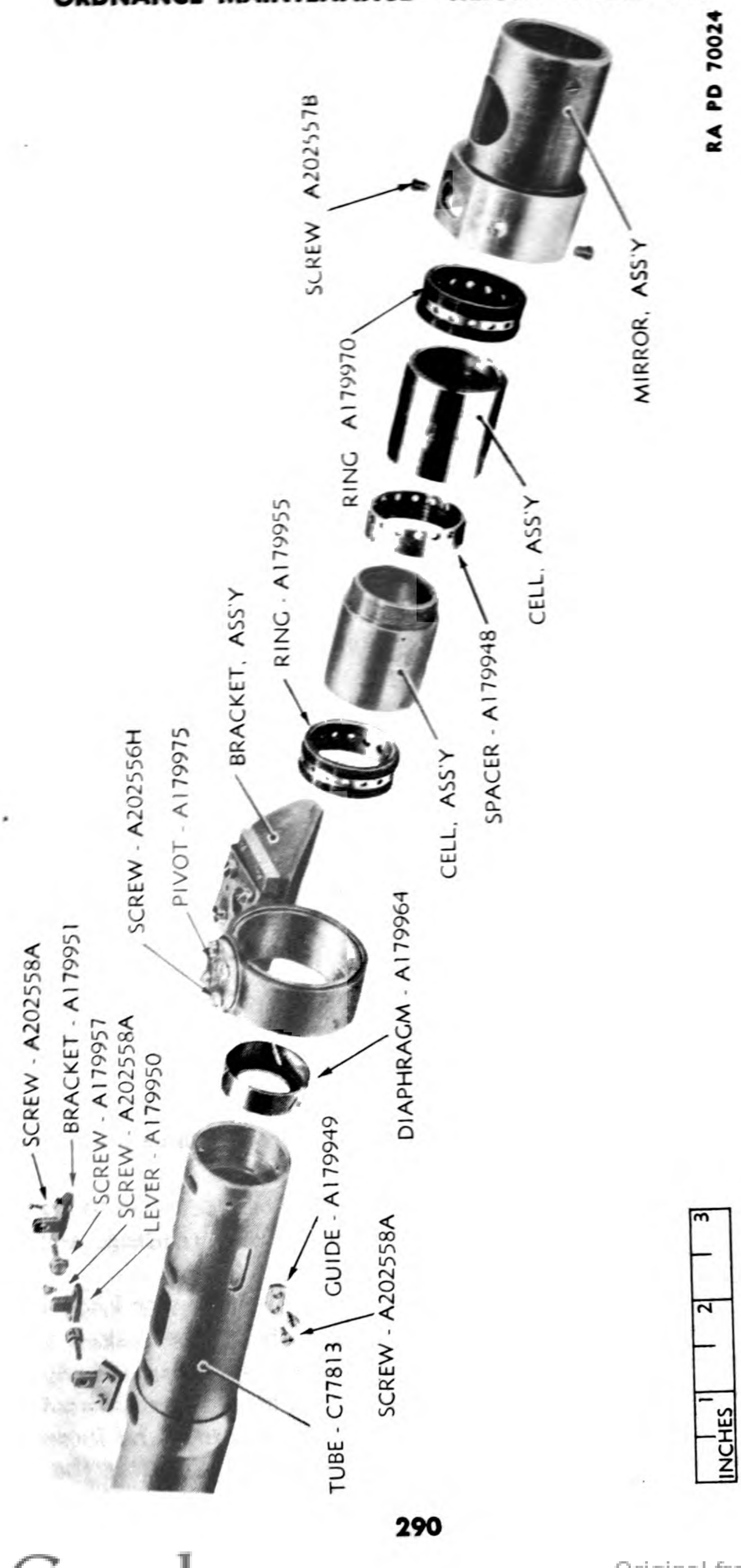


Figure 172 — Internal Target Collimator Assembly (Left End) — Exploded View

(b) Loosen the *outer* adjusting ring A179970 and rotate the lens spacing ring A179948 (fig. 172) in the direction which separates the elements of the objectives (adjusting holes move down). NOTE: *Do not rotate the inner adjusting ring, A179955 (fig. 172) in this case.*

(c) Rotating the inner adjusting ring, and moving the inner objective cell assembly, changes the focus for the right eyepiece.

(d) Secure the objective with the outer adjusting ring.

(e) Check the focus and secure the adapter cover temporarily. NOTE: *Focusing of the right objective cell (fig. 171) will not be necessary unless, while following the above adjustments it is found that proper focusing is not possible due to the extreme plus or minus movement of the left-side adjusting rings. If more movement in a plus direction is desired, then move the right objective and reticle mount in the direction to increase the distance between the objectives, until proper focus is obtained.*

c. Parallelism of the Internal Target (Collimator) Reticles.

(1) The collimator reticles are properly adjusted when the lines on one reticle are parallel to those on the other.

(2) This adjustment should be made when the collimator is mounted in the instrument.

(3) Check the parallelism of the collimator lines in both eyepieces with the central measuring marks. Lack of parallelism is corrected by manipulating adjusting screws A179957 (fig. 171).

(a) Make a careful height adjustment on an outside target and mark the height adjuster knob for center of motion; note number of turns clockwise and counterclockwise.

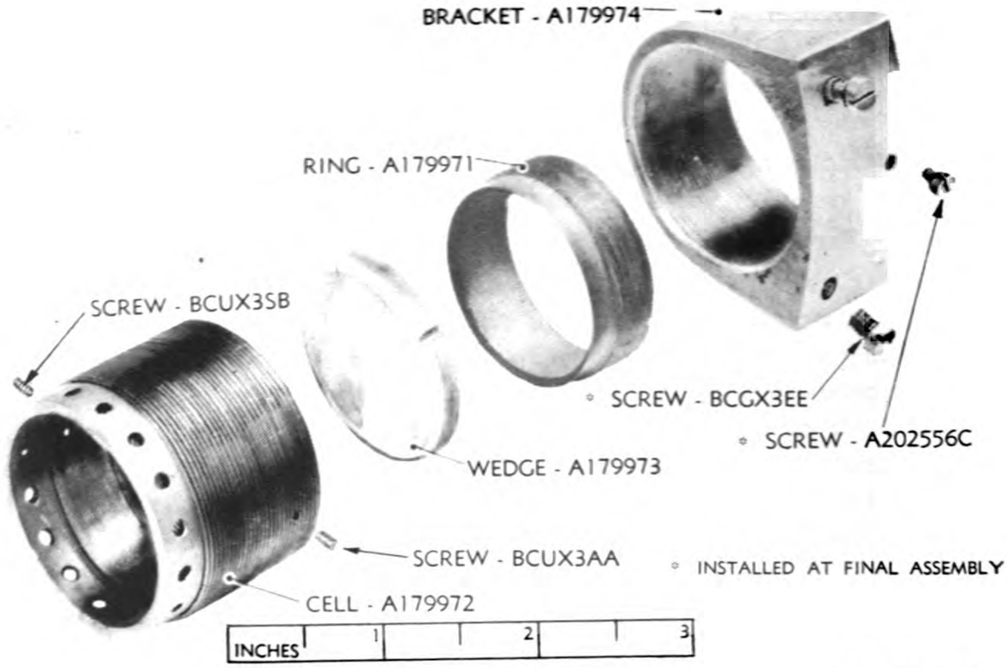
(b) Set the range-height scale on infinity and adjuster drive in position for internal readings.

(c) Take five internal readings with the height adjuster knob in the central position and record the average.

(d) Turn the height adjuster knob clockwise to the end of its motion, and again take five internal adjuster readings and record the average.

(e) Turn the height adjuster knob counterclockwise to the end of its motion, and again take five internal adjuster readings and record the average.

(f) If the readings taken when the height adjuster knob is clockwise to the end of its motion are higher than those taken with the height adjuster at the end of motion counterclockwise, the movement of the adjusting lever A179950 on the right objective of the collimator is down (fig. 171). One of the adjusting rings must be loosened before making adjustments to the lever (fig. 171). After the adjustment is made, the adjusting ring must be tightened.



RA PD 70028

Figure 173 — Internal Target Alinement Wedge — Exploded View

(*g*) If the average adjuster readings in steps (*c*), (*d*), and (*e*), above, differ by more than two units, then the right collimator objective cell must be rotated by means of the adjusting screws. This is a sensitive adjustment.

d. Method of Adjusting the Right Collimator Objective.

(1) Remove the right adapter cover.

(2) Loosen adjusting ring A179970.

(3) Loosen lever adjusting screw A179950 in the lower bracket A179951 (fig. 171).

(4) Tighten upper adjusting screw.

(5) Tighten the adjusting ring.

(6) Repeat the reading taken in steps (*c*), (*d*), and (*e*), above, and adjust the objective lever until the readings taken are within tolerance. NOTE: *Tolerance is 1½ units difference between the high and low averages of the three sets of readings taken in steps (c), (d), and (e), above.*

(7) Secure the adapter cover with two screws and check for tilt.

e. Tilt of Target Lines.

(1) Tilt of the target line when observed stereoscopically is caused by a slight difference in lean of the target lines in each objective.

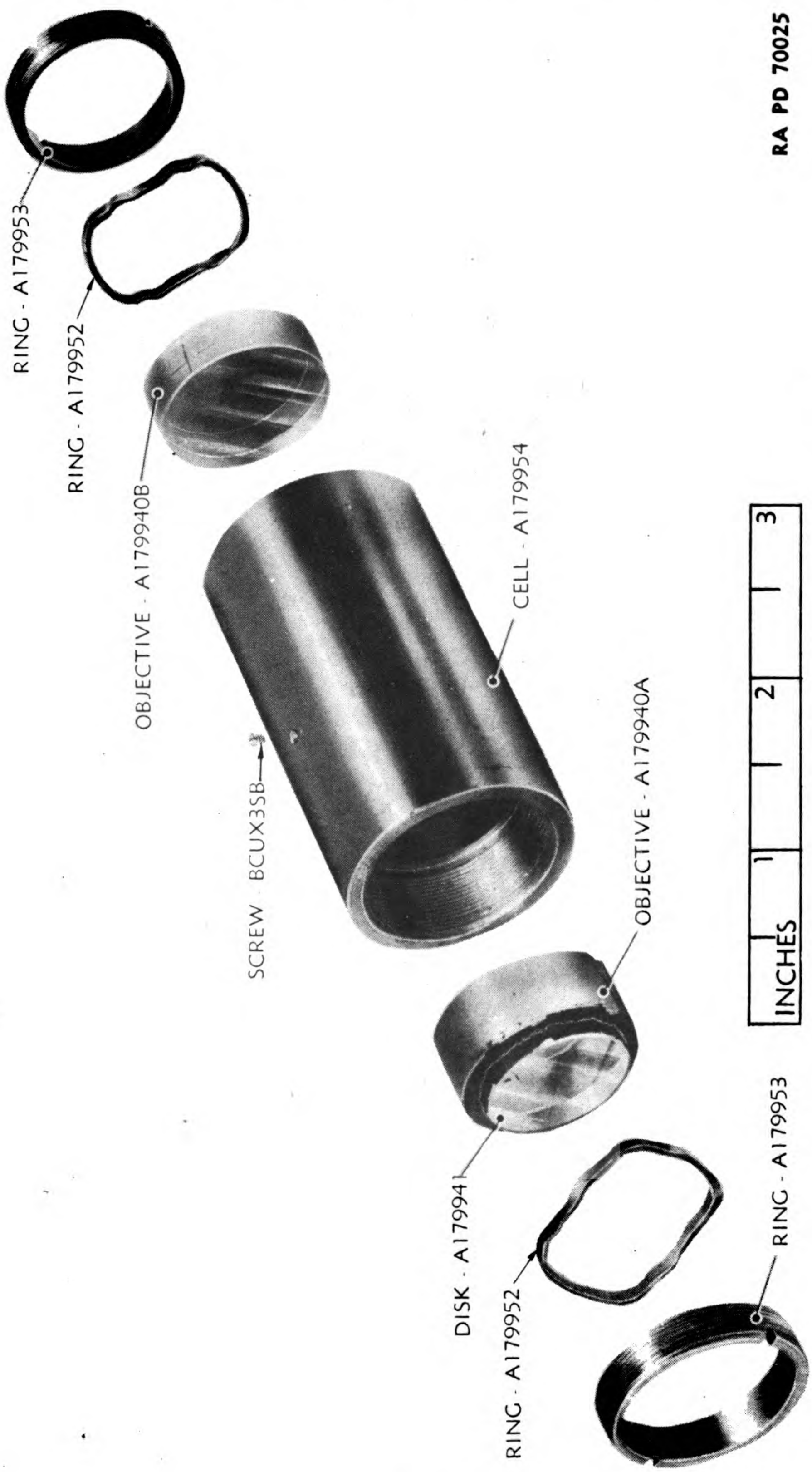


Figure 174 — Internal Target Disk and Objective — Exploded View

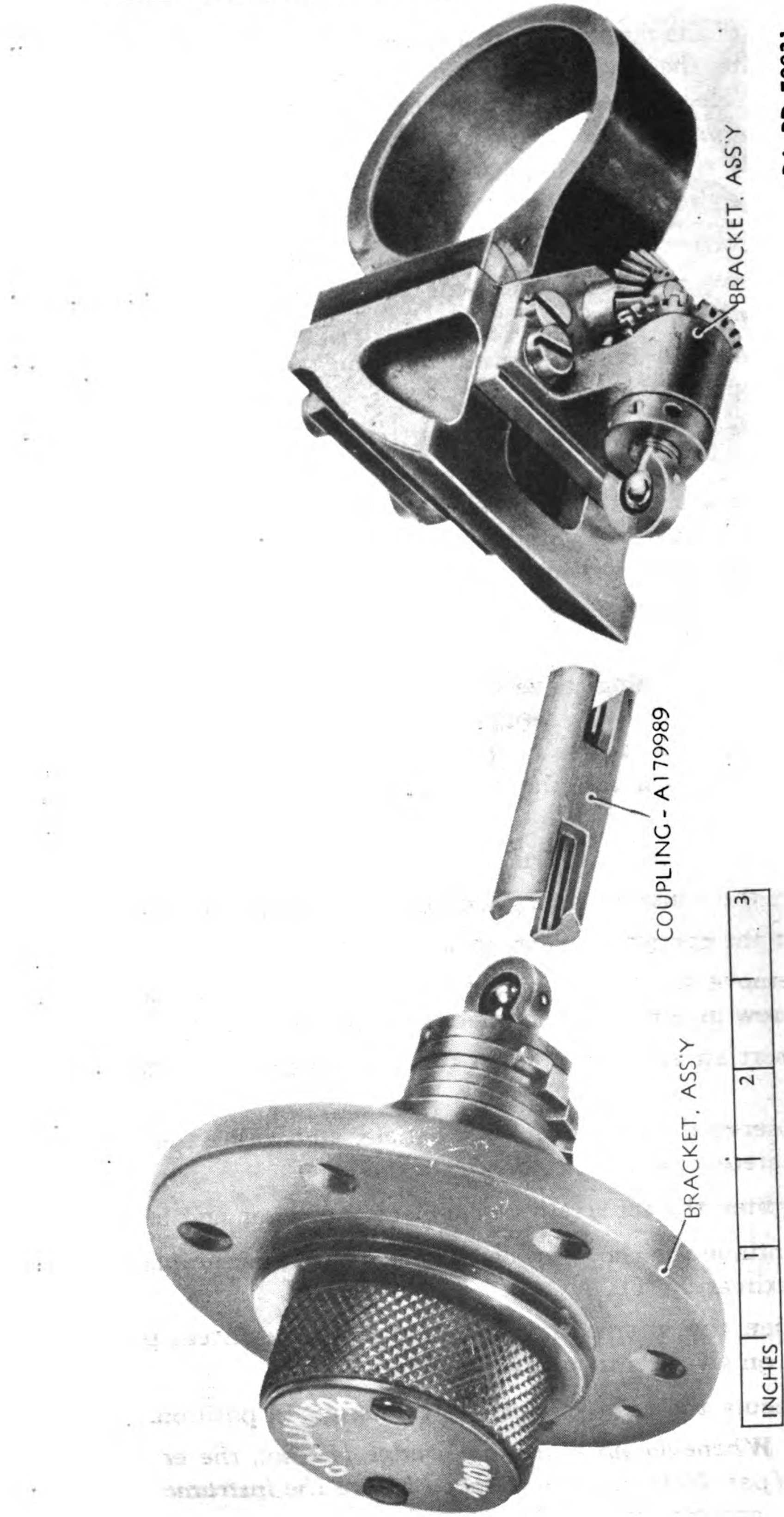


Figure 175 — Collimator Adjuster — Functional View

(2) Tilt of the target lines is also evident if five internal readings are made, using the top of the reticle to make stereo contact with the target lines. Record the readings, then take five readings, using the bottom of the reticle mark to make stereo contact. If the average of the first set of readings is high, the reticles are tilted toward the observer, and they must be tilted back or down.

(3) To correct reticle tilt proceed as follows:

(a) Remove the left illuminator adapter cover and loosen one end adjusting ring.

(b) Loosen the bottom lever adjusting screw (fig. 171) and tighten the top screw.

(c) Secure the loosened adjusting ring. This is a sensitive adjustment.

(d) Recheck adjustment covered under subparagraph *(c)*, above, and refine the adjustments under subparagraph *(c)*, above, until the parallelism adjustment average readings are within tolerance and there is no apparent tilt of the target lines.

f. **Internal Target Alinement Wedge (Collimator).** When a series of internal readings have been made with the height finder adjusted for internal readings, range-infinity position, the average of the series of readings, should be in the vicinity of "60" on the correction knob scale. If this is not the case, adjust the alinement wedge as follows:

(1) Set the measuring drum scale at infinity.

(2) Set the conversion ring lock over the range locking bracket.

(3) Set the correction knob scale on "60."

(4) Remove the left illuminator adapter cover and loosen the small set screw in the alinement wedge adapter (fig. 173).

(5) Insert an adjusting pin in the adjusting holes of the wedge cell.

(6) Observe the target line and reticle, and rotate the cell until apparent stereoscopic contact has been made.

(7) Tighten the set screw and replace the cover and lamp.

(8) Continue the above procedure until the correction scale reading is approximately "60."

(9) When the internal target collimator is adjusted, place varnish shellac on all parts that have been moved.

(10) Secure the cover plates and the lamps in position.

NOTE: *Whenever an alinement wedge is reset, the end window adjustment (par. 160) must be checked before the instrument may be considered ready for range or height finding.*

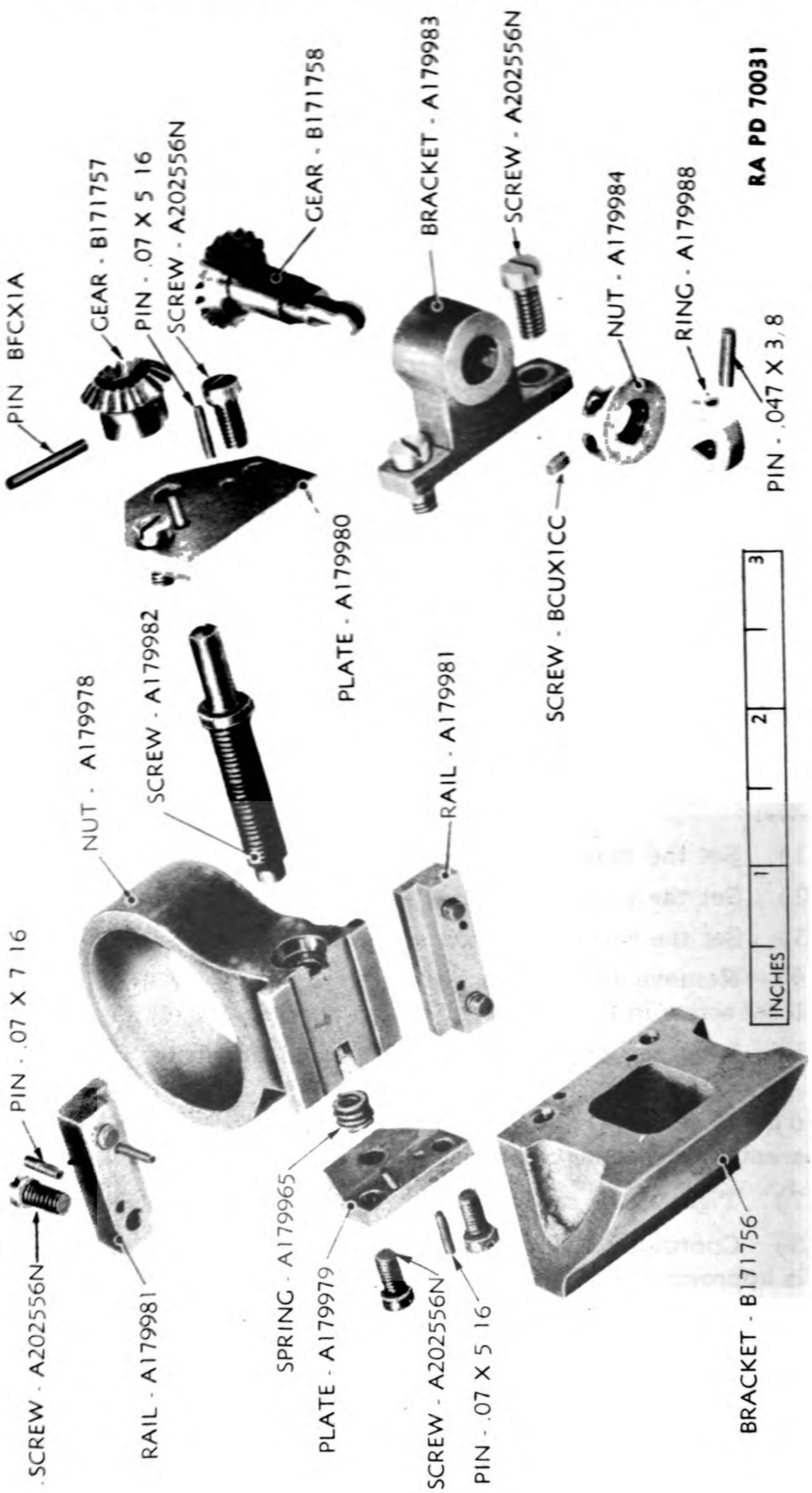


Figure 176 — Collimator Adjuster Bracket Assembly — Exploded View

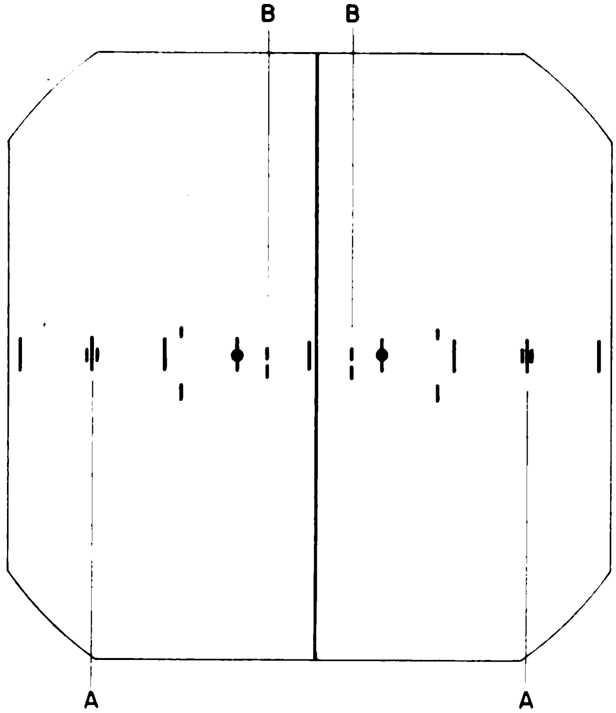


Figure 177 — Movement of the Internal Target Line

154. COLLIMATOR KNOB.

a. The position of the target line in the reticle field can be adjusted for the convenience of the stereo observer. When making internal readings, the target line should be placed near the right or left side of the center main reticle mark. The observer can set the distance he desires the reticle and target line to be separated by rotating the collimator knob.

b. The rotation of the collimator knob (fig. 175) is transmitted by the bevel gears B171757 and B171758 to a screw A179982 which engages the right support nut A179978 (fig. 176). The support nut is accurately fitted to a slide in support bracket B171756 which is secured to the inner tube.

c. Rotation of the knob causes the support nut and the right end of the collimator to move in a horizontal plane toward the front or rear of the instrument with the left support bracket (fig. 178) acting as a pivot.

d. The adjustment of the stops in the collimator knob are properly set when the target line moves from "A" to "A" (fig. 177) as the target line is observed through the eyepiece and the knob is rotated from stop to stop.

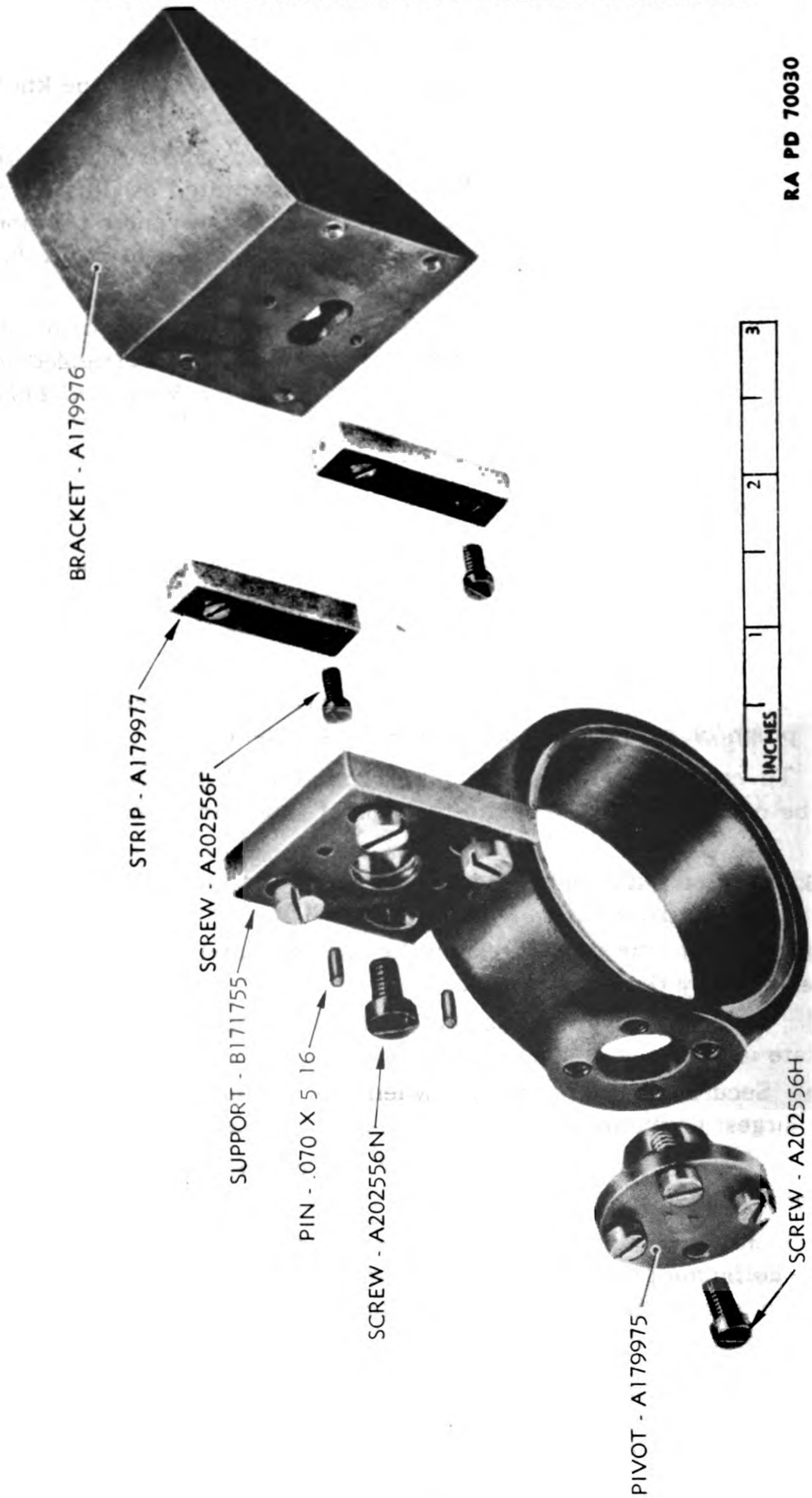


Figure 178 — Collimator Support Assembly (Left) — Exploded View

e. If the target line travel is not as illustrated:

(1) Remove the screws holding the bracket assembly of the knob to the height finder.

(2) Hold the knob and rotate the bracket to a position where the target line has the travel when the knob is rotated as illustrated in figure 177. Center of travel of the knob is in the center position when the target line is placed close to the center reticle mark for stereo readings.

(3) Replace the holding screws and check the adjustment. NOTE: *On high-numbered instruments, the stops are so arranged in the knob that the complete travel of the collimator knob will only move the target line the distance illustrated from "B" to "B"* (fig. 177).

155. PENTA PRISMS.

a. The illumination of the internal target fields is properly adjusted when the stereoscopic reticle marks appear centered up and down and sideways in the illuminated fields, using the unaided eyes to observe the centering.

b. The end boxes must be removed to perform adjustments on the penta prism or penta prism assemblies (par. 164).

c. To center the illumination "right and left," the penta prism must be moved perpendicular to the axis of the instrument (front to rear).

(1) Place a pupil loupe on the eyepiece of the side that the penta prism is to be adjusted.

(2) Focus to the small circle on the objective and to the illumination reflected by the penta prism.

(3) Loosen screws holding plate A180156 (fig. 179) and rotate the plate around the enlarged screw holes.

(4) Secure the screws tightly when the illumination is centered to the largest point, and centered to the optical tube circle.

d. To center the illumination "up and down," the penta prism must be tilted.

e. The direction to tilt the prism may be determined by loosening the screws in the prism plate A180156 (fig. 179) and inserting strips of paper under the bosses on the plate, and by observing the direction the light moves while observing through the eyepiece with an unaided eye.

f. Remove the plate and stone the bosses until the illuminated field is centered to the reticle. Secure the screws and varnish shellac the heads.

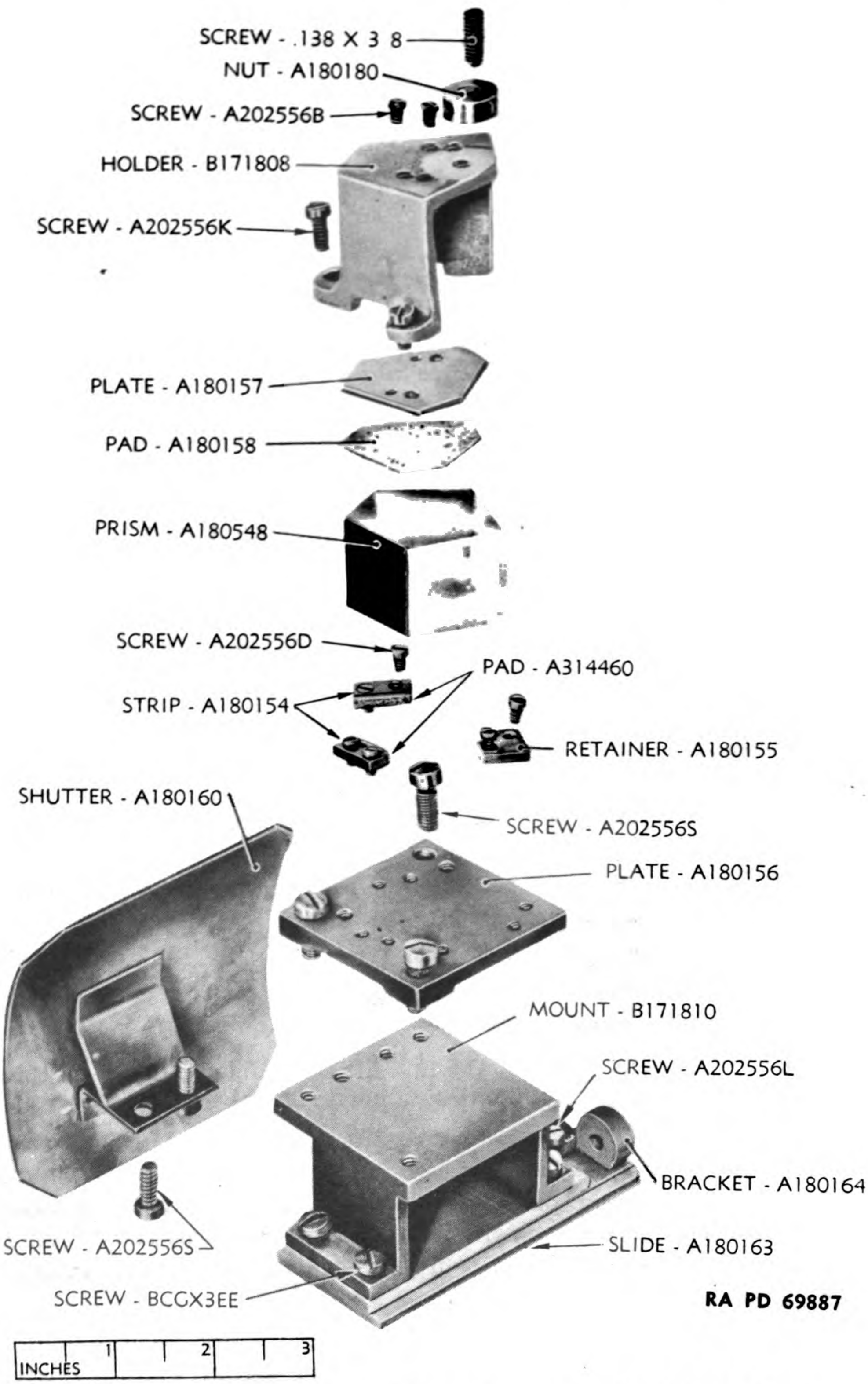


Figure 179 — Adjuster Penta Prism Assembly — Exploded View

NOTE: *When making adjustments to the penta prisms, a piece of black paper placed around the end reflectors and prism brackets will exclude most of the external light.*

g. A decentered prism may be corrected as follows:

(1) Place a pupil loupe on the eyepiece of the side the prism is to be adjusted and focus it to the small objective circle and prism pupil which should appear in the center of the eyepiece field.

(2) Any one or a combination of the following adjustments are necessary to properly position the pupil:

(a) Moving stop A180166 (fig. 87).

(b) Rotating plate A180156 (fig. 179).

(c) Shifting plate mount B171810 on slide A180163 (fig. 179).

NOTE: *The width of the pupil varies slightly when the penta prism is rotated in azimuth.*

156. PENTA PRISM DISASSEMBLY AND ASSEMBLY.

a. Removal of the penta prisms from plate A180156 will only be necessary to replace a damaged prism. The prisms should be cleaned and adjusted while assembled to the plate.

b. Remove the penta prism assembly from the height finder in the following manner:

(1) Remove the end box (par. 164).

(2) Remove stop A180167 (fig. 87).

(3) Remove round nut A180129 (fig. 190).

(4) Remove the penta prism assembly from the support.

(5) Remove and replace the penta prism in the following manner:

(a) Remove screws A202556K (fig. 179).

(b) Remove holder B171808.

(c) Remove retainer A180155 and lift the damaged prism off the prism plate.

(d) Assemble the new prism to the prism plate and replace the retainer.

NOTE: *Not all penta prisms are of the same size, so slight adjustments may be necessary on strips A180154 and the retainer.*

(e) Loosen nut A180180 and screw 0.138 x 3/8, this will take the pressure off plate A180157.

(f) Assemble the holder over the new prism, taking care that the holder fits over the prism without touching the prism.

(g) Secure the holder in place with the three holding screws.

(h) Hold nut A180180 and tighten the nut screw down against plate A180157 just tight enough to hold the prism in place, then tighten the nut and apply varnish shellac to the nut, and screw in place. CAUTION: *If too much pressure is applied to plate A180157 by the nut screw, the prism will develop strain and will be useless.*

c. Clean slide A180163 and the area that the slide operates on the support. Lightly grease the slide and assemble to the height finder in reverse order of disassembly, taking care to observe the NOTE in paragraph 159 **b** (8) *(f)*.

d. Check and adjust the illuminated field of the internal target as directed in paragraph 153 **c**.

e. Adjust the alinement wedge as outlined in paragraph 153 **f**.

f. Replace the end box.

g. Check the end window adjustment (par. 160).

h. Replace the carrier handles.

157. INTERNAL TARGET SYSTEM —REQUIREMENTS FOR REMOVING COLLIMATOR OBJECTIVES (INSTRUMENT ASSEMBLED).

a. General. After the height finder has been in service over a long period of time in varying climates, it may be necessary to clean the optical elements of the internal target system. Important among these elements are the internal target (reticle) plates.

NOTE: *On low-numbered instruments that have double target lines, if it is impossible to focus the objectives to a point of sharp focus, it will be necessary to replace the old type of objectives and target lines with new matched single-line target lines and objectives.*

b. Requirements. It will not be necessary to disassemble the height finder to remove the optical elements of the internal collimator. To remove the optical elements, it will be necessary to rotate the collimator tube and shift it right and left through its supports. The location of all parts must be marked before removal, and all screws must be returned to the holes from which they were removed. Parts that are sealed with varnish shellac must have the varnish shellac removed from them. It may be necessary to file a slight amount off the outer tube at the openings listed below. If so, extreme care should be taken to catch and remove all the metal filings from inside the tubes before assembly.

158. INTERNAL TARGET SYSTEM — REMOVING COLLIMATOR OBJECTIVES (INSTRUMENT ASSEMBLED).

a. Remove collimator illuminator covers.

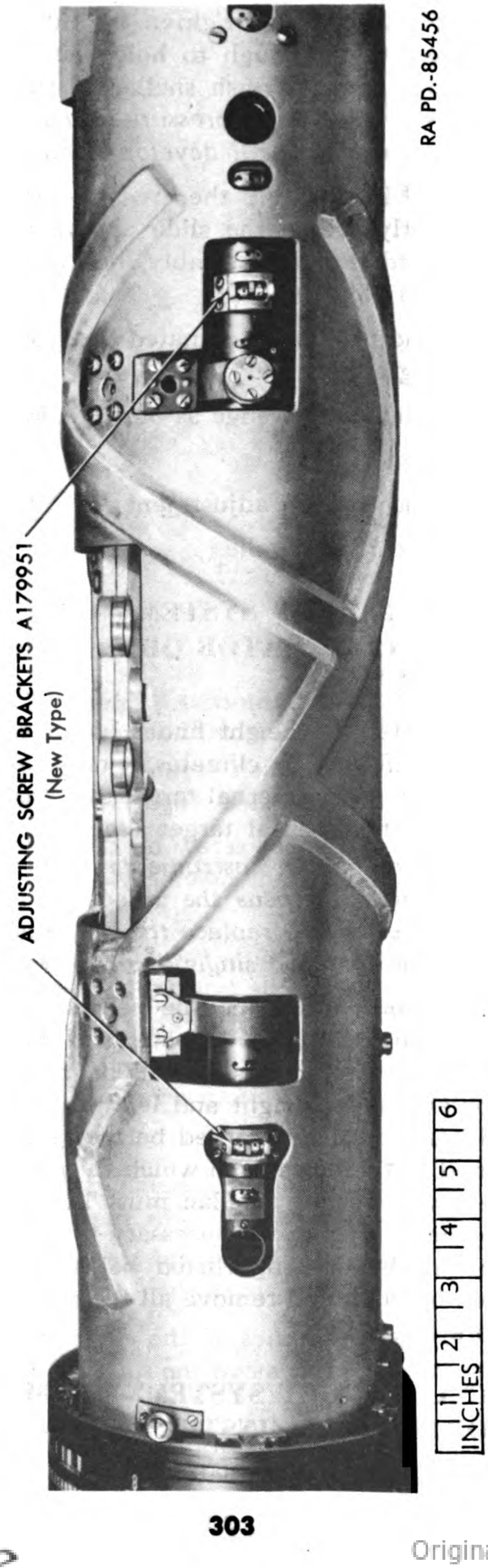


Figure 180 — View of Inner Tube Showing Collimator Adjuster Openings

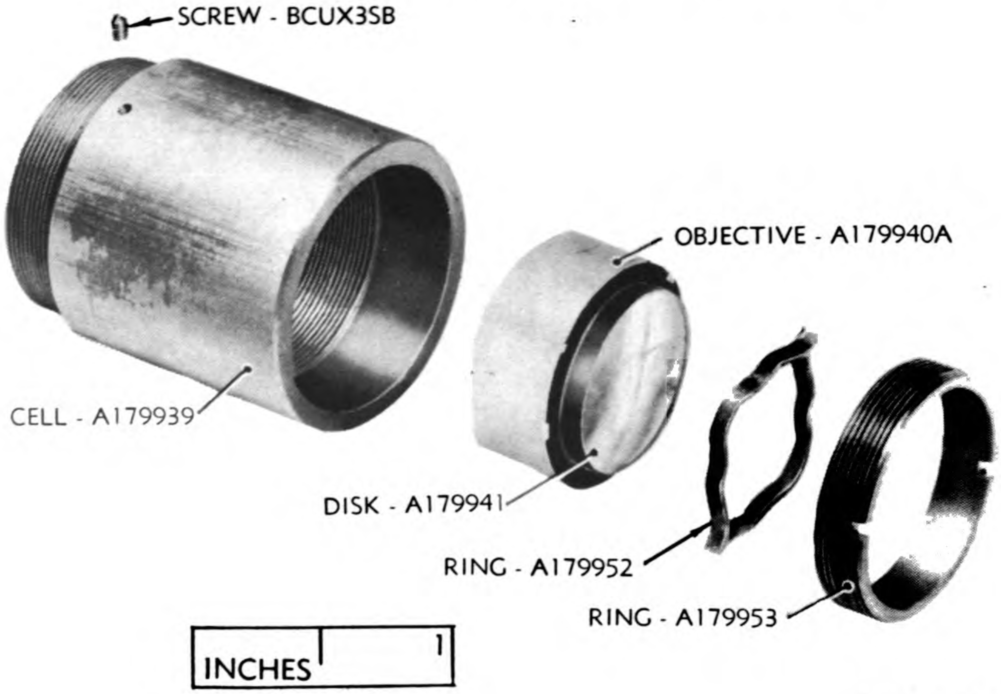


Figure 181 — Collimator Objective (Inner) — Exploded View

b. Remove four screws which secure the pivot A179975 to the bracket assembly on the left side (fig. 178). Remove the pivot.

c. Secure a string to the set screw on the alinement wedge (fig. 173). The string will assist in the assembly of the wedge to the inner tube at assembly.

d. Remove two screws holding the alinement wedge and gently lower the wedge assembly to the bottom of the inner tube.

e. From both sides remove the adjusting screw brackets A179951 (fig. 171). NOTE: *On later type of instruments, these brackets are made in one piece and held with four screws.*

f. Remove reticle adjusting levers A179950.

g. Soften and remove varnish shellac from all surfaces with alcohol.

h. Rotate the tube and remove the screws holding the mirror assemblies to the tube.

i. Force the mirror assemblies off the end of the tube. NOTE: *It will be necessary to rotate and move the tube right and left to accomplish this.*

j. Place the mirror assemblies out of the way in the bottom of the inner tube.

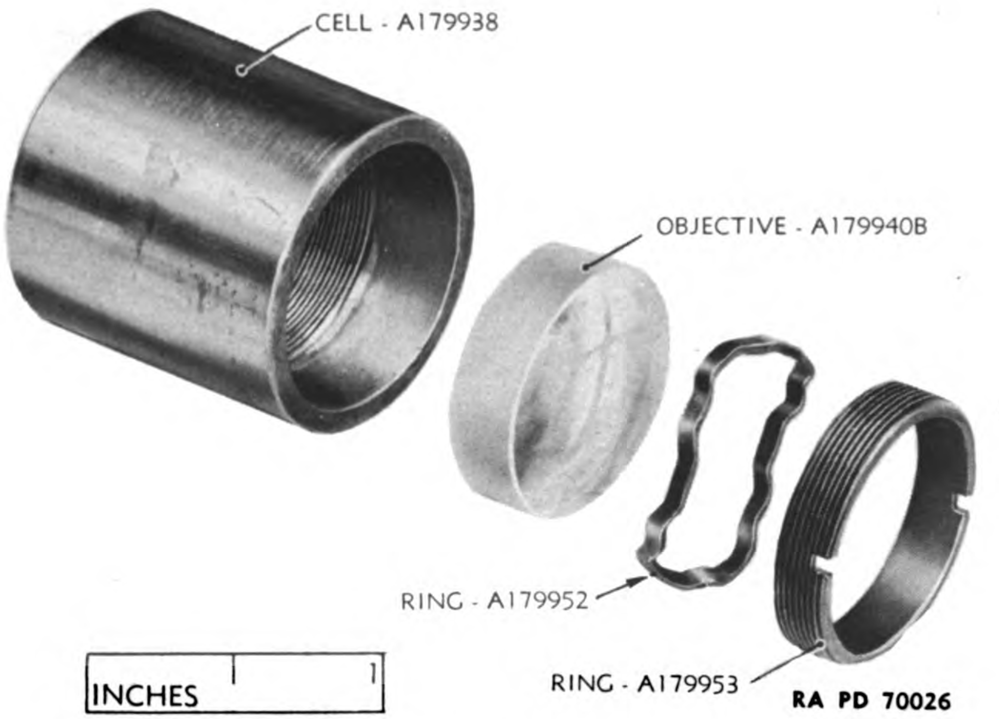


Figure 182 — Collimator Objective (Outer) — Exploded View

k. Rotate the tube until the small guide A179949 (fig. 172) secured to the air space section of the left objective cell A179938 comes into view. Remove this guide.

l. Determine which objective it is desired to remove first, the procedure being slightly different for each side. The removal procedure for the left side will be described first.

(1) With the aid of the collimator adjusting pin, unscrew the adjusting lock ring A179970 (fig. 172) until the adjusting holes reach the opening in the tube.

(2) It will be necessary to further rotate this ring after the holes reach the opening.

(3) To do this, reach inside the collimator tube with the bent end of the adjusting pin and turn the ring until it is free of the tube.

(4) Cell assembly A179938 (fig. 182) can then be forced free of the tube, taking advantage of the numerous openings to find room to force the cell out. CAUTION: *Extreme care should be taken not to damage the flint glass section in this cell, or the threads inside of tube. The glass is close to the cell shoulder toward the center of the instrument.*

(5) It may also be necessary to start the cell movement by rotat-

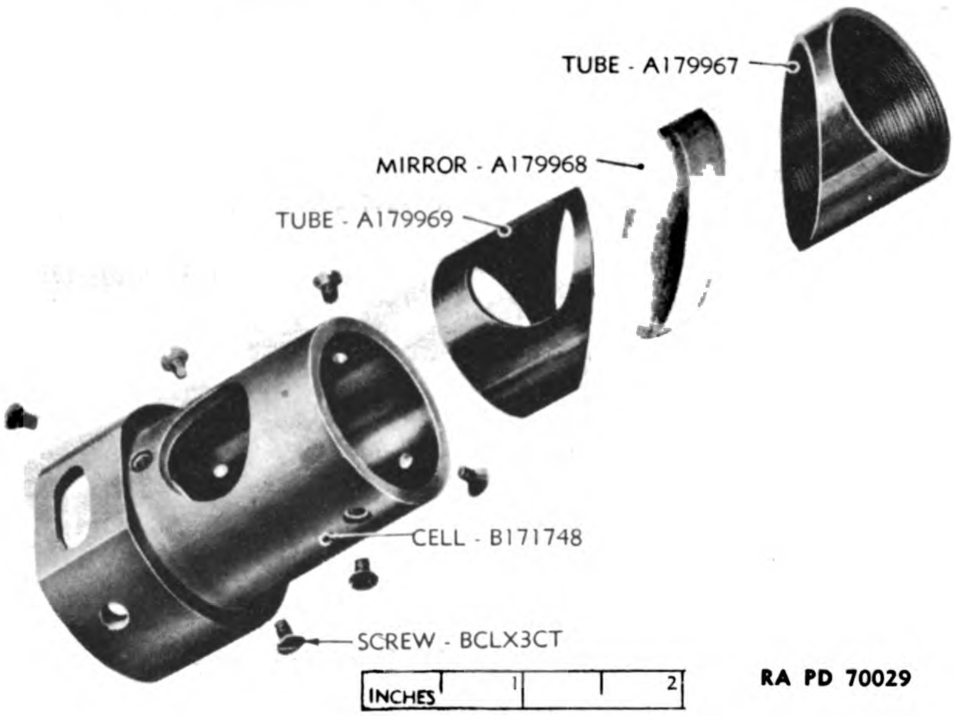


Figure 183 — Collimator Mirror Assembly — Exploded View

ing adjusting lock ring A177955 and spacer ring A179948 (fig. 172), using their force to move the cell part way out of the tube.

(6) When cell is free of tube, set correction wedge knob scale on "60," and remove correction knob scale assembly from tube.

(7) Place the objective cell on the upper side of the optical tube and remove it from the height finder through the elongated opening in the inner tube (correction knob opening). NOTE: *It may be necessary to file the sides of this opening to allow room for the cell to be withdrawn. Usual precautions are necessary to catch and remove the filings.*

m. Remove the reticle and objective cell assembly A179939 (fig. 181) in the same manner as the first cell.

n. Leave the spacer ring screwed to the reticle and objective cell assembly, as it can be used to assist in removal of the cell.

o. The objective and reticle assembly A179954 on the right side can be removed the same as the left except that it will be only necessary to remove one ring and cell.

p. After the cell is free of the tube, move the tube as far as it will go to the left, and remove the cell through the opening in the inner tube. It may be necessary to file a small amount here also.

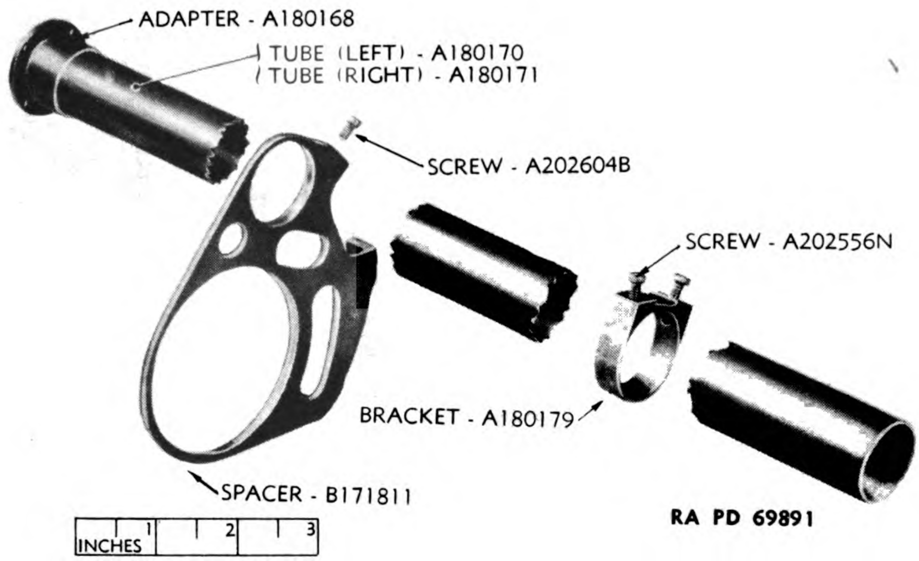


Figure 184 — Adjuster Air Tube Assembly

q. The objective and reticle disk are held in the cell with a set screw BCUX3SB, spacer ring A179952, and retainer ring A179953 (fig. 181). NOTE: *It is important to make a sketch of the optics as they are removed from the cell so that they may be reassembled properly after they are cleaned.* CAUTION: *When the set screw BCUX3SB is replaced, it must be seated very lightly against the objective and then backed off a half turn.*

r. The mirrors and alinement wedge may be cleaned while inside the height finder, and only under extreme cases of damage will it be necessary to remove them from the height finder.

s. The right mirror assembly may be removed through the collimator opening on the right side of the inner tube. It may be necessary to do additional filing on the sides of the inner tube to remove the mirror assembly through this opening.

t. To remove the left mirror assembly (fig. 183):

(1) Loosen the left collimator support B171755 (fig. 178) after it has been carefully marked for reassembly position.

(2) Four screws and two pins hold the support to the bracket. These must be removed to allow the support to be lowered. Use offset screwdrivers.

(3) Lower the tube enough to allow clearance for the mirror assembly and alinement wedge to be withdrawn from the height finder through the left collimator opening.

(4) Reassembly is done in reverse order of disassembly.

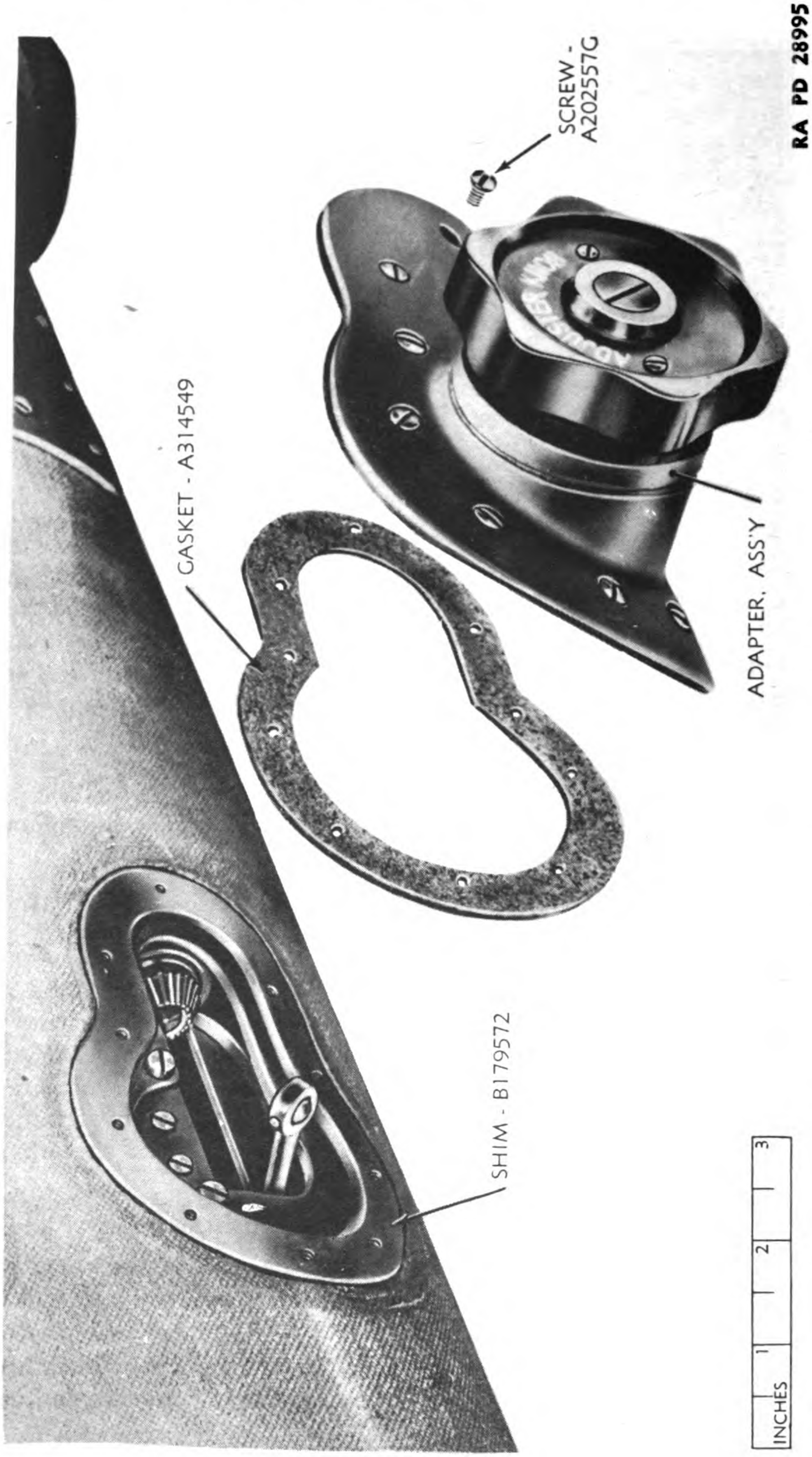


Figure 185 — Removing the Adjuster Knob Adapter Assembly

NOTE A. *Low-numbered instruments have collimator objective adjusting and lock rings A179970 and A179955 (fig. 172) with the entire outer surface of the ring threaded. Extreme care should be taken when removing these rings that they do not freeze to the collimator tube due to burs. It is suggested that the threads close to the adjusting holes in the adjusting ring be chased before attempting to remove these rings.*

NOTE B: *On earlier instruments, numbered below 70, the collimator openings in the inner tube are square and not large enough to allow the mirror assembly objective cells and alinement wedge to be removed as easily as with the later instruments. More left and right movement of the collimator tube may be necessary to allow room to remove the objective assemblies and cells.*

u. The adjuster tube A180171 (fig. 184) will have to be moved to allow more room for the collimator tube movement.

v. It will then be necessary to remove the right end box (par. 164), adjuster prism assembly (par. 159), and reflectors and end reflector support (par. 93). NOTE: *Remove the screws in the tube adapter and pull the tube out just enough to give the desired room to perform the removal of the mirror assemblies, objective cells, and alinement wedge.*

w. Completely reassemble the collimator in reverse order of disassembly, and adjust as directed in paragraphs 153 and 154.

x. Reassemble assembly units at right end of height finder and check focus, height and tilt, and adjustment (pars. 93 to 98).

159. ADJUSTER PRISM SHIFT ASSEMBLY.

a. Explanation. The adjuster knob operates the prism connector rods to bring the internal target penta prisms into position in front of the end mirrors for internal target readings, and to move them out of the way for external observations. Removal of the adjuster knob assembly will break the hermetic seal. However, since the knob does not require any sensitive adjustment, removal is unnecessary except to repair mechanical damage or when the inner tube is to be removed.

b. Removal and Disassembly. To disassemble the adjuster knob assembly, proceed as follows:

(1) Rotate the adjuster knob until the prism slide assemblies are in the position for external readings.

(2) Remove the ten holding screws and pry the knob assembly from the outer tube, taking care not to damage the cork gasket.

NOTE: *The adjuster knob assembly does not require sensitive adjustments, but the spring tension on the roller assembly should*

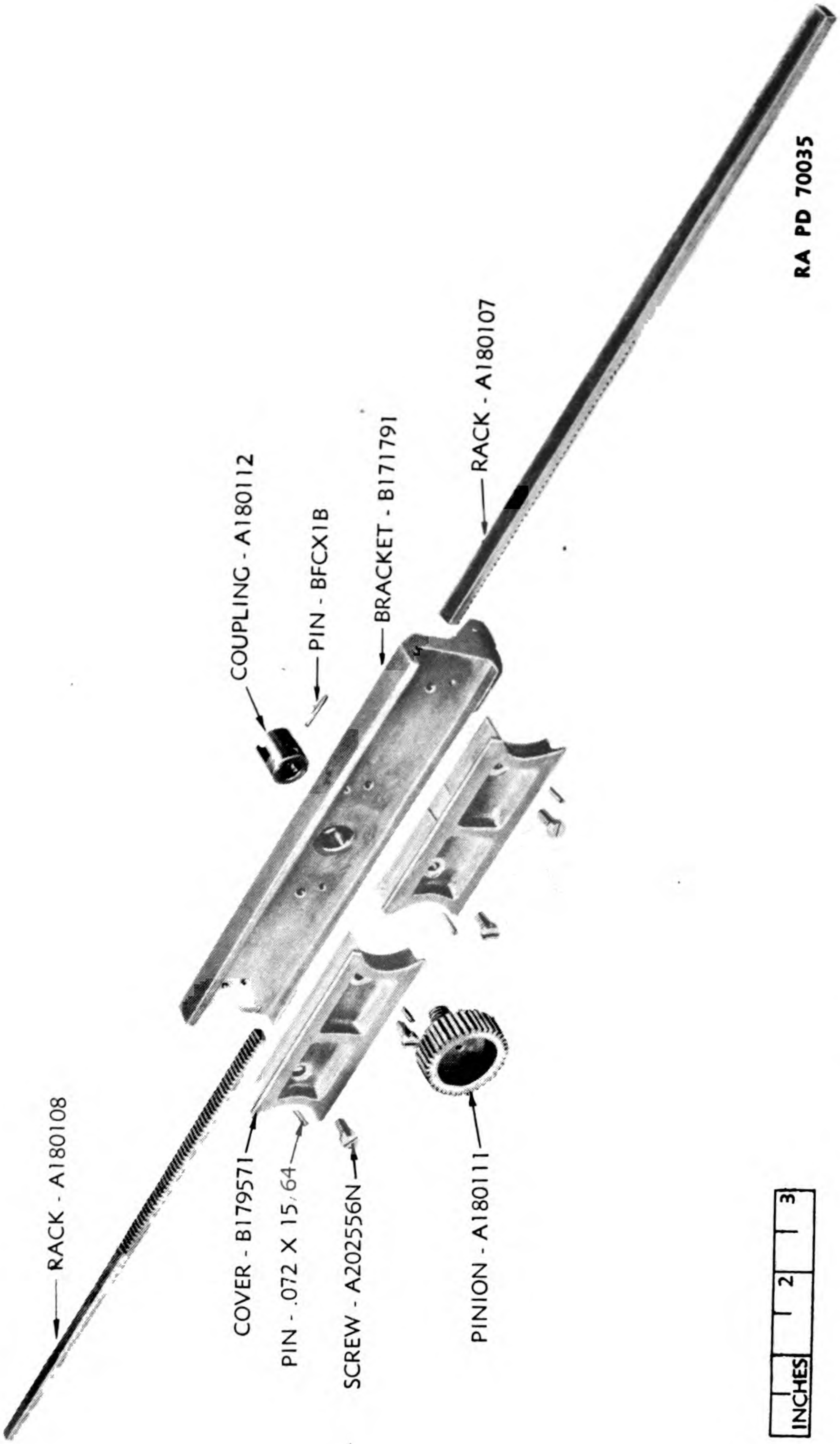


Figure 186 — Adjusting Drive Bracket Assembly — Exploded View

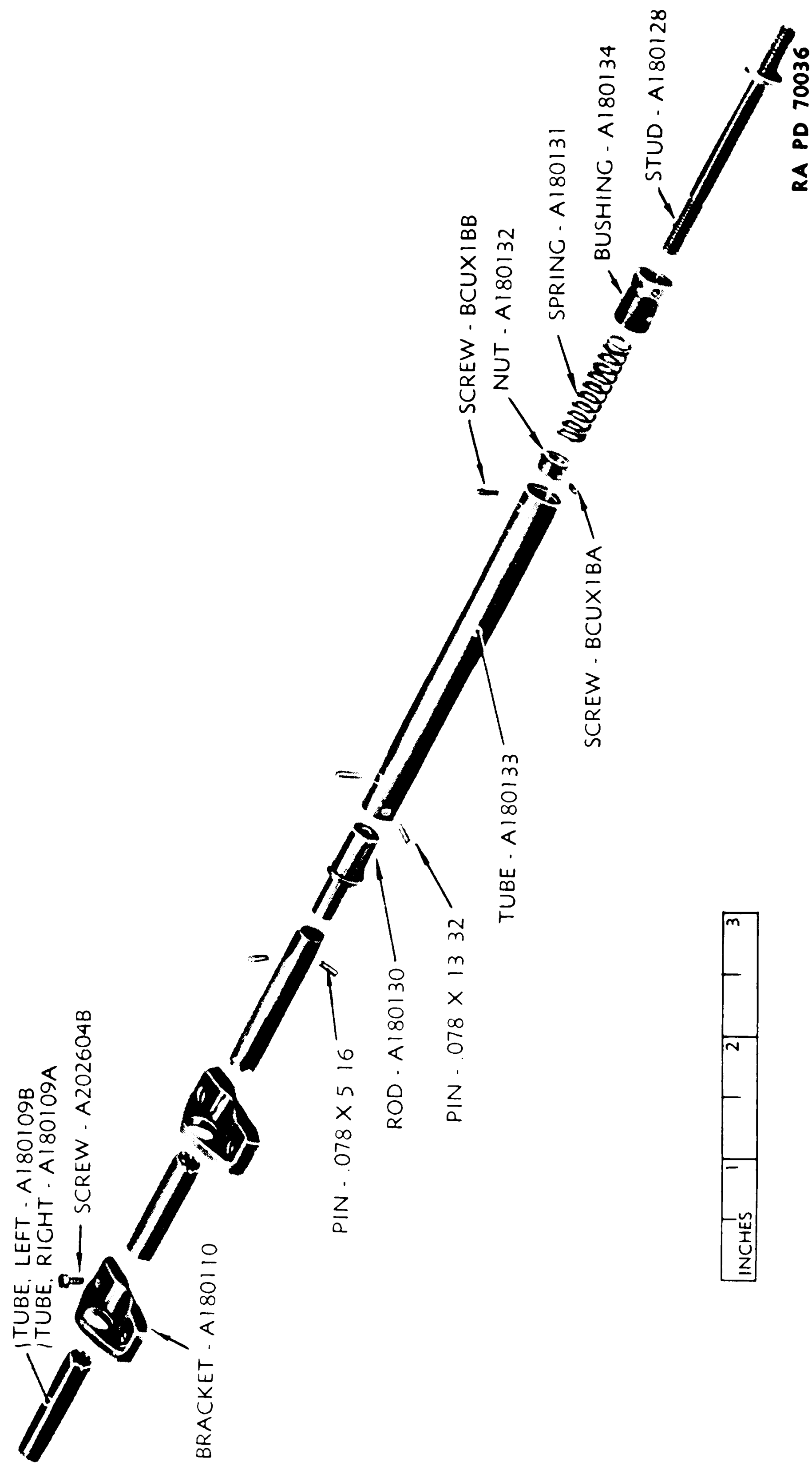


Figure 187 — Adjusting Drive Tube Assembly — Exploded View

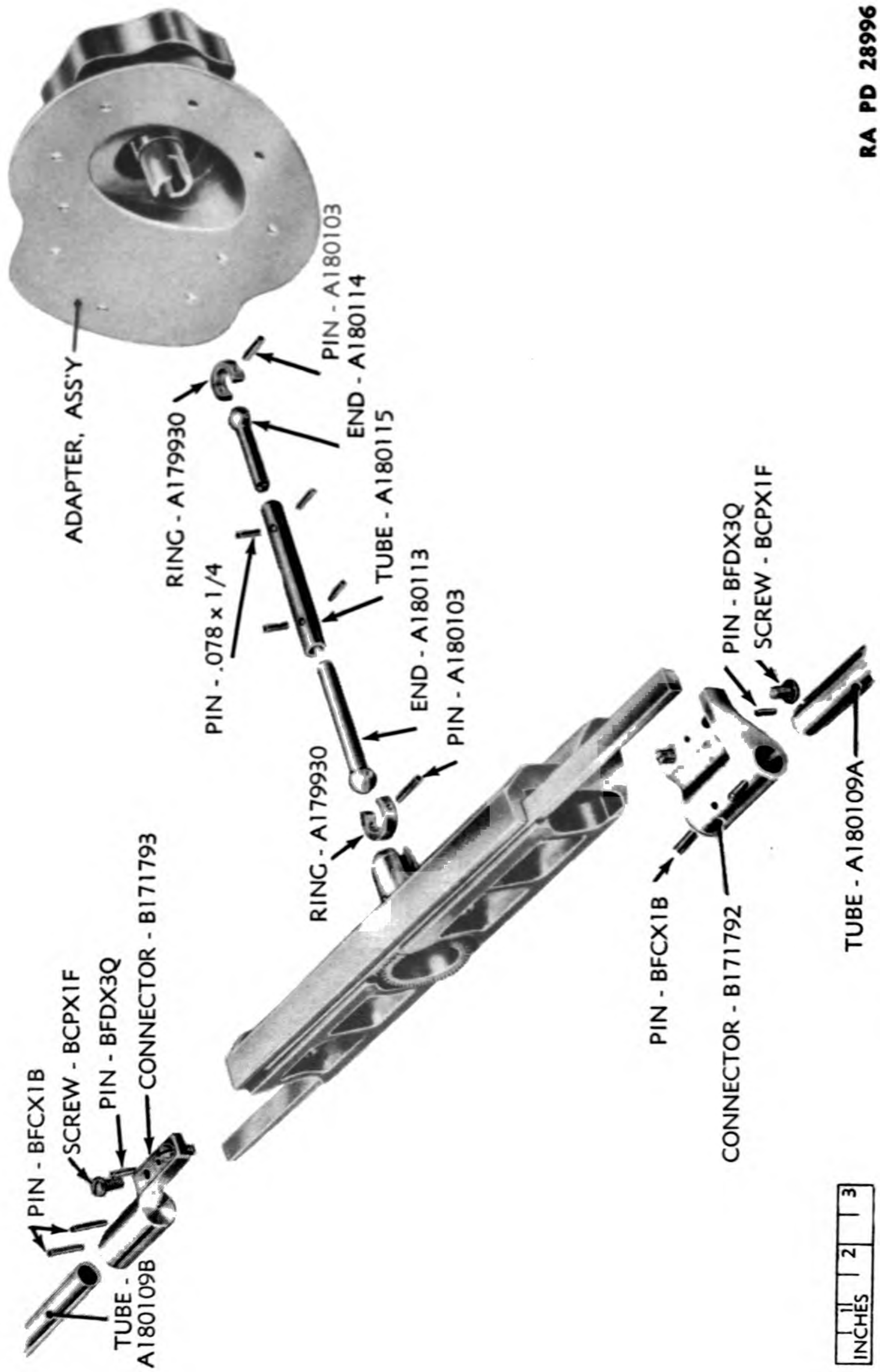


Figure 188 — Adjuster Drive Mechanism — Partly Exploded View

engage the detent and hold the prism assemblies in position for internal readings. When the springs in the adjuster rods are compressed, there should be about a 1/16-inch separation of the collar on stud A180128 and the face of bushing A180134 (fig. 187).

(3) If the knob does not remain locked when the prisms are in position for internal readings, correct as follows:

(a) Remove screw A202556T (fig. 189).

(b) Remove knob after it has been properly marked for reassembly to the shaft.

(c) Clean the inside of the unit.

(d) Bend the spring to cause more pressure of the roller to the detent in the knob.

(e) If necessary, file the detent deeper.

(f) Assemble the knob and screw and check the adjustment. The roller should engage the detent with a good firm click.

(4) Replace the knob assembly on the tube after engaging the ball tube to the adjuster rack and pinion drive, and knob ball couplings.

(5) Rotate the knob to position the prisms for internal readings.

(6) Remove the end boxes (par. 164).

(7) Check the tension on the spring A180131 (fig. 187). The prism slides should be pulled up tightly against the stops A180166 (fig. 87), and the spring should have enough tension to separate the stud shoulder and bushing one-sixteenth inch.

(8) The springs may become weak after the instrument is in service for a long period and it may be necessary to stretch the springs. Correct as follows:

(a) Remove the set screw in the round nut A180129 and remove the nut, holding the slide bracket to stud A180128 (fig. 190), and slide the prism assembly out of the way.

(b) Slide the drive tubes out until set screw BCUXIBB (fig. 187) is observed. Remove this screw.

(c) Measure the distance the bushing A180134 extends from the tube and unscrew the bushing from the tube.

(d) Remove screw and nut from the end of the stud.

(e) Remove the spring and stretch it, or replace with new spring.

(f) Assemble in the reverse order of disassembly.

NOTE: *The nut holding the prisms slide assembly to the stud should not be screwed up tightly.* Leave the nut loose enough so that the stud will rotate when moved by hand after the nut is locked with the set screw.

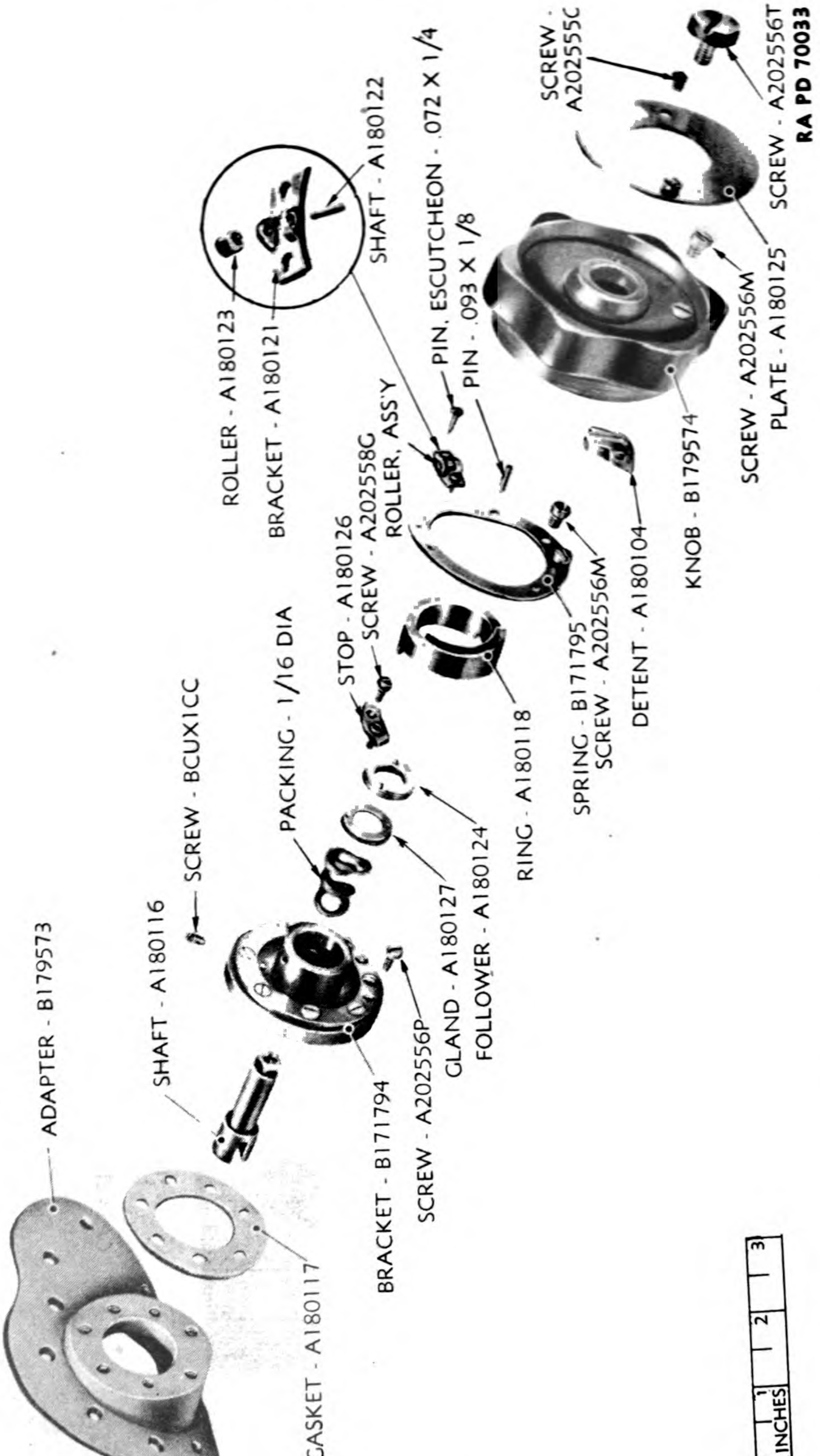


Figure 189 — Adjuster Drive Knob Adapter Assembly — Exploded View

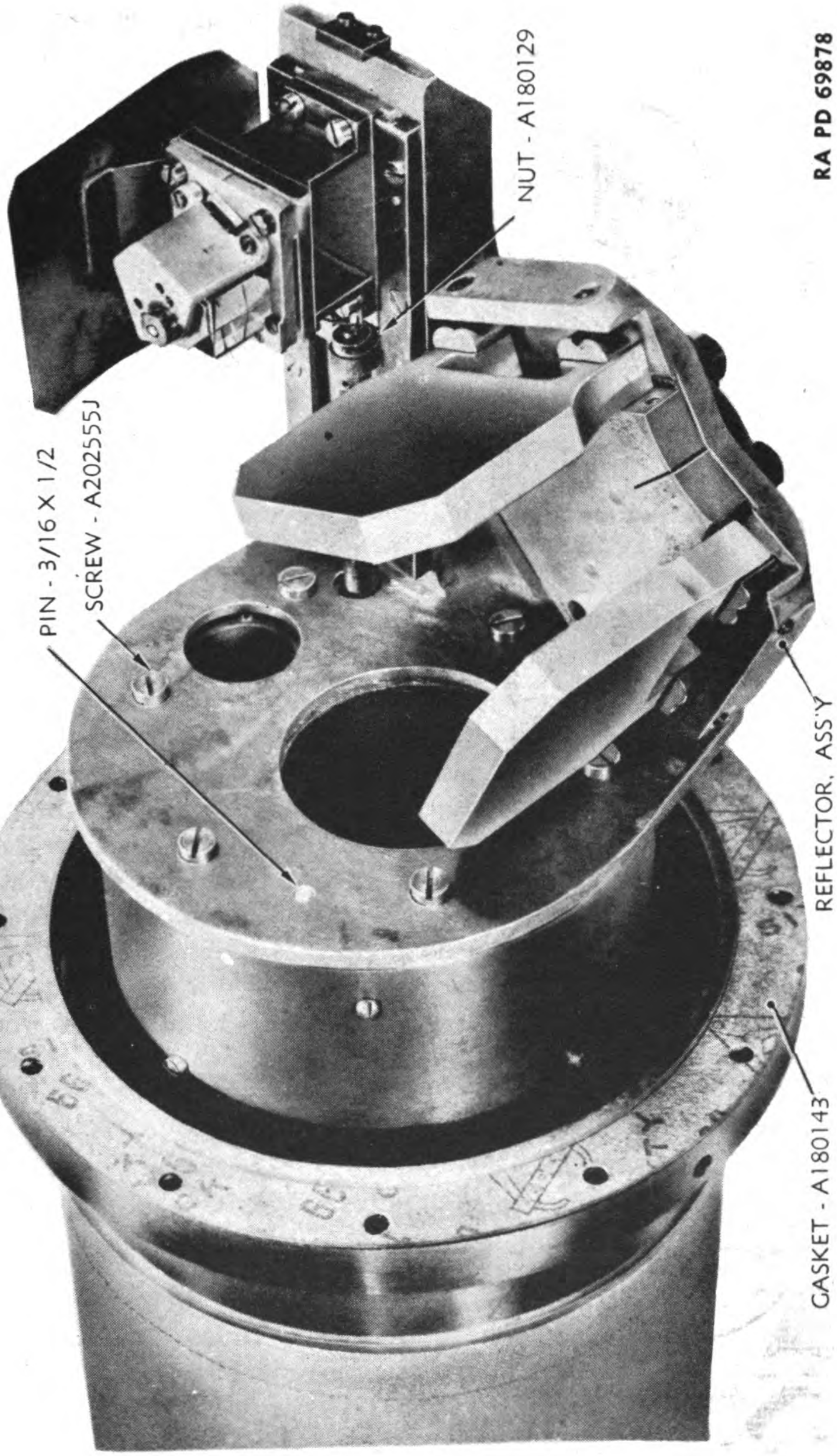


Figure 190 — End Reflector and Adjuster Prism Assembly

(9) Disassembly and removal of the rack and pinion bracket. and removal of the right and left prism shift tubes, is possible only after the inner tube is removed from the outer tube and the inner tube is partially disassembled (pars. 171 and 172).

160. END WINDOW ADJUSTMENT — REQUIREMENTS.

a. The end windows consist of wedges of very acute angle or low refracting power. They provide a final adjustment to obtain correct range readings on external targets after the height finder optical system has been alined on the infinity target provided by the internal target system. Adjustment of the end windows will be required when the range readings on an outside target at known range are not within tolerance when the correction knob scale is set for the internal target reading. Such adjustment should not be made until a second observer has checked the settings and also found that the range reading differs from the true range by more than 1½ units of error. Adjustment of the end windows will also be necessary after any adjustments have been made to the internal target system which change the settings of the correction knob scale. The end window setting is the last major optical adjustment to be made on an instrument before it is ready for actual use.

b. All necessary adjustments to the internal target system and the main optical system should be completed before the end windows are adjusted. The instrument must be at a stable temperature for at least 4 hours previous to, as well as during, the adjustment (less than a 3-degree Fahrenheit change in temperature per hour). Readings must be made by an experienced stereo observer. The weather should be good; heat waves or haze may change readings considerably. The adjustment will not necessarily break the hermetic seal, but replacement of a window will break the seal. It will be necessary to have an external target at a known range greater than 3,000 yards.

161. END WINDOW ADJUSTMENT—ADJUSTMENT ON OUTSIDE TARGET.

a. Set the height-range lever in range position, the measuring drum at infinity, and the adjuster knob for internal target readings.

b. Make five readings and record the mean value.

c. Turn the adjuster knob for external readings, set the measuring drum at the known target distance, and make five settings, bringing the target into stereo contact by means of the correction knob. Record the average of the readings.

d. If the necessary correction (difference between the average values (subpars. b and c, above), is greater than 1½ UOE but less than 10 UOE, make the correction on the *left* end windows as follows:

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT

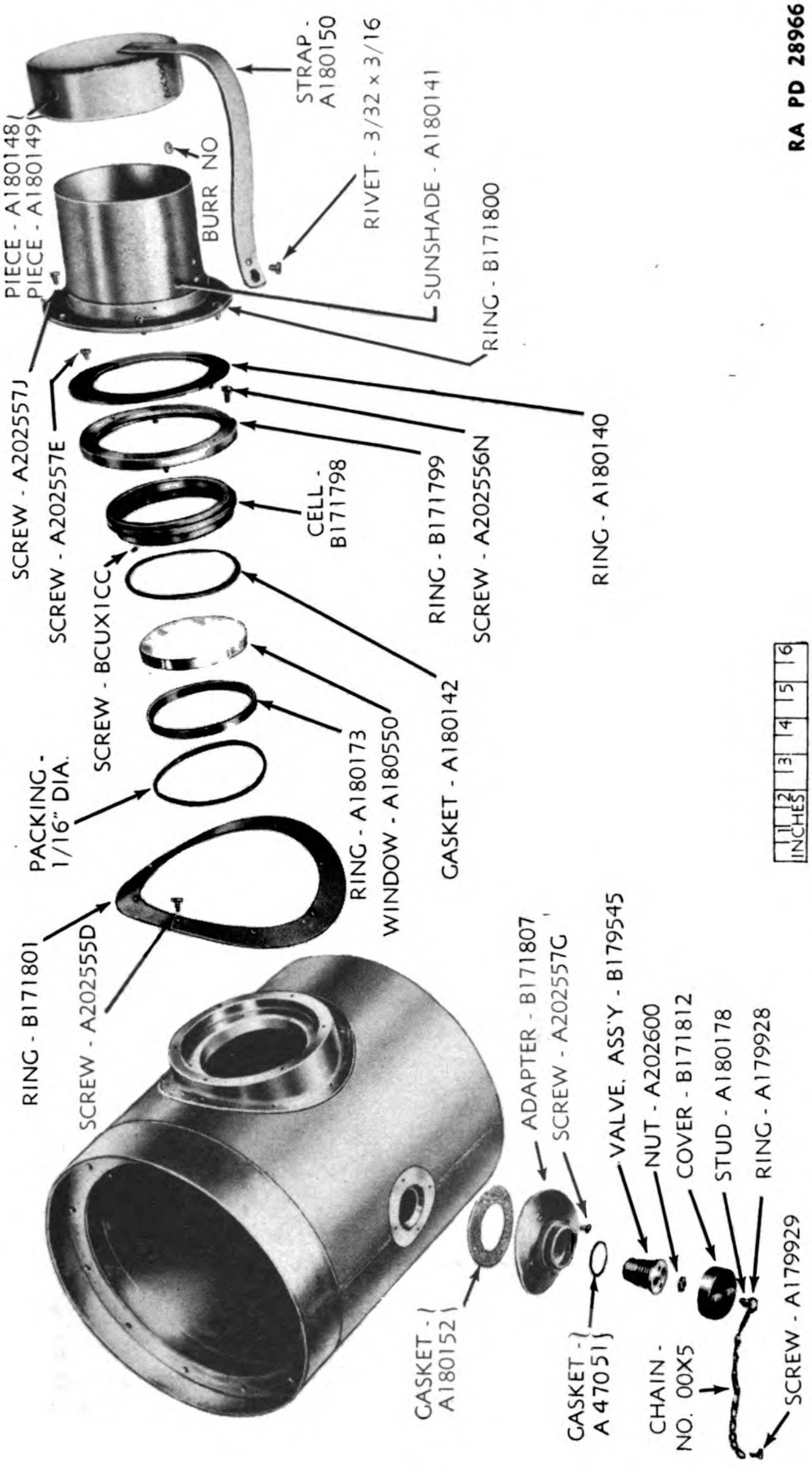


Figure 191 — End Box — Exploded View

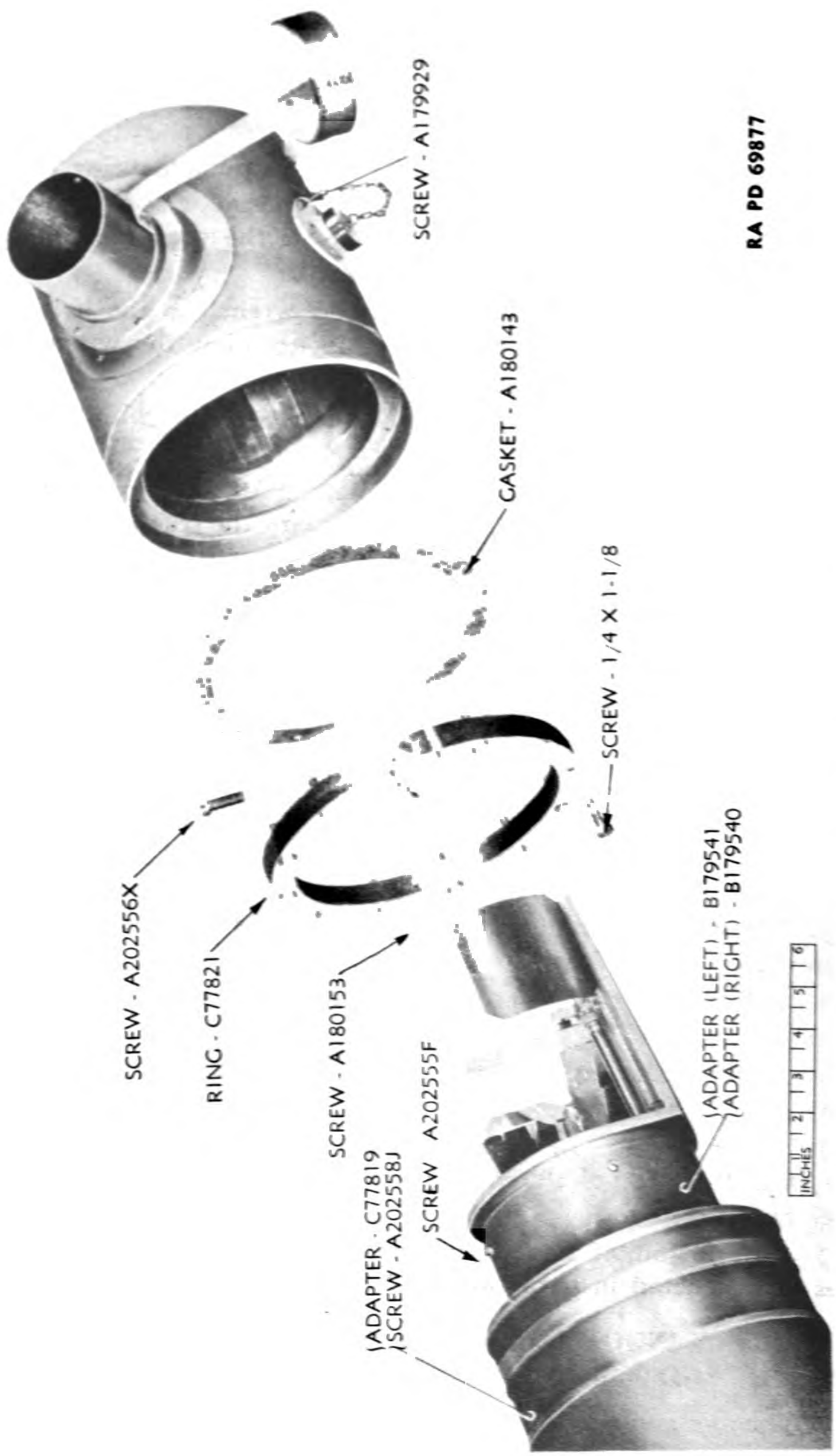


Figure 192 — Removal of End Box

(1) Set the correction knob scale at the mean value for the internal target reading (subpar. b, above).

(2) Remove the sunshade by removing the six holding screws.

(3) Remove ring A180140 (fig. 191) by removing the four holding screws.

(4) Slightly loosen the screws around the end window ring (one-half turn only) in order to avoid breaking the hermetic seal and loosing the gas pressure on the instrument. Note the plus, minus, and center position marks on the end window ring.

(5) Engage the pins of the end window wrench in the holes of the end window assembly. (Be careful not to allow the wrench to slip, as it may damage the end window.)

(6) Turn the end window slightly (about 5 degrees) with the end window wrench.

(7) Check the window position by making 10 range readings on the outside target and comparing the mean with the true range.

(8) Repeat steps (6) and (7) until the average of the 10 range readings is within 1½ UOE of true range. The adjustment is not difficult to make, and it is advisable to hold the readings to within ½ UOE.

(9) Tighten the clamping screws in the window ring and replace ring A180140 and the sunshade.

e. If the necessary correction is for more than 10 UOE, it will be advisable to make the adjustments equally and in opposite directions on both end windows. (This will then require checking and, if necessary, realinement of the M13 Tracking Telescopes.)

(1) Make five internal readings and set the average of the readings on the correction knob scale.

(2) Adjust the right end window as described in (subpar. d, above).

(3) Adjust the left end window as described in (subpar. d, above).

(4) Refer to step (7), above, and repeat steps d (2) and d (3), above, until the mean of 10 readings agrees with the true range within the tolerance.

(5) Check and, if necessary, realine the M13 Tracking Telescopes as instructed in paragraph 189.

162. END WINDOW ADJUSTMENT — REPLACEMENT OF THE END WINDOWS.

a. When an end window is replaced, it will be necessary to adjust the new window in the end window cell before making the final adjustments described in the foregoing paragraphs.

b. If only one new window is being installed, proceed as follows:

(1) Remove the sunshade, the end window ring A180140, screws, and ring (fig. 191).

(2) Remove the screws in the end window retaining ring B171799 and take out the ring. The end window cell assembly can then be removed from its seat.

(3) If the new window is to be placed in the old cell, remove set screw BCUXICC and retaining ring A180173.

(4) Remove the old window, taking care not to damage the rubber sealing gasket. (When replacing the new window this gasket *must* be in place to provide a gastight mounting.)

NOTE: *Most end windows have a mark on the edge of the window designating the base of the wedge or window. If the mark has been removed, locate the base of the window (image-down position) by placing the window between collimators or engineering telescopes as suggested in paragraphs 122 and 129.*

CAUTION: *Mount the new end window with the base of the window (image-down position) in the cell opposite the index mark on the cell, with the beveled edge of the window toward the retaining ring.*

(5) Assemble the window in the reverse order of disassembly, making sure the string packing is in place on the sealing surface of the cell.

(6) Replace the cell in the end box with the index mark on the cell up, and the base of the window down.

(7) Replace the window retaining ring with the "+" and "–" marks up, and tighten the screws in the ring just tight enough to allow the window to be adjusted.

(8) Make the final adjustments of the end window as described in paragraph 161 before tightening the window in place.

(9) Check parallax on each side.

(10) If both end windows are to be replaced, follow the procedure outlined above.

163. END WINDOW ADJUSTMENT — REMOVAL OF END WINDOW FOR CLEANING.

a. If an end window is to be removed for cleaning only, place a scribe mark on the window clamp ring opposite the index on the cell ring. This will make it possible to replace the window without readjustment.

b. Remove and replace the window as described above, making sure that the mark is replaced opposite the zero point. The procedure for cleaning is given in paragraph 87.

164. END BOXES.

a. **General.** The end boxes contain the end windows and the charging valves, and house the end reflectors which extend beyond the outer and inner tubes of the instrument. The end boxes must be removed for various other operations on the height finder. Removal of the end boxes breaks the hermetic seal of the instrument (fig. 192).

b. **Removal and Replacement.**

(1) Turn the adjuster prism shift knob for external readings.

(2) Mark the location of the carrier handles on the outer tube, for ease in reassembly.

(3) Remove the four cap screws BCWXIDF that hold the carrier handles to the outer tube (fig. 219). Remove the carrier handles.

(4) Remove the 12 hexagonal-head screws ¼ inch x 1⅛ inches which hold the end box (fig. 192).

(5) Lift the end box straight off the height finder, being careful to keep it from touching the end bracket, mirror mount, or penta prism. This is best done by looping one arm around the end box, and using the other hand to hold the bottom of the box straight.

(6) To replace the end box, reverse the above procedure, again being careful to prevent its touching any part of the penta prism or end reflector assemblies or their supports.

165. RIGHT MAIN BEARING AND HEIGHT CONVERSION MECHANISM — DISASSEMBLY.

a. **General.** The right bearing housing forms the right support for the outer tube and contains the bearing rings, segment, and bevel gears which operate the height conversion mechanism.

(1) There should be no need to disassemble the housing except in case of damage to the bearings or disassembly of the inner and outer tubes.

(2) The ball races may be packed with grease at the time the instrument is completely serviced.

(3) Disassembly requires breaking the hermetical seal.

b. **Disassembly.**

(1) Remove the outer tube from the telescope support assembly in the following manner:

(a) Set the height finder telescope indexes at zero elevation, set the measuring drum at infinity, and lock the conversion ring over the range locking bracket.

(b) Remove three hexagonal-head screws and two countersunk alining screws holding right housing to the right support assembly

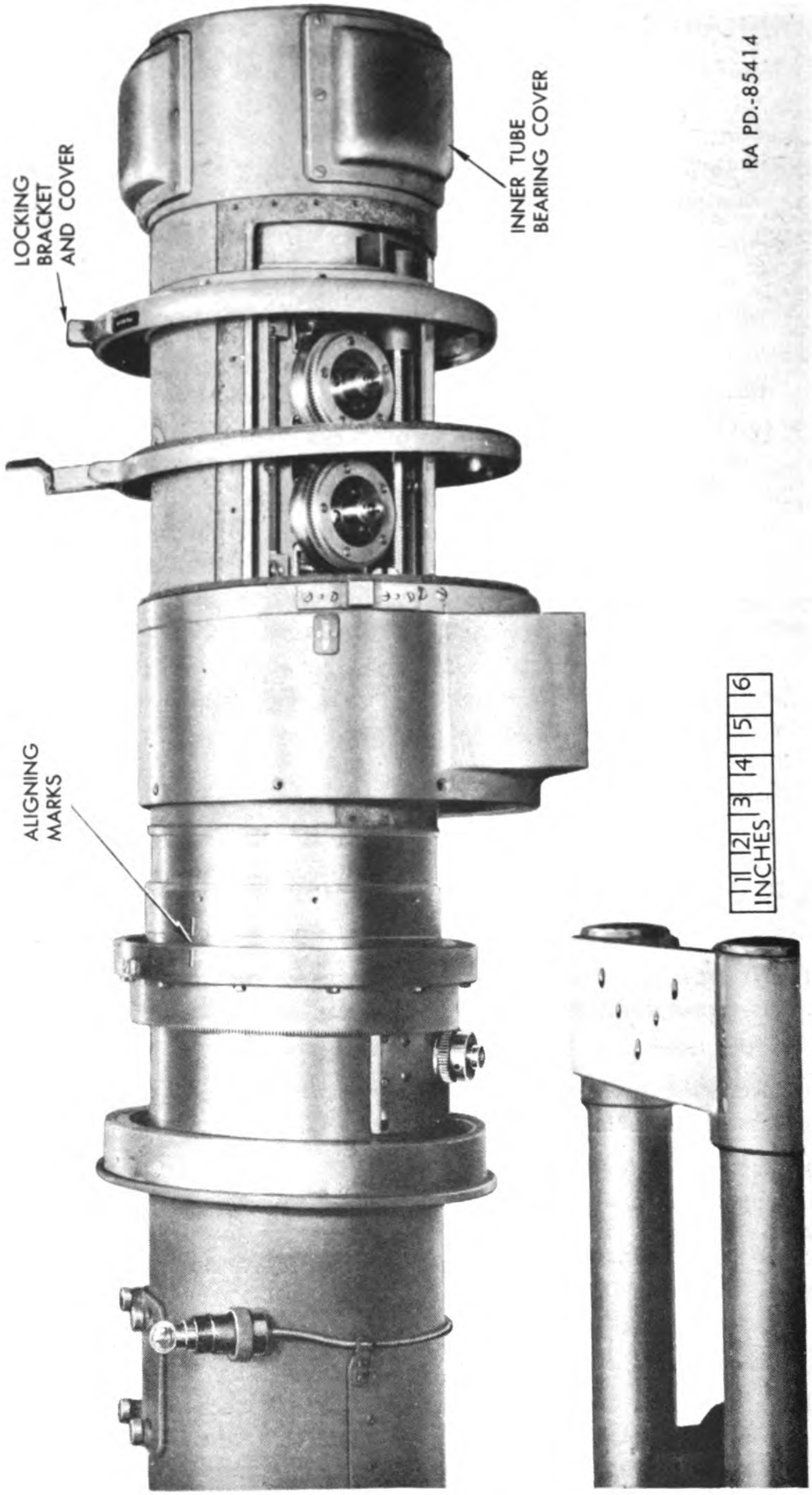


Figure 193 — Telescope M2 Lifted From Support — Right Bearing Housing Partly Disassembled

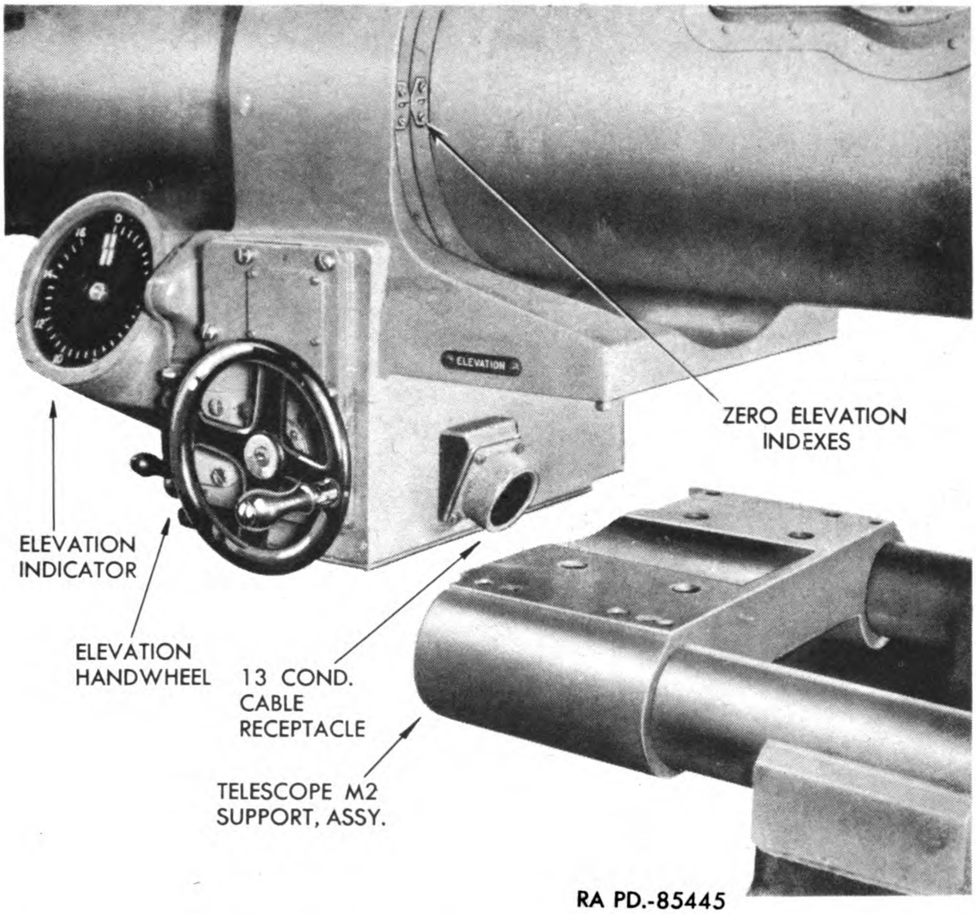


Figure 194 — View Showing Telescope Lifted and Moved to the Left To Clear Cable Receptacles

(fig. 193). NOTE: *Low-numbered instruments do not have the two countersunk alining screws.*

(c) Disconnect the 13-conductor cable plug.

(2) Remove the five hexagonal-head screws holding the telescope support to the left bearing housing (fig. 194).

(3) Lift the telescope off the support, taking care to raise both ends at the same time and only high enough to disengage the guide pins in the left bearing housing from the support, then move the telescope to the left several inches to clear the 13-conductor receptacle (fig. 194).

(4) Lift the telescope off and place on wood V-blocks placed either on the support bars or on a long table. The V-blocks should be sufficiently high to allow room to remove the screws in the conversion gear bracket. CAUTION: *Place the V-blocks so that telescope will rest on them without damaging the illumination wire tubing.*

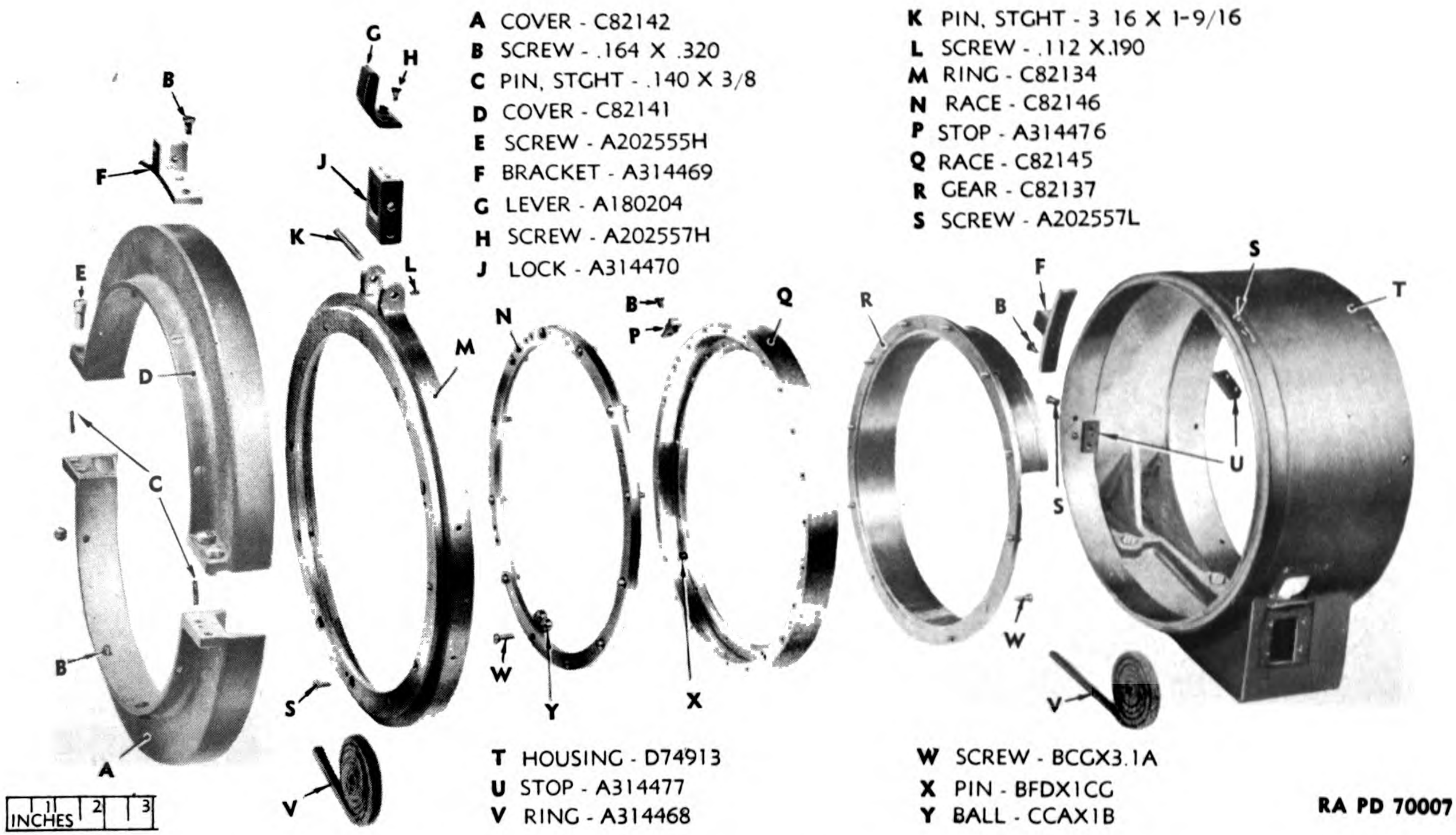


Figure 195 — Right Main Bearing Housing Assembly (Right Side) — Exploded View

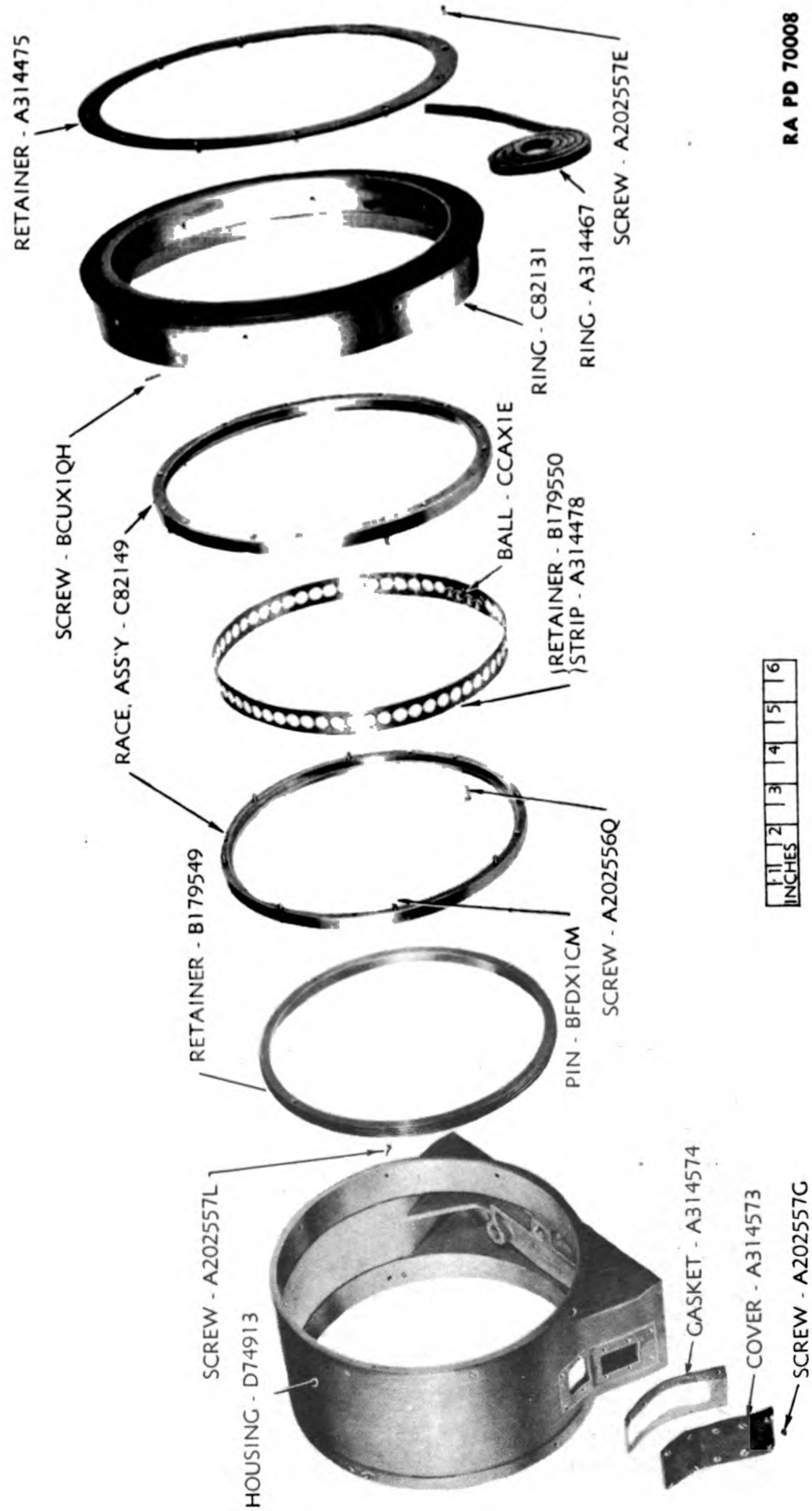


Figure 196 — Right Main Bearing Housing Assembly (Left Side) — Exploded View

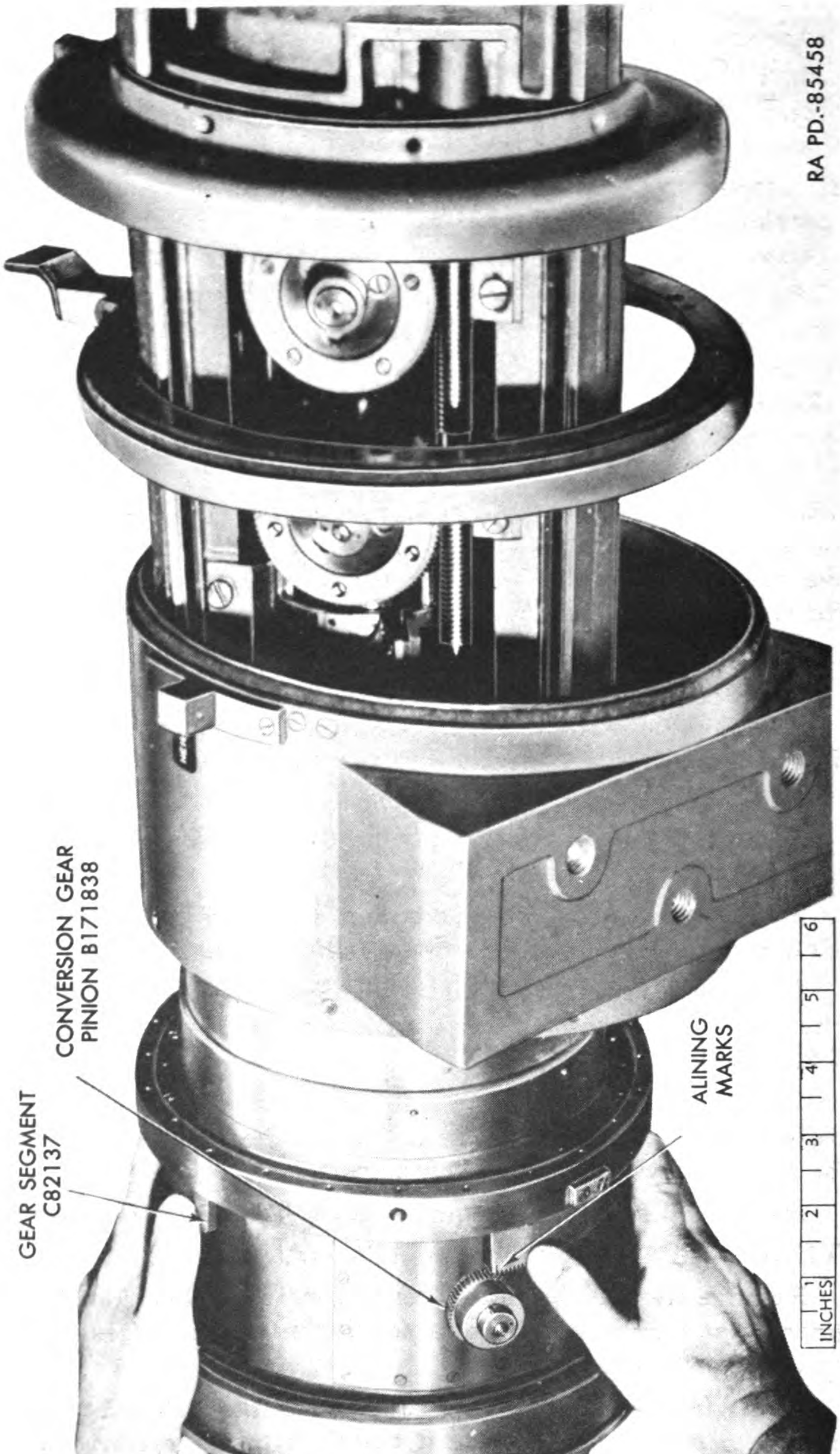


Figure 197 — Disassembling the Right Main Bearing Housing

(5) Remove the right end box (par. 164).

(6) Place two wedges between the inner and outer tubes to support the inner tube when the inner tube bearings are removed.

(7) Remove the inner tube bearings after they have been punch-marked for ease in location at assembly.

NOTE: *Inner tube bearing covers, illustrated in figure 193, must first be carefully removed. Care must be taken not to damage the cork gaskets.*

(8) The compensator cover (fig. 125) and compensator level cover must first be removed before the locking bracket cover, as illustrated in figure 195, can be removed.

(9) Remove the screws in the locking bracket cover and slide it off the tube. Covers C82141 and C82142 (fig. 195) can be separated and removed.

CAUTION: *Do not rotate the conversion ring until the position of the conversion ring C82134, race C82146 (fig. 193), and the outer tube have been scribed with locating lines, as these units must be assembled exactly as disassembled.*

(10) Remove the screws from the conversion ring and slide the ring off the tube.

(11) Remove the screws in ring C82131, holding the housing D74913 (fig. 196) in place, gently tap the housing until it is free of ring C82131, and slide it off the end of the tube.

(12) Remove the backlash spring from the compensator (on instruments that have the spring A314526 (fig. 137)).

(13) Rotate the conversion gear pinion B171838 and gear segment C82137 (fig. 197) toward the open section of the segment.

(14) Just before the teeth become disengaged, scribe a line on the last full tooth of the gear segment and on the corresponding tooth space of the pinion (fig. 197).

(15) Rotate the conversion gear segment out of the way and, without disturbing the pinion, scribe a line on the adapter directly under the line made at the pinion tooth space.

(16) Remove the adapter assembly screws A202556N (fig. 198).

CAUTION: *Do not loosen screws A202537J.*

(17) Remove the height range bevel gear assembly. NOTE: *The segment gear must be rotated to a position where the edges of the adapter will clear the gear teeth.*

(18) Removing the adapter also disconnects the ball tube from the compensator coupling. Care must be taken that the conversion gears and pinion are not rotated during removal because the meshing bevel gears must be marked on the under side of the adapter to

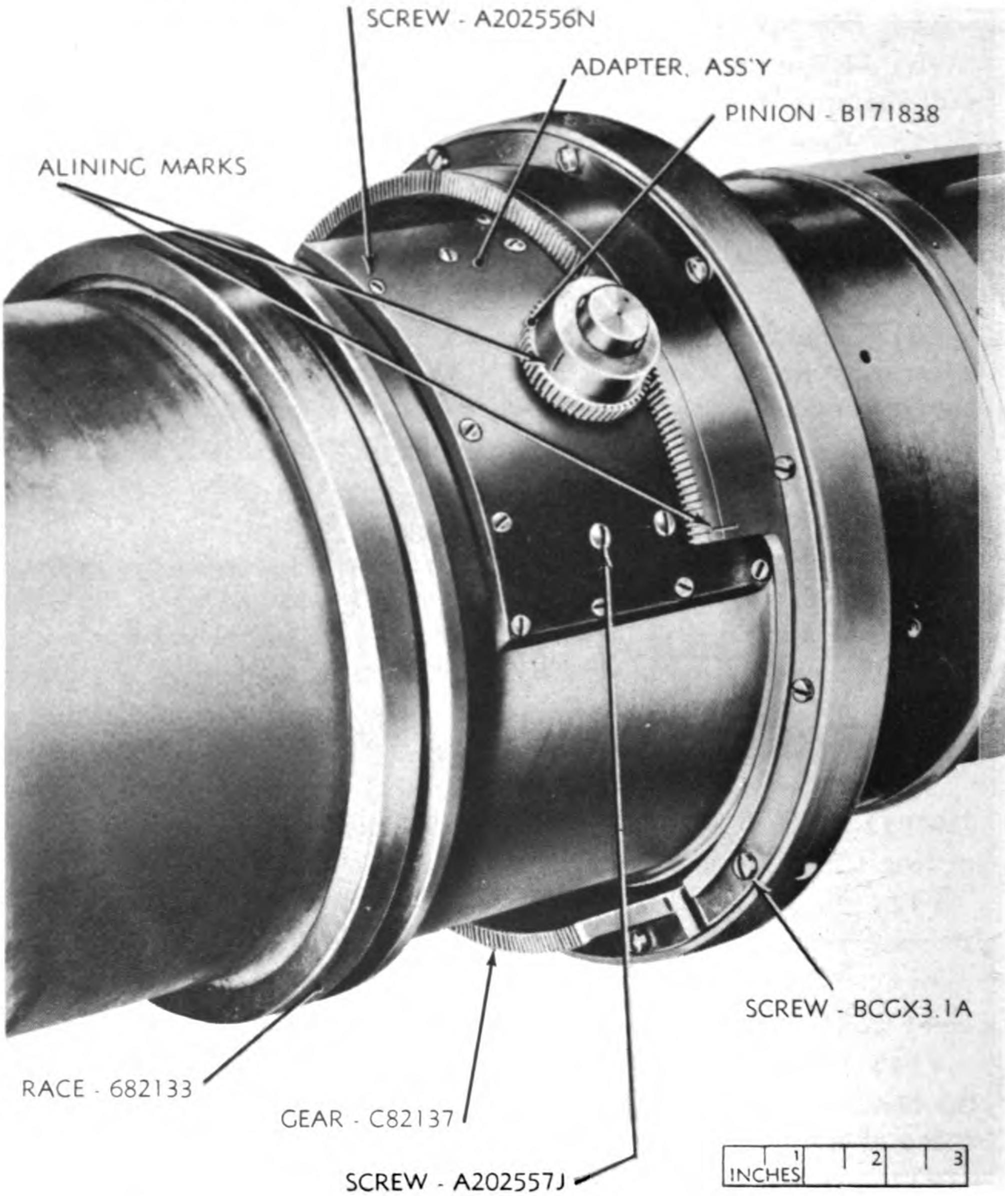


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Figure 198 — Right Main Bearing Housing Removed Showing Conversion Gears

insure correct engagement of the gear segment and pinion during assembly (fig. 199).

(19) The ball tube must be replaced in the compensator coupling when the conversion gear bracket is removed.

CAUTION: *Do not rotate the compensator at any time during this disassembly* (steps (17) to (19), above).

(20) Remove race C82146, balls CCAX1B, and gear C82137 (fig. 195).

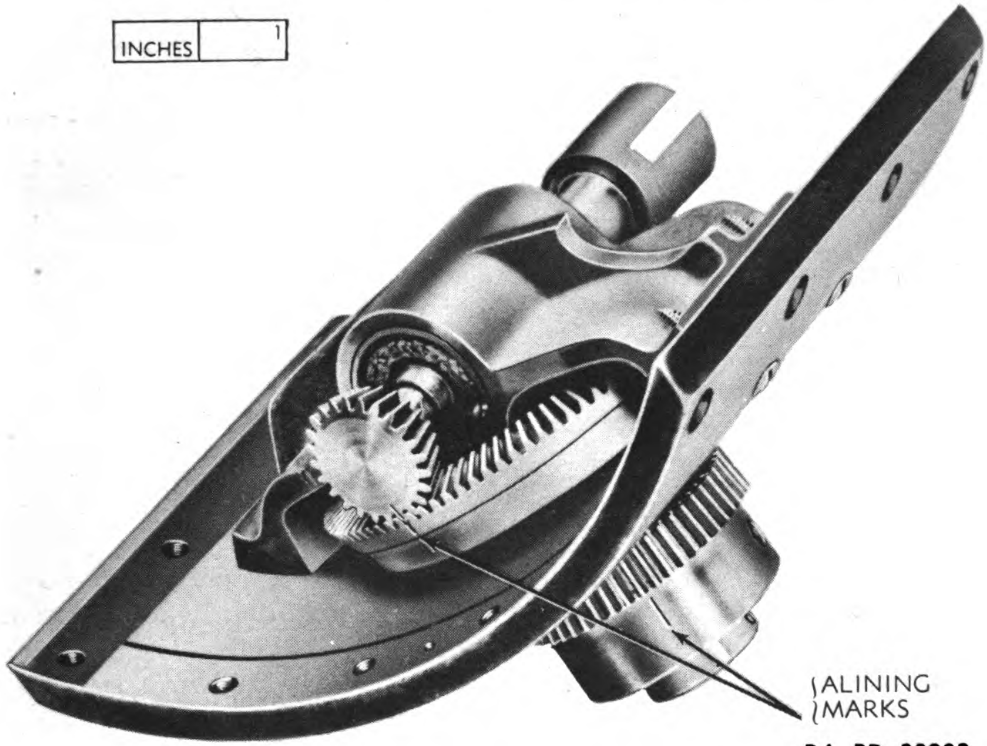


Figure 199 — Height Range Bevel Gear Adapter Assembly

(21) Mark gear C82137 and race C82145, and separate by removing screws BCGX3.1A (fig. 195).

(22) Remove retaining ring A314475 (fig. 196).

(23) Remove set screw BCUXIQH.

(24) Unscrew and remove retainer ring B179549.

(25) Remove ball race from ring C82131 and separate race assembly C82149 (fig. 196).

(26) The disassembled rings and races can now be removed from the telescope.

166. RIGHT MAIN BEARING AND HEIGHT CONVERSION MECHANISM — ASSEMBLY.

a. Assembly should be performed in the reverse of disassembly, after the bearing races on the tube have been cleaned and packed with grease, and the cork gasket of the height-range bracket is covered with sealing compound for height finders. NOTE: *A looped string will assist in positioning the height ball tube connector to the height-range bevel gear assembly.*

b. When the pinion and segment gear are assembled and adjusted, the gears *must mesh tightly* but the travel should be smooth.

c. If the pinion and segment gear teeth do not mesh tightly:

(1) Loosen all the adapter holding screws (fig. 198), and have an assistant place two large screwdrivers between the adapter and ring C82137 (fig. 195) and apply pressure to force the adapter toward the segment gear.

(2) While pressure is being applied, tighten all bracket screws.

(3) Check for shake between the meshing teeth of the gears.

(4) Travel of the segment and pinion gears should be tight but smooth.

NOTE: *These gears, being meshed tightly, will cause the readings taken at height-900 to be held within tolerance when the height finder is leveled from zero-degree elevation.*

167. LEFT MAIN BEARING HOUSING AND ELEVATION INDICATOR — GENERAL.

a. The left bearing housing contains the left main bearing and the elevation worm gear mechanism. It also contains the elevation speed change and the stop shaft mechanism. The elevation indicator housing is bolted to the left bearing housing, and the wires from the repeater are connected to a terminal block which is accessible when the bottom cover is removed (fig. 200). The receptacle for the 13-conductor cable that connects the cradle electrical mechanism with the height finder is located on a boss on the under and inner side of the housing (fig. 201). The receptacle for the 5-wire cable to the illumination junction box is mounted on the upper front side of the housing.

b. Most adjustments can be made by removing the bottom cover plate A180264 (fig. 203) which permits access to the greater part of the elevation mechanism, as can be seen in figure 205. It is advisable to check screws in gear segment B171846 (fig. 200) to make sure that they are not loose. It is very important that these screws be tightened securely.

c. Complete disassembly will be necessary only if the main tube bearings have too much play or require greasing, or if the elevation worm and worm segment have too much backlash. Disassembly does *not* break the hermetic seal of the instrument.

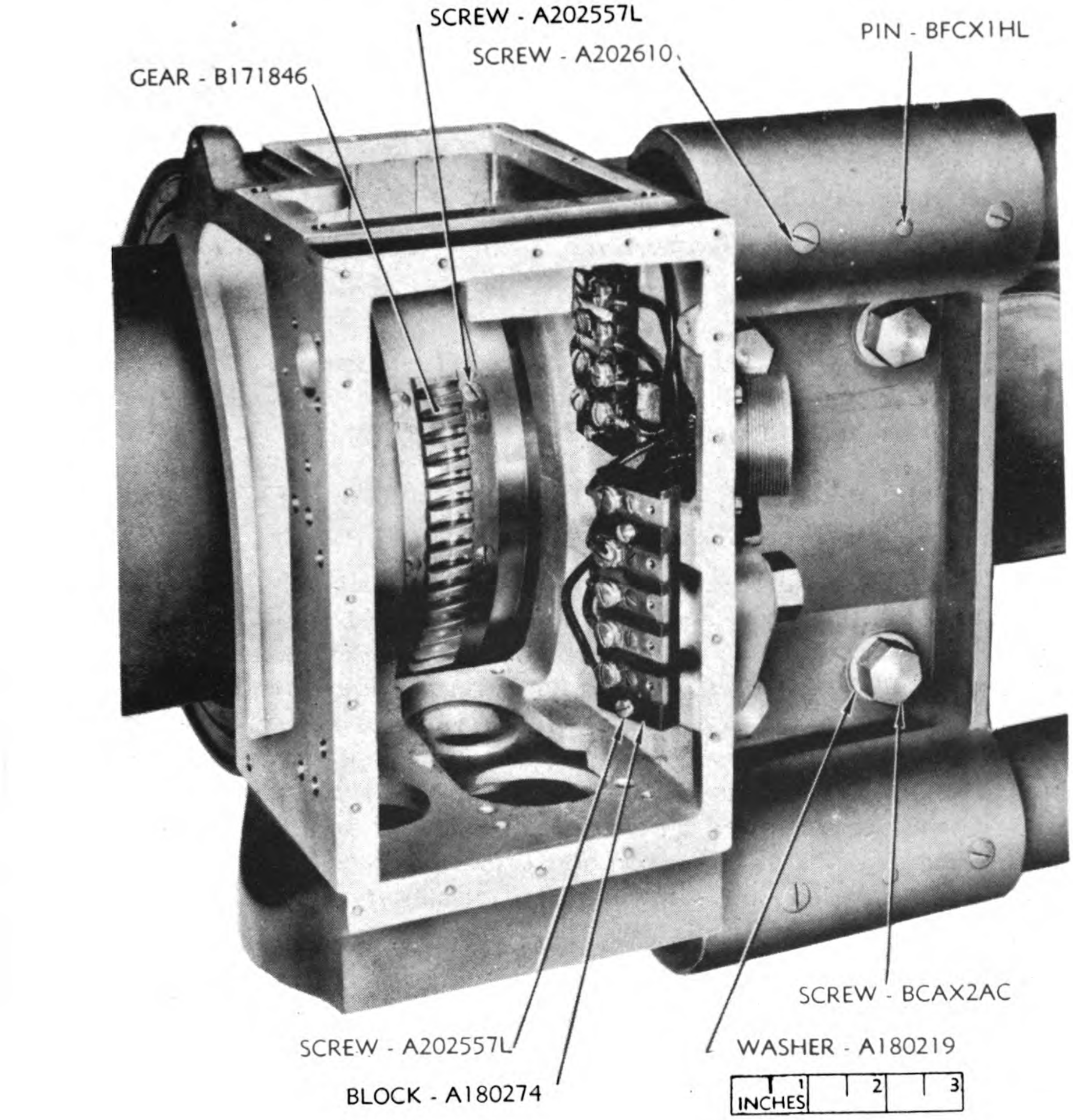
168. LEFT MAIN BEARING HOUSING — DISASSEMBLY.

a. Set the height finder telescope at zero elevation according to the zero elevation indexes (figs. 83 or 84).

b. Remove bottom cover plate A180264 (fig. 203).

c. Disconnect the elevation repeater leads from the terminal block and remove holding clamp.

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT



RA PD 69999

Figure 200 — Left Main Bearing Housing — Bottom View

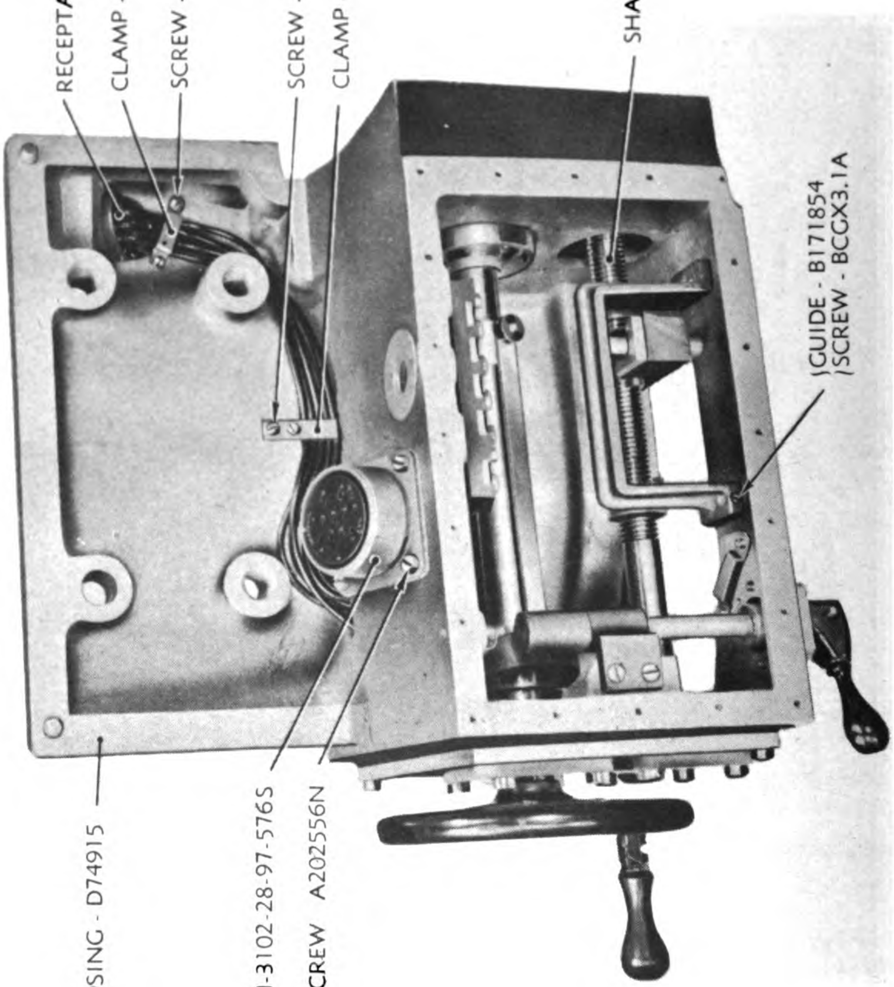
d. Remove screws A202609 (fig. 203) holding elevation indicator housing, and remove the entire unit. Do not rotate the repeater as this would disturb the zero setting.

e. Remove rear plate A180246 (fig. 203).

f. Remove the plate that covers the gears at the front of the main housing.

g. Mark the meshing position of all accessible gears.

h. Mark the position of guide B171854 (fig. 207) and remove.



RA PD 69993

Figure 201 — Left Main Bearing Housing — Rear Bottom View

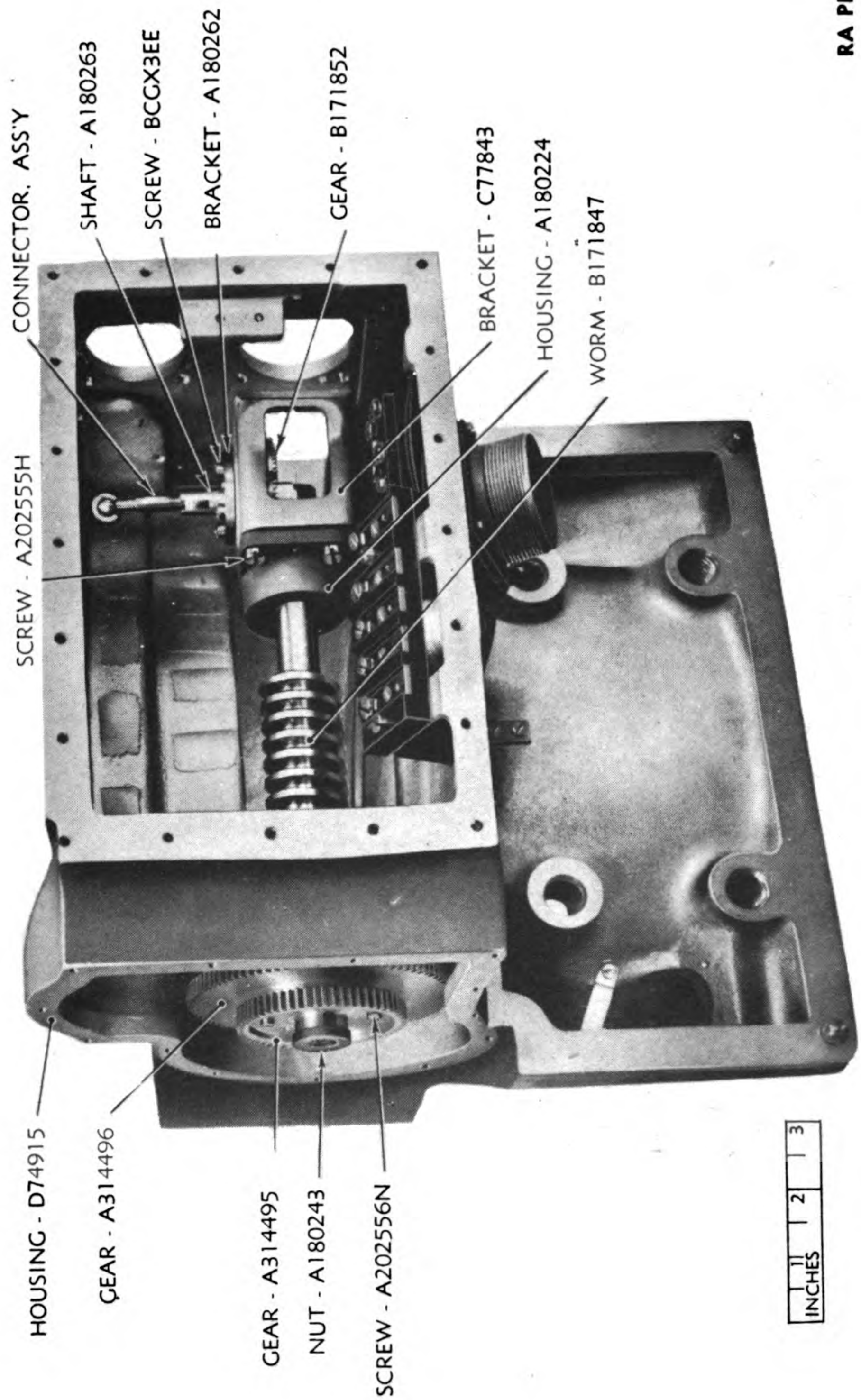


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Figure 202 — Left Main Bearing Housing — Bottom View — Handwheel Shaft Removed

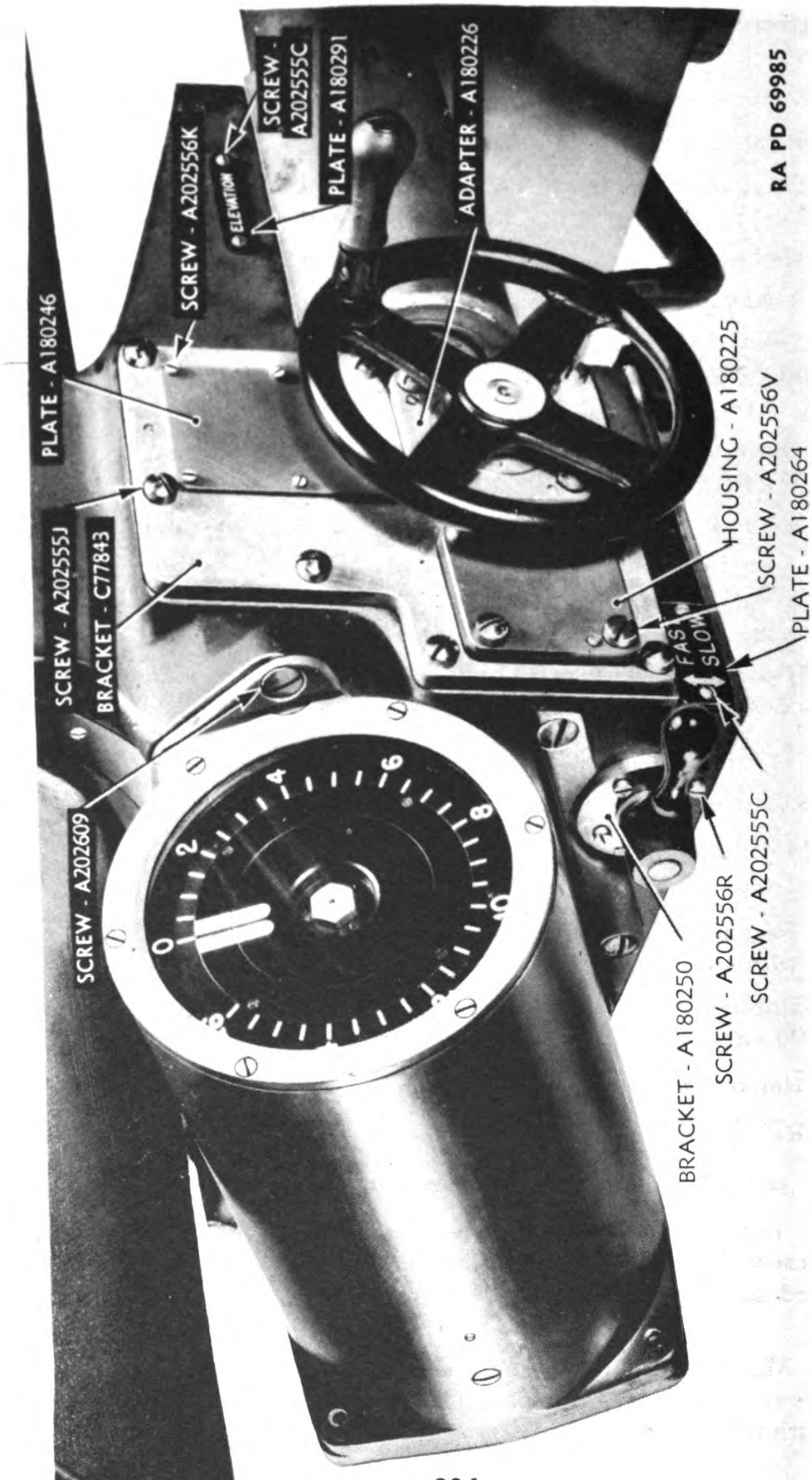


Figure 203 — Left Bearing Housing Showing Elevation Indicator and Handwheel

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT

i. Unscrew nut A314486 (fig. 206) and remove large spur gear A314499.

j. Remove screws and take off bearing adapter A180227.

k. Remove thread stop shaft assembly.

l. Drive out taper pin and remove change speed handle (adapter) A180251 (fig. 208).

m. Remove screws and take off brackets A180250 and A180249.

n. Take out spring A180258 and remove shaft and yoke assembly.

o. Drive out taper pin and remove elevation handwheel assembly (fig. 209). Remove retainer A180245, packing, retainer A180244, and nut A180242 (fig. 211).

p. Drive out taper pin and remove collar A180240 and large gear A314494 (fig. 207).

q. Remove screws and take off bearing adapter A180226 (fig. 211).

r. Withdraw complete shaft assembly (fig. 211) from the rear of the housing.

s. If complete disassembly of this 2-speed shaft is required, refer to exploded views (figs. 207 and 211).

t. Remove zero elevation indexes (if new type) (fig. 84).

u. Remove ball connector assembly (fig. 202).

v. Mark meshing position of bevel gear and pinion, drive out taper pin, and remove bevel gear B171852 (fig. 213).

w. Remove screws and take out bearing bracket A180262 together with coupling shaft A180263.

x. Unscrew nut A180243 and remove spur gears A314495 and A314496 (fig. 212).

y. Remove screws and take off housing bracket C77843 (fig. 213).

z. Remove worm shaft B171847 (fig. 212).

aa. Disconnect 5-conductor cable plug.

bb. In order to disassemble the main bearings, the five hexagonal-head screws BCAX2AC in the bottom of the housing will have to be removed, and the housing D74915 moved along the outer tube (par. 172).

cc. Mark the position of gear segment B171846 (fig. 200), take out screws, and remove this part. If shims are used, be sure they are kept with the segment.

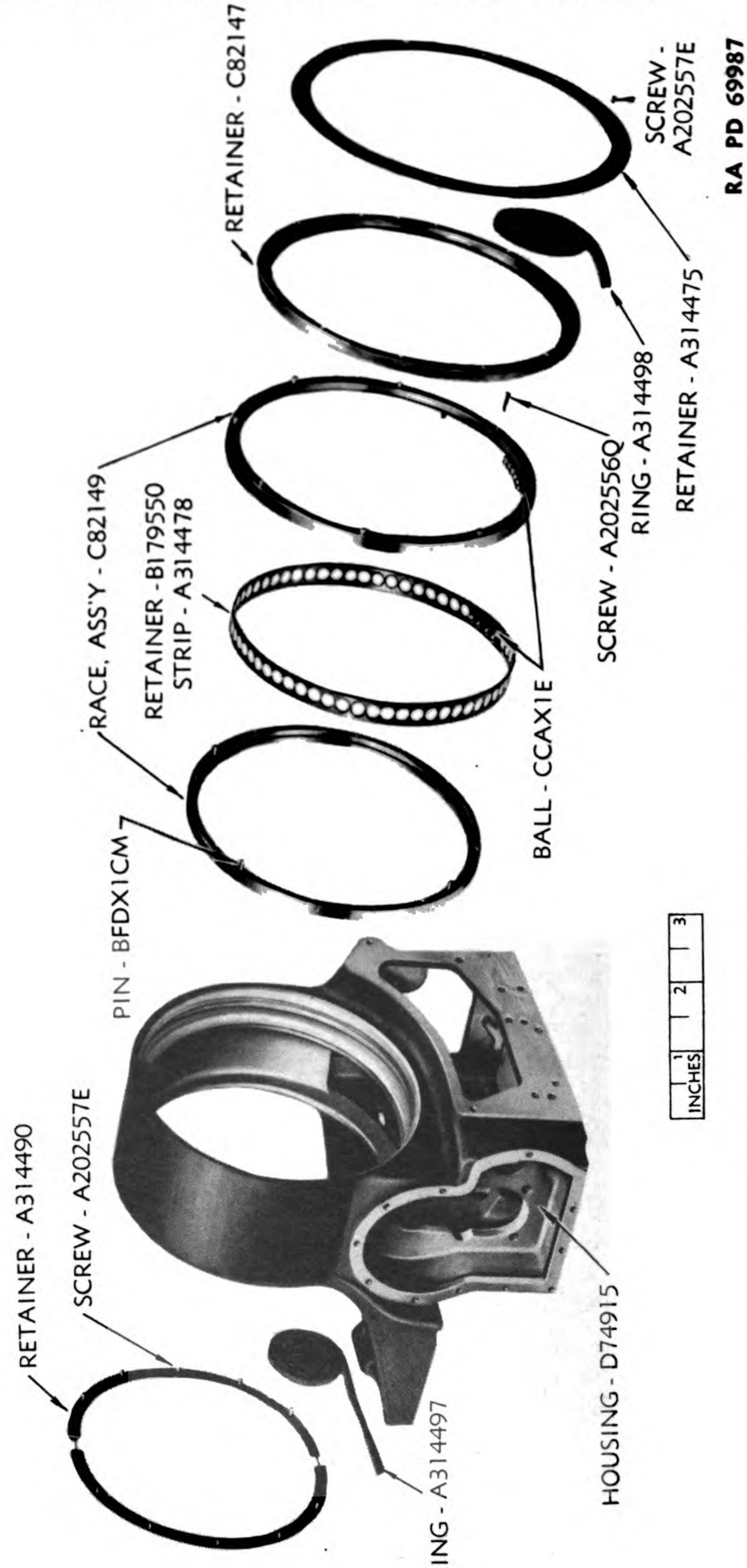


Figure 204 — Left Main Bearing Housing — Bearings

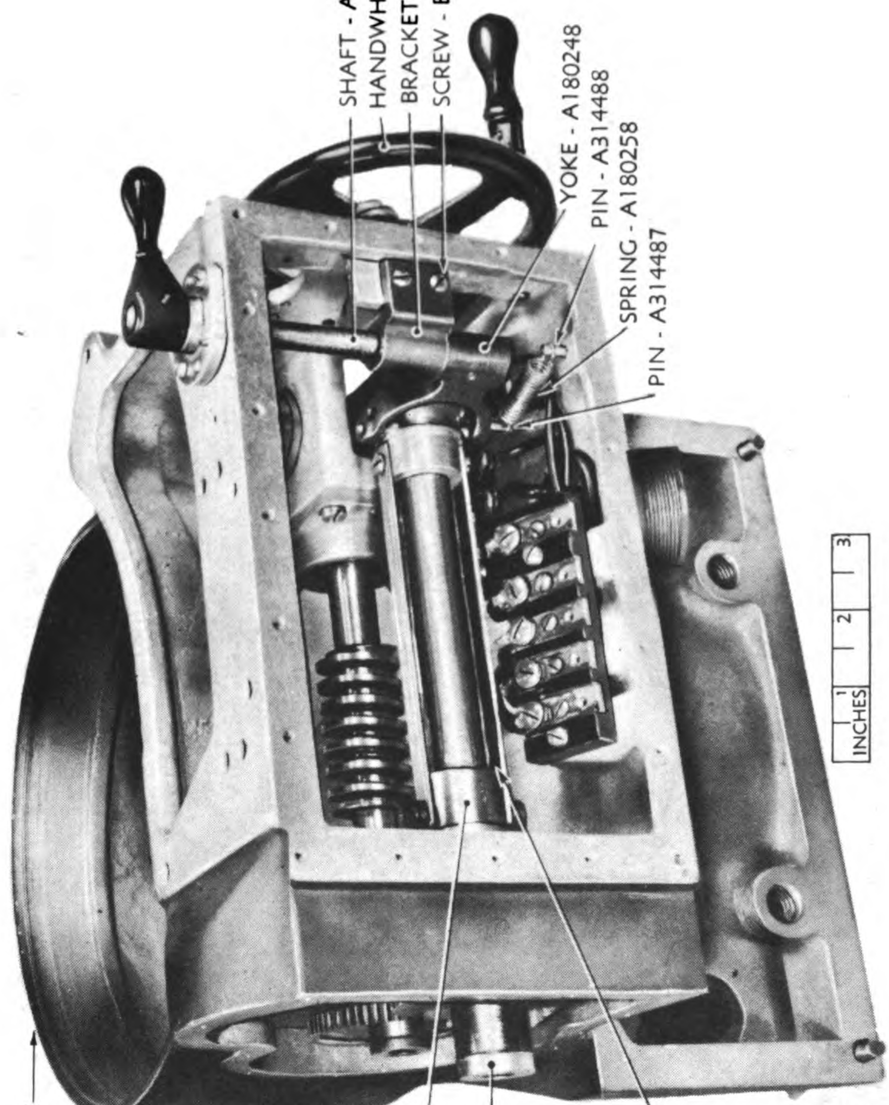
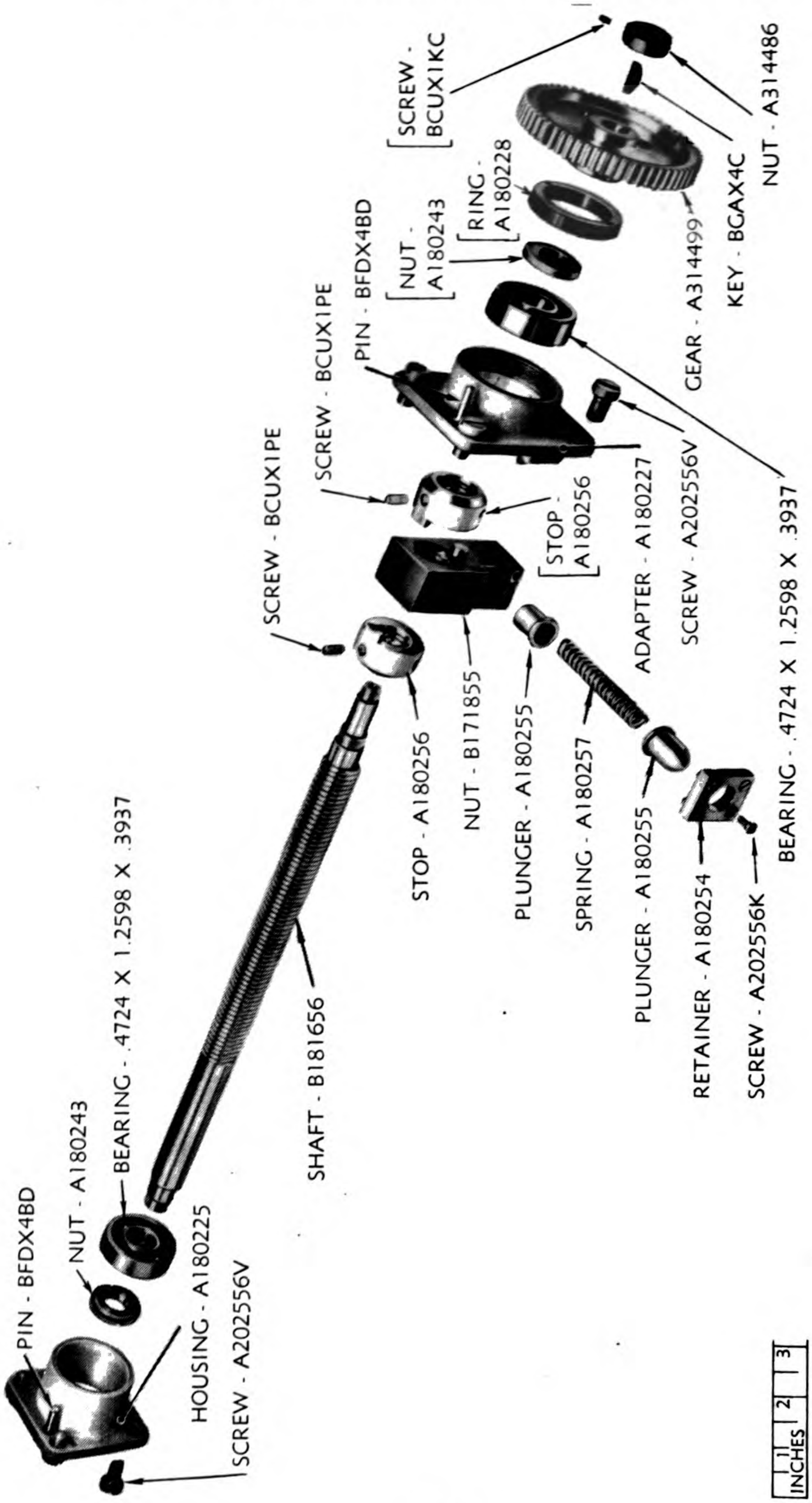


Figure 205 — Left Main Bearing Housing — Front Bottom View



RA PD 69995

Figure 206 — Elevation Stop Shaft Assembly — Exploded View

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT

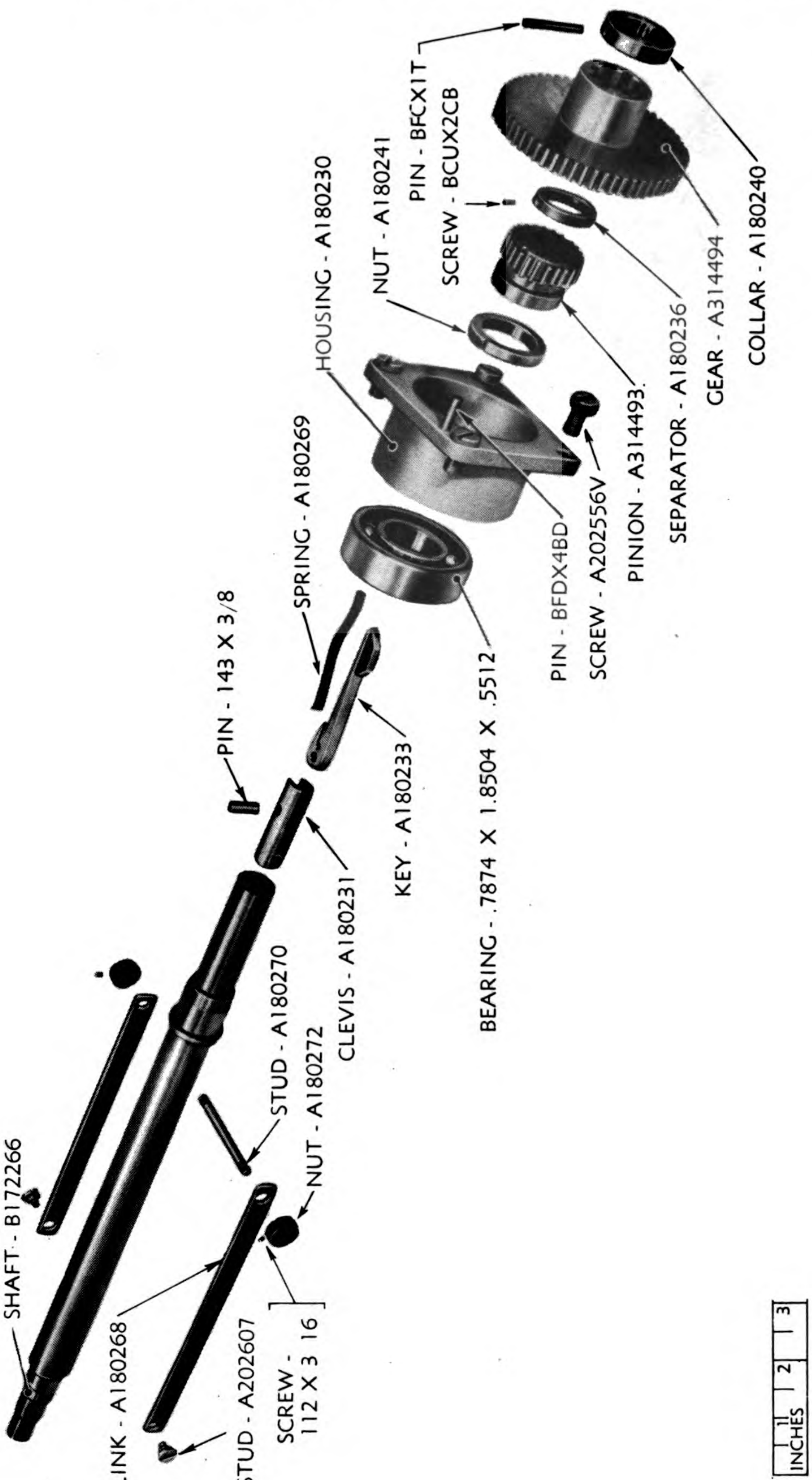
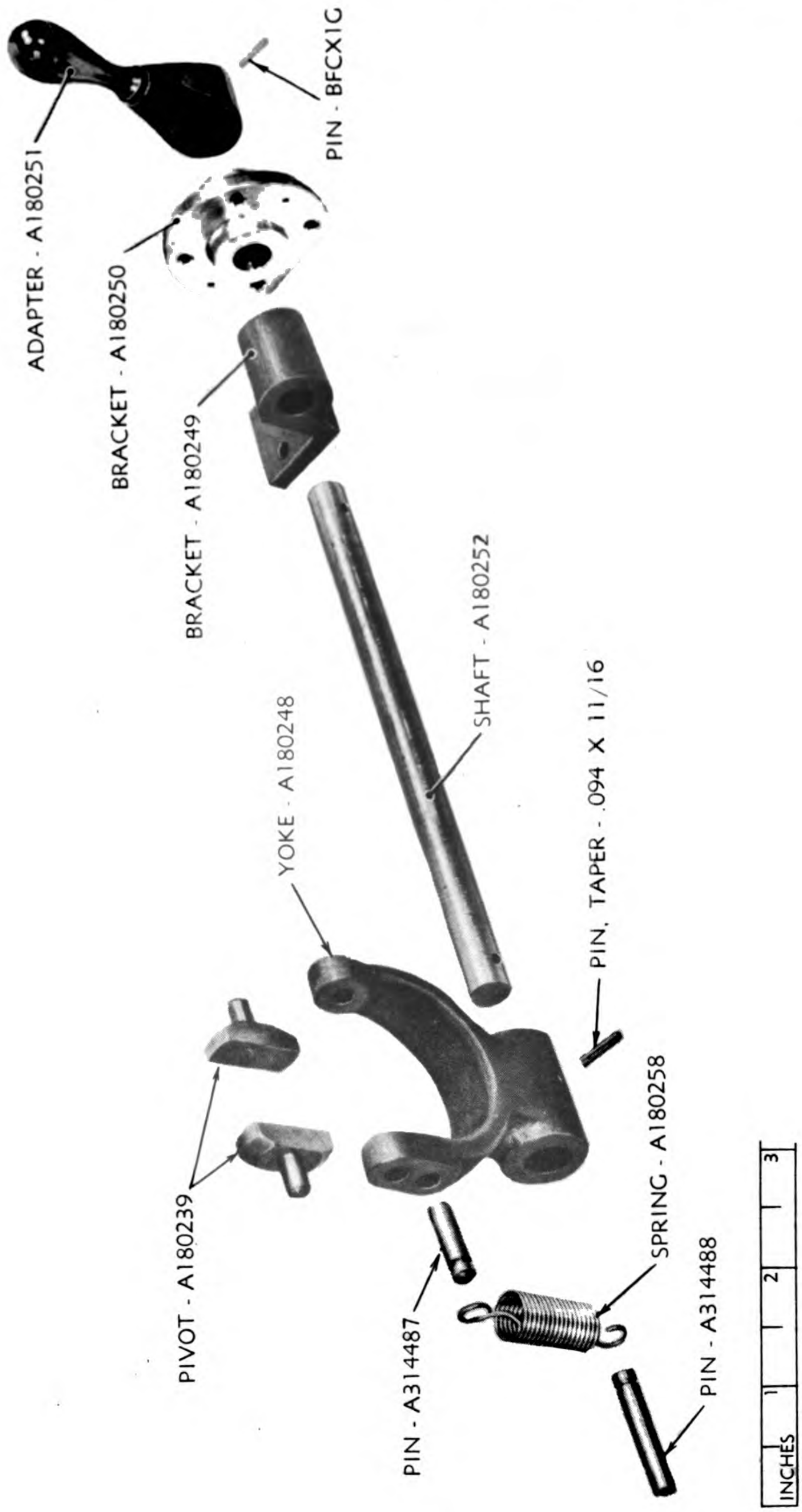


Figure 207 — Elevation Handwheel Shaft Assembly — Exploded View



RA PD 69992

Figure 208 — Elevation Change Speed Shaft Assembly — Exploded View

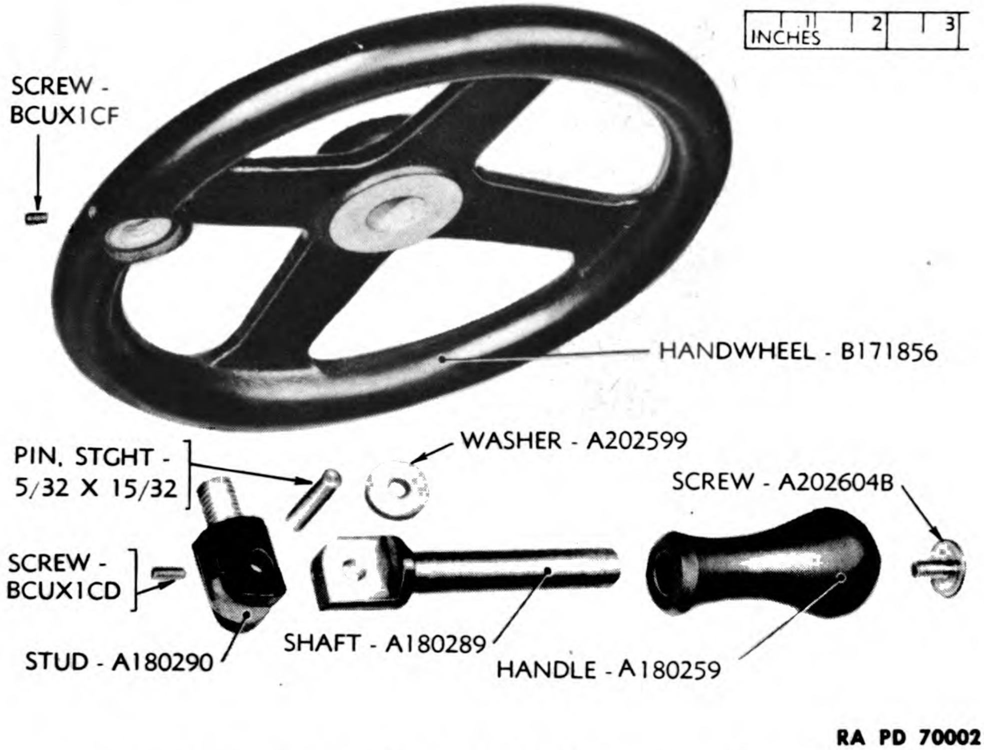


Figure 209 — Elevation Handwheel Assembly — Exploded View

dd. Mark the position, remove the screws, and slide off retainer ring A314475 (fig. 204). Remove the packing.

ee. Unscrew the retainer C82147 and slide along the tube.

ff. The housing D74915 will then have to be moved toward the center of the height finder a short distance to gain access to the ball bearing race.

gg. By removing screws that hold the two halves of the ball race assembly C82149 together (fig. 204), the halves can be separated, and the balls removed and placed in cleaning solution.

hh. Disassemble the left inner tube supports, and remove the bearing rings off the left end of the tube in the manner described for the right bearing (par. 166).

ii. The housing can then be moved along the tube as far as necessary toward the end box.

jj. Slide the ball retainer B179550 along the tube and carefully clean.

kk. Pack the ball races with grease, replace the balls, and secure these together with screws.

RA PD 69989

Figure 210 — Elevation Handwheel Shaft Assembly

ll. Reassembly should be made in the reverse order of disassembly.

NOTE: *If excessive backlash occurs between the worm and segment, this can be corrected by placing a shim under the worm segment. It will then be necessary to lap the worm and gear together to get smooth action.*

169. LEFT MAIN BEARING HOUSING — ELEVATION INDICATOR.

a. General.

(1) The elevation indicator is equipped with a "follow-the-pointer" dial system. One pointer (the electrical pointer) is fastened to the rotor of the elevation repeater and, through cable connection with the antiaircraft director, always moves in elevation the same amount as the director. The other pointer of the indicator is connected through gearing to the elevation worm shaft of the height finder. This pointer turns within a scale graduated every 50 mils from zero to 1,600 (90 degrees).

(2) The elevation receiver is contained in a housing which is secured to the side of the left tube support housing (fig. 203).

(3) Replacement of the transmitter does not require complete disassembly, and can be accomplished as described below.

(4) Complete disassembly is necessary only for replacement of parts due to damage or failure to function.

b. Disassembly and Assembly.

(1) The elevation repeater can be removed from the housing without complete disassembly. Proceed as follows:

(a) Remove bottom cover plate A180264 (fig. 203) and disconnect the leads from the terminal block. Remove wire clamp.

(b) Remove screws and take off ring B171863. Remove gasket and window (fig. 214).

(c) Unscrew nut A46804 and remove index disk A180285 (fig. 214).

(d) Remove screws and take off retainer B171865.

(e) Remove countersunk screw in the side of housing which keeps the spacer A314555 from turning, and take out this part.

(f) The elevation repeater can then be removed from the bottom of the housing.

(2) For complete disassembly of the elevation indicator, the entire housing D43437 should be removed from the left support housing.

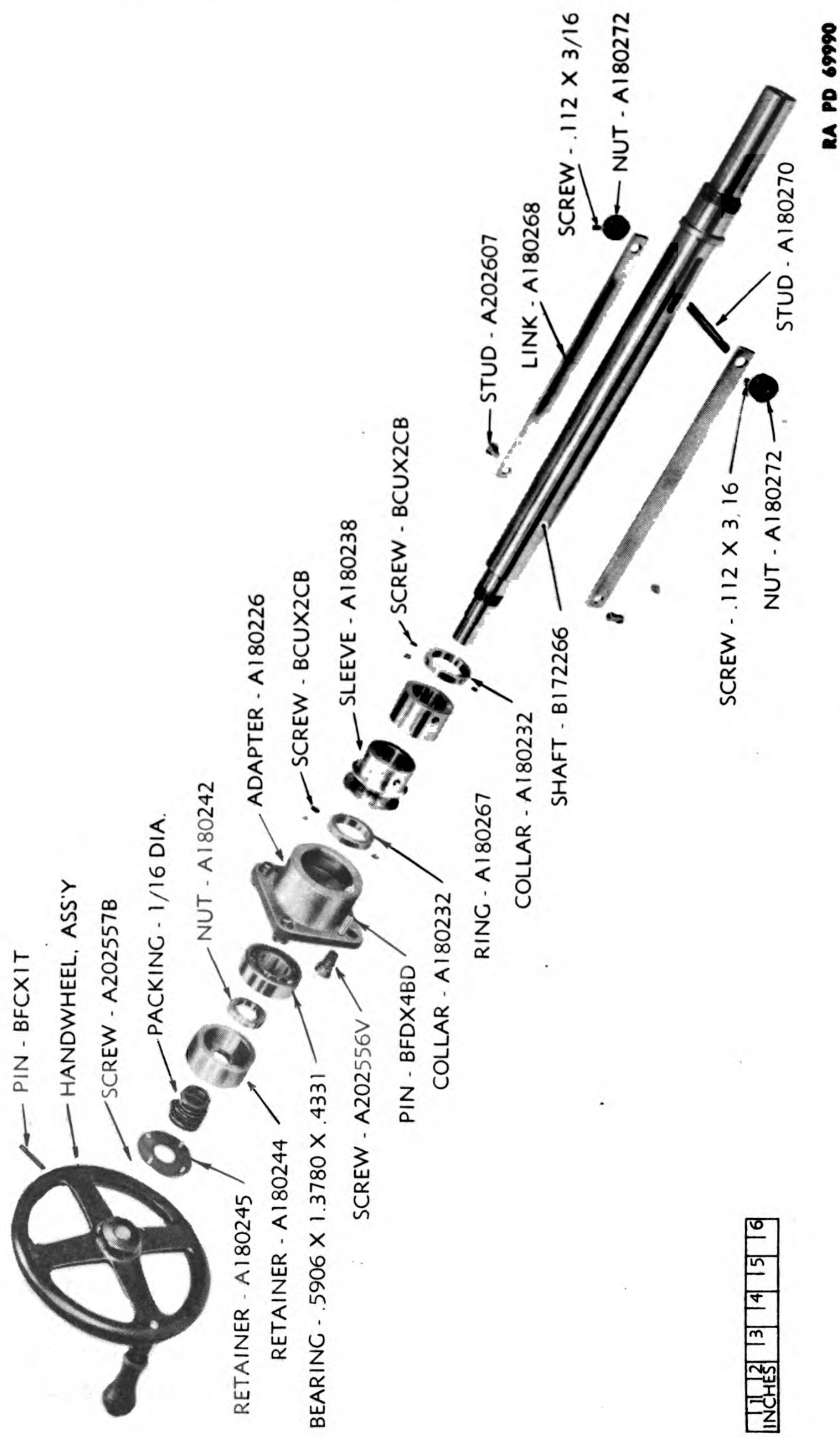
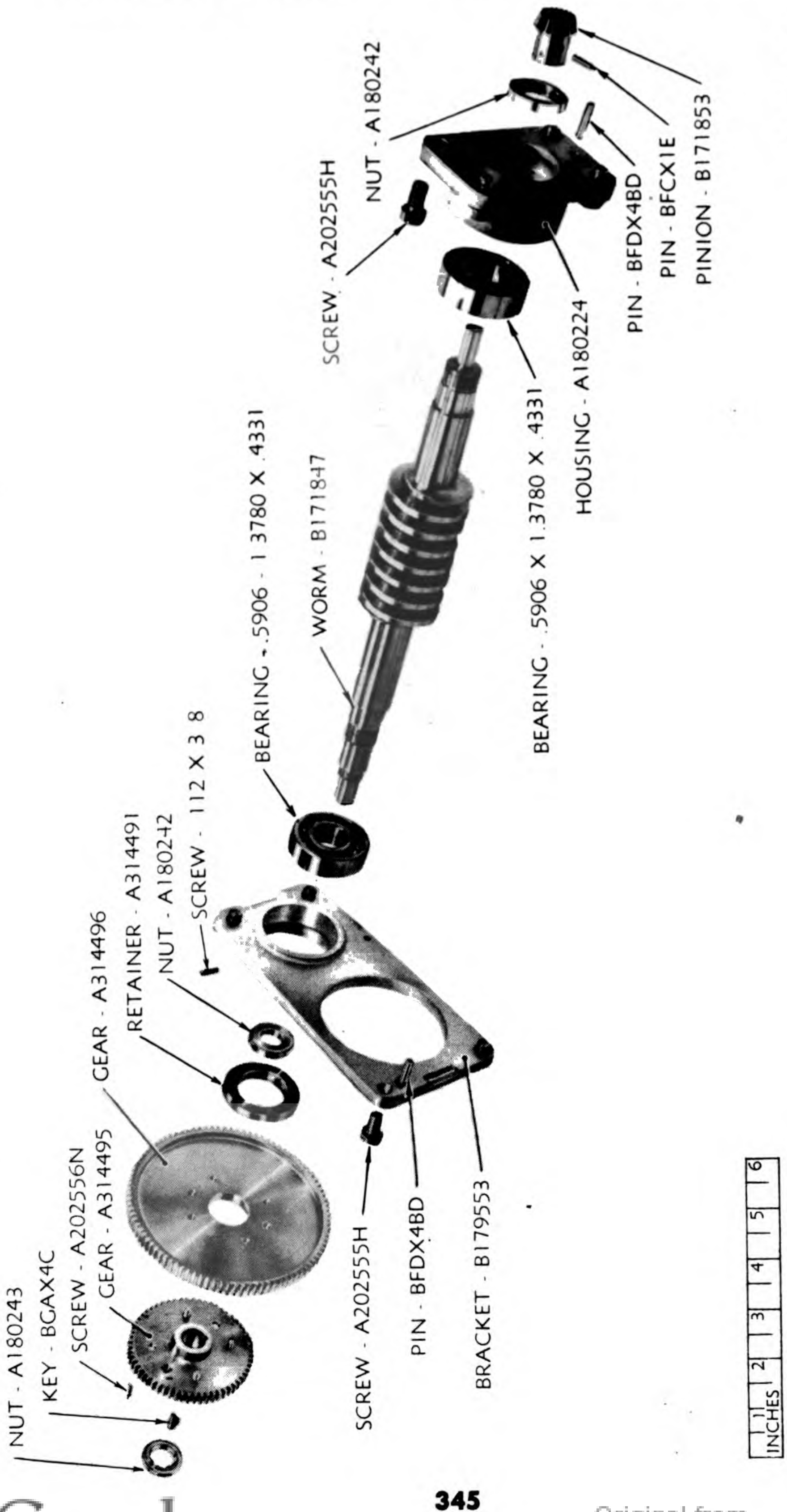


Figure 211 — Elevation Handwheel Shaft Assembly — Exploded View

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT



RA PD 69997

Figure 212 — Elevation Worm Shaft and Bearings — Exploded View

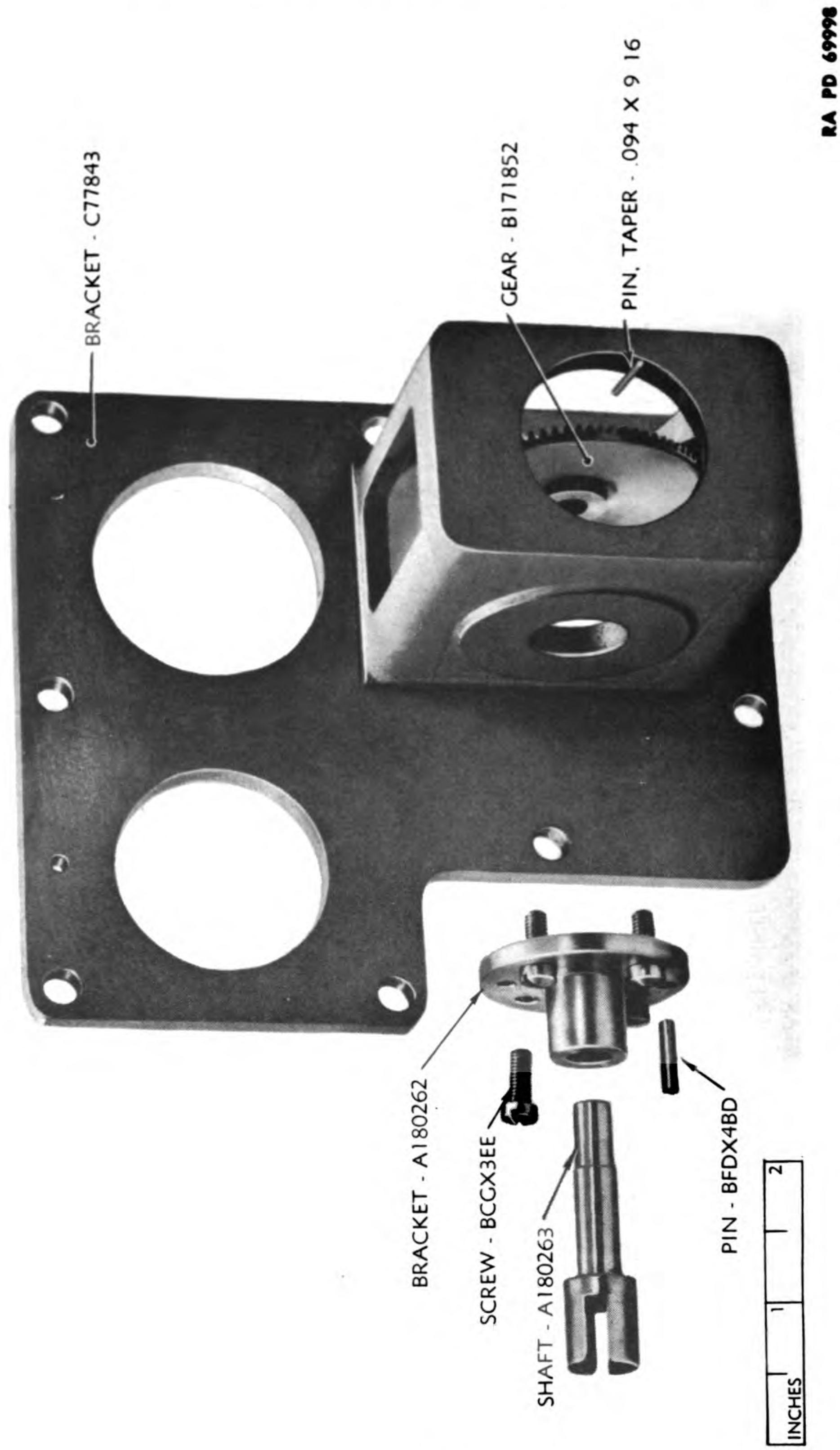


Figure 213 — Left Bearing Housing — Rear Bracket

HEIGHT FINDER TELESCOPE — REPAIR AND ADJUSTMENT

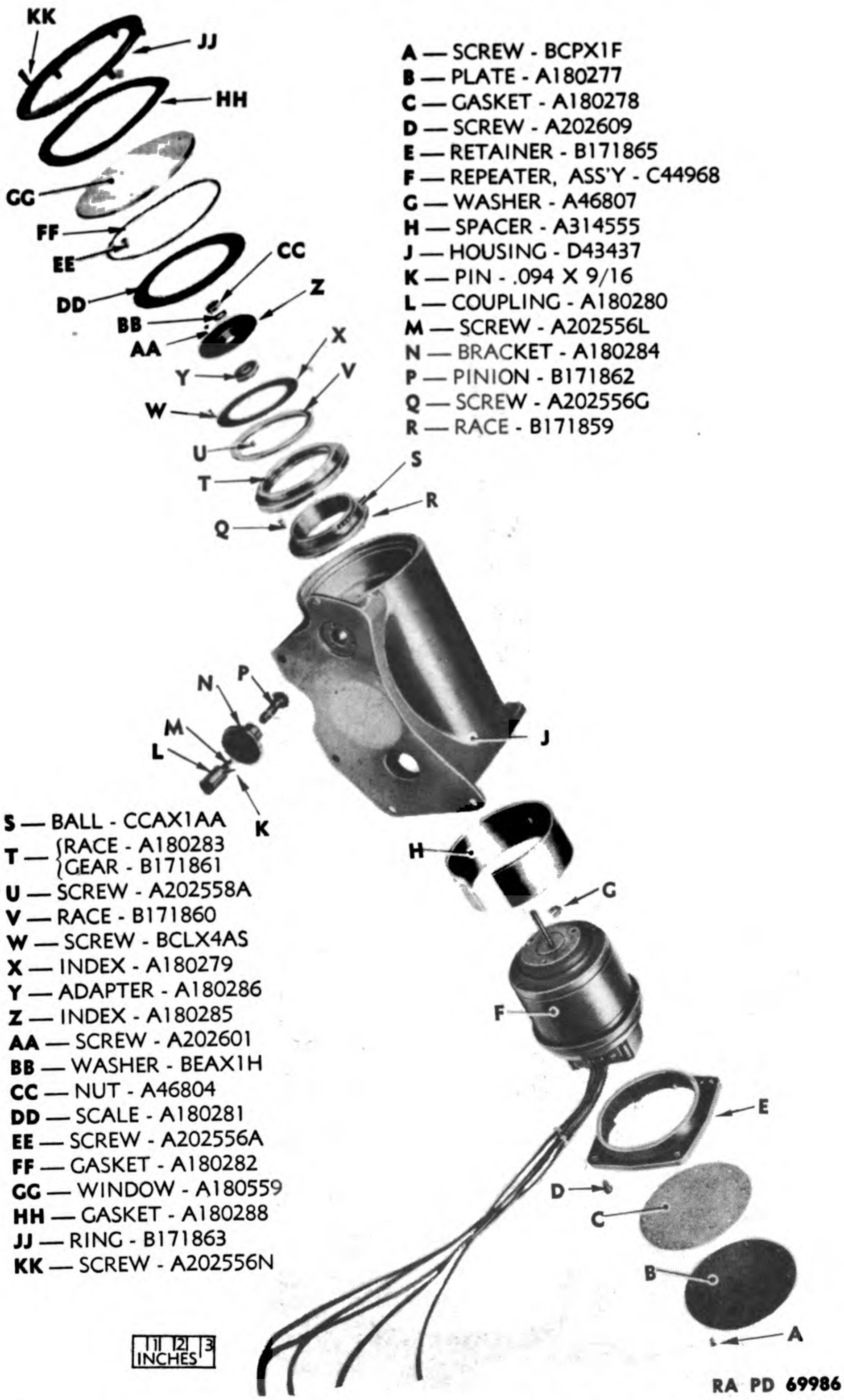
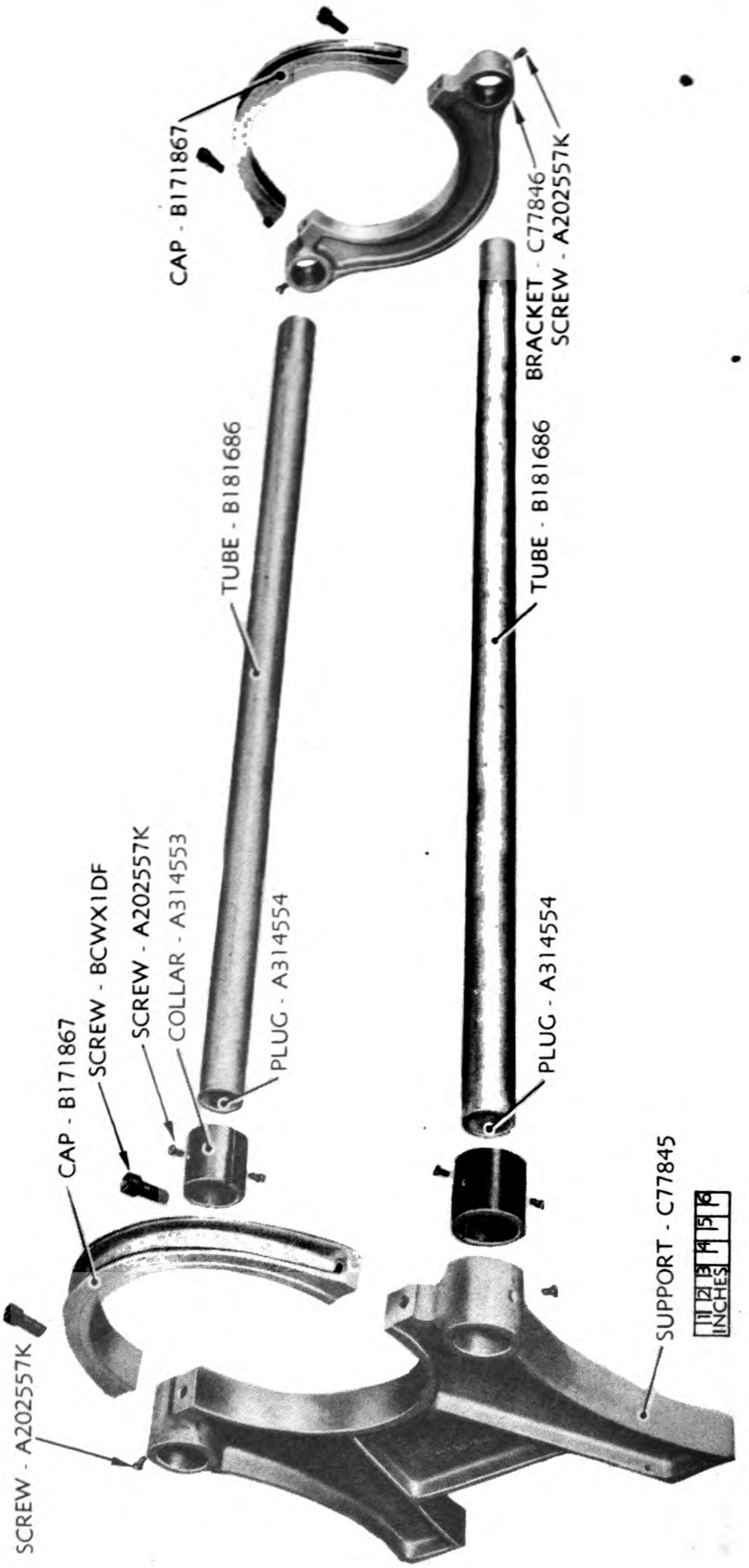


Figure 214 — Elevation Indicator Assembly — Exploded View



RA PD 69890

Figure 215 — *Right Carrier Handle Assembly — Exploded View*

(a) Remove ball rod connector, take out screws, and remove bracket A180284 together with pinion and coupling (fig. 214).

(b) Remove screws and take off scale A180281.

(c) Remove screws and take out ball race B171860. Remove balls and clean in dry-cleaning solvent.

(d) The bevel gear B171861 can then be removed.

(e) If necessary, remove screws and take out race B171859.

(3) Assembly should be done in the reverse of disassembly.

(4) For electrical zeroing, see paragraph 213.

170. CARRIER HANDLES.

a. General. The carrier handles support the full weight of the height finder telescope during lifting, storage, and shipment. It is important, therefore, that the carrier handle assemblies be mounted accurately and parallel. The carrier handles do not need to be removed unless they are damaged, or if it is necessary to disassemble the main bearing housings, or for removing the compensator. Removal of the carrier handles does not affect the hermetic seal of the instrument. Before removing the handles, the instrument must be mounted on its cradle or rested on padded V-blocks or other adequate and firm supports.

b. Removal and Replacement.

(1) Remove the four screws (fig. 215). Drop down the bar assembly and lift off the two caps.

(2) When replacing the bar assemblies, make sure they are mounted parallel to each other.

(a) Level the height finder on its cradle or other support.

(b) Use an ordinary spirit level across the bottom of the legs of the bar assembly to level the inner support. Use the level on the carrier handle tubes when adjusting the outer bracket, to make the carrier handles parallel.

(c) The carrier handle bar assemblies at the two ends of the height finder should be parallel with each other to within 3 minutes.

Section X

HEIGHT FINDER TELESCOPE — DISASSEMBLY AND ASSEMBLY

171. DISASSEMBLY OF HEIGHT FINDER TELESCOPE — REQUIREMENTS.

a. Partial Disassembly. Removal of the various units and their disassembly, as required for cleaning, adjustment, or repairs, is described in the various paragraphs dealing with the adjustment and repair of the individual units.

b. Conditions Requiring Major Disassembly.

(1) Removal of the inner tube from the outer tube will be necessary to grease and adjust the measuring drum drive assembly, measuring drum pinion and gear bracket, measuring drum, measuring drum bearing assemblies, and measuring drum thrust roller assemblies, and for cleaning and replacing the correction wedge assembly.

(2) Removal of the optical tube from the inner tube will be necessary to clean and replace the main objectives for adjustment or replacement of the optical tube level, for adjustments necessary on the gimbal support, and for removal and replacement of the internal target collimator tube.

(3) Major disassembly will be necessary for removal of dirt and moisture on the main objective and correction wedge.

(4) Dirt or moisture creating a blurred appearance may be caused by moisture on one of the optical surfaces between the reticle and the eye, or by dirty optics in the eyepiece unit which will not require a major disassembly to correct. Before starting a major disassembly, therefore, test the instrument as follows:

(a) Remove the eyepiece unit.

(b) Inspect all optical surfaces and clean where necessary.

(c) Replace and secure the eyepiece unit.

(d) If the blurred appearance persists after replacing the eyepiece unit, desiccate the instrument (par. 85).

(e) If the blurred appearance of the reticles persists after cleaning and desiccation, it can be definitely assumed that the trouble is within the instrument, and a major disassembly will be required.

172. DISASSEMBLY OF HEIGHT FINDER TELESCOPE — REMOVAL OF THE INNER TUBE.

a. This disassembly may be performed only at a base shop where complete equipment and qualified personnel are available.

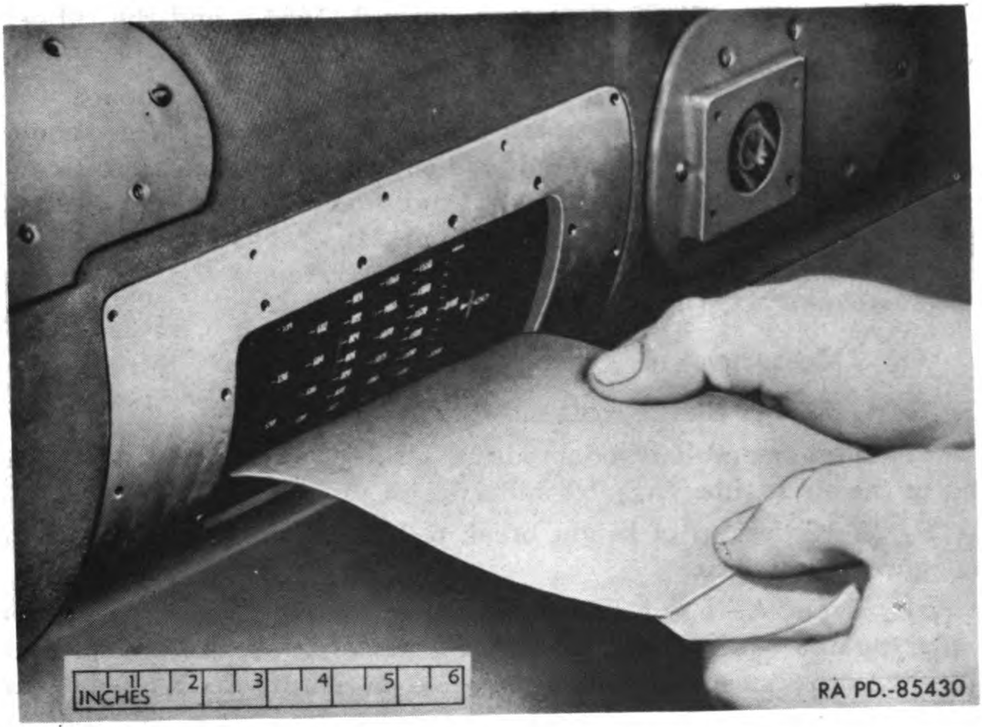


Figure 216 — Inserting Measuring Drum Cardboard Protective Cover Through Window

b. Remove the following assemblies, referring to the paragraphs indicated for details of procedure, and taking all precautions to avoid disturbing the various adjustments. Wrap each optical unit in tissue paper and mount in a closed box to prevent damage and exclude dust.

(1) Height adjuster knob (par. 148).
(2) Collimator knob (par. 153).
(3) Right bearing housing (par. 165).
(4) Carrier handles (par. 170).
(5) Elbow (Tracking) Telescopes M13 (par. 193).
(6) Stereo reticle illuminators (par. 142).
(7) Adjuster knob (par. 159).
(8) Correction knob and scale assembly (par. 124).
(9) Correction wedge pinion assembly (par. 120 to 123).
(10) Eyepiece plate assembly (par. 109).
(11) Eyepiece bracket assembly (par. 109).
(12) Compensator assembly (par. 135).
(13) MEASURING DRUM WINDOW (par. 140).
(a) Remove illuminator bracket B179570 (fig. 146).
(b) Remove window retainer plate B171780.

(c) Remove measuring drum window A314547, and the rubber gasket.

(d) Cover the measuring drum with a strip of cardboard 4¾ inches wide by 23 inches long and about $\frac{1}{32}$ inch thick. This should be inserted through the window frame and around the index rail, continuing until the end can be reached, and drawn up snugly and taped to form a complete band (figs. 153 and 216). NOTE: *This precaution is absolutely necessary to prevent scratching the scale when the inner tube is withdrawn.*

(14) Measuring knob assembly (par. 139).

(15) HEIGHT BREAK ROLLER.

(a) This assembly is mounted just inside the adjuster drive opening in the outer tube (figs. 69 and 70).

(b) Two designs of height break rollers are in service, as shown in figures 69 and 70.

(c) Type "A," figure 69, is installed on most of the instruments under number 180. To disassemble, remove two shim screws and lift the entire assembly up through the measuring knob opening in the outer tube.

(d) Type "B," figure 70, is a later and more rugged design, and has been installed on all instruments number 181 and above, and several below this number, many of which have been changed in the field. To disassemble, remove three bracket screws and lift the bracket out through the measuring knob opening, then loosen five plate screws and lift the plate out through the measuring knob opening (fig. 142).

(16) Left and right end boxes (par. 164).

(17) End reflectors (par. 93).

(18) Penta prism slide assembly (par. 155).

(19) Left and right end reflector supports (par. 93).

(20) Remove the left and right objective and adjuster tubes after the screws holding them in the inner tube adapter are removed. NOTE: *Before removal, mark their position for assembly alinement.*

(21) Right outer tube support (par. 165).

(22) Left outer tube support (par. 168). NOTE: *The left outer tube support need not be disassembled when disassembling the inner and outer tubes.*

(23) Lift and rotate the height finder on the V-blocks until the eyepiece adapter is depressed about 15 degrees below the horizontal; this will position the outer tube so there will be no openings for the inner tube support rollers to drop into.

HEIGHT FINDER TELESCOPE — DISASSEMBLY AND ASSEMBLY

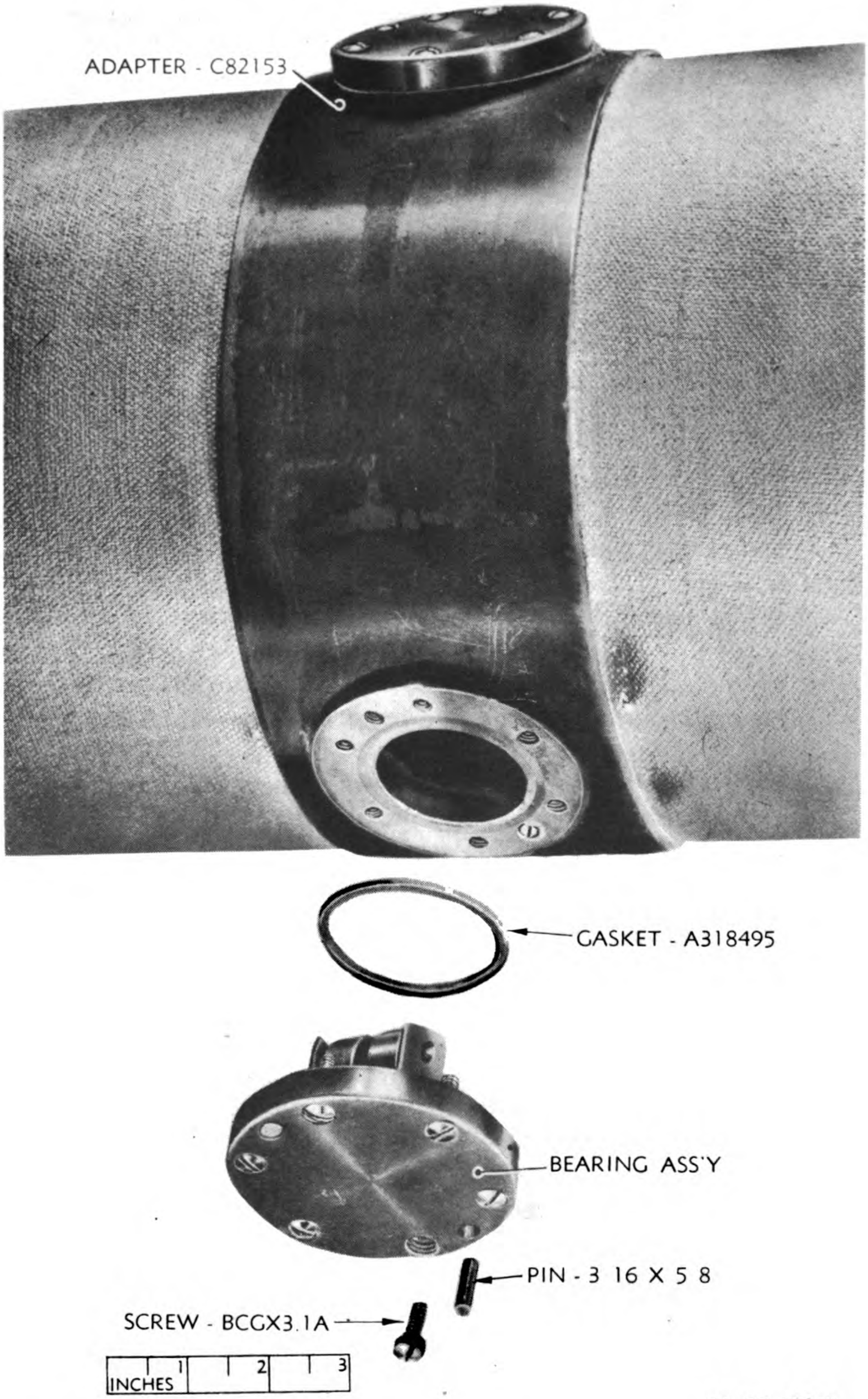


Figure 217 — Removing the Inner Tube Bearing Assemblies

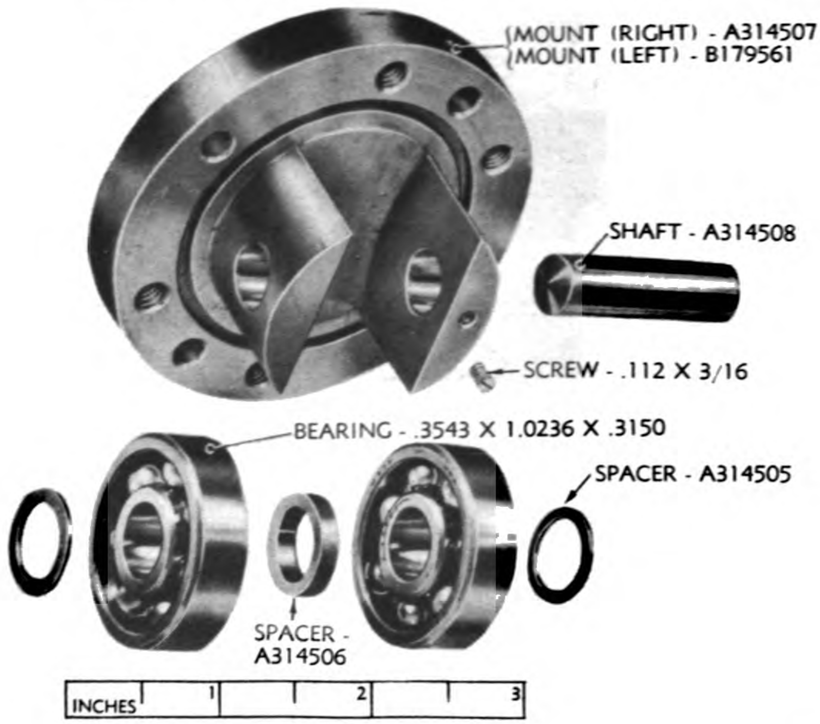


Figure 218 — Inner Tube Bearing Assembly — Exploded View

(24) Place two small wood wedges between inner and outer tube at each end to support, and prevent the inner tube from rotating when the fine elevation knob assembly is removed.

(25) Remove fine elevation knob bracket assembly (par. 151).

(26) INNER TUBE SUPPORTS.

(a) Remove covers and gaskets (used on earlier instruments only).

(b) Mark each of the inner tube support bearing assemblies (figs. 217 and 218) so that they can be reassembled in the same position, and remove each in the following order: top bearings, left and right, and lower bearings, front and rear, on both right and left sides.

(c) Remove the wood holding wedges and, at the same time, lift and rotate the inner tube until these guide rollers are on the under side.

(d) Two guide roller assemblies (fig. 151) are mounted on the inner tube near each end to facilitate its removal from the outer tube. To make certain that these rollers do not drop into any of the openings, the outer tube should be rotated slightly in either direction if necessary, so that, on sighting through, a clear track is observed.

(e) Using six men stationed at intervals, withdraw the inner tube

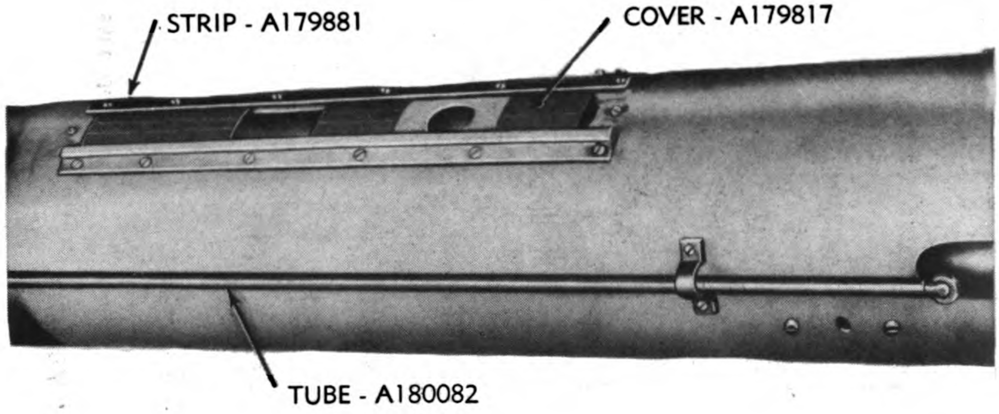


Figure 219 — Inner Tube — Left Side Showing Objective Adjusting Openings

from the right end of the outer tube slowly, making sure it is kept *parallel* to the outer tube in order *not to damage the measuring drum and index rail.*

(f) Place the inner tube on wooden V-blocks, and cover with clean wrapping paper. Only that portion on which work is being done should be left exposed.

173. DISASSEMBLY OF HEIGHT FINDER TELESCOPE — DISASSEMBLING THE INNER TUBE.

a. Place one reference mark on the inner tube and another on the end reflector bracket adapter (fig. 192) (both left and right) and remove these parts.

b. Remove screws in inner tube and take out right and left objective tube spacer B171811 (fig. 184).

c. Remove left and right adjuster tube brackets A180179 (fig. 184). NOTE: *On the left side, this bracket must be removed through the main objective adjusting opening (fig. 219).*

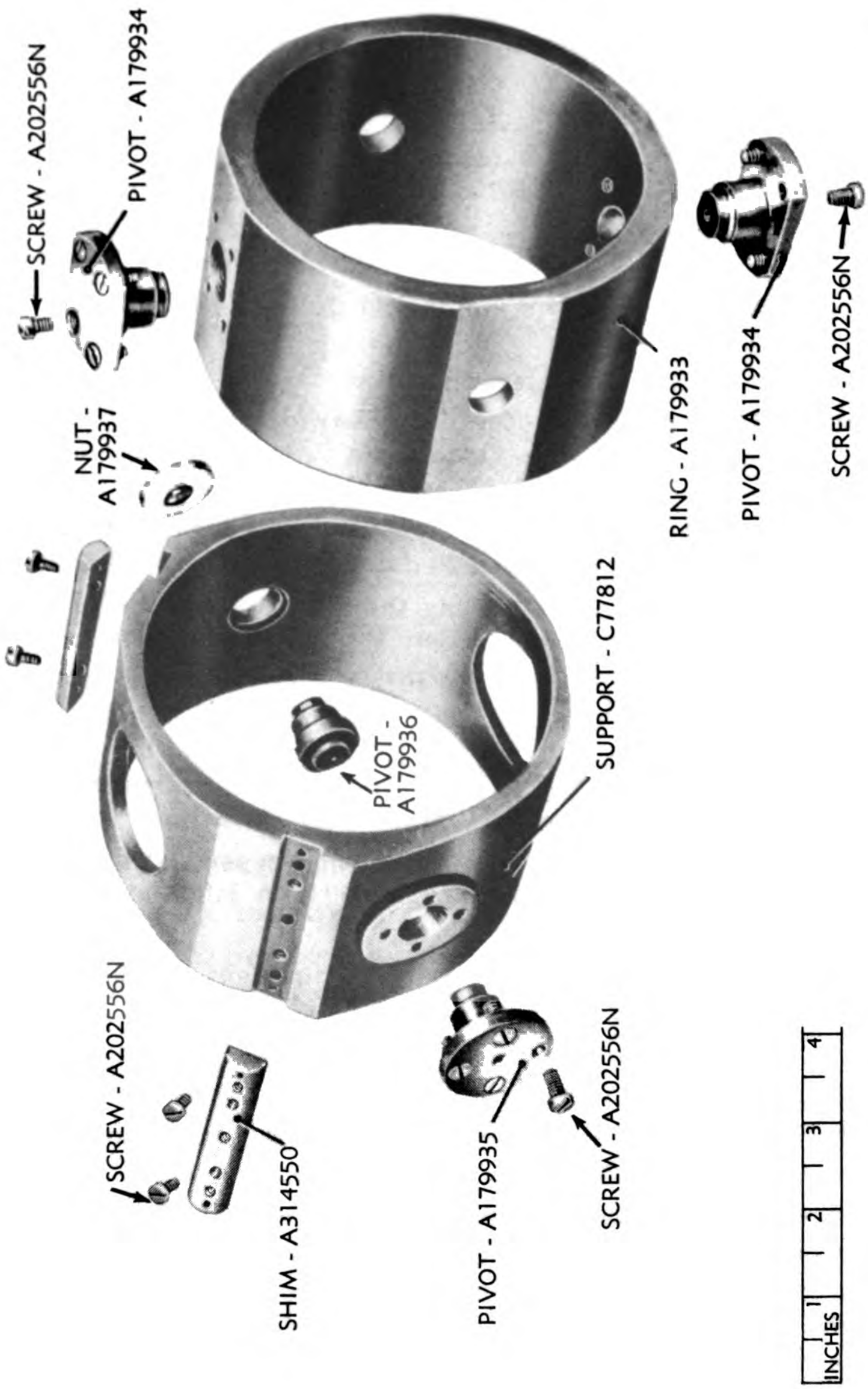
d. Correction Wedge Assembly.

(1) Remove the screws that go through the inner tube into the correction wedge adapter mount B171712 (fig. 110).

(2) Slide the correction wedge assembly out of the tube, making sure that the gear segment B171713 (fig. 111) does not strike and damage the teeth.

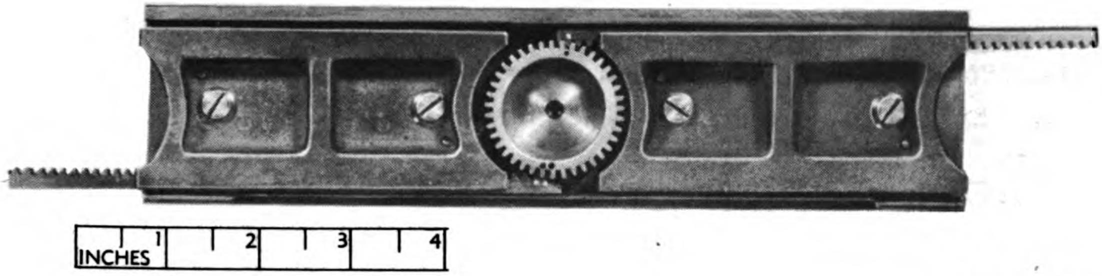
e. Optical Tube Assembly.

(1) Remove the flat weights from the center of the optical tube (fig. 67).



RA PD 28992

Figure 220 — Optical Tube Gimbal Joint Support — Exploded View



RA PD 85465

Figure 221 — Adjuster Drive Pinion and Bracket Assembly

(2) Unscrew the right counterweight tube B171722 and remove it from the right end of the optical tube (fig. 109).

(3) Apply gummed tape to the exposed threads on the end of the optical tube for protection against damage while removing.

(4) Rotate the inner tube until the screws holding the gimbal support are at the bottom.

(5) Remove the six screws holding the gimbal support C77812 (fig. 220).

(6) Carefully withdraw the optical tube through the right optical tube bearing support B171746 (fig. 109), and remove the optical tube from the left end of the inner tube. NOTE: *The optical tube right bearing support can be removed at any time after the internal target collimator and measuring drum have been removed.*

(7) Wrap the optical tube carefully in clean paper and place on wooden V-blocks.

f. Internal Target Collimator Assembly.

(1) Remove the screws in the inner tube which secure the collimator left and right brackets A179976 (fig. 178) and B171756 (fig. 176) and remove the internal target collimator assembly through the eyepiece opening.

(2) Mark the position of the wedge bracket and remove the internal target (collimator) alinement wedge assembly (fig. 173).

(3) Wrap both of these assemblies in clean lens-tissue paper.

g. Adjuster Drive Rack and Pinion Assembly (fig. 221).

(1) Just before disengaging the racks and pinion, be *sure* that *double punch marks* have been made on one *rack* opposite *double punch marks* on the *pinion*, and a *single punch mark* on the other *rack* opposite a *single punch mark* on the *pinion.*

(2) Remove the screws which secure the right and left adjusting drive tube brackets A180110 (fig. 187) to the inner tube.

(3) Disengage and remove the right and left adjusting drive rack and tube assemblies.

(4) Remove the screws that hold the rack bracket B171791 (fig. 186) in place and remove from the inner tube.

h. Measuring Drum Assembly.

(1) Remove the cardboard protective cover.

(2) Set the measuring drum to infinity.

(3) Mark the engaging position of all gears (fig. 147).

(4) Mark the engaging position of couplings.

(5) Mark and remove the index rail assembly by removing the four screws that hold the two supports A180069 (fig. 148) on the inner tube.

(6) Remove the six drum thrust roller assemblies (fig. 150).

(7) Remove counterweights B171826, and B171828, guide roller assemblies and studs A180185 (fig. 151) from the right end of the inner tube.

(8) Remove the height-range drive tube assembly (fig. 147).

(9) Remove the measuring drum pinion and gear bracket assembly (fig. 147).

(10) Rotate the measuring drum off the rollers toward the right, and remove carefully over the end of the inner tube. NOTE: *Do not* slide *the drum on the inner tube as this will damage the gear teeth.*

(11) Remove the eight measuring drum bearings (fig. 149). These should all be marked for positioning in reassembly.

(12) Remove the measuring drum drive assembly (figs. 152 and 147). CAUTION: *Be sure to secure all loose shims to the parts on which they are used.*

NOTE: *On instruments that have inner tube reenforcing ribs, the measuring drum will have to be first moved to the right and then be removed from the left end of the tube when the above units are removed.*

(13) If complete disassembly of the inner tube is necessary, the remaining parts not referred to in the above description can be removed in any order that suits the repairman.

174. ASSEMBLY AND ADJUSTMENT OF OPTICAL TUBE — REQUIREMENTS.

a. General. The optical tube carries the heart of the optical system of the height finder, and it is essential that each of the components be properly mounted and adjusted. In order to attain the proper adjustment, the various units must be mounted and adjusted in a certain definite order as described below. The procedure given is based on the assumption that any or all of the optical units may be out of adjustment or damaged so as to require replacement. If the units were all in adjustment prior to disassembly of the height finder, the units of the optical tube and adjustments should not be disturbed.

b. Requirements.

(1) Certain of the mechanical adjustments require the use of special fixtures which can be made up by careful maintenance men. Two collimators (fig. 75) and a collimator eyepiece are needed for centering new reticle mounts, for focusing the main objectives, and to check the proper adjustment of the height adjuster disk. A divergence tester and low-power telescope, used in conjunction with the eyepiece unit, which will be used on the height finder and which must be in perfect working condition, is also needed for centering the reticles and alining the ocular prisms (fig. 72).

(2) The optical tube and the various optical and mechanical parts should be properly cleaned and free from dust or lint before assembly is started. The work should be done in a reasonably dust-free room. Even then, the reticles will probably need cleaning after the assembly and adjustment of the height finder have been completed.

c. Optical Tube Adjusting Fixture. When the height finder telescope has been disassembled for repairs, the optical tube should be examined carefully to determine if any of the elements have been disturbed, damaged, or require cleaning. If disassembly or replacement has been made of any of the optical parts, then these will have to be carefully adjusted before the optical tube is reassembled in the instrument.

(1) A narrow surface plate (or other suitable surface) long enough to accommodate the optical tube and two collimators, together with a double telescope (fig. 72) will make a satisfactory testing fixture (fig. 75).

(2) The height finder eyepiece assembly (if properly adjusted) can be used in place of a double telescope for a testing fixture, when suitably mounted, using the low-power telescope and divergence tester to check adjustments (figs. 72 and 74).

(3) An eyepiece mounted in an adapter that fits the collimator tubes will be required. A pupil loupe may be used to check cut-off of the apertures (fig. 72).

(4) The axis of two collimators must be in line and parallel to the top and front finished surfaces of the surface plate.

(5) Prepare for the optical tube test as follows:

(a) Place the optical tube on steel V-blocks between the two col-

limators so that its axis coincides with the axis of the two collimators. Check by use of indicator.

(b) Level the optical tube lengthwise by means of sensitive level placed on the inner lower ground surface, or by indicating with height gage.

(c) Level the optical tube by rotating until the bubble in the attached optical tube level is centered.

NOTE: *If this level has been damaged or is possibly out of adjustment, place a sensitive level on the inner ground surface of the optical tube, and when the ocular prisms have been removed, level carefully, and reset the attached optical tube level.*

175. ASSEMBLY AND ADJUSTMENT OF OPTICAL TUBE — CHECKING THE HEIGHT ADJUSTER DISK.

a. Place the double telescope (or eyepiece) into position over the ocular prisms.

b. Set the height adjuster disk in the true perpendicular position by using a small square placed so the blade rests against the face of the disk cell, with the base of the square resting on the inside bottom ground surface of the optical bar.

c. Place a parallel bar against the back surface of the optical tube, and adjust the steel square to the parallel and the face of the adjuster disk. The face of the disk should be perpendicular to the longitudinal axis of the optical tube. NOTE: *Figures (such as 7.5) will be found painted on the upper surface of the optical bar near the hole through which height adjusting screw projects. These figures represent the distance the screw should project to bring the height adjuster wedge into perpendicular position, measured in millimeters, from the top of the optical tube surface to the top of the screw.*

d. The height adjuster is properly mounted when rotation of the disk produces a deviation in the vertical plane only.

e. This can be determined by observing the motion of the collimator cross lines, viewed through the double telescope, when the height adjuster disk is rotated. If the vertical cross line of the collimator and the vertical cross line in the left telescope remain superimposed during the rotation of the height adjuster disk, then it has been properly mounted.

f. If not, the axis of rotation of the disk is not horizontal, and must be corrected by filing the bosses on the top of the support B171743 (fig. 160).

NOTE: *By placing shims between the support B171743 (fig. 160) and the optical tube and rechecking, the location and amount of filing can be readily determined.*

HEIGHT FINDER TELESCOPE — DISASSEMBLY AND ASSEMBLY

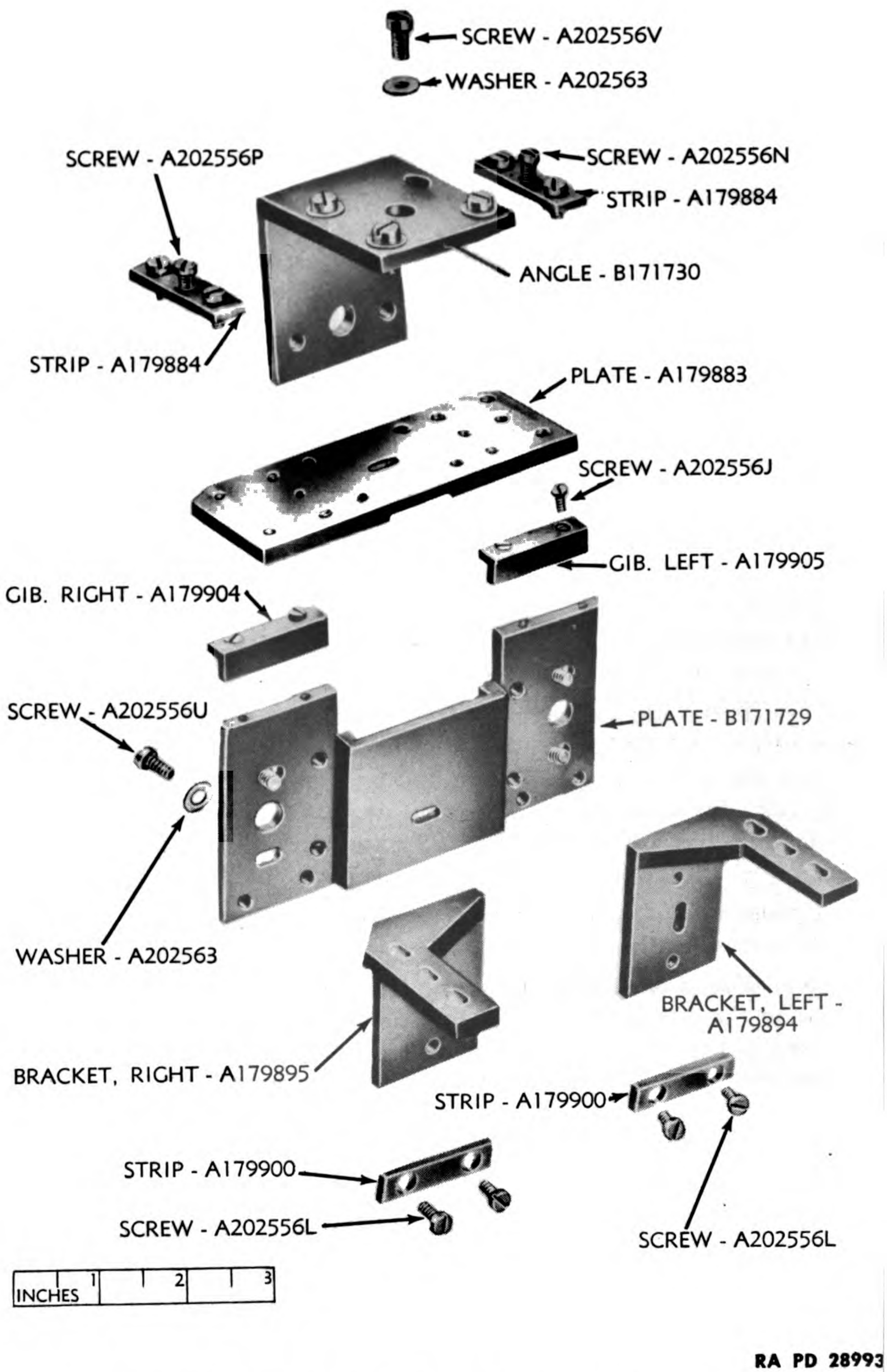


Figure 222 — Ocular Prism Plate Assembly — Exploded View

176. ASSEMBLY AND ADJUSTMENT OF OPTICAL TUBE — CENTERING AND ADJUSTING RETICLES.

a. Centering the reticles is necessary only when replacing a new pair of reticles or repairing damage caused by inexperienced personnel.

NOTE: *The operator will find it advantageous if similar operations are performed on both the right and left sides of the optical tube at the same time, rather than completing all adjustments on one side before beginning the other side. The adjustments described in this paragraph are to be performed when the optical tube is removed from the height finder. In view of the fact that the adjustments for the right and left side of the optical tube are identical, the following discussion will be limited to the right side, and it will be understood that the same operation must also be performed on the left side.*

b. Before centering the reticles, the reticle cells will have to be checked for squareness with the bottom plate B171729 (fig. 222). To accomplish this proceed as follows:

(1) Remove the bottom plate, with attached reticle mounts and brackets, from the optical tube.

(2) Remove four screws ("2" fig. 156). *Do not remove screws at "1" and "3."* The reticle and plate assembly can then be slid out.

(3) Place the entire reticle and plate assembly on end, with the face of ring A179893 (fig. 158) on a surface plate and, with a steel square, check the ground bottom and back edge of the plate B171729 (fig. 222) for squareness. Correct if necessary, and make sure screws A202556L and A202556N (fig. 222) are tightened securely.

(4) Place reticle and plate assembly on ground parallel blocks, and place reticle in front of microscope (or transit) fitted with horizontal cross hairline.

(5) Focus on the reticle marks. Rotate reticle disk if necessary to bring the horizontal center line of marks on the horizontal cross hairline of the telescope. To do this it will be necessary to loosen set screw and unscrew retaining ring A179893 (fig. 158).

(6) Move the mount back and forth in front of the microscope to see that if at any point the cross line moves across the horizontal center of the reticle marks. If it does, rotate the reticle slightly until corrected, and then secure retainer ring A179893 (fig. 158) and tighten set screw.

(7) Reassemble the entire unit in the optical tube following the reverse of procedure outlined above.

c. Rotate the optical tube so that the back edge of the bottom plate B171729 (fig. 222) is horizontal, and place a sensitive level on this surface or indicate to check for levelness with the axis of the optical tube.

d. Place the eyepiece and adapter in the right collimator, and focus on the collimator cross lines and reticle marks.

e. Rotate the optical bar on the V-blocks, and note if the center of the center reticle stays in the center of the collimator cross lines.

f. If this condition does not exist, then the reticles must be shifted until there is no change of centers when the optical bar is rotated.

g. Both right and left reticles can be moved back and forth by loosening screws at "2," (fig. 156) and using eccentric wrench (fig. 77). If the left reticle has been closely centered and the right one is still off, a small amount of correction can be accomplished by careful filing and shifting of the gib A179904 and strip A179900 (fig. 222).

h. Up-and-down adjustment of each reticle can be made when the three screws A202556N (fig. 155) are loosened.

177. ASSEMBLY AND ADJUSTMENT OF OPTICAL TUBE — FOCUSING OBJECTIVES.

a. This will be necessary only when elements have been removed from the optical tube for cleaning, or replacement parts have been added. The optical tube is properly focused when the focal plane of the main objectives and the plane of the stereoscopic reticle marks are coincident.

b. To determine whether or not the focal plane of the main objective coincides with the plane of the stereoscopic reticle, proceed as follows:

(1) First determine the zero diopter setting of the double telescope or eyepiece, and then place the low-power telescope on the right eyepiece of the double telescope or eyepiece.

(2) Rotate the eyepiece focusing ring until the stereoscopic reticle appears sharply focused.

(3) If the diopter scale reading is not zero, then the stereoscopic reticle must be shifted laterally to the right or left, depending on whether the reading is positive or negative. At the same time, check to determine if there is full movement of the diopter scale.

(4) The reticles may be shifted laterally with the eccentric wrench after loosening the two screws ("3," fig. 156) which secure the angle bracket A179895 (fig. 222) to the bottom plate B171729.

(5) To determine whether the focal point of the main objective coincides with the plane of the stereoscopic reticle marks:

(a) Place the low-power telescope on the right eyepiece of the double telescope and rotate the eyepiece focusing ring until the col-

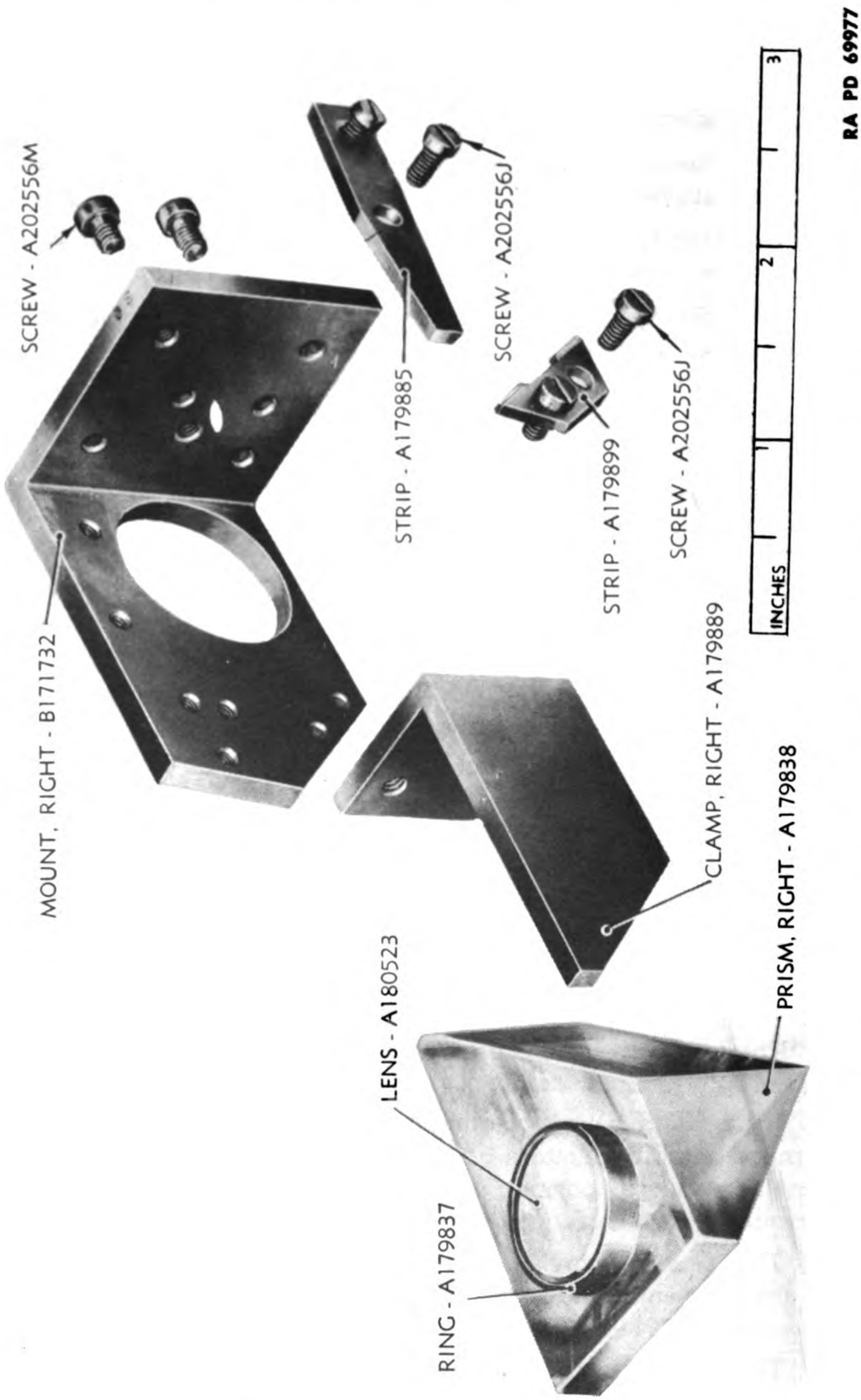


Figure 223 — Ocular Prism and Mount — Exploded View

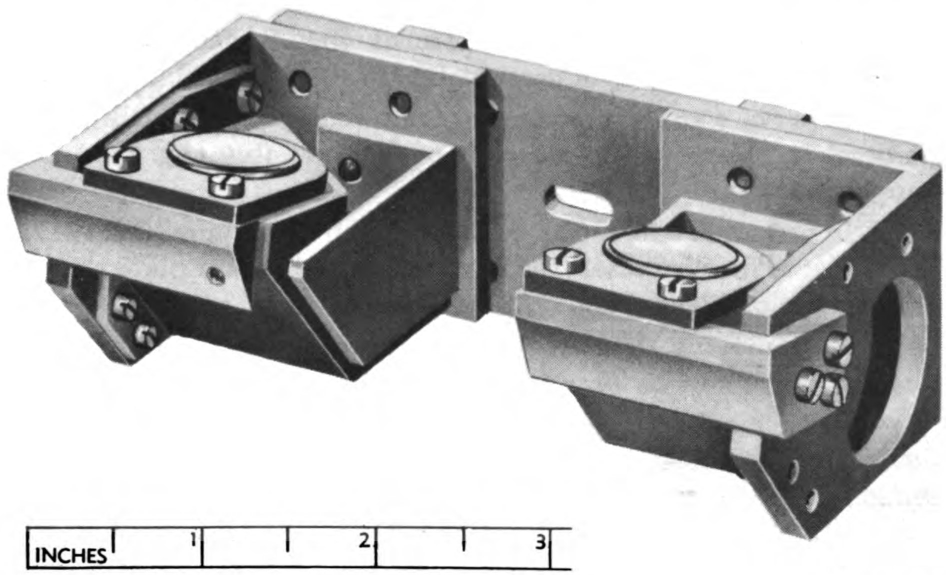


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Figure 224 — Ocular Prism Mount Assembly

limator cross line appears sharply focused, and the reticles also appear sharply focused with the same diopter setting.

(b) A zero reading of the diopter scale shows that they are focused correctly.

(c) A plus ("+"), or minus ("–") diopter scale reading indicates that the main objective must be shifted to the right or left by means of the objective adjusting rings B171720 and B171708 (fig. 108 and par. 117).

178. ASSEMBLY AND ADJUSTMENT OF OPTICAL TUBE — OCULAR PRISMS.

a. The purpose of the ocular prisms is to reflect the images of the target and the stereoscopic reticle to the eyes of the observer. The end reflectors reflect the rays of the target at right angles into the instrument; and the ocular prisms reflect them at right angles out of the instrument, and also incline the line of sight so that the observer looks into the instrument at a convenient angle. To the upper surface of each ocular prism is cemented a doublet lens which collimates the light from the stereoscopic reticle. The ocular prisms are clamped rigidly in special steel mounts which are capable of adjustment in any direction in a plane perpendicular to the axis of sight. The ocular prisms should be removed from the optical tube only if damaged, or for cleaning that cannot be done in the instrument.

b. Removing the Ocular Prism.

(1) Carefully mark the position of the ocular prism plate A179883 in relation to angle bracket B171730 (fig. 222).

(2) Remove four screws holding the ocular prism plate to the angle bracket. Remove the complete ocular assembly (fig. 224) from the angle bracket.

(3) In order to remove the ocular prism from its mount B171732 (fig. 223), it is first necessary to remove the top clamp plate that fits over the auxiliary lens A180523 (fig. 223).

(4) By removing strip A179885 and loosening clamp A179889, the ocular prism can be removed and cleaned.

(5) If the auxiliary lens has become loose or damaged, it can be removed by warming the prism until the cement holding it has softened.

(6) When replacing the auxiliary lens, make sure that it is mounted in exactly the same spot as the one removed. Use warm Canada turpentine for cementing, and be sure to work the lens around with slight pressure to free any air bubbles. Wait at least an hour to allow the cement to set before assembling.

(7) Reassembly can be done in the reverse order of disassembly.

NOTE: *When replacing the clamp plate around the auxiliary lens, make sure that no strain is placed on this part when the screws are replaced. File holes if misalined.*

(8) Check alinement of pupils, divergence, dipvergence, and focus.

c. Adjusting the Image and Pupils.

(1) Loosen the four screws A202556V which secure the prism plate A179883 to the angle bracket B171730 (fig. 222). Both ocular prism mounts can be moved up or down, which moves the image up or down and moves the pupils in the opposite direction.

(2) Loosening the four screws at "1" (fig. 156) which secure the base of the angle bracket B171730 (fig. 222) to the optical tube, allows both ocular prisms to be moved back or forward with the aid of the optical tube eccentric wrench. This movement will cause the image to move in a converging or diverging direction, and the pupils to move in the opposite direction.

(3) If moving both ocular prisms by the horizontal or vertical adjustments described above, does not result in equal centering of both right and left apertures (pupils) and reticle marks, then adjustment should be made so that correction is divided as close as possible in the right and left eyepiece and adjustments made on each prism individually.

(4) Stoning or filing the back of the prism mount B171732 (fig.

223) can be accomplished to tilt the ocular prism and move the pupils in the direction indicated in the chart below.

(5) OCULAR PRISM TILT TABLE. NOTE: *Image movement is opposite the movement of the pupils when following the instructions below:*

Left Prism	Right Prism
Tilt prism clockwise in horizontal plane—moves pupil to the left, and the image in the opposite direction.	Tilt prism clockwise in horizontal plane—moves pupil to the left, and the image in the opposite direction.
Tilt prism counterclockwise in horizontal plane — moves pupil to the right, and the image in the opposite direction.	Tilt prism counterclockwise in horizontal plane — moves pupil to the right and the image in the opposite direction.
Tilt top of prism toward the observer—moves the pupil up, and the image in the opposite direction.	Tilt top of prism away from the observer—moves the pupil down, and the image in the opposite direction.
Tilt top of prism away from the observer — moves the pupil down, and the image in the opposite direction.	Tilt top of prism toward the observer—moves the pupil up, and the image in the opposite direction.

(6) The ocular prisms and reticles are properly adjusted when:

(a) The pupils formed by the objective apertures and those formed by the eyepiece are concentric.

(b) The reticles are centered to the optical center of the optical tube, and are not tilted in relation to a horizontal target or in relation to each other.

(c) Divergence is between zero and 30 minutes.

(d) Dipvergence is within 10 minutes.

(e) Eyepiece cells, when focused for divergence tester, project the same distance (within 1 mm) from the eyepiece plate. Each eyepiece must have free movement for focusing four diopters down and three diopters up from this point.

179. ASSEMBLY AND ADJUSTMENT OF OPTICAL TUBE — GIMBAL SUPPORT.

a. Inspect the gimbal support (fig. 220) for shake between the pivots, support C77812, and the ring A179933. The pivots projecting into the optical tube should fit snugly but be free enough to rotate.

b. If the pivots have become worn and shake has developed, procure bronze stock and make new pivots to suit.

c. Check both shims A314550 that they are not sprung away from the support.

d. The optical tube is held to the inner tube by four short and two long 8-36 screws. The screws are screwed into the support shims, and the shims are the only part of the support that should rest against the inner tube. If the edges of the support itself contact the inner tube, binding or looseness of the gimbal support assembly will result.

e. After all units of the optical bar have been adjusted and cleaned, cover the optical tube with clean lens-tissue paper to keep out dust and dirt, and place the tube on V-blocks until ready to assemble to the inner tube.

180. ASSEMBLY AND ADJUSTMENT OF UNITS TO THE HEIGHT FINDER — GENERAL.

a. After the optical tube has been assembled and adjusted, it is assembled to the inside of the inner tube. The inner tube is then replaced in the outer tube, and the various other units, which must be in proper operating condition, are replaced and adjusted. The order of assembly and adjustment given below must be followed in order to avoid difficulties.

181. ASSEMBLY OF UNITS TO THE INNER TUBE.

a. Inspect the inner tube for cleanliness. Blow out any dust, lint, or metal chips.

b. Assemble the internal target pinion bracket in the inner tube after the pinion coupling shaft has been lightly greased.

c. Replace the right and left racks and adjuster drive tube assemblies; the right drive tube rack is inserted in the bottom channel of the rack bracket. The two racks should be engaged by the pinion at the same time to cause the punch marks on both the racks and the pinion to aline properly (fig. 221). Secure the four tube guide brackets in place.

d. Place a light coating of grease on the bearing surface of the right optical tube support, and mount it in place inside the inner tube. Secure the holding screws tight.

e. Replace the measuring drum on the inner tube and mount the measuring drum drive assemblies and measuring drum as described in paragraph 141. Mount the index rail and check the alinement of all gears. Rotate the drum a number of turns and check for smoothness of operation.

f. Replace the measuring drum drive tube assembly and tape the free end to the inner tube near the compensator opening.

g. Replace the cardboard protection cover, noting position of the taped ends as shown in figure 153.

h. Mount the internal target alinement wedge assembly in place and secure with two screws (fig. 173).

i. Place a film of light grease on the bearing rings of the internal target collimator tube. Place the collimator tube in the inner tube and secure both support brackets securely to the inner tube.

j. Rotate the inner tube on the V-blocks until the holes for the gimbal support screws are in the lowest possible position.

k. Remove the right optical tube counterweight sleeve (fig. 67), and tape the exposed threads on the end of the optical tube, for protection as the optical tube is assembled in the inner tube.

l. Remove the tissue paper covering from the optical tube and rotate the tube until the shims on the gimbal support are in the down position, to line up with the screw holes in the inner tube.

m. Slide the optical bar carefully into the left end of the inner tube. Care should be taken to not damage the bearing surface of the right support as the right end of the optical tube is inserted.

n. Insert the tube until the bearing ring of the optical tube is resting in the right support.

o. Move the optical tube back and forth and rotate it until the holes in the gimbal support shims can be located. Secure the optical tube to the inner tube temporarily with the two long screws placed in the center holes of the inner tube and center holes of the shims.

p. Locate the gimbal support accurately by inserting alining pins in the holes in the inner tube and gimbal support.

q. Replace the four short screws and secure the optical tube to the inner tube securely.

r. Check the optical bar at this time to determine if there is any looseness or shake.

s. Replace the flat optical bar weights, and remove the tape from around the threads of the right end of the tube and replace the right counterweight. Screw the sleeve snugly up to the shoulder.

t. Insert the correction wedge assembly in the inner tube until it is in its mounting position, and secure the mount to the inner tube.

NOTE: *The correction wedge pinion bracket assembly is not mounted at this time. If retaining brackets were installed to hold the correction wedge drive tube, place the drive tube inside the brackets* *and tape both ball ends to the inner tube, after determining that the marks on the ball ends are properly oriented. If retaining brackets were not used, tape the drive tube ball ends to the inner tube when the drive rod is properly located in the operating position.*

u. Secure the objective and collimator air tube spacers in place. The two collimator air tube hanger brackets can be installed by using the objective adjusting holes as openings to locate the hangers in place.

v. Replace the inner tube guide rollers, studs, and counterweights on the inner tube. Punch marks will be found on the tube and counterweight to assist in positioning the weights properly.

w. Replace the right and left end reflector support adapters, making sure to line up with reference marks on the tube.

x. Slide the right and left adjuster air tubes into place with the punch marks alined and secure. NOTE: *On the left end, correct alinement is necessary to insure that the rectangular opening cut in this air tube is next to the gimbal support, as this provides necessary clearance. The right adjuster air tube is also provided with openings that clear the compensator ribs and must be checked for position.*

y. Slide the right and left objective air tubes into place and secure.

z. Mount the compensator in position on the inner tube adapter and secure with the holding screws. Rotate the inner tube until the bubble in the compensator level and optical tube are exactly centralized.

aa. If there is any appreciable difference between the optical tube level and the compensator level, then relevel the optical tube and note the amount the compensator level is off. To correct this, it will be necessary to file off or shim the compensator level bracket to make the compensator and optical bar levels agree.

bb. Remove the compensator. This will be assembled to the instrument again later.

182. ASSEMBLY OF INNER TUBE TO HEIGHT FINDER.

a. The inner tube should now be completely assembled with the exception of the compensator assembly, the right and left end reflector supports, end reflector assemblies, adjuster prism assemblies, and the correction wedge pinion bracket assembly.

b. Position the outer tube as directed in paragraph 172 b (23). Rotate slightly either way until a clear track through the tube is sighted for the inner tube guide rollers.

c. Using six men stationed at intervals, insert the left end of the inner tube carefully, with rollers down, into the right end of the outer tube. Be sure to keep both tubes parallel, and continue until the paper, covering the measuring drum, is centered in the window, and the inner tube bearing rings are centered in the bearing holes in the outer tube.

d. Lift slightly and rotate the inner tube until the measuring drum index guide rail is positioned in the recess provided inside the window adapter, and the ocular prisms in the optical tube are seen through the eyepiece opening in their proper position.

e. Block with wooden wedges, or hold the inner tube until the bearing assemblies are secured.

183. ASSEMBLY OF UNITS TO THE OUTER TUBE.

a. Inner Tube Bearings.

(1) Assemble the inner tube bearings in the following order: First the lower, front and rear, both left and right; then the upper left and right, making sure that the marks on each match the corresponding marks made on the tube, according to directions in paragraph 172 b (26)*(b)*. On instruments 13 to 52, bearing covers are used. These should be replaced next after the cork gaskets have been sealed with sealing compound for height finders.

NOTE: *Do not elevate or depress the tubes at this time.*

(2) Turn the fine elevation knob to the locked position and mount the fine elevation assembly in place on the height finder, taking care to engage the ball follower in the cam on the inner tube. CAUTION: *Do not rotate the knob again until the inner tube is properly balanced.*

b. Right Outer Tube Support.

(1) Place sealing compound for height finders on the cork gasket, and mount the bevel gear adapter assembly in place after marks on the bevel gears on the under side of the adapter, and the marks on the adapter and bevel pinion, are all alined. CAUTION: *Do not rotate the pinion until the adapter is secured in place.*

(2) Bring the conversion gear segment into engagement with the pinion gear, taking care to rotate the segment gear into the pinion in the opposite direction from that from which it was disengaged to aline the engaging gear teeth. CAUTION: *There should be absolutely no backlash in the mesh of these gears.*

(3) Rotate the gear segment and bearing ring until the marks on the bearing ring and outer tube line up.

(4) Completely assemble the right outer tube support and place the conversion ring lock lever over the range locking bracket.

c. Lower the telescope onto the support bar and secure in place with all screws tight.

d. Rotate the elevation handwheel through the entire travel of the elevation mechanism, to make certain that the stops are set to allow the elevation receiver scale to overtravel zero by one quarter inch, and the same amount beyond 90 degrees (1,600 mils on scale) to check the elevation mechanism. If the mechanism has been forced out of alinement during assembly or disassembly, refer to paragraph 168, for adjustment.

e. Connect the 5-conductor (junction box) cable plug into place.

f. **Compensator.**

(1) Remove the protecting paper cover from the measuring drum and set the measuring drum at infinity.

(2) Make sure that the conversion lock lever is positioned in the range lock bracket. Level the height finder with the optical tube level, and check to see that the elevation indexes are set at zero.

(3) Set the compensator scales to the scribed lines (fig. 132) as described in paragraph 130 **h**.

(4) Mount the compensator in place on the inner tube with the height drive tube and the range-height drive tube in the correct marked position. A bent wire hook will be of help to locate the height drive tube in the compensator coupling. The height tube should be connected first. Replace the backlash spring and adjust the tension.

NOTE: *When the compensator is secured in place, the scribed infinity mark and indexes should still be in alinement if the measuring drum is still set at infinity.*

(5) Replace dust cover if used.

(6) Replace the compensator cover. Make sure the gasket is in good condition, and covered on both side with sealing compound for height finder.

g. **Eyepiece.**

(1) Make certain that all exposed optical surfaces are properly cleaned. Place sealing compound for height finders on the cork gasket (pars. 108 and 109).

(2) Replace the eyepiece bracket assembly (par. 109).

(3) Replace the plate assembly (par. 109).

(4) Replace the filter index plate and the filter lever (par. 112).

h. **Correction Wedge.**

(1) Assemble the correction wedge pinion bracket in place on the correction wedge adapter, replacing shim if used. Be sure the alinement marks are matched and that the gears roll freely with minimum backlash (par. 124).

(2) Place sealing compound for height finders on the cork gasket, and replace correction wedge knob and dial assembly on the adapter, and at the same time assemble the drive tube to connect with the pinion coupling at the wedge. Make sure that the alining marks are properly matched (par. 124).

(3) Replace the collection knob illuminator bracket cover. Rotate the knob from zero to 120 on the scale, and then back to zero, to test for smoothness of operation.

i. **Measuring Drum.**

(1) Clean the measuring drum carefully and wipe dry with lens-tissue paper.

(2) Replace the rubber gasket in the measuring drum window opening.

(3) Carefully clean the measuring drum window and place it against the rubber gasket.

(4) Cover the measuring drum retainer with sealing compound for height finders and replace the retainer, taking care to tighten all holding screws equally tight.

(5) Mount the drum illuminator housing in place.

j. Mount the height break roller in position (figs. 69 and 70 and par. 75) for method of adjustment.

k. Place sealing compound for height finders on the cork gasket of the measuring knob and install as directed in paragraph 139.

l. Place sealing compound for height finders on the cork gasket, and mount the illuminator rod holders and the reticle lamp brackets in place.

m. Mount the left and right end reflector supports in place on their respective adapters (par. 98).

n. Place sealing compound for height finders on the cork gasket of the height adjuster knob adapter, and replace the height adjuster connector rod and knob as described in paragraph 148.

o. Place sealing compound for height finders on the collimator knob adapter gasket and assemble the connector and the knob to the height finder as described in paragraph 153. Do not adjust at this time.

p. Place sealing compound for height finders on the adjuster knob cork gasket and assemble the adjuster connector and knob to the height finder. Rotate the knob as a check on the location of the stops in the knob.

q. Seal and replace the correction wedge covers on the top of the tube. Seal and replace the cover over the adjusting screws on the under side of the tube.

r. Replace the elevation tracking telescope bracket.

s. Mount both elbow tracking telescopes on their adapters.

NOTE: *When the height finder is fully elevated, make certain that the azimuth elbow telescope blinder assembly, when in operating position, clears the support bars. If not, adjust the elevation stop in the left bearing housing by repositioning the stop gear.*

184. INSTALLATION AND ADJUSTMENT OF THE MAIN OPTICAL SYSTEM.

a. Place the fine elevation knob in the locked position.

b. Carefully level the cradle levels.

c. Set the instrument at zero elevation by carefully centering the optical tube level.

d. Place a 12-inch combination square on the end reflector bosses of each of the right and left supports, with the scales vertical and both visible to an observer standing a short distance away from one end of the telescope.

e. Set up and level a transit at a distance of 15 or 20 feet away from one end of the telescope, so that both scales are visible in the eyepiece.

f. Focus the transit eyepiece on the nearest scale and note the reading.

g. Focus on the farthest scale and observe the reading. When the instrument is level, the reading on both scales must be equal.

NOTE: *The above procedure is necessary only if the end reflector supports have been damaged or replaced with new ones.*

h. Replace end reflectors. For installation and adjustments, refer to paragraph 94. After the end reflectors are adjusted, check for cut-off in the field.

i. Place a pupil loupe with a diaphragm attachment (fig. 74) on the eyepieces, and focus it on the circular opening in the end reflector support.

j. Cut-off in the field at the sides of the circular aperture may be made equal by loosening the holding screws and rotating the end reflector assembly slightly.

k. Cut-off in the field at the bottom is not harmful as long as the proper size entrance pupil is formed as measured with the pupil loupe at the end reflector aperture. Cut-off on the left side is corrected as suggested in paragraph 121.

l. Install and adjust the adjuster prism assemblies as outlined in paragraph 155.

m. Before mounting the end boxes, clean the end windows and penta prisms. Clean end reflectors as directed in paragraph 87.

n. Place sealing compound for height finders on the end box gaskets and mount the end boxes; draw all bolts up equally tight.

o. Mount the carrier handles as outlined in paragraph 170.

185. FINAL ADJUSTMENT.

a. Adjust the high- and low-power field as outlined in paragraph 149.

b. When the reticles are adjusted to the eyepiece as outlined in paragraph 151, remove the fine elevation knob and place sealing compound for height finders on the cork gasket, and secure the knob bracket to the height finder.

c. Check and adjust the eyepiece as outlined in paragraphs 99 to 114.

d. Adjust the main objectives as directed in paragraph 115.

e. Adjust the internal target system as outlined in paragraph 152.

f. Adjust the collimator knob so the target line travel is as illustrated in figure 177 (par. 153).

g. Check the range-infinity, height-infinity, and height-900 positions, and check the lockng brackets positions as directed in paragraphs 58 and 92.

h. Adjust and set the end windows as directed in paragraph 160.

i. Adjust the instrument to a level line of sight and adjust the tracking telescopes as directed in paragraph 186.

j. Set the main objectives for helium charging (par. 115).

k. **Pressure Test and Desiccation.**

(1) Make certain that all assemblies on the outer tube and all covers are secured.

(2) Attach the pressure gage and the connector from the accessory box to one end box air valve, and an air hose connector to the other.

(3) Allow dry air or helium to enter until the pressure has reached 4 pounds per square inch.

(4) Look for possible leaks by applying soap solution with sash-tool brush around each of the assemblies and covers on the outer tube.

(5) The instrument may be considered pressuretight if the loss in 8 hours is less than 1 pound per square inch, assuming that the temperature has remained constant.

(6) Desiccate and charge with helium (TM 9-624).

(7) Make fine adjustments of end windows (pars. 160 to 162) to bring range readings within 1½ UOE of true range.

(8) Perform basic inspection (pars. 38 to 59) to check operation and performance of instrument.

Section XI

ELBOW TELESCOPE M13 — ADJUSTMENT, REPAIR, AND DISASSEMBLY

186. GENERAL.

a. These instructions cover alinement, adjustments, and complete disassembly and assembly of the Elbow Tracking Telescopes M13 as supplied on the Height Finder M2, serial numbers 13 and later.

b. **Optical Characteristics.** Each height finder is equipped with one elevation and one azimuth tracking telescope. These telescopes are optically identical and have optical characteristics listed below.

Magnification	8x	Eye Distance	23 mm
Exit Pupil	6 mm	Filters	Red, amber, clear, and dark neutral.
Field of View	6 deg.		

The optical system of the tracking telescope is shown in the diagram (fig. 45).

c. **Explanation.**

(1) The objective forms an image of a distant target in the plane of the cross lines on the reticle, and the eyepiece forms an enlarged virtual image of the cross lines and the target image. The filters are used in the same manner as those discussed in paragraph 21 d. The amici and porro prisms erect the image and place it in a suitable position for observation. At night the reticle cross lines may be illuminated by means of a 3-candlepower 6-volt Mazda lamp.

(2) Since the function of the tracking telescopes is to aline the height finder on the target, both telescopes must be parallel to each other and to the line of sight of the instrument in the azimuth direction. They must be adjusted vertically so that, with the height finder level (90-degree travel of height conversion ring), they will aline on a distant target at the same altitude as the height finder. When the height finder is then sighted on this same target, the fine elevation adjustment must be locked in the mid position. These relations are shown in figure 226, and must be accurately maintained if the height finder is to give satisfactory height readings. The telescope target images must also fall in the exact plane of the reticle to avoid

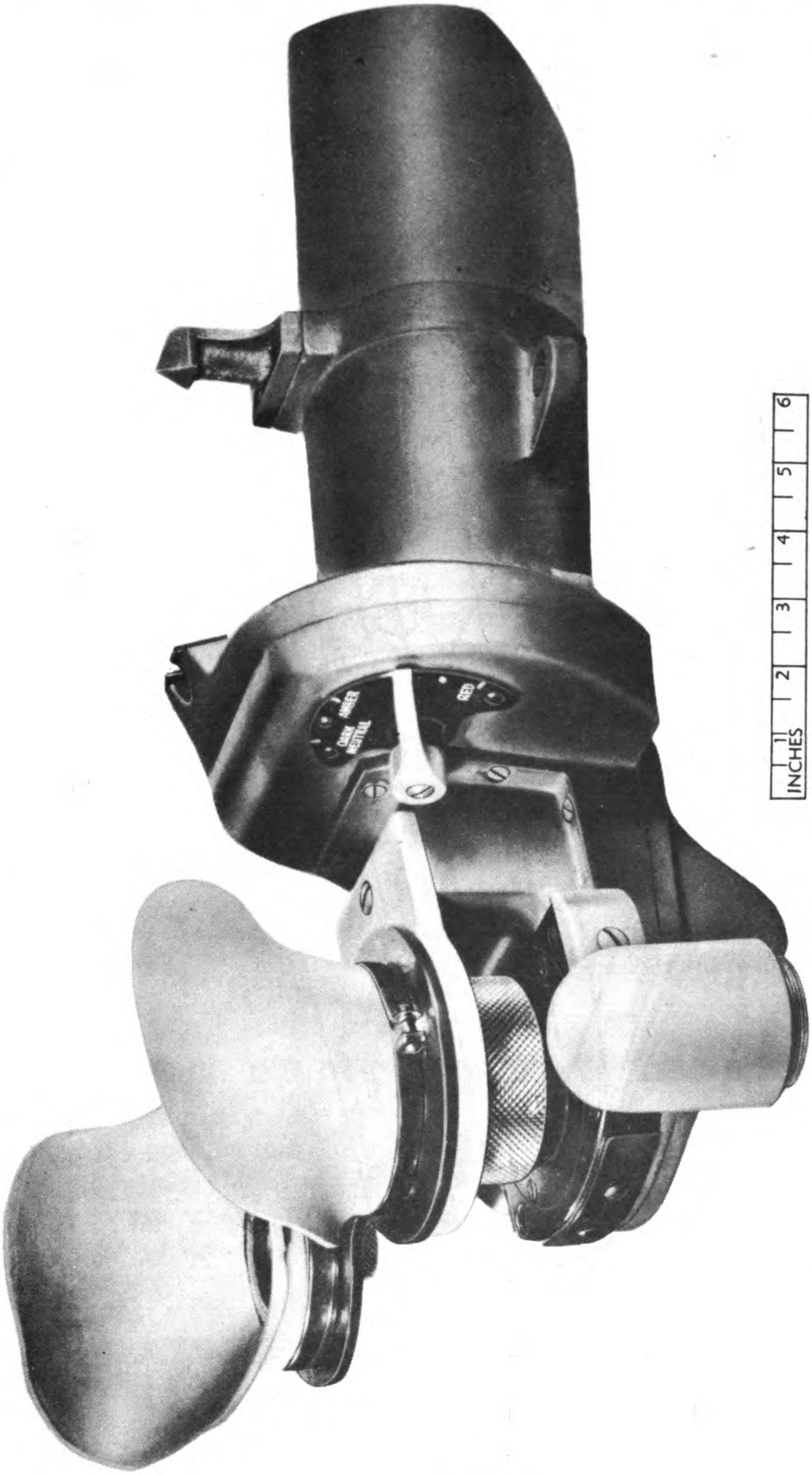

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Figure 225 — Elbow (Tracking) Telescope M13

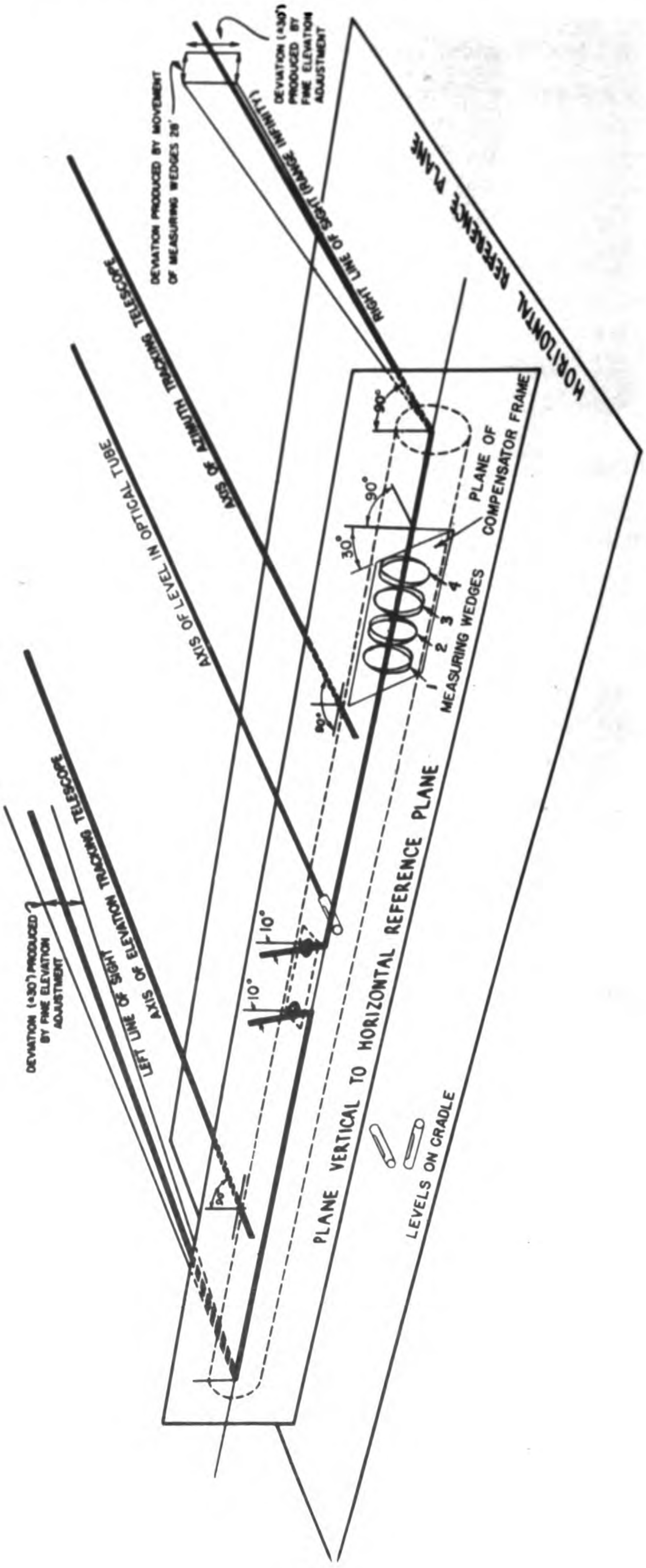

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Figure 226 — Relations Between the Various Axes of the Height Finder Cradle and Telescope and the Tracking Telescopes

parallax. In addition, the telescope must function properly in all optical and mechanical respects.

(3) It must be noted that the azimuth and elevation telescopes are interchangeable, and differ in only one respect. The azimuth reticle adjusting cover has the under side of the cover cut off. For this reason, the "azimuth" or "elevation" telescope number is stamped with an "A" or "E" preceding the serial number.

(4) The elbow telescopes are optical units, and disassembly or replacement of any parts will allow dust and dirt to collect on the optical elements unless the work is done in a dust-free room. Resealing with sealing compound for optical lenses is required.

(5) The M13 Telescope is described in detail in paragraph 28.

187. CHECKING THE DIOPTER SCALE.

a. It is improbable that any adjustment of the eyepiece diopter scale will be necessary, since the scales are correctly and firmly fixed in place with three set screws.

b. If there is reason to believe the scale is reading incorrectly, or if the focusing nut will not turn throughout the entire scale, the eyepiece can be checked with a dioptometer or a low-power telescope. If the zero mark on the scale, which is indicated by plus or minus marks on either side, at zero eyepiece power is out of coincidence with the index line by more than one-fourth diopter on the plus or minus side, there is probably some condition which needs correction. The set screws which secure the diopter ring may become loose and backed off, or the eyepiece may have been disassembled and reassembled incorrectly.

c. If a scale correction is needed, it can be done quite simply by loosening the set screws and adjusting the diopter scale to zero diopters, as determined with the low-power telescope, and securing the set screws.

188. FOCUSING THE OBJECTIVE TO REMOVE PARALLAX.

a. Explanation. When parallax is present, the objective is in such a position that the image of the target falls in front of, or behind, the reticle plane, and a stationary target image appears to move sideways relative to the reticle as the eye is moved sideways If the target image, relative to the reticle, moves in the same direction as the movement of the eye, the image, lies ahead of the reticle. Conversely, apparent movement opposite in direction indicates that the target image is on the near side of the reticle. Parallax, if present, will usually be evident for both horizontal and vertical eye movements, but the azimuth telescope should be examined for parallax by a horizontal eye movement, and the elevation telescope by a vertical

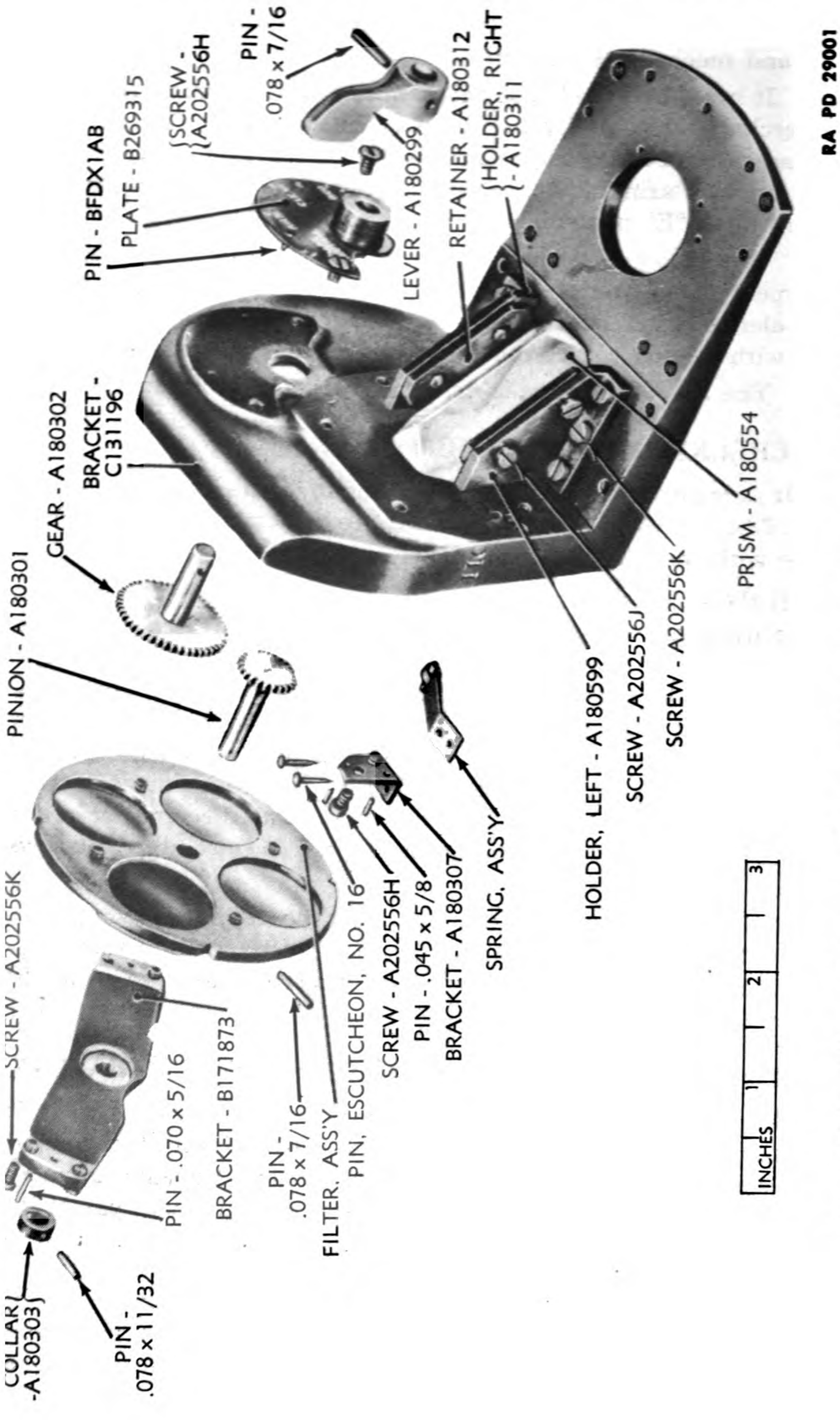

Figure 227 — Elbow Telescope Filter Bracket Assembly — Partly Exploded View

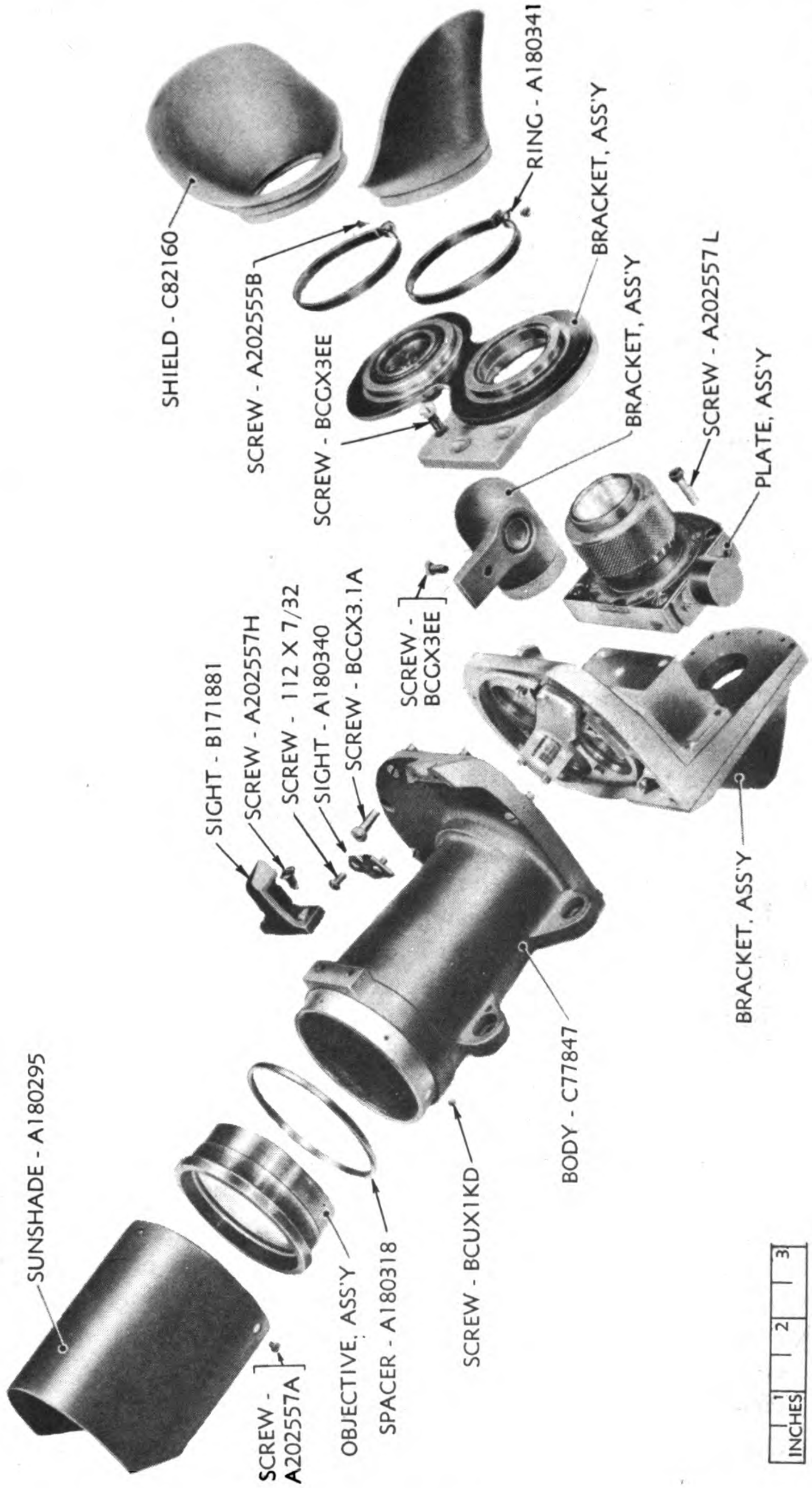

Figure 228 — Elbow Telescope — Partly Exploded View

eye movement. If parallax exists, it can be eliminated by focusing the objective as explained below.

b. **Focusing To Remove Parallax.** The objective is properly focused when its focal plane coincides with the plane of the reticle engraving.

(1) To determine if this condition exists:

(a) Direct the tracking telescope toward a target, at a distance of 1,000 yards or more, which presents a well-defined outline and offers good contrast.

(b) Place a low power telescope on the eyepiece and focus to the *reticles.*

(c) Rotate the eyepiece until the *reticle* is in sharp focus.

(d) The diopter scale should be then set to zero diopter.

(2) Place a low-power telescope on the eyepiece, and rotate the focusing ring until the *target* is sharply focused. The reading on the diopter scale should be zero.

(3) If not, then the objective spacer ring A180318 (fig. 228) between the objective assembly and body C77847 must be replaced. A negative ("–") reading requires a thinner spacer ring, and a positive ("+") reading requires a thicker ring.

(4) If the ring has to be replaced, proceed as follows:

(a) Loosen the three sunshade screws, and remove the sunshade.

(b) Loosen the objective set screw BCUXIKD (fig. 228), unscrew the objective assembly with the special tracking telescope objective wrench, and remove the spacer ring.

(c) Replace the objective assembly in the tube and screw in until the target is focused sharply and the diopter reading is zero.

(d) The space between the body and the shoulder of the objective cell should be measured and, if this distance is greater than the thickness of the spacer ring, a new one will have to be made.

(e) If the measurement is less than the thickness of the spacer ring, turn off or stone down to suit.

(f) Remove the objective again, and insert the spacer ring in place on the objective assembly and screw into the body until tight.

(5) Check for parallax and, if it has been eliminated, replace objective set screw snugly and place warm sealing compound for optical lenses around the outside of the spacer ring to form a seal.

(6) Replace the sunshade and screws.

189. ALINEMENT OF M13 TELESCOPES.

a. **General.** The Tracking Telescopes M13 supplied with the M2 Height Finder are adjustable in the azimuth and elevation directions. Means are provided to move the reticle housing to correct for errors in alinement. The reticle can also be rotated in the housing to aline the reticle cross lines vertically and horizontally.

b. Requirements. A distant target exactly level with the height finder is required. The height finder must be carefully leveled.

c. Method.

(1) When the fine elevation knob is in the locked position, the elbow tracking telescopes are properly alined when:

(a) Their lines of sight are parallel in elevation to the lines of sight of the main system of the height finder.

(b) Their lines of sight and the line of sight of the main system intersect in azimuth at a distance of approximately 5,000 yards.

(2) To check the alinement of the tracking telescopes, proceed as follows:

(a) Level the height finder as described in paragraphs 91 c and 92.

(b) Turn the fine elevation knob to the locked position.

(c) Check the height adjustment (par. 40).

(d) Direct the height finder in azimuth and elevation on a target at approximately 5,000 yards.

(e) Make stereo contact on the target with the height finder reticles. NOTE: *The target should be centered in the height finder reticle field, half of the height finder center reticles above the top center of the target.*

(f) Adjust the height finder in azimuth until the center reticle is on the exact center of the target.

(g) Remove the reticle adjusting plates A180328 and covers A180343 and A180344 (fig. 228) on both elbow telescopes.

(h) Manipulate the reticle adjusting screws A180329 and A180330 (fig. 229), and bring the cross lines of the reticle on the exact center of the target.

(3) If the errors in alinement are so great that the above adjustments will not correct them, then proceed as follows:

(a) Manipulate the adjusting screws to bring the reticle into its central position (par. 190).

(b) Loosen the four holding screws and carefully pry the elbow telescope from its doweled position on the adapter.

(c) Remove the dowel pins from the base, and replace the telescope on the adapter and screw down lightly.

(d) Make sure that the height finder reticles are still centered on the target.

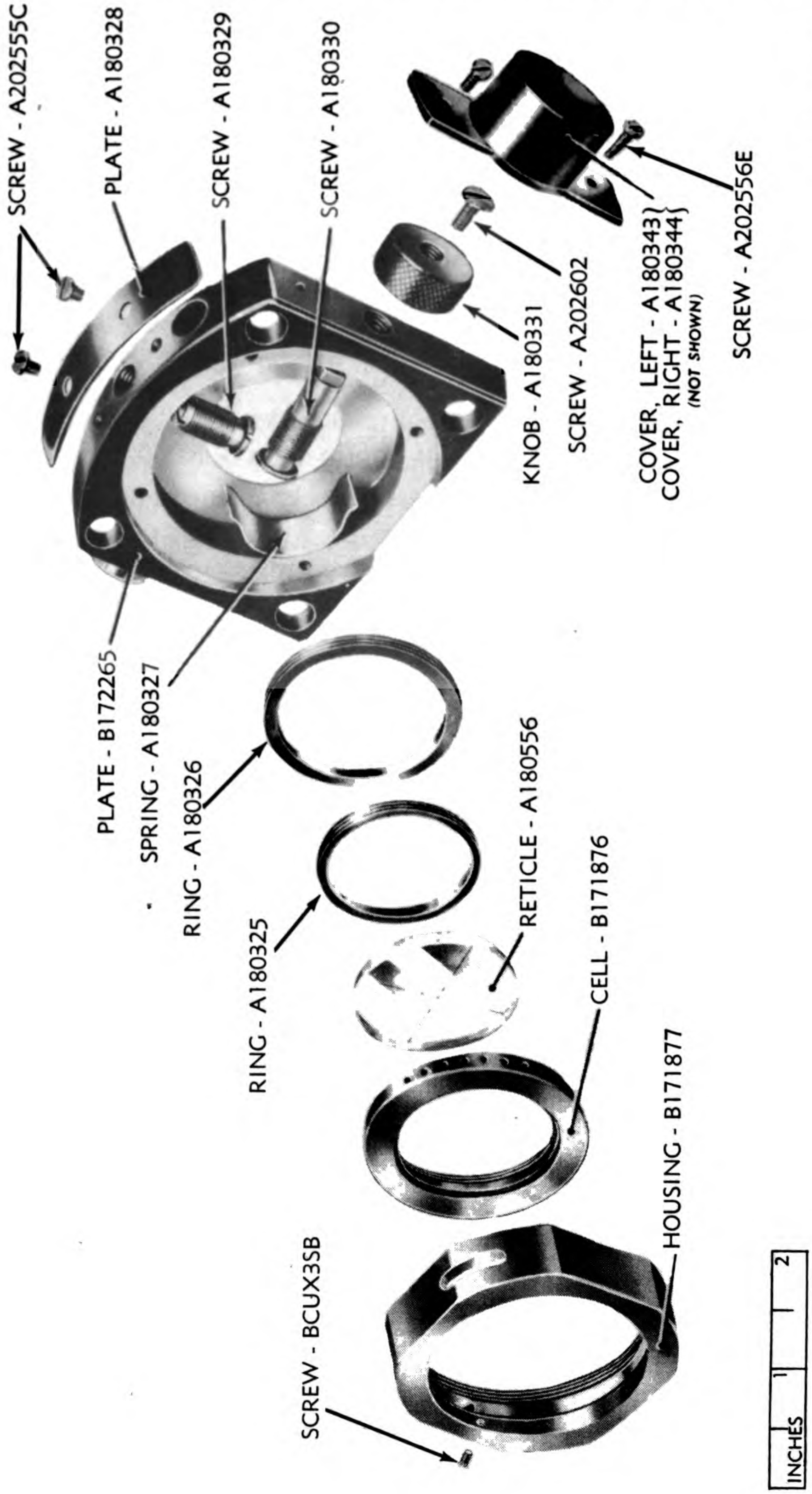

Figure 229 — Elbow Telescope Reticle Plate Assembly — Exploded View

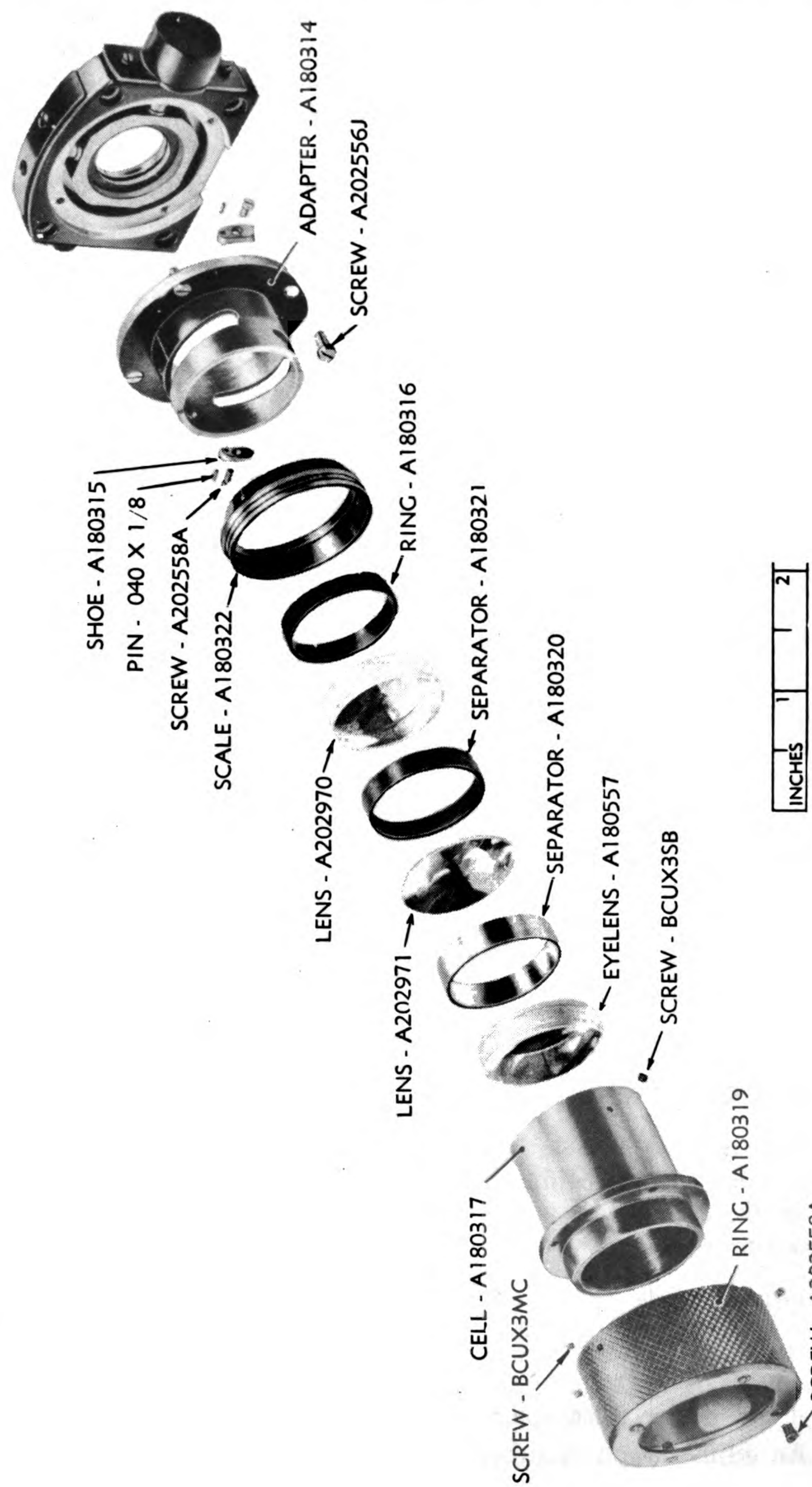

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Figure 230 — Elbow Telescope Eyepiece Assembly — Exploded View

(e) Move the elbow telescope slightly in azimuth until the vertical cross line of the reticle is centered as closely as possible on the center of the target. NOTE: *It may be necessary to turn down the screw heads slightly to provide clearance in the holes of the telescope body, to shift the telescope the desired amount.*

(f) Tighten the screws securely, and redrill the dowel hole to the next larger dowel size available. Drive the new dowel pins in place.

(4) For large errors in alinement of the horizontal cross line, the elbow telescope adapter bosses will have to be filed or stoned to elevate or depress the line of sight, until the horizontal cross line is centered as closely as possible on the center of the target. Redoweling will be necessary in this case.

(5) Again check to be certain that the height finder reticles are still centered on the target. Manipulate the elbow telescope reticle adjusting screws as described above, until the cross lines are exactly centered on the target.

(6) Replace the reticle adjusting plates and covers.

d. Alinement of Open Sight.

(1) The open sights B171881 and A180340 (fig. 228) should be so alined that, when the target is centered in the sights, the image of the target will appear at the same point that the target appears in the center of the telescope reticle.

(2) The open sight alinement should be checked after any movement of the reticles or adjustment of the objective to eliminate parallax.

(3) Azimuth adjustment can be made by loosening both screws, shifting the rear sight A180340 (fig. 228) and tightening the screws. It may be necessary to file and elongate the screw holes in the rear sight if a large adjustment is necessary.

190. ADJUSTING THE RETICLE.

a. Centering the Reticle in the Field of View. The elbow telescope reticle is properly centered when the intersections of the cross lines are in the center of the field of view, and the cross lines appear vertical and horizontal.

b. Requirements.

(1) A distant target with well-defined vertical and horizontal lines.

(2) A low-power telescope with centering adapter.

(3) An adjusting pin number 42 (drill size).

(4) Height finder must be level.

c. **Method of Adjustment.**

(1) Centering of the reticle may be determined by rotating the low-power telescope on the eyepiece of the tracking telescope (eyeshield bracket assembly removed). The center of the cross lines in the low-power telescope describes a circle, the center of which should coincide with the center of the tracking telescope reticle.

(2) If it does not, shift the reticle with the adjusting screws A180329 and A180330 (fig. 229) until it is properly centered.

(3) Any target such as a flat-roofed building may be used to check vertical and horizontal travel of the reticles.

(4) Traverse the height finder in azimuth until the vertical cross line in the tracking telescope lies along the vertical side of the target. Elevate and depress the height finder and observe the travel of the vertical cross line.

(5) Elevate the height finder until the horizontal cross line lies along the horizontal part of the target. Traverse the height finder in azimuth, and check the horizontal movement of the cross line.

(6) If the reticle lines do not stay on the horizontal and vertical sides of the target when the height finder is level, then adjustment is necessary.

(7) Remove the reticle adjustment plate, insert an adjusting pin or number 42 drill in the adjusting holes of the reticle cell B171876 (fig. 229), and rotate in the desired direction.

(8) The reticle should be checked again to make sure that it is still properly centered (steps (2) and (3), above).

191. RETICLE ILLUMINATION.

a. Illumination failures in the M13 Telescopes are generally due to burnt-out bulbs, which can be corrected as follows:

(1) Remove screw BCGX3EE (fig. 228) and separate the lamp bracket assembly from the tracking telescope housing.

(2) Remove the bracket assembly from the socket housing and replace the bulb.

(3) Assemble and replace the lamp bracket.

(4) Place sealing compound for optical lenses around the lamp bracket and plate at the illumination opening.

b. If the lamp bulbs burn brightly, and there is still no illumination transmitted to the reticles, it is an indication that the reticle openings in cell B171876 and housing B171877 are not properly adjusted to the illumination opening in plate B172265 (fig. 229). Check and correct as follows:

(1) Remove plate A180328 and insert a small adjuster pin in the large opening in the plate B172265.

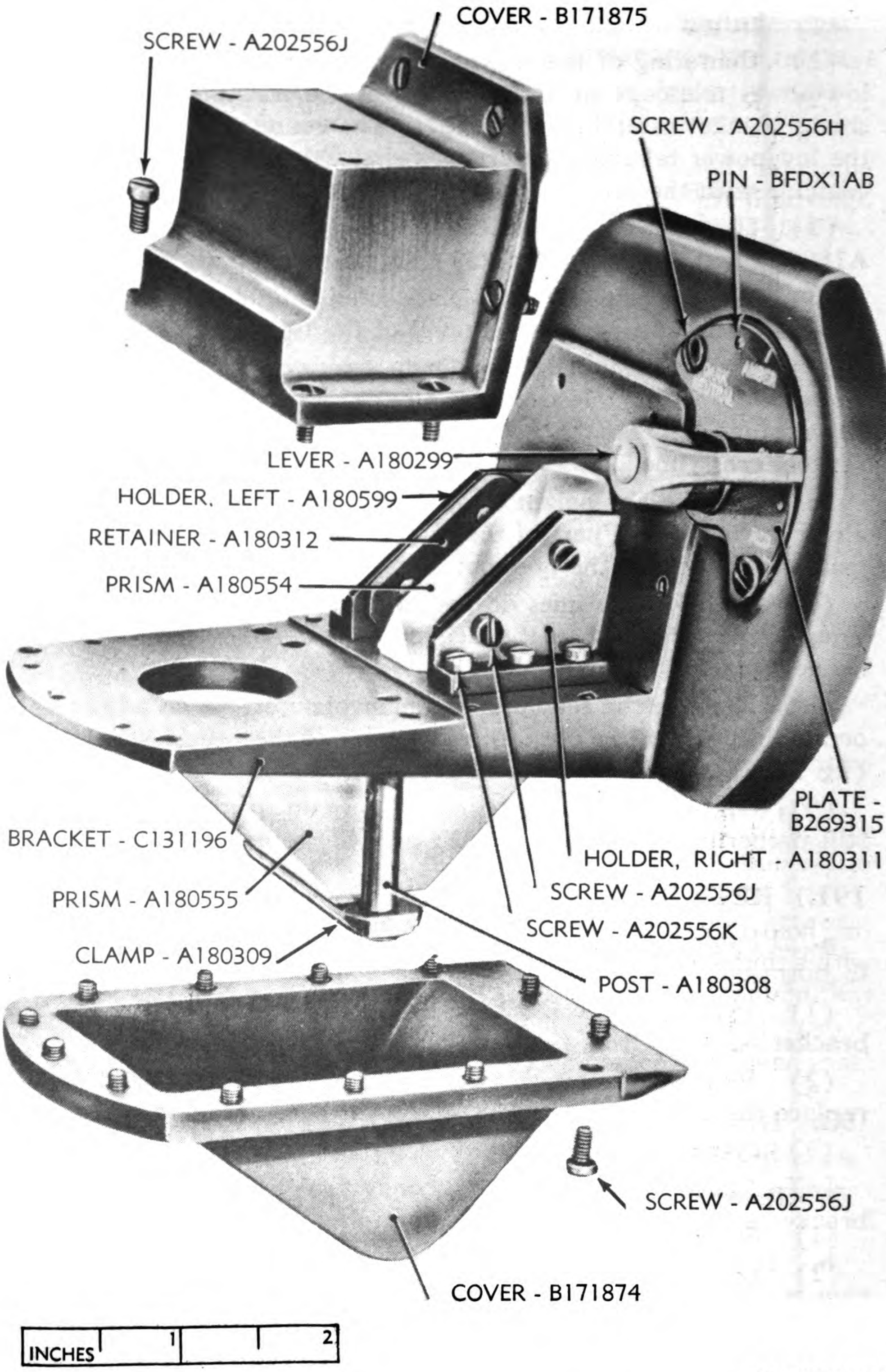

Figure 231 — Elbow Telescope Prism Bracket Assembly — Partly Exploded

(2) If the small adjusting holes in cell B171876 cannot be reached, then the cell is not properly positioned.

(3) Remove adapter A180314 (fig. 230) and rotate the reticle cell until the adjusting holes in the cell are alined in the small elongated hole in housing B171877 (fig. 229), and the elongated opening in the reticle cell alined to the long elongated hole in the cell housing.

c. The above adjustment will result in a dirty reticle and it must be cleaned and recentered as outlined in paragraphs 86 and 87.

192. ADJUSTING THE ROOF PRISM (AMICI).

a. **General.** The pupils formed by the aperture of the telescope should be concentric as viewed with a pupil loupe on the eyepiece, or by looking through the telescope in a reverse manner.

(1) If they do not appear concentric, shift the filter assembly until the clear window is adjusted to the proper detent.

(2) If the pupils are still off center, the roof prism must be shifted until it covers both apertures in bracket C131196. Proceed as follows:

(a) Remove prism cover B171875 (fig. 231).

(b) Loosen screws A202556J in retainers A180312 and shift the prism.

(c) If the retainers do not allow enough movement, loosen the screws in holders A180311 and A180599 (fig. 231), and shift the prism until it covers the apertures.

(d) The holders should not touch the sides of the prism when the holder screws are tight. Press the retainers against the prism with a thumb or finger, taking care not to touch the prism and tighten the retainer screws.

(e) Clean the prism and replace the cover after the mating surfaces have been covered with sealing compound for optical lenses.

193. DISASSEMBLY AND ASSEMBLY OF ELBOW TELESCOPE M13.

a. **Requirements.**

(1) Special wrench for removing objective lens cell (fig. 79).

(2) Lens tissue paper for wrapping optical parts.

(3) Cleaning materials for optical parts.

(4) Sealing compound for height finders.

b. **Removing Telescopes M13 From Height Finder.**

(1) Remove the screw holding the lamp bracket and the lamp assembly (fig. 228).

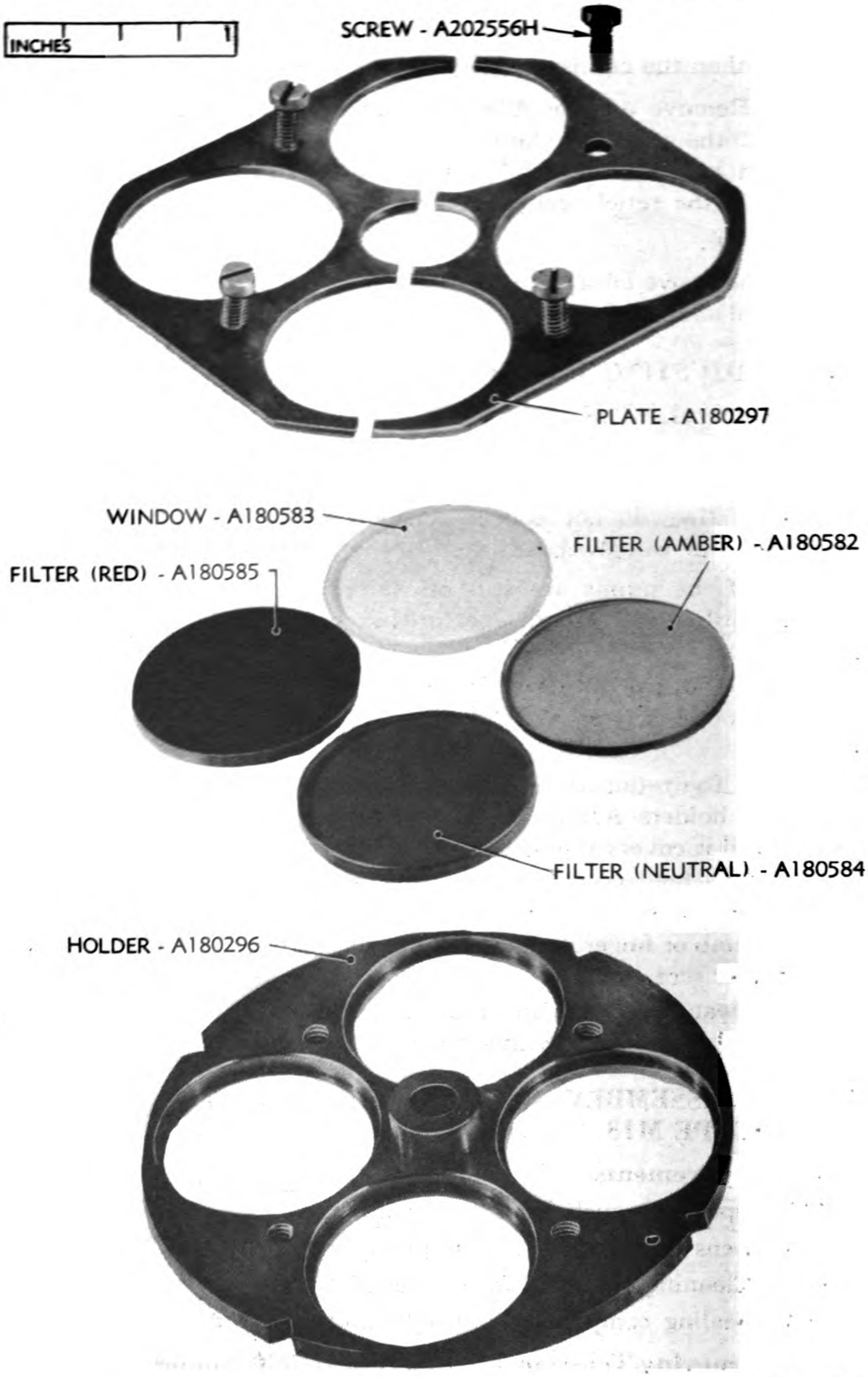

Figure 232 — Elbow Telescope Filter Holder Assembly — Exploded View

(2) Remove the four holding screws and carefully pry the telescope off the adapter on the height finder, taking care not to bend the (guide) dowel pins.

c. **Objective.** Remove and disassemble the objective as follows:

(1) Remove the sunshade locking screws A202557A, and objective locking screw BCUXIKD (fig. 228).

(2) Unscrew the objective cell assembly and remove.

(3) To disassemble the objective cell assembly:

(a) Loosen the retaining ring set screw and remove the retaining ring.

(b) Withdraw the objective lens from the cell.

d. **Eyepiece Assembly.** Moisture in eyepiece may be due to defective sealing of eyelens. To remedy this:

(1) Remove eyepiece adapter A180314 (fig. 230).

(2) Unscrew eyepiece lens retainer ring A180316 (fig. 230).

(3) Remove lenses and spacer rings, and note and mark position and shape of each, so they will be reassembled properly.

(4) Seal eyelens flange in cell A180317 (fig. 230) with warm sealing compound for optical lenses.

(5) Clean and replace lenses and spacers in the correct order.

(6) Tighten the retaining ring until the surplus warm sealing compound for optical lenses is forced out at the top of the eyelens. Clean off surplus sealing compound.

(7) Clean reticle carefully.

(8) Replace eyepiece adapter.

(9) Check parallax.

e. **Reticle.** To remove the reticle, proceed as follows:

(1) Remove the eyepiece adapter A180314 (fig. 230) and lift from plate B172265 (fig. 229).

(2) Loosen the two adjusting screws (fig. 229). Remove the spring and the reticle housing B171877.

(3) Loosen set screw BCUX3SB (fig. 229), unscrew ring A180325, and remove cell B171876 from the housing.

(4) Remove ring A180325 and the reticle A180556 (fig. 229).

(5) Assemble in the reverse order of disassembly, taking care to properly aline the reticle in the cell B171876 so that the reticle lines will be vertical and horizontal in the telescope, and so that the adjusting holes and illumination openings are properly alined. CAUTION: *Do not tighten set screw BCUX3SB too tightly.*

f. Filter Mechanism.

(1) Filters may be broken because of too much pressure by the retainer plate A180297 (fig. 232). To install new filter glass:

(a) Remove objective body from prism bracket. Remove four screws holding bracket B171873 to the prism bracket C131196 (fig. 227).

(b) Remove filter assembly from prism bracket. Remove screws A202556H holding filter plate to filter holder (fig. 232).

(c) Remove broken filter and one shim.

(d) Replace new filter and clean all exposed optical surfaces.

(2) To position the window for reassembly:

(a) Set the filter shift lever to "CLEAR" on the index plate and hold it in position.

(b) Center the clear filter over the aperture in the bracket in front of the amici prism.

(c) Engage the filter assembly gears with the shift lever gear.

(d) Spring the detent roller into the detent.

(e) Rotate the filters to make sure that the colors aline to agree with the index plate, and that the detent roller engages the detents properly and with snug spring tension.

(3) Secure the filter assembly and objective body.

(4) If the clear filter has been broken, replace and check for parallax.

g. Porro Prism. These prisms sometimes are broken due to too much pressure on the prism clamp, or too much pressure on the end of the prism clamp. To correct this condition:

(1) Remove porro prism cover C171874 (fig. 231).

(2) Loosen clamp screws and remove porro prism.

(3) Replace with new prism that has been carefully cleaned.

(4) In securing the prism clamp, the screws must be drawn up equally and *just snug*, but not too tight.

(5) Rewax and replace the cover. Screw down securely. CAUTION: *Two short screws must be in the cover just under the filter assembly holder.*

(6) Check parallax.

h. Dirt on the Reticle.

(1) Check the reticle for cleanliness.

(a) When the eyepiece is focused to the stop on the minus side, any dirt seen will be on the under side of the reticle.

(b) When the eyepiece is in proper focus, any dirt seen will be on the upper surface.

(2) To clean the reticle:

(a) Remove the eyepiece plate B172265 (fig. 229) and clean the reticle carefully.

(b) Replace eyepiece plate and secure.

(c) Check parallax.

i. Reassembly of Elbow Telescope M13.

(1) Reassembly is accomplished by reversing the procedure for disassembly.

(2) It is important to note the proper filter orientation in the filter assembly.

(3) Practically all filters show a small but unavoidable amount of wedging, and this wedging must not be allowed to interfere with the elevation alinement of the elevation telescope. For this reason, the filters are assembled so that, in the elevation telescope, wedging, if present, throws the image slightly sideways. The slight error introduced into the azimuth telescope due to wedge angle variations is negligible.

(4) After assembly, the telescope should be checked for the various conditions described in paragraphs 186 to 192.

194. BLINDER ADJUSTMENT.

a. Blinder Bracket. The blinder bracket B171879 can be shifted from side to side so that either right or left eye can be used for tracking. It is held in operating position by a plunger A180335 engaging a detent in the bracket.

b. The blinder assembly will need very little adjustment unless it is damaged by striking against the support bars when the height finder is elevated. To avoid this, the bracket B171879 (fig. 233) should always be kept in the operating position, that is parallel with the height finder tube.

c. The stops in the elevation mechanism should be adjusted so there is clearance between the blinder assembly and the support bar when the height finder is elevated to the maximum elevation.

d. The diopter scale and blank eyepiece movement should be kept free of sand and dirt, and a light coat of grease should be applied, after each cleaning, between adapter B171880 and bracket B171879 (fig. 233).

e. If the movement of bracket B171879 becomes rough and uneven, correct as follows:

(1) Remove the three holding screws holding plate A180333 to the roof prism cover.

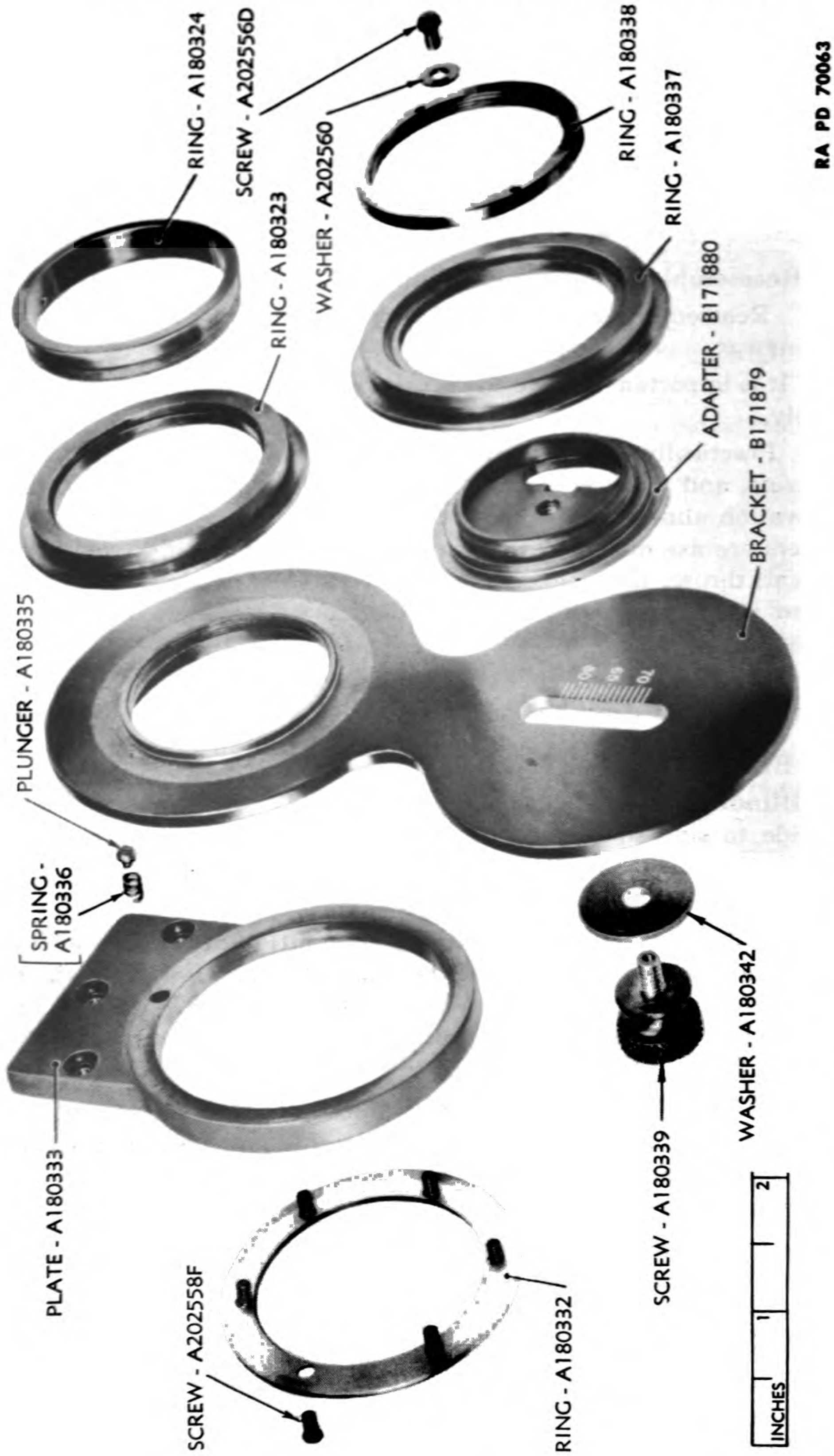

Figure 233 — Elbow Telescope Blinder Assembly — Exploded View

(2) Remove screws and ring A180332, which will allow separation of the blinder bracket and plate. CAUTION: *Do not lose spring A180336 or plunger A180335 (fig. 233).*

(3) Carefully clean all bearing surfaces and grease lightly.

(4) Assemble in reverse order of disassembly.

Section XII

CRADLE M2 — ADJUSTMENT, DISASSEMBLY, AND REPAIR

195. CARE AND ADJUSTMENT OF CRADLE M2.

a. General.

(1) The Cradle M2 (fig. 46) serves as a base for the height finder telescope, and contains intricate mechanical and electrical apparatus that requires careful handling. A description of this equipment and their functions is contained in paragraph 29.

(2) When placing the height finder telescope on the cradle, observe the following precautions:

(a) That the four mounting surfaces are wiped clean.

(b) That the alining pin on the cradle is not damaged by careless handling.

(c) That no burs or nicks prevent the mounting surfaces from joining perfectly.

(d) That the cradle locking screw knobs are locked as tight as possible by hand.

(3) When removing the height finder telescope from the cradle, it is extremely important to entirely disengage all four locking screws from the height finder support before lifting. Failure to observe this precaution will result in bent locking screws or stripped threads in telescope support.

(4) The mechanical and electrical equipment of the cradle is well sealed and protected within the main housing, and very little care is required outside of periodic inspection and lubrication, as outlined in paragraph 60.

(5) Repairs requiring disassembly will be necessary only if failure of mechanism occurs, or if damage has been caused by accident or shell fire.

(6) When not in use, the cradle is stored in a watertight transportation case in which an accessory box is provided containing numerous spare parts and special tools required for the height finder (fig. 51).

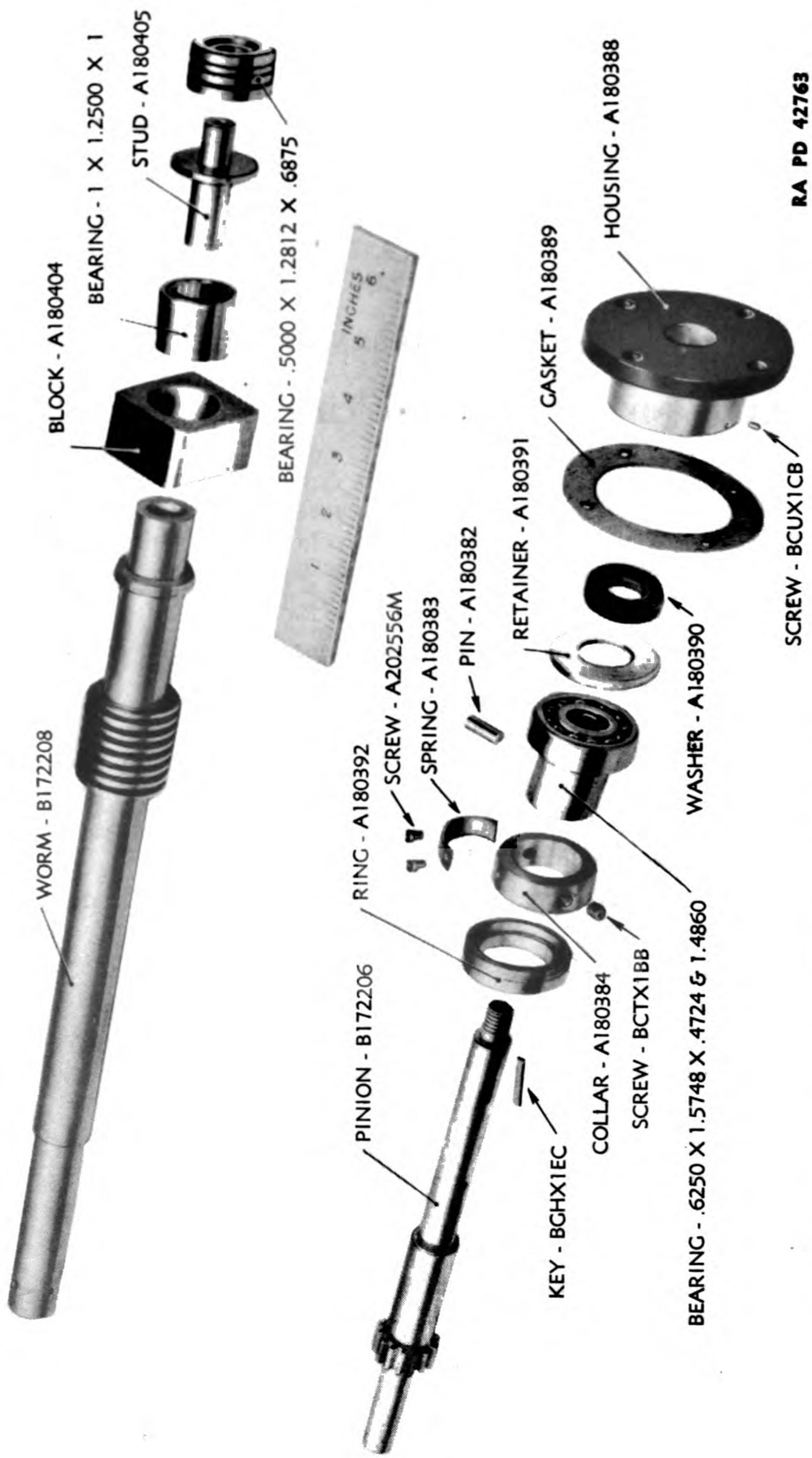

Figure 234 — Azimuth Worm Shaft and Handwheel Pinion Assemblies — Exploded View

CRADLE M2 — ADJUSTMENT, DISASSEMBLY, AND REPAIR

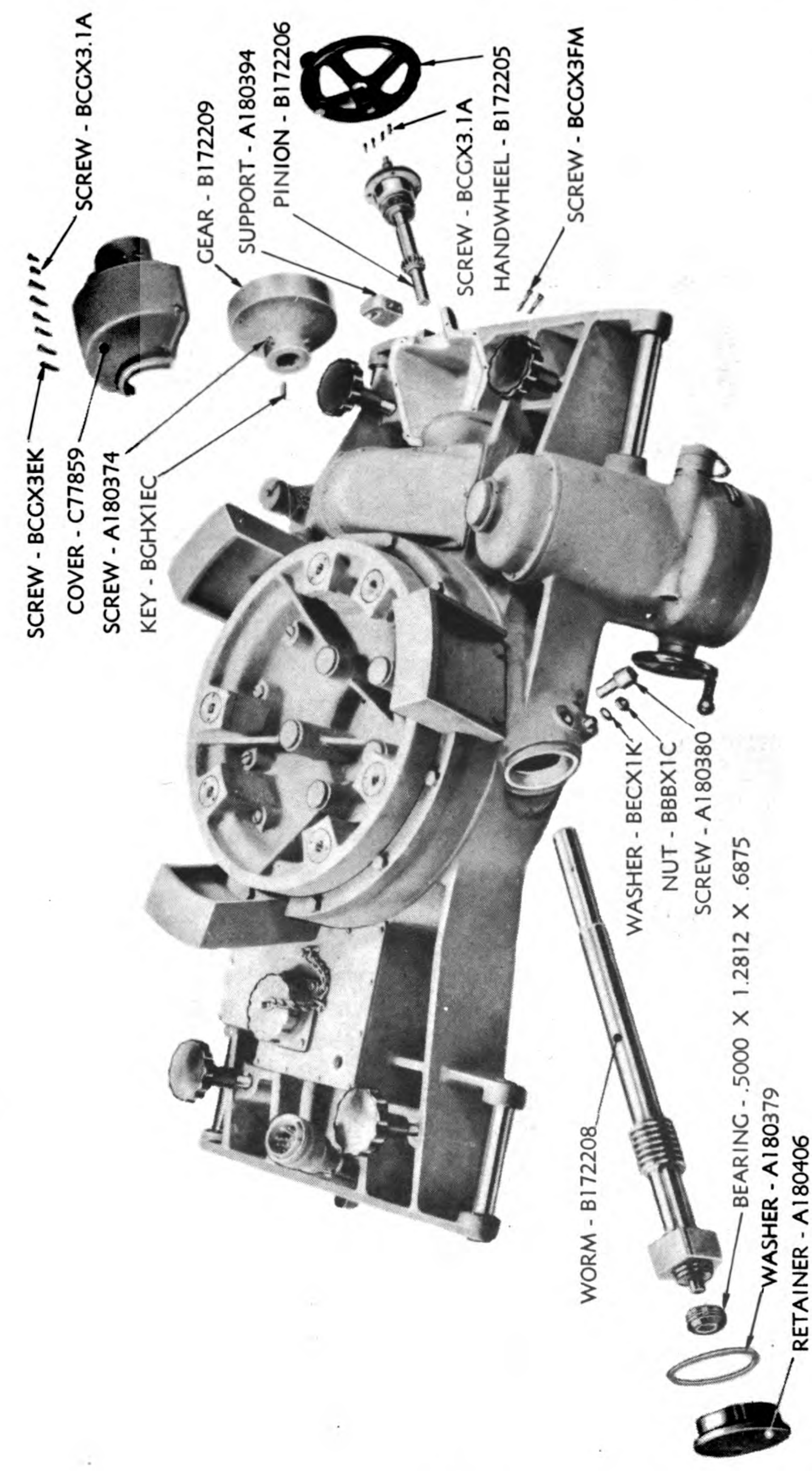

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Figure 235 — Cradle Showing Azimuth Worm Shaft and Handwheel Exploded — Bottom View

RA PD 42764

Figure 236 — Azimuth Handwheel and Gears — Exploded View

b. Adjustments. For the sake of clarity and better sequence, the adjustments are described after each subassembly group.

c. Lubrication. Lubrication of the Cradle M2 is covered fully in paragraph 89.

d. Disassembly and Assembly. The cradle will require disassembly only for the purpose of replacing worn or damaged parts, or for cleaning and inspection when inaccessible parts are involved.

196. AZIMUTH HANDWHEEL AND WORM SHAFT ASSEMBLY.

a. Description. The purpose of this assembly is to provide a means of traversing the height finder steadily in azimuth, during tracking, by the rotation of a handwheel connected through internal gear and pinions to a worm that engages a fixed central worm gear. The traversing speed can be changed from high to low by pushing in or pulling out the handwheel.

b. Disassembly and Assembly.

(1) Remove the four screws securing housing A180388 (fig. 234), which will allow the azimuth handwheel pinion assembly to be withdrawn.

(2) When the cover C77859 (fig. 235) is removed and support A180394 is taken out, the azimuth change speed bracket A180393, together with pinion, gear, and studs (fig. 236) can be removed.

(3) Loosen the two set screws A180374 (fig. 236) holding internal gear B172209 to the azimuth worm shaft B172208, and remove this part next.

(4) By loosening adjusting screw A180380 and nut BBBX1C (fig. 235) and unscrewing retainer A180406, the worm shaft B172208 can be forced out by rotating the cradle slightly. The ball thrust bearing and the needle bearing block A180404 (fig. 234) will come out with the worm shaft.

(5) Reassembly can be accomplished by reversing the above procedure.

c. Adjustments.

(1) Adjustment for end play in the worm shaft can be made by reducing or increasing the thickness of washer A180379 (fig. 235). To increase the end play, a thicker washer should be used; to decrease, a small amount should be removed from the washer.

(2) Backlash between the worm and the worm gear can be controlled by adjustments to nut BBBX1C and screw A180380 (fig. 235). The screw when forced against the bearing block thereby tightens the mesh. Tightening the nut causes the block to move outward,

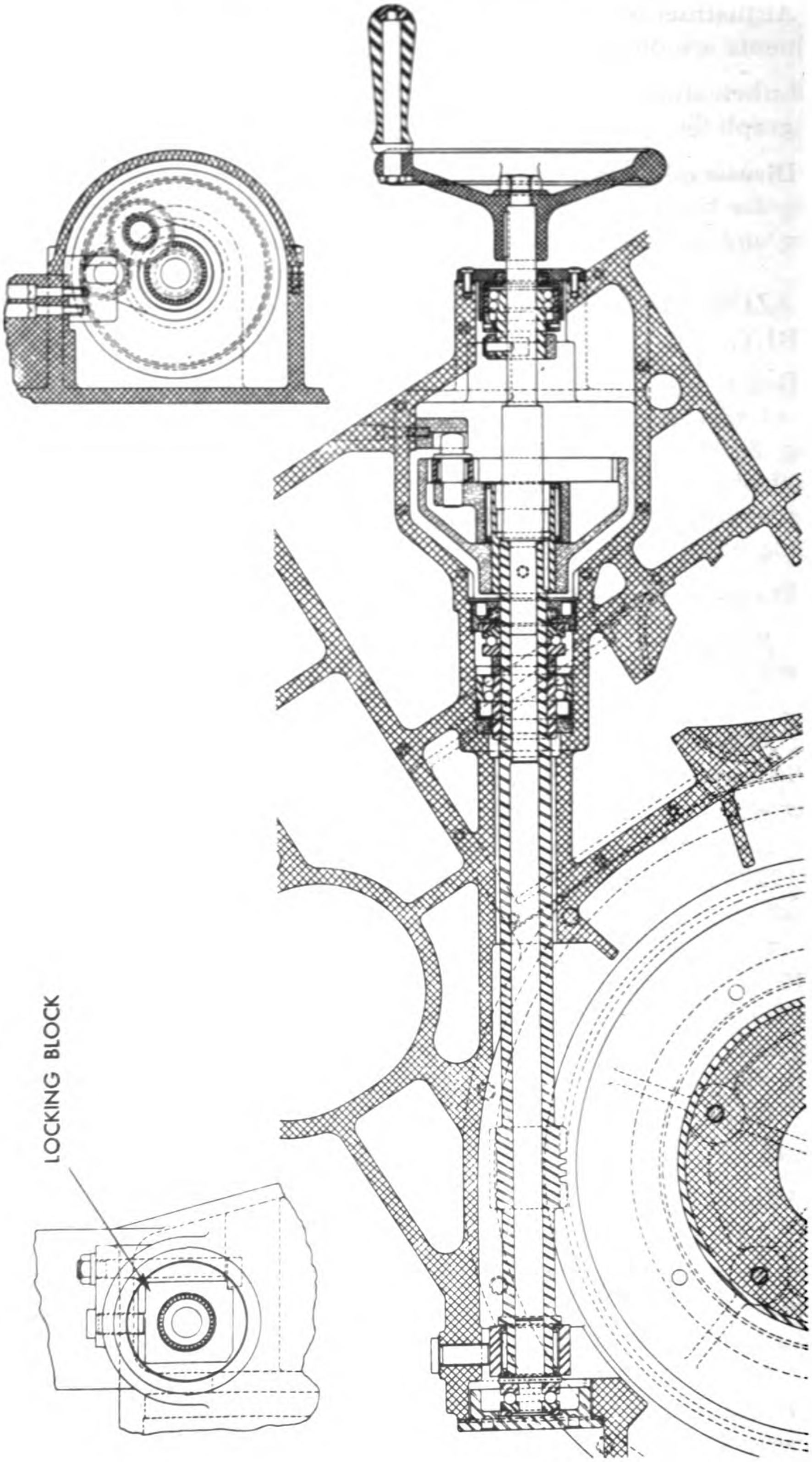

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Figure 237 — Azimuth Shaft and Handwheel Assembly — Sectional View

CRADLE M2 — ADJUSTMENT, DISASSEMBLY, AND REPAIR

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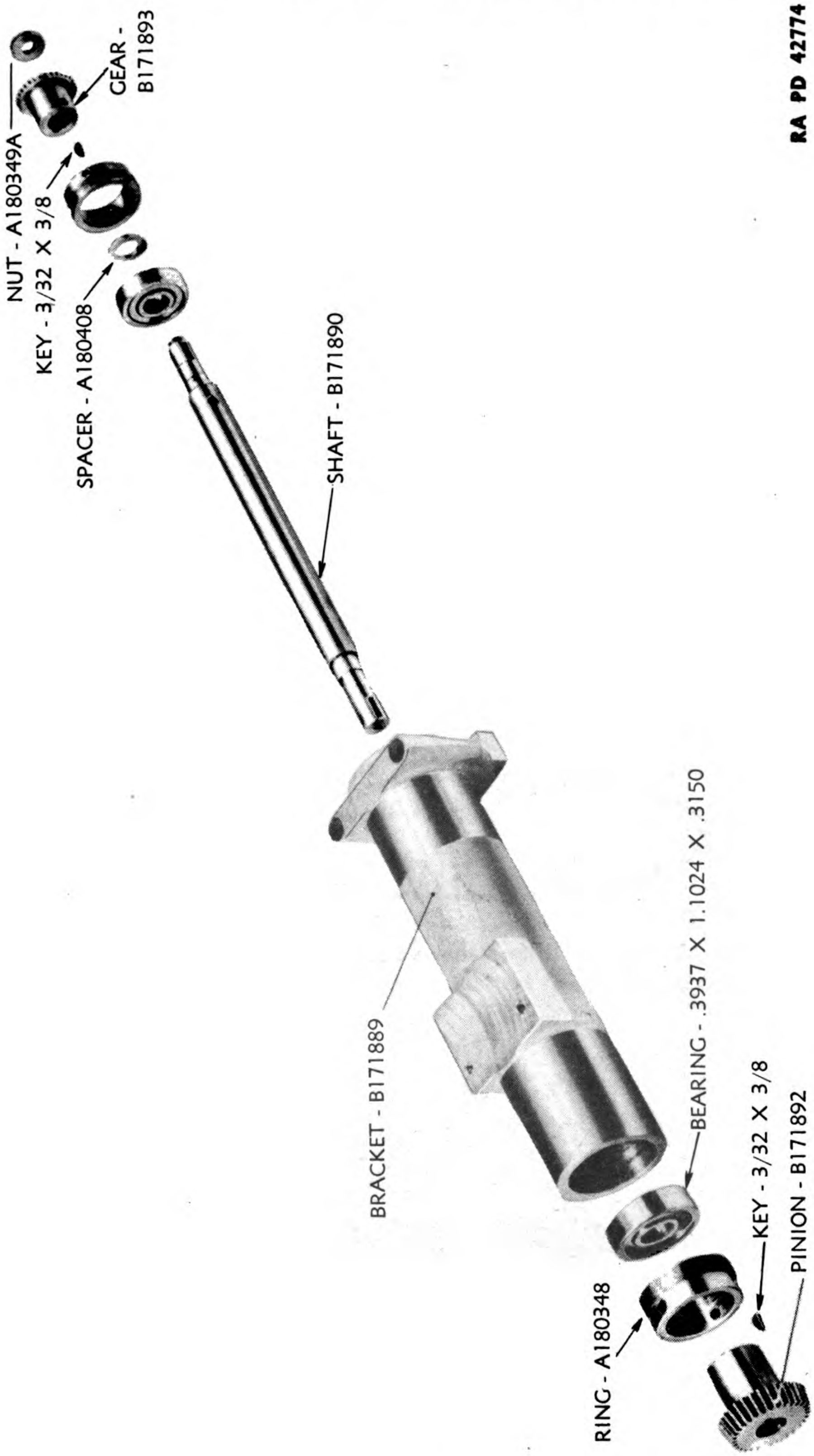

Figure 238 — Azimuth Indicator Intermediate Drive Assembly — Exploded View

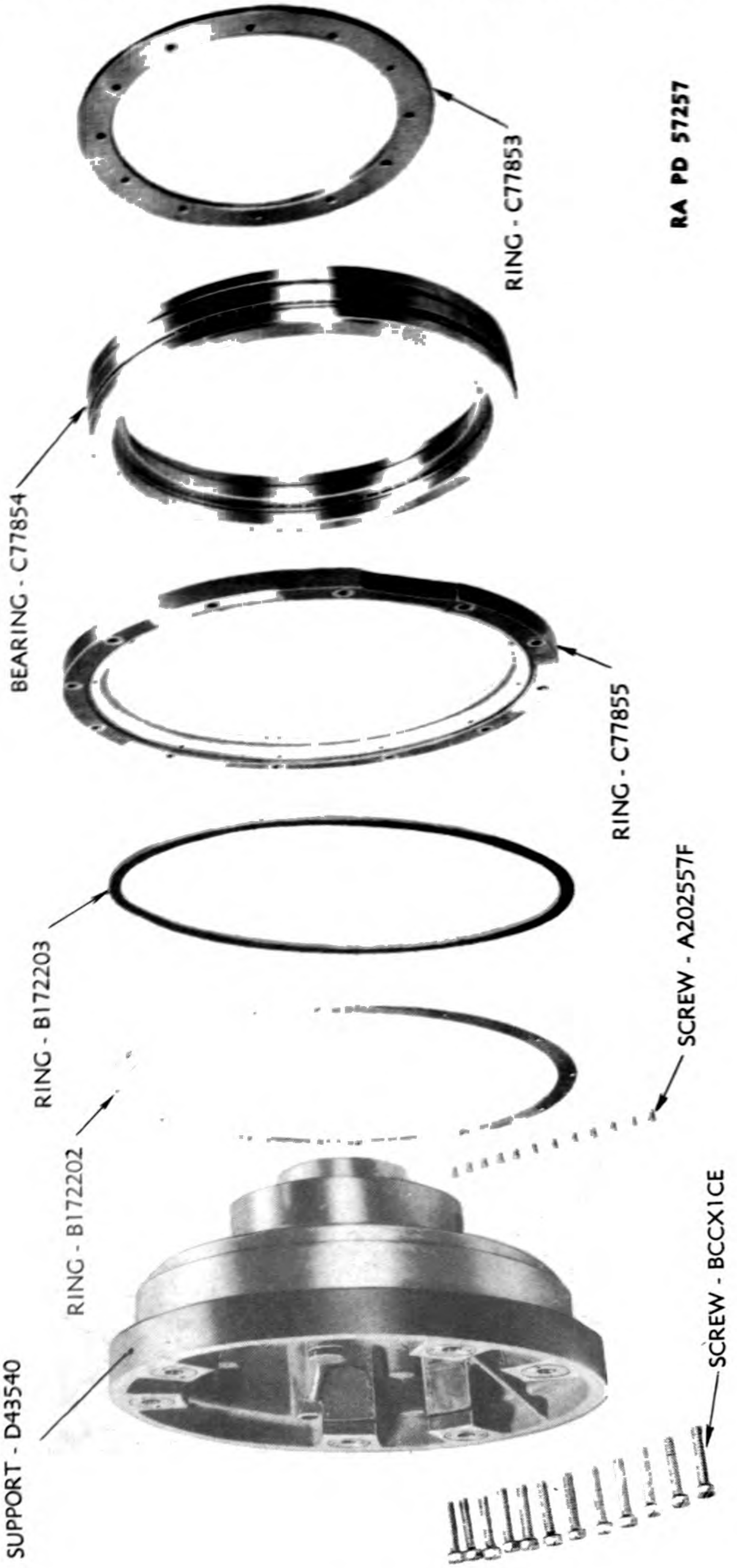

Figure 239 — Cradle Support and Bearings — Exploded View

increasing the backlash between the worm and gear. When final adjustment has been made, both screw and nut must be tight. View at top left of figure 237 shows method of locking block.

197. AZIMUTH INDICATOR INTERMEDIATE DRIVE ASSEMBLY.

a. Description. This assembly (fig. 238) is located on the top of the cradle and may be seen after the two cover plates B171885 and B180345 (fig. 241) have been removed. Its purpose is to connect the traversing mechanism to the mechanical index (pointer) of the azimuth receiver so that the correct azimuth position of the height finder will be registered at the dial. To accomplish this action, a ring gear B171891 is attached to the top of main support D43540 which always remains fixed on the tripod. As the cradle revolves about this gear, motion is transmitted to the pinion B171892 and through shaft B171890 to the azimuth receiver.

b. Disassembly and Reassembly.

(1) The azimuth indicator intermediate drive assembly (fig. 238) and the azimuth indicator cross drive assembly (fig. 247) must be removed from the cradle housing before the traversing and friction assemblies can be removed.

(2) Remove the two cover plates in the top of the cradle.

(3) Remove the plug A180453 (fig. 246).

(4) Remove the screws from the azimuth indicator window frame retaining ring B172210 (fig. 248), and remove the ring B172210, gasket B172211, window A180559, gasket A180414, dial B172213, and the frame B172212. NOTE: *The above parts except the screws may be removed as a unit. Care must be taken that none of the parts are dropped and damaged.*

(5) Turn the support or cradle until the screw A202474 (fig. 247) appears in the opening for plug A180453 (fig. 246). Remove the screw A202474, insert a number 8-36 screw in the front end of shaft A180412 (fig. 247) and, with a pair of pliers, remove the shaft by pulling it out of shaft A180410 (fig. 247). Remove the small bevel pinion B172217 (fig. 247). NOTE: *When removing the shaft A180412, hold the bevel pinion to keep it from falling.*

(6) Turn the sleeve A180413 (fig. 247) into the cradle housing until there is sufficient clearance to remove the azimuth intermediate drive assembly (fig. 237).

(7) Remove the four screws holding the azimuth indicator intermediate drive assembly (fig. 238) to the housing, and remove the drive assembly from the housing through the right opening.

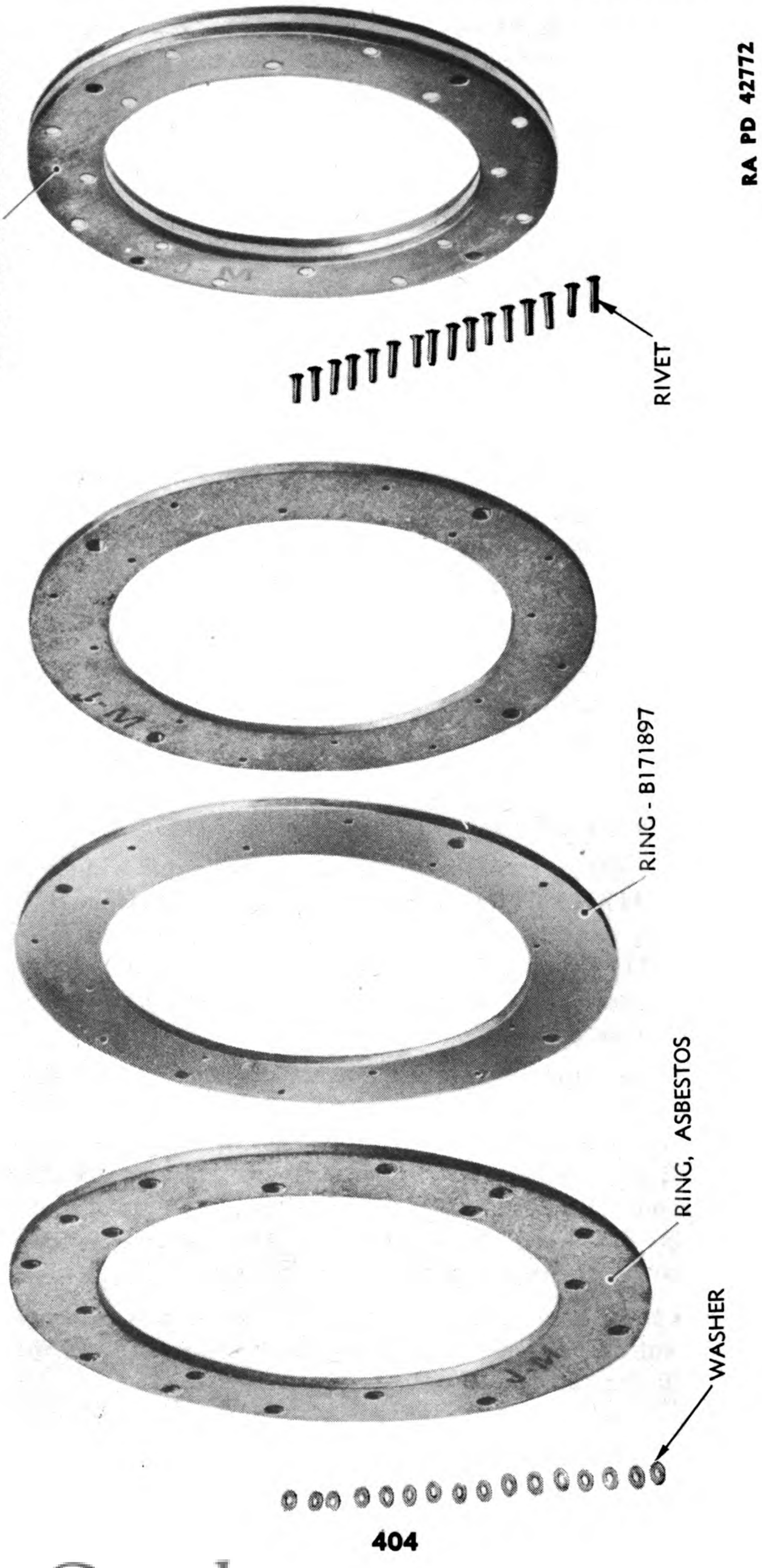

Figure 240 — Friction Ring — Exploded and Assembled Views

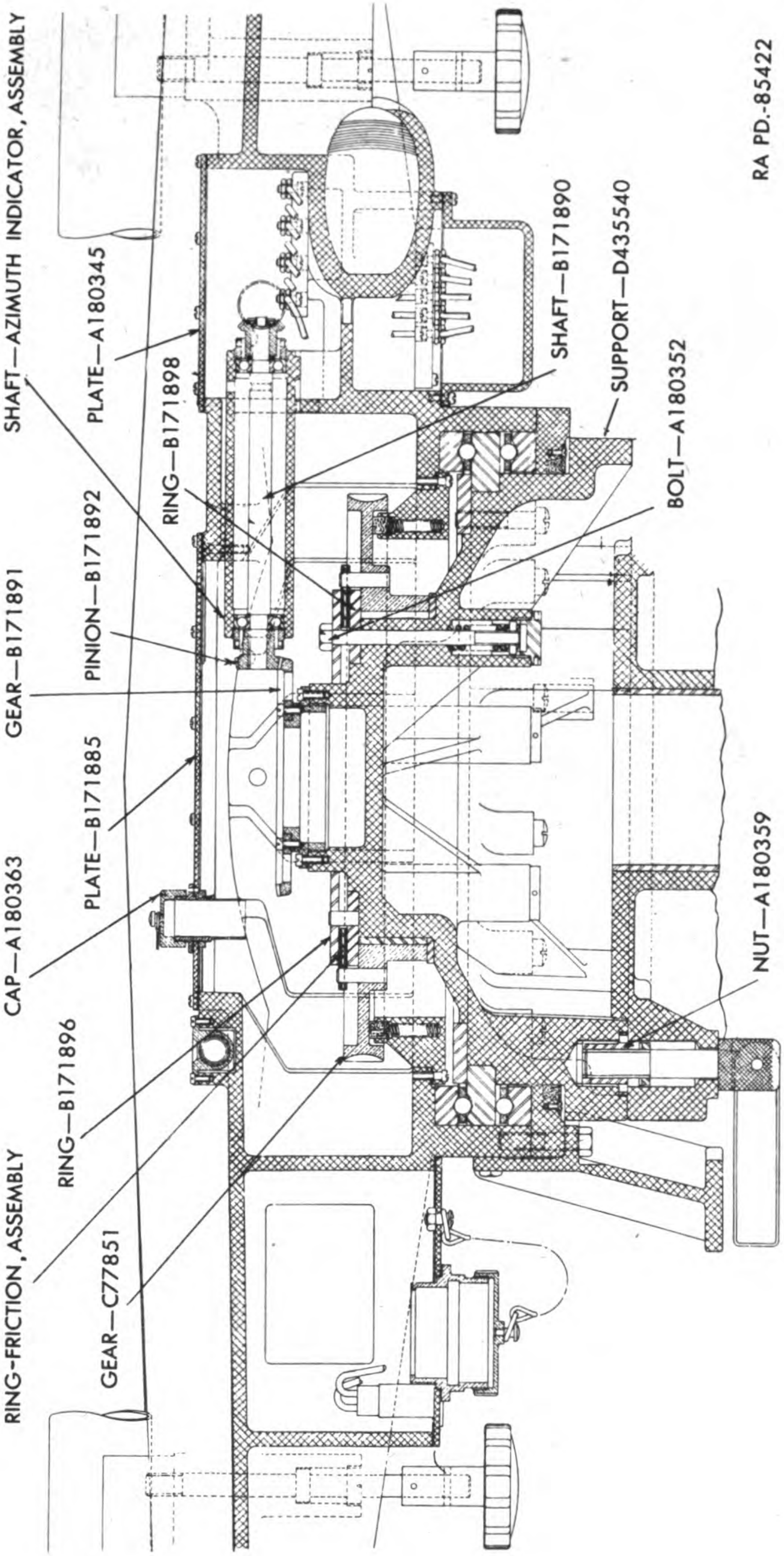

Figure 241 — Cradle Showing Azimuth Worm Gear and Bearings — Sectional View

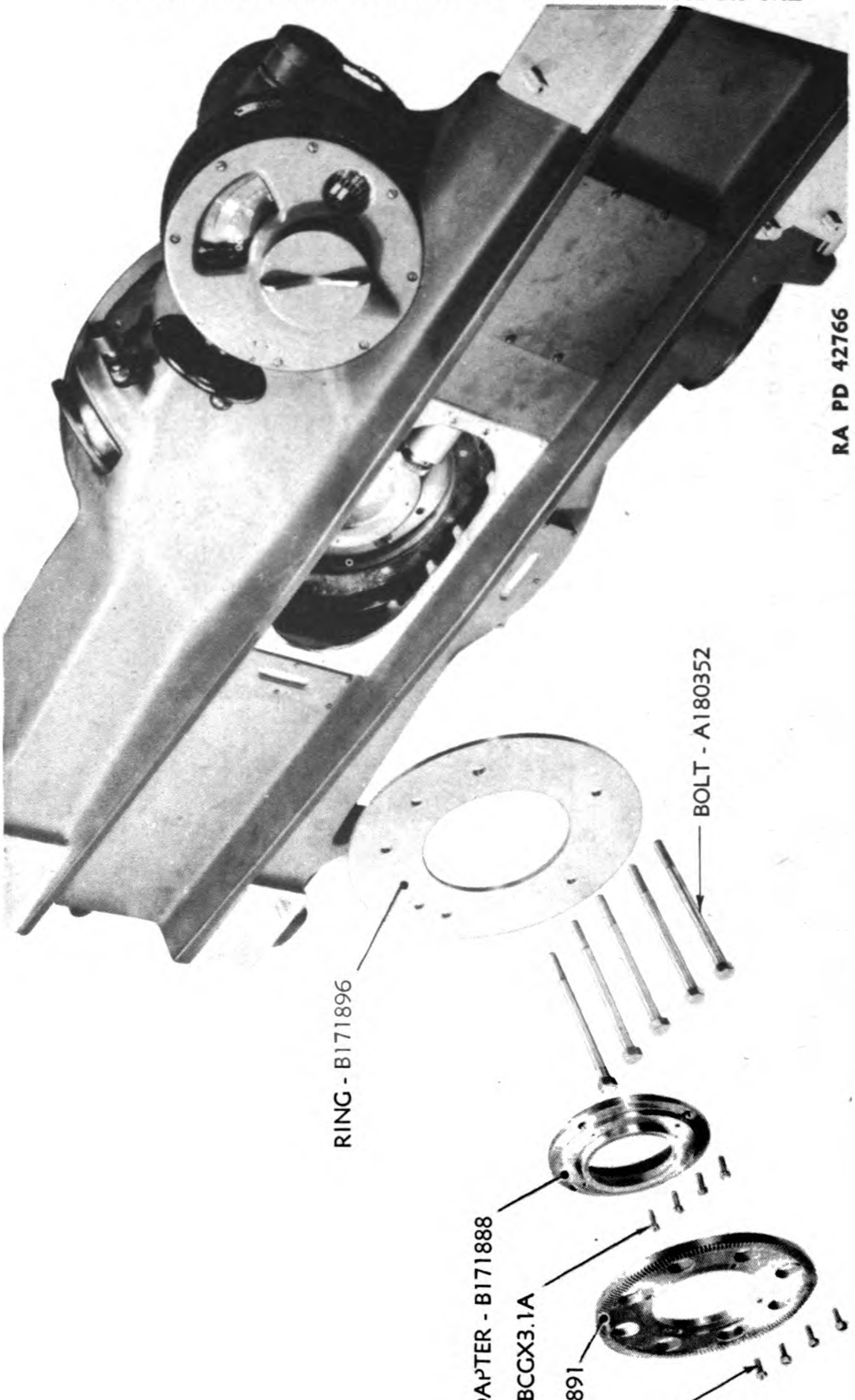

Figure 242 — Azimuth Drive Gear and Friction Ring — Exploded View

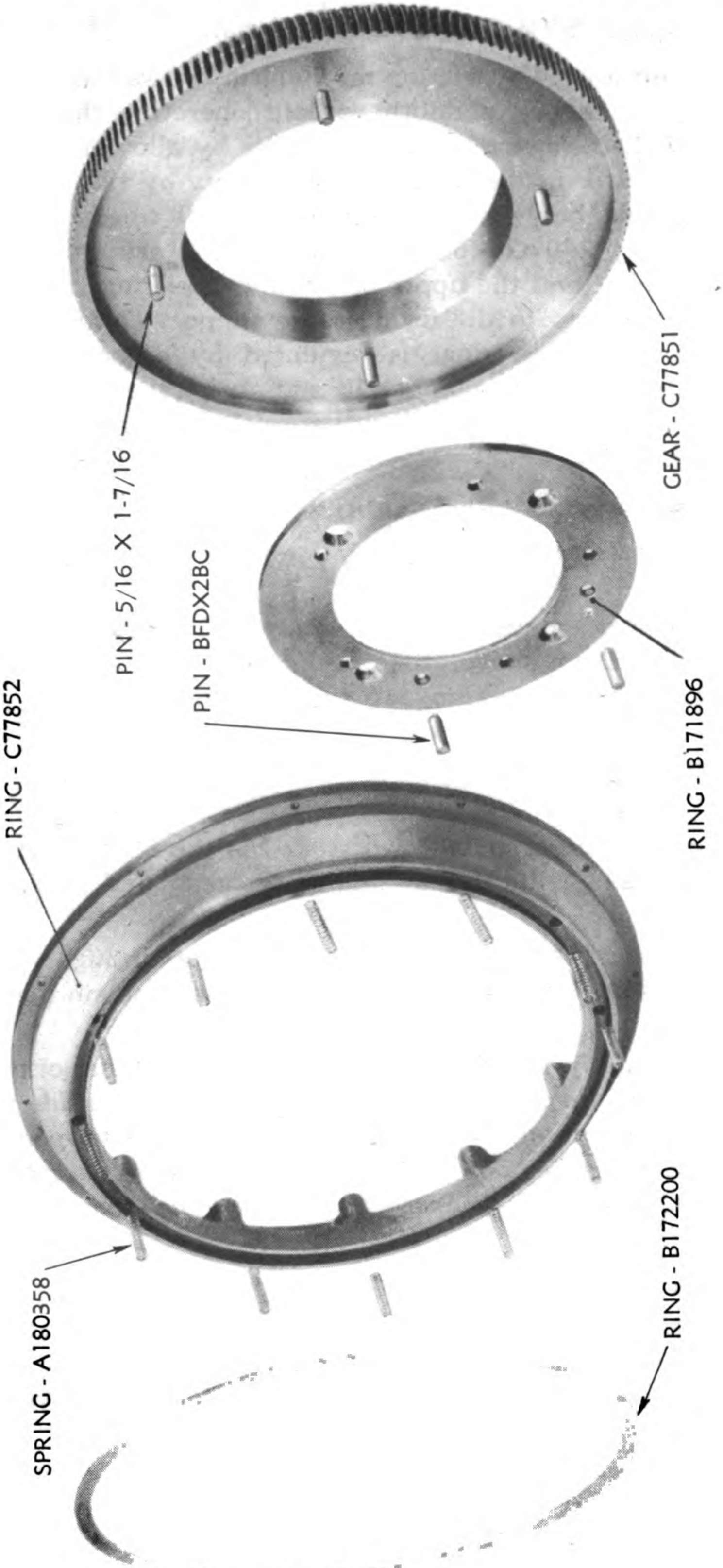

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Figure 243 — Azimuth Worm Gear and Dust Ring — Exploded View

198. AZIMUTH FRICTION MECHANISM.

a. Description. The friction mechanism allows the height finder to be swung quickly in azimuth without operating the handwheel. This action, called slewing, is made possible by allowing the azimuth worm gear to turn on the fixed cradle support by the slipping of a friction ring held between two stationary steel rings. The central friction ring (fig. 240) is loosely pinned to the azimuth worm gear C77851 (fig. 241) and the upper and lower steel rings B171896 and B171898 are secured to the fixed cradle support D43540. Friction pressure between these rings is regulated by adjusting five bolts A180352. On instrument number 13 and above, the center steel friction ring is faced on both sides with special Graylock asbestos held on with copper rivets.

b. Disassembly and Reassembly.

(1) To disassemble, unscrew and remove the five spring bolts A180352 (fig. 242).

(2) After the azimuth indicator intermediate shaft has been removed as described above, the ring gear B171891 and the gear adapter B171888 can be removed (fig. 242).

(3) The top and center friction ring will now be free, and can be lifted off the pins and moved out of the way but cannot be taken out of the housing at this time.

(4) Remove the four flat-head screws in the lower friction plate B171896 (fig. 243), lift this off the worm gear, and move aside in the housing.

(5) All three friction rings can be taken out through the bottom of the cradle housing when the main support and worm gear are removed later on.

(6) Reassembly should be made in the reverse order of procedure above. NOTE: *Be sure these three rings are placed inside the housing before reassembling the worm gear and cradle support. When reassembling the five adjusting bolts, only a few turns should be made into the nuts, as the main adjustment must be done when the telescope is placed on the cradle.*

c. Adjustment.

(1) Pressure between the friction rings can be adjusted by increasing or decreasing the tension on five springs A180353 (fig. 244), and by turning bolts A180352 (fig. 242) into the fixed nuts A180354 (fig. 244).

(2) The head of each bolt is alternately accessible through capped opening A180363 (fig. 241) in top center cover when the cradle is turned. When each bolt comes into proper position, the special socket wrench can be inserted for adjustment.

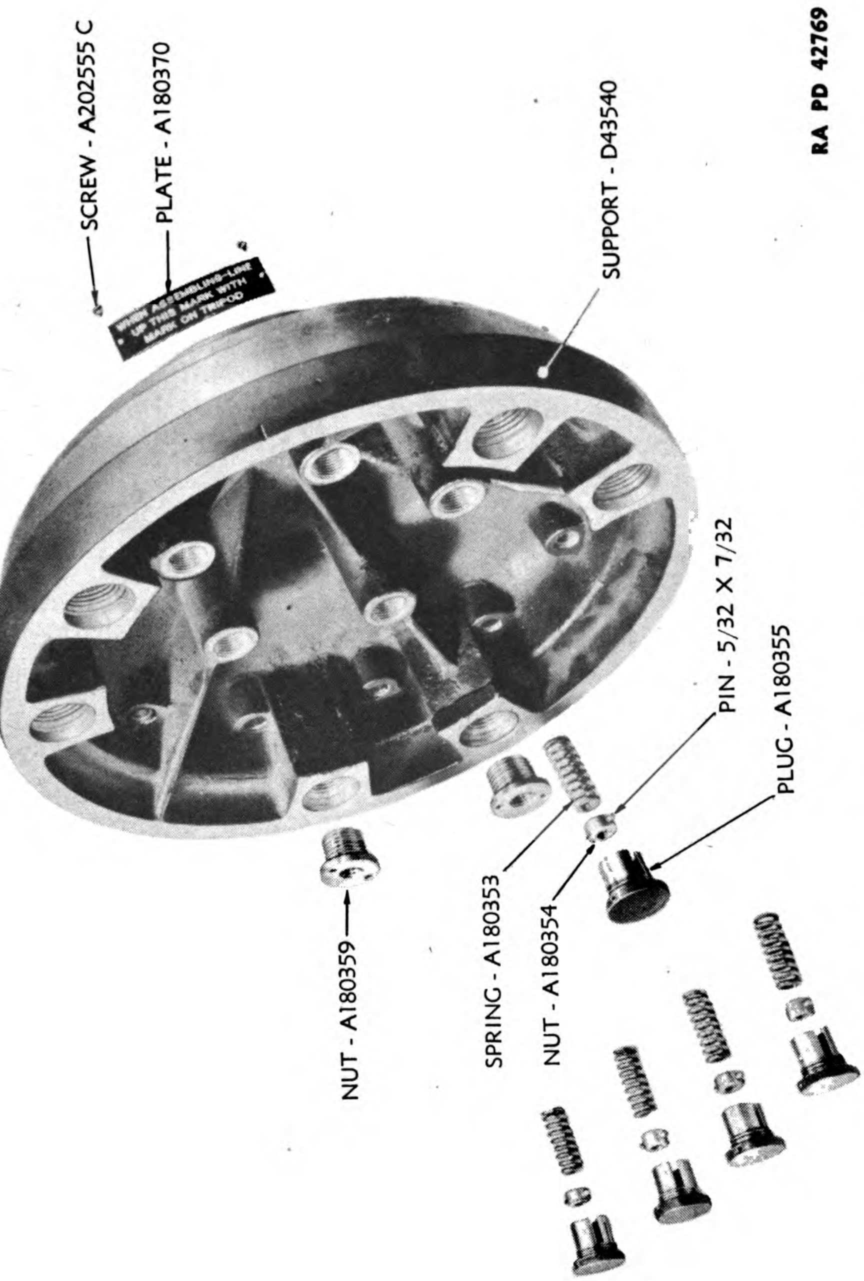

Figure 244 — *Friction Springs and Nuts — Exploded View*

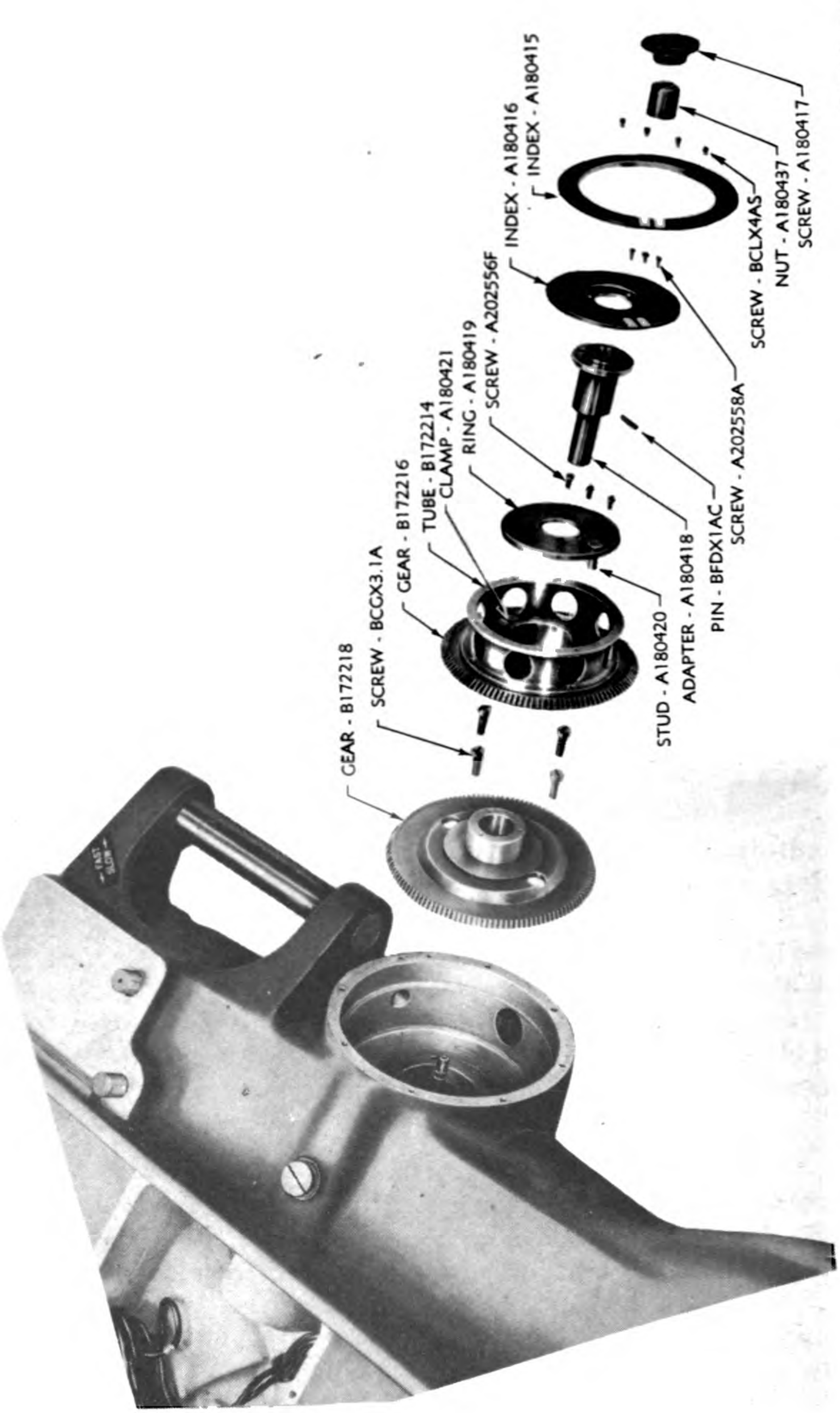

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Figure 245 — Azimuth Receiver Gears — Exploded View

(3) Each bolt should be tightened (or loosened), in turn, an equal number of turns until the desired friction is obtained.

(4) The instrument should remain at any desired position in azimuth and should move with not more than normal pressure exerted against the carrier handles. However, this condition is arbitrary, and some instruments may be tightened more than others depending upon the desire of the operators.

199. CRADLE HOUSING SUPPORT.

a. Description. The cradle support D43540 (fig. 244) is the stationary part of the cradle about which the instrument revolves during traversing. It is secured to the tripod by six lever-handled screws that engage steel nuts A180359 (fig. 244) bedded into the lower part of the casting. This part supports the inner race of the main azimuth ball bearing upon which the height finder revolves, and also acts as a mount for the azimuth worm gear. It is held in place by a heavy retainer ring secured with 12 fillister-head screws.

b. Disassembly and Reassembly.

(1) Remove the 12 fillister-head screws BCCX1CE (fig. 239), which are accessible underneath the cradle, to free the cradle support D43540. It may be necessary to use a wooden block and pound on the top of this part to loosen it sufficiently for removal.

(2) Remove the 12 hexagonal-head screws BCBXICE in the rings C77855 (fig. 239) on the under side of the cradle housing.

(3) The retainer ring C77855 can then be taken off and the main bearing C77854 removed.

(4) On reassembly, the cradle support D43540 (with ball bearing C77854 in place) can be secured on the tripod in such a manner that the cradle can be lowered onto it. In general, reassembly can be performed by reversing the above procedure.

200. AZIMUTH WORM GEAR ASSEMBLY.

a. The azimuth worm gear C77851 (fig. 243) will be forced off the cradle support D43540 when this part drops down, and will remain in the cradle housing.

b. The dust ring C77852 which contains the felt sealing ring and spring pressure plate can next be taken out by removing the 12 fillister-head screws that hold it in place. This allows the azimuth worm gear to be taken out through the bottom of the cradle housing.

c. The three friction rings can now be removed from the cradle housing.

NOTE: *Reassembly should, in general, be performed in the reverse order of procedur outlined above. Be sure to insert the three friction rings as the first step.*

201. AZIMUTH INDICATOR.

a. **Description.** The azimuth receiver is equipped with a follow-the-pointer dial system. One pointer (the electrical pointer) is fastened to the rotor of the azimuth receiver and, through electrical connection with the antiaircraft director, always moves in azimuth exactly the same amount as the director. The second pointer of the azimuth receiver is connected mechanically to the fixed center of the cradle, so that traversing of the instrument either by driving it with the handwheel mechanism provided, or by slewing, will turn this second pointer within an outer fixed scale, graduated every 20 mils in a full circle from zero to 6,400 mils. A reset (orientation) knob and suitable gearing, together with a friction device, are provided, so that the mechanical pointer of the traversing receiver may be oriented to agree with the actual direction in which the instrument is pointing. This arrangement permits the height finder to be always positioned in the same azimuth direction as the director, and permits orientation on a target of known azimuth location.

b. **Partial Disassembly and Assembly.** It is not necessary to disassemble the azimuth receiver mechanism in order to remove the repeater assembly. Proceed as follows:

(1) Remove window retainer ring and gasket.

(2) Remove window and unscrew central screw plug A180417 (fig. 245).

(3) Reach down into hole in adapter A180418 with screwdriver and remove nut A180437 from the end of rotor shaft.

(4) Take off bottom cover C77850 (fig. 246) and disconnect motor lead wires from the terminal block A180274.

(5) Remove the two holding screws in back; the synchro motor can be taken out through the bottom of cradle housing. NOTE: *It may sometimes be necessary to loosen secondary cover C77860 (fig. 246) before the repeater assembly can be taken out.*

(6) Reassembly should be performed by reversing the above procedure.

c. **Complete Disassembly and Assembly.**

(1) Remove reset knob cover A180455 (fig. 246) and detach chain.

(2) Unscrew lock nut A180349B and remove reset knob A180454.

(3) Unscrew adapter A180451 and withdraw bevel pinion shaft B172215 which will bring the bearings and spacers out with it.

(4) Remove frame B172212 (fig. 248) and graduated dial B172213.

CRADLE M2 — ADJUSTMENT, DISASSEMBLY, AND REPAIR

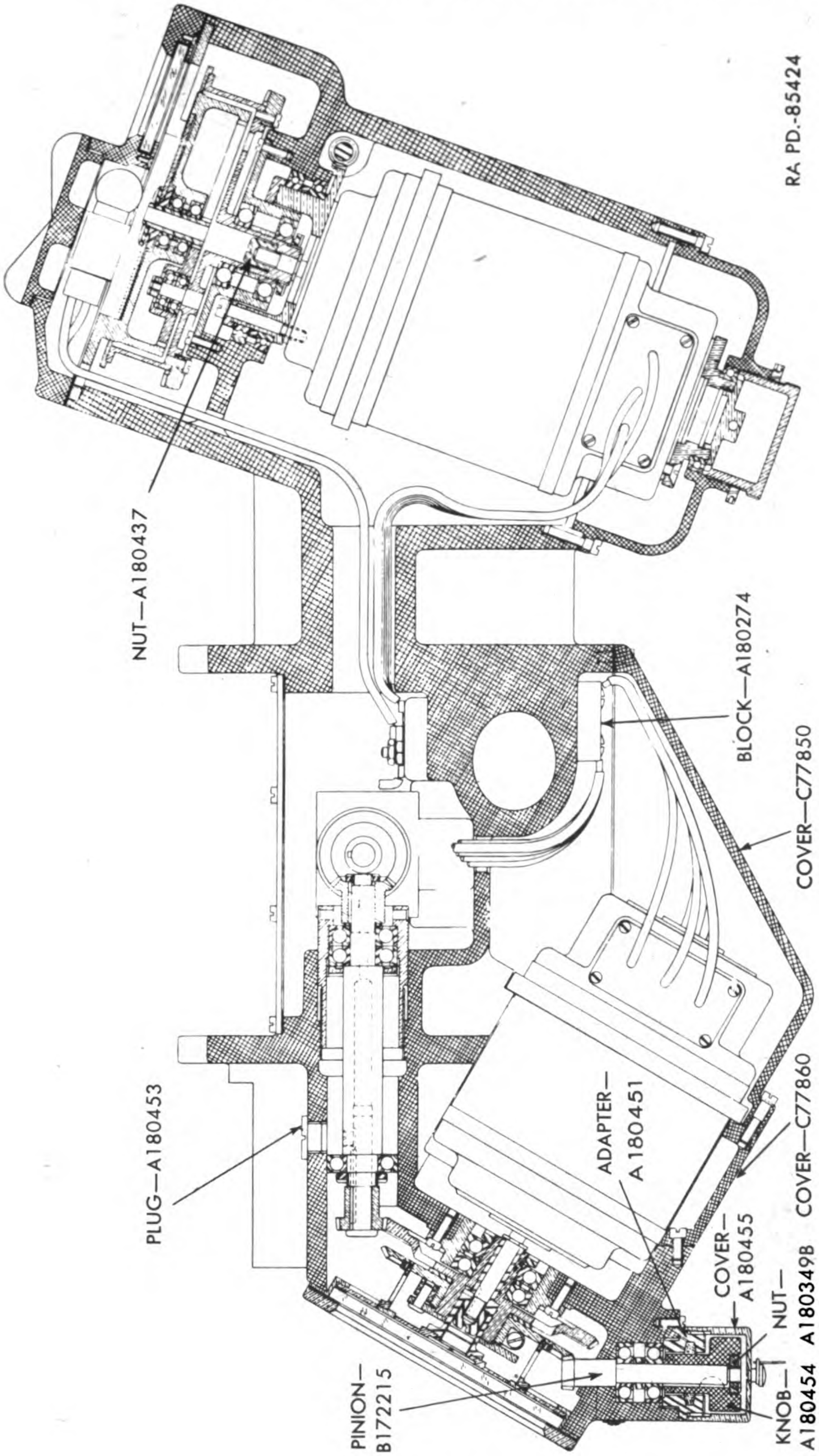

Figure 246 — Cradle Showing Transmitter and Azimuth Indicator — Cross-sectional View

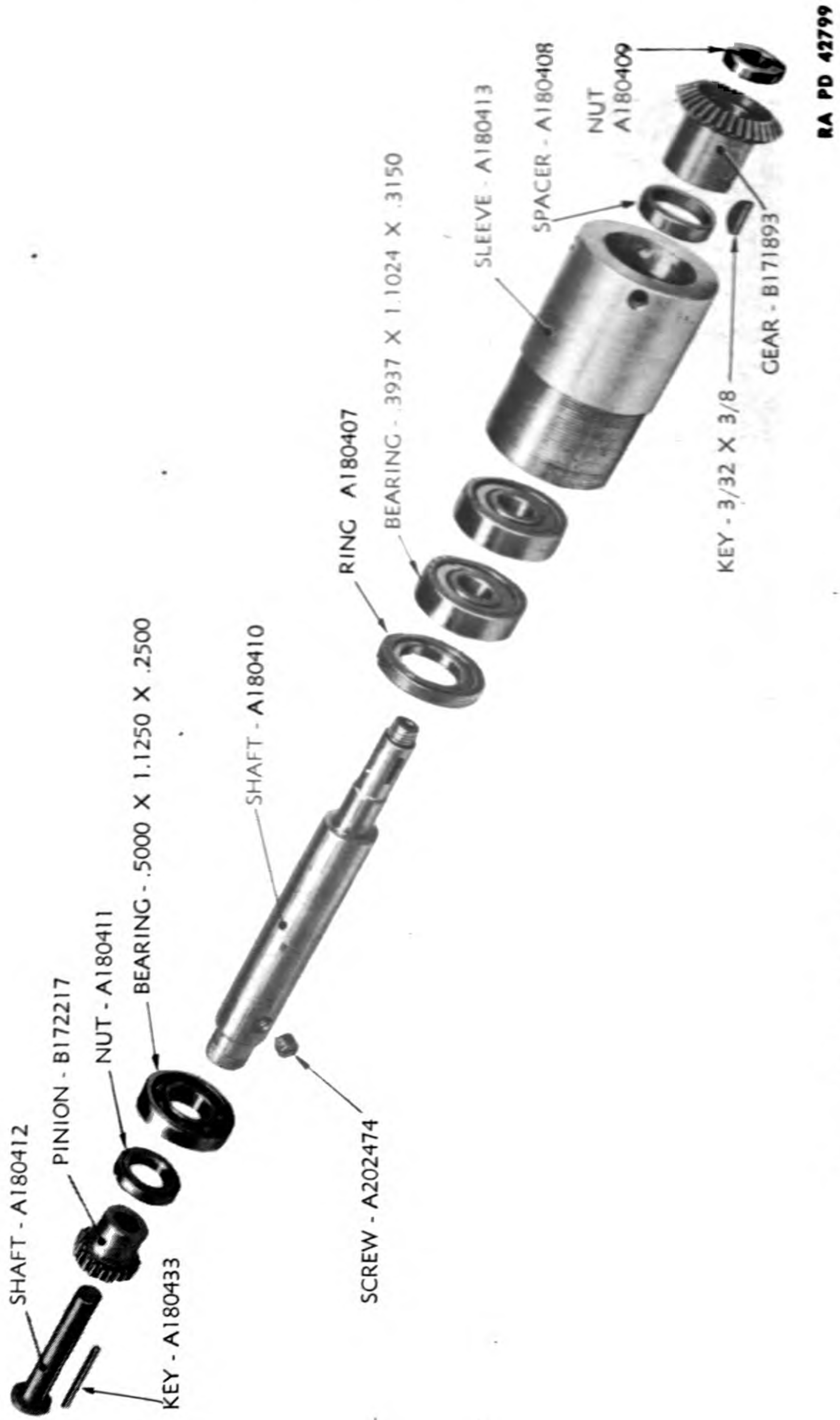

Figure 247 — Azimuth Indicator Cross Drive Assembly — Exploded View

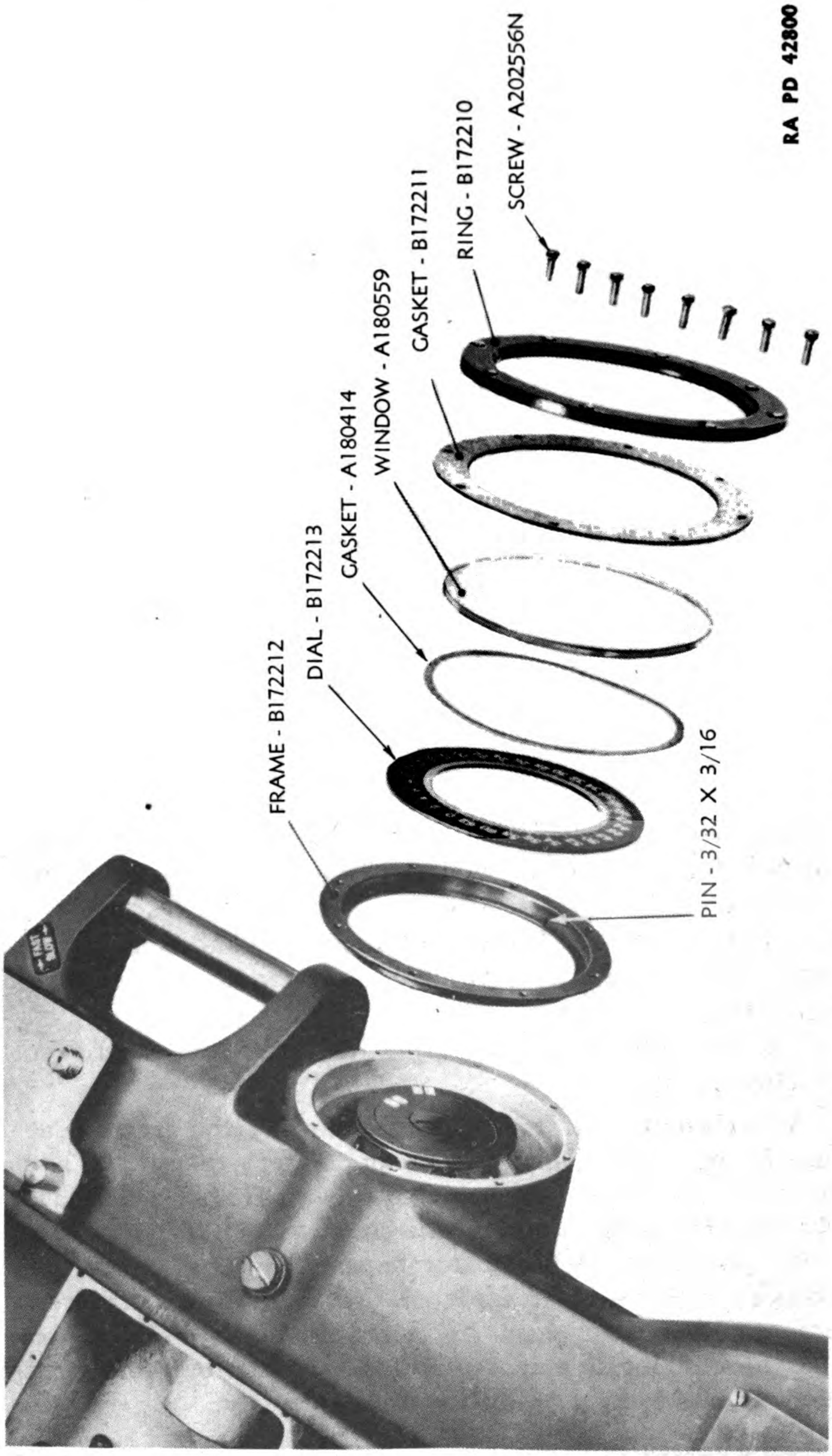

Figure 248 — Azimuth Receiver Dial and Window — Exploded View

(5) When the center screw A180417 (fig. 245) has been removed and the nut A180437 removed from the end of the rotor shaft, as described in subparagraph b, above, and the center index disk (electrical pointer) A180416 and adapter A180418 to which it is screwed on can be taken out.

(6) The outer index A180415 (traversing pointer) assembly which includes the tube B172214, bevel gear B172216, friction ring A180419, and clamp A180421 can next be taken out as a unit.

(7) In order to get the large bevel gear B172218 out, it will be necessary to remove the meshing pinion B172217 (fig. 247). This can be done by removing plug A180453 in the top of housing and loosening set screw in shaft A180410. Insert a screw in front end of shaft A180412 and, with a pair of pliers, remove this shaft by pulling it out of shaft A180410. Bevel pinion B172217 can then be lifted out of azimuth repeater housing (figs. 245 and 247).

(8) By reaching through holes in the web of bevel gear B172216 (fig. 245), the screws that secure the bearing adapter to the housing can be removed. This will allow the adapter, ball bearings, and bevel gear B172218 to be taken out as a unit.

d. Indicator Cross Drive Disassembly.

(1) Unscrew lock nut A180409 (fig. 247) and remove bevel gear B171893.

(2) Shaft A180410 can be pushed out by tapping on the inner end with a rawhide mallet. This action will force out the single ball bearing which can be removed together with shaft through the window opening.

(3) Sleeve A180413, containing the double ball bearing, can then be unscrewed and removed through the opening in the top of the cradle housing.

(4) Reassembly should be performed in the reverse order of procedure outlined above.

e. Adjustments. If traversing or slewing the instrument does not turn the outer index ring (traversing pointer), then it will be necessary to adjust the friction between bevel gears B172218 and B172216 by tightening the spring screw in the clamp A180421 (fig. 245). Remove the plug from the indicator housing (located at about the 4 o'clock position) and, by rotating the reset knob and traversing the instrument, the friction adjusting screw in clamp A180421 can be reached through the opening provided. A turn or more should be sufficient to make the friction function correctly.

202. TRANSMITTER.

a. General Description. The transmitter is a device for transmitting range or height electrically to the director located some dis-

CRADLE M2 — ADJUSTMENT, DISASSEMBLY, AND REPAIR

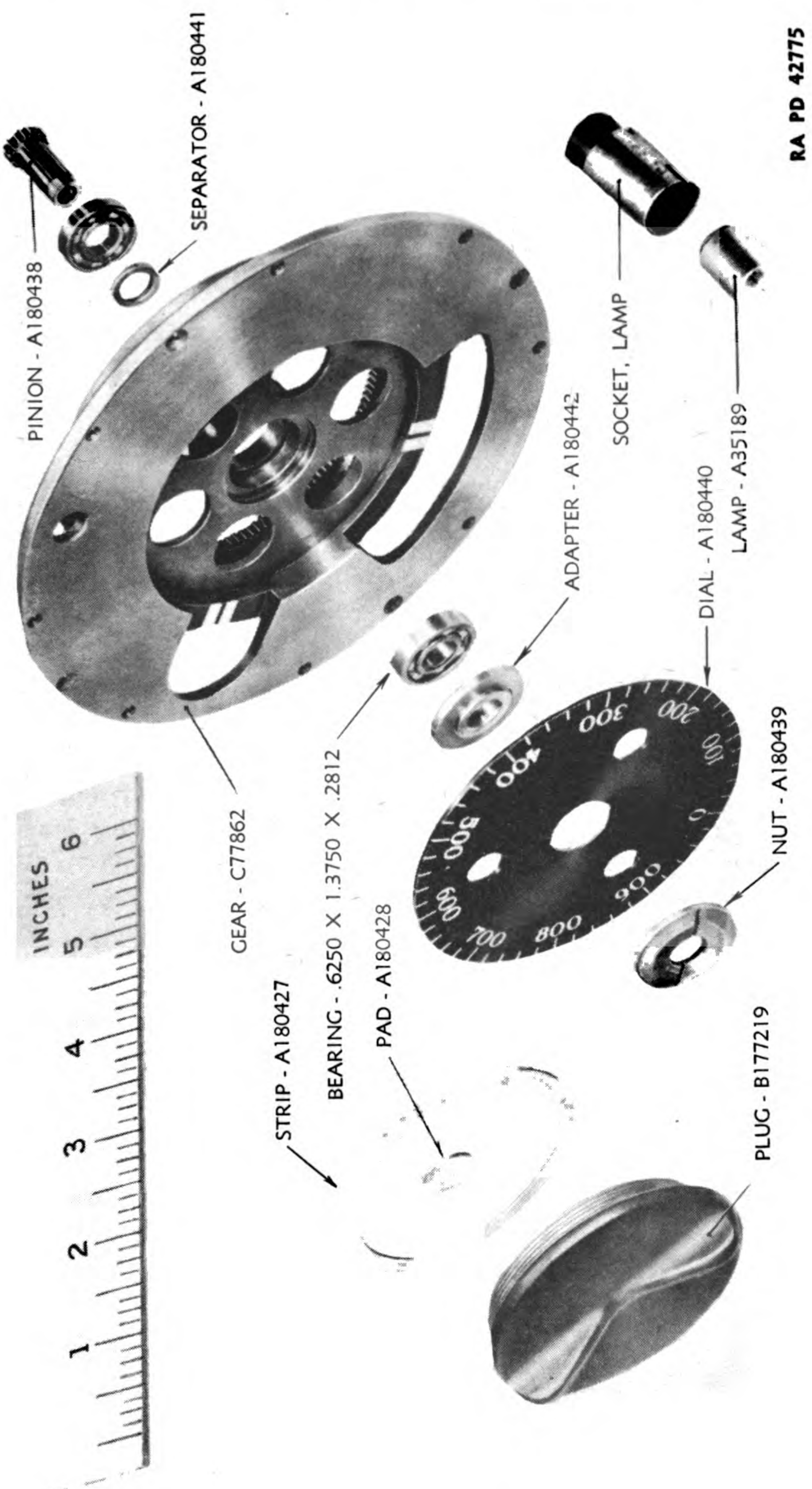

Figure 249 — Transmitter Dial and Gears — Exploded View

Figure 250 — Transmitter Mechanism — Exploded View

tance away from the height finder. The transmitter rotor is geared to two interconnected dials that are rotated by a small handwheel. The inner (fast) dial is graduated every 20 yards from zero to 100, and the outer (slow) dial is graduated from zero to 10, reading in thousands of yards. A calibration knob and scale is provided to introduce corrections into the transmitted range or height.

b. Partial Disassembly and Reassembly. The transmitter assembly may be removed without disassembly of the dial mechanism. This can be done as follows:

(1) The small cover plate in the top right side of the cradle must be removed and wires tagged "H1," "H2," "H3," "H4," and "H5" which lead to the motor, and wires tagged "21" and "22" which lead to the small illuminating lamp, disconnected from the terminal block.

(2) Remove the transmitter upper cover, take out lamp socket, and loosen wires. Unscrew nut A180439 (fig. 249), and the dial A180440 can be taken off.

(3) By proper manipulation of the transmitter handwheel and calibration knob, the holes in gear C77862 (fig. 249), adapter B172223 (fig. 250), and adapter B172221 (fig. 251) may be so alined that the screws that secure the transmitter to adapter B172224 (fig. 250) can be reached with a screwdriver and loosened.

(4) By inserting a screwdriver in the small hole in central sleeve (pinion), the nut A180437 (fig. 246) may be unscrewed from the threaded end of the rotor shaft, thereby freeing the transmitter.

(5) Remove the lower cover B172229 (fig. 252) and the transmitter C69405 may be withdrawn through the bottom opening in the housing.

(6) Reassembly should be done in the reverse order of above procedure.

c. Complete Disassembly and Assembly.

(1) By using a spanner wrench and unscrewing adapter A180458 (fig. 253) from the transmitter housing, the handwheel bearings and pinion shaft B172228 can be removed as a unit.

(2) Take off transmitter upper cover, and remove nut A180439 (fig. 249) and dial A180440 as outlined above in subparagraph **b** (2), above.

(3) Take out the four screws holding internal gear C77862, and remove this subassembly (fig. 249).

(4) Correction scale A180449 (fig. 253) should be removed from its adapter next.

(5) Rotate adapter B172223 (fig. 250) until four screws that secure adapter B172221 (fig. 252) can be loosened through holes in the web, and remove this part with the gears, bearings, etc., as a unit.

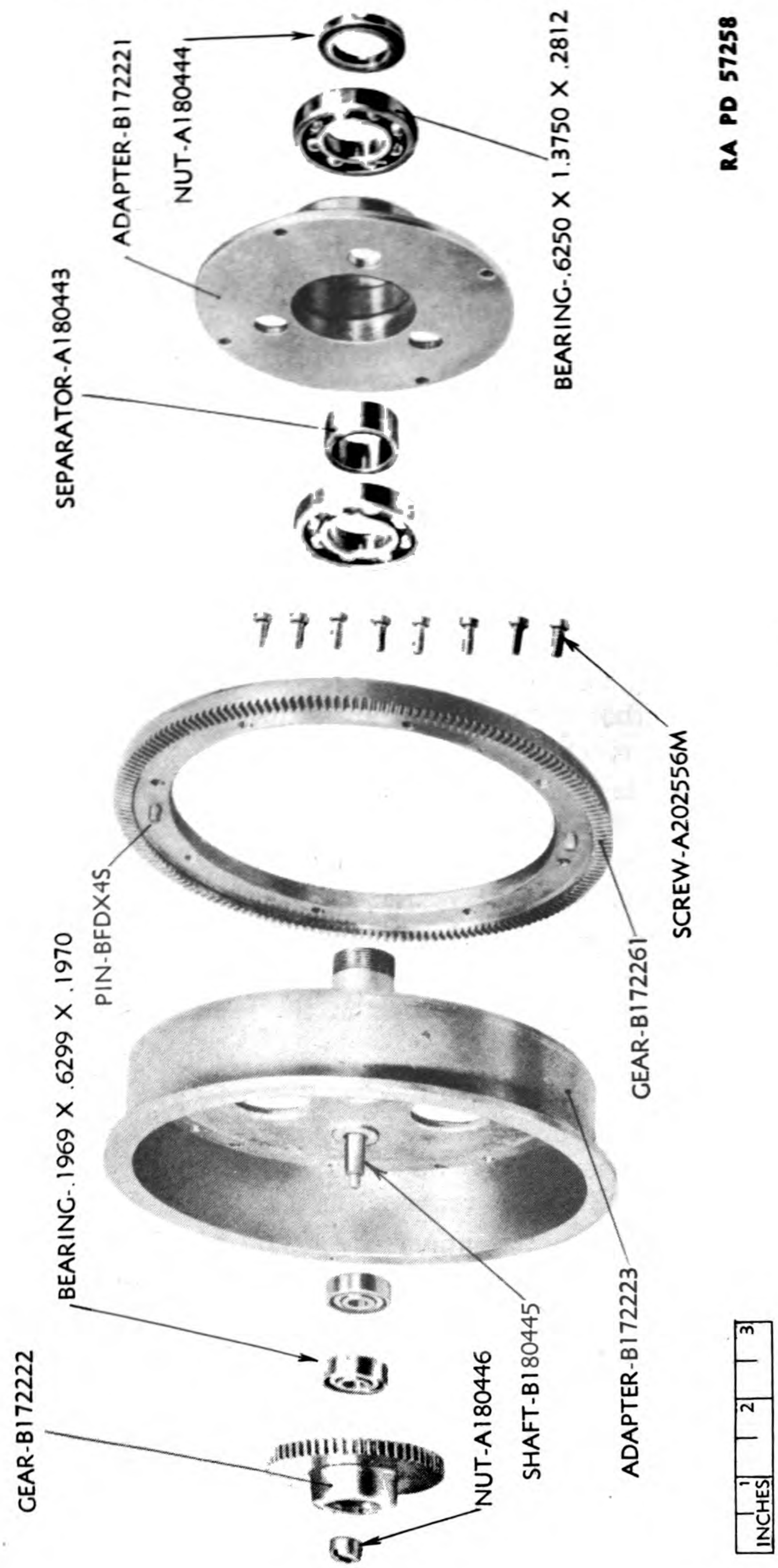

Figure 251 — Transmitter Gears and Bearings — Exploded View

CRADLE M2 — ADJUSTMENT, DISASSEMBLY, AND REPAIR

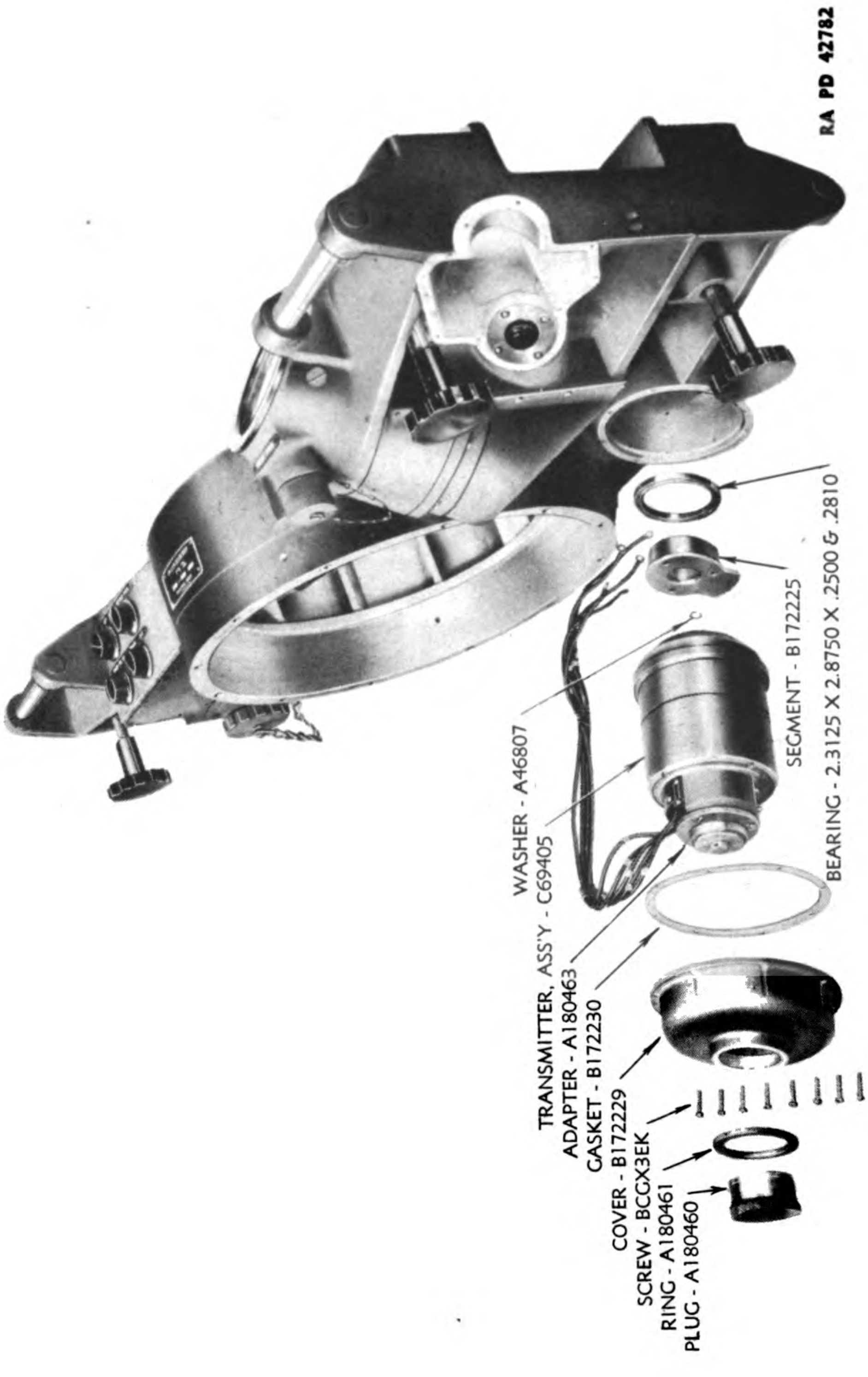

Figure 252 — Range-Height Transmitter — Exploded View

(6) Remove lockscrew that holds adapter A180451 (fig. 246) in place. Take off cap and chain assembly. The adapter may now be unscrewed and removed, together with bearings and calibration worm B172226, as a complete unit (fig. 250).

(7) Remove calibration scale adapter B172224 (fig. 250). This will allow the calibration worm wheel segment B172225 (fig. 252) and one of the ball bearings and separator to be removed through the bottom of the housing. The other ball bearing can be removed from the top of the housing.

(8) Reassembly should be performed in the reverse of above procedure.

d. **Adjustments.**

(1) The range-height transmitter C69405 should be mounted snugly within the housing. End play, if any, can be removed by adjustment of plug A180460 and retainer ring A180461 (fig. 252).

(2) The fast (inner) dial and slow (outer) scale should be alined at zero. The fast dial will then read zero at each number on the slow scale. Loosening nut A180439 (fig. 249), and slipping the fine dial A180440 as required when the slow scale B172220 (fig. 253) is at zero, should aline them for all readings after electrical zero has been checked (par. 212).

e. **Levels.** For care and replacement of levels, see paragraph 91.

203. ELECTRICAL EQUIPMENT.

a. The cradle contains the controls and forms the distributing center for the electrical equipment for the operation of the height finder. The wiring diagram (fig. 260) shows schematically the cradle electrical components and their connection with the electrical components of the telescope proper. Besides the azimuth receiver and the range-height transmitter, these components consist of the following units:

(1) The 19-pole receptacle assembly C69409 (fig. 254) to which the director cable plug is attached.

(2) The double-contact socket to which auxiliary electrical connection for 6-volt battery is made. These two units are located in a removable plate C77857 which serves as a cover for the wiring distribution box cast in the under side of the cradle housing.

(3) The transformer B134814 that transforms 110-volt current received from the director to 6 volts for use in the lamp circuits is located in this box.

(4) The 13-conductor cable and plug that forms a detachable connection between the cradle and the height finder telescope.

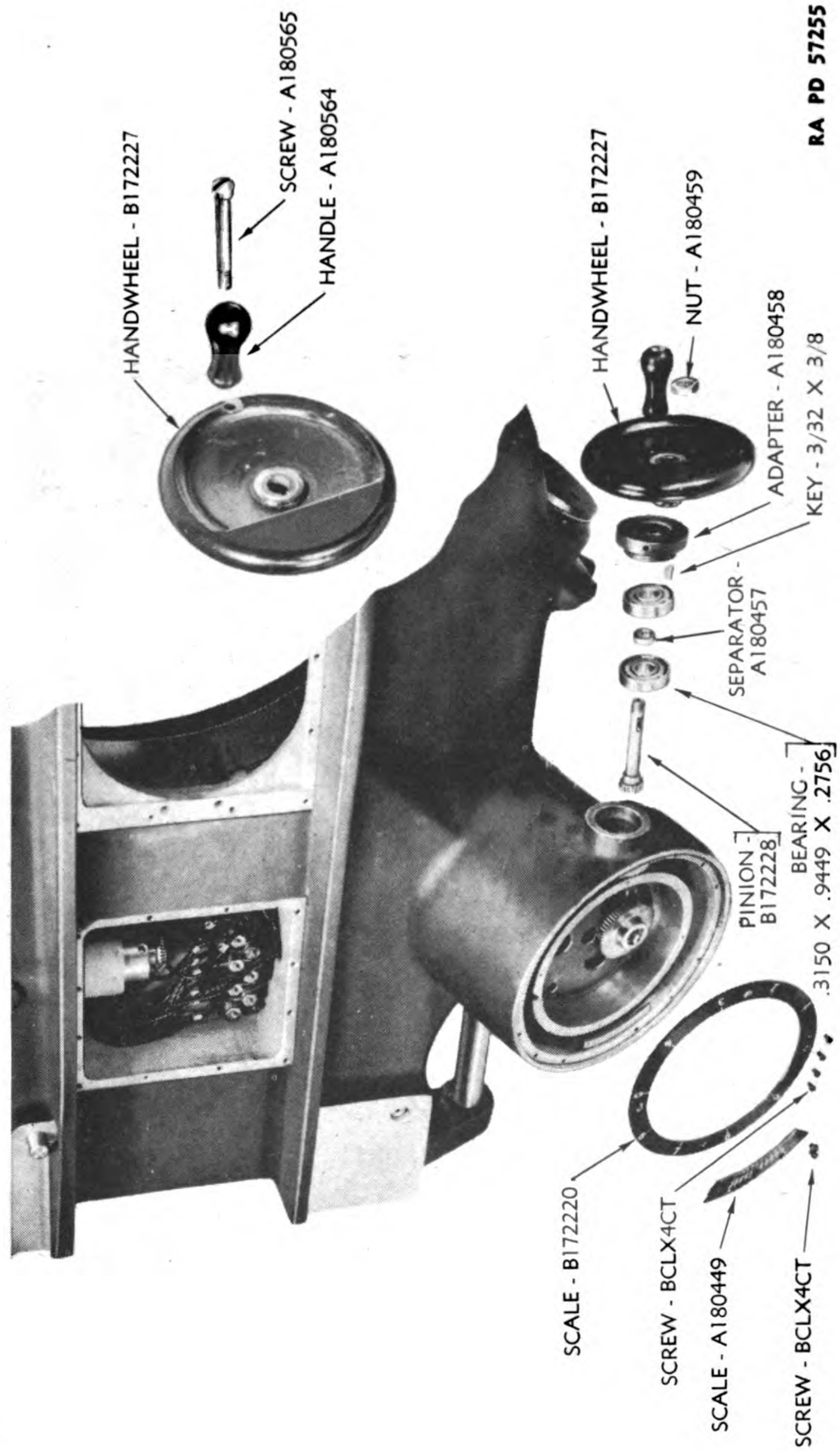

Figure 253 — Transmitter Handwheel Assembly — Exploded View

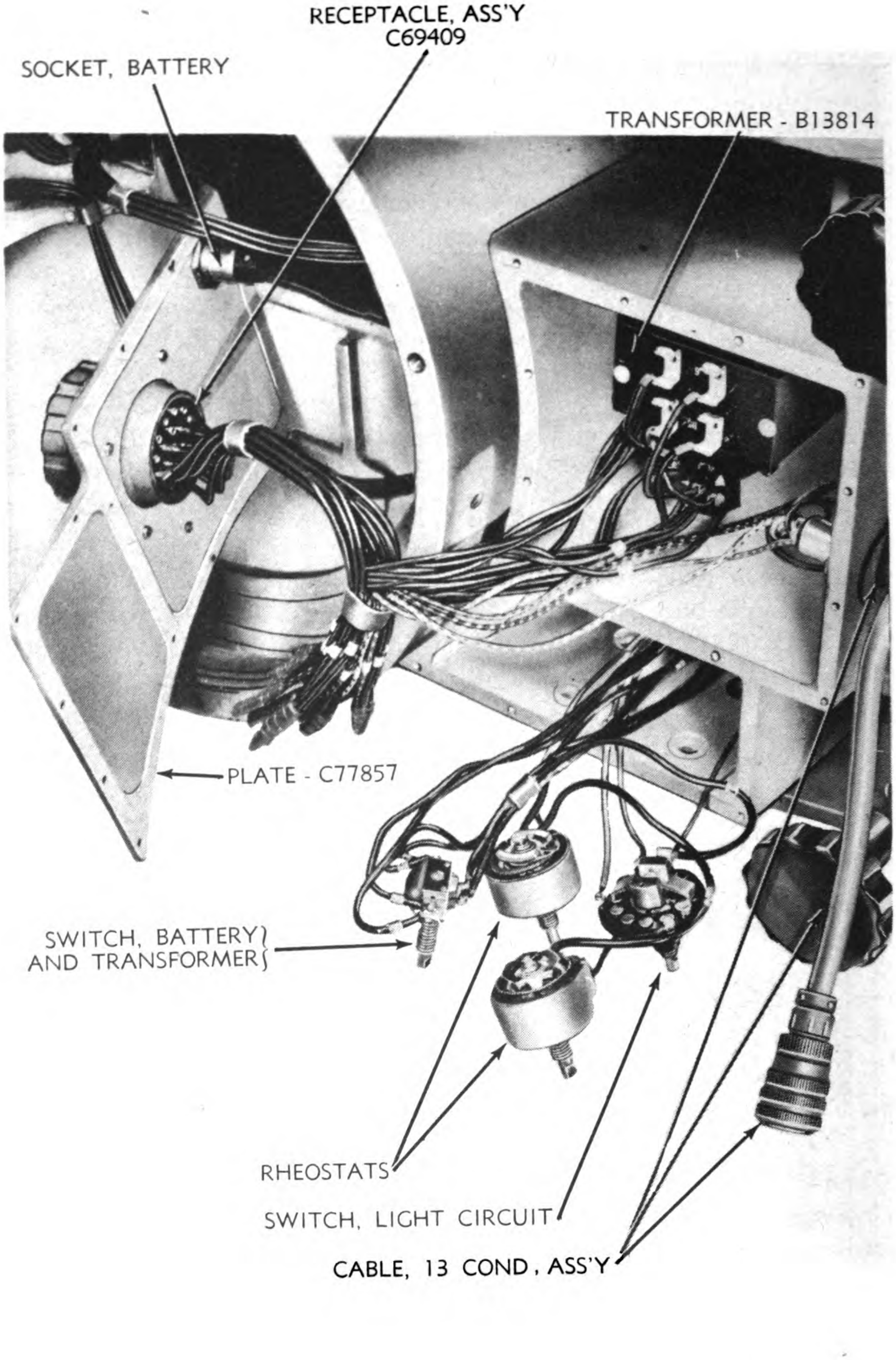

Figure 254 — Cradle Electrical Equipment — Exploded View

(5) Two rheostats to control the intensity of light at the lamps, one for the stereo reticle and the other for tracking telescope reticles.

(6) A light circuit switch to provide illumination for the main system (position "1," fig. 48), the internal system (position "2," fig. 48), and the off position.

(7) A battery and transformer switch that connects the lamp circuit either to battery or to transformer, whichever is to be used. Rheostat and switch panel is shown in figure 48.

Section XIII

TRIPOD M9 — ADJUSTMENT, DISASSEMBLY, AND REPAIR

204. CARE AND ADJUSTMENT.

a. Lubrication. In regular use, the tripod will need lubrication at frequent intervals (par. 89).

205. DISASSEMBLY AND ASSEMBLY.

a. Tripod Leg and Foot Assembly.

(1) Remove the hinge pin nut A180473 (fig. 255) and drive out hinge pin A180472.

(2) Remove the stud nut A180473 and drive out the stud A180486.

(3) Remove the entire leg assembly.

(4) Repeat steps (1), (2), and (3), above, for the other two leg assemblies.

(5) Remove the stud A180486 (fig. 257) and take off spreader tube B172236.

(6) Loosen set screw in cap A180478 (fig. 256), unscrew this part, and remove.

(7) The foot adjusting screw A180475 can then be unscrewed and removed.

(8) Unscrew cap A180479, and shoe B172232 can be taken off.

(9) Drive out key, and nut B172231 can be removed.

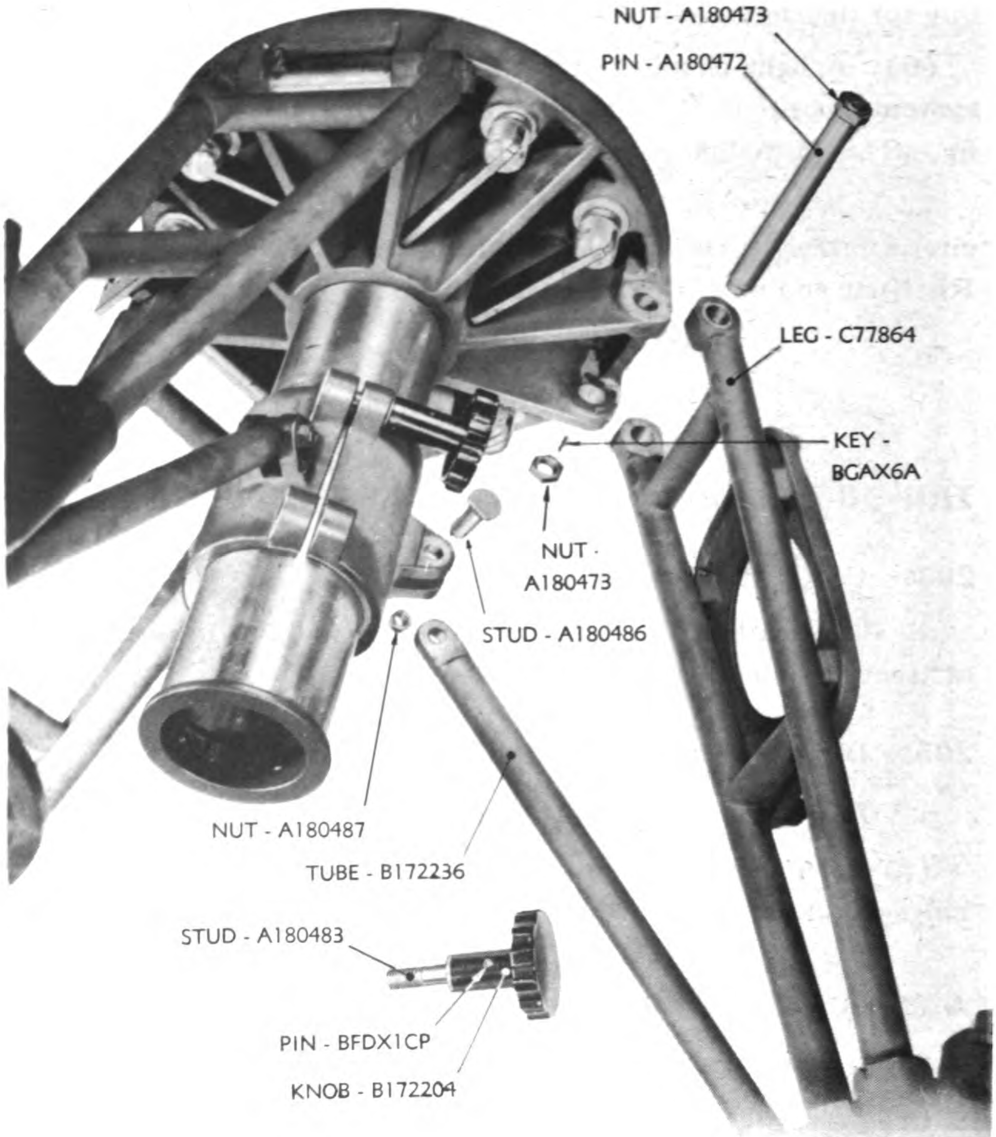

Figure 255 — Tripod M9 — Leg Assembly Removed

(10) Repeat steps (5), (6), (7), (8), and (9), above, for the other two foot assemblies.

b. Tube and Sleeve Assembly. Disassembly of the tripod tube will be necessary only if so damaged that the sleeve will not slide up and down readily.

TRIPOD M9 — ADJUSTMENT, DISASSEMBLY, AND REPAIR

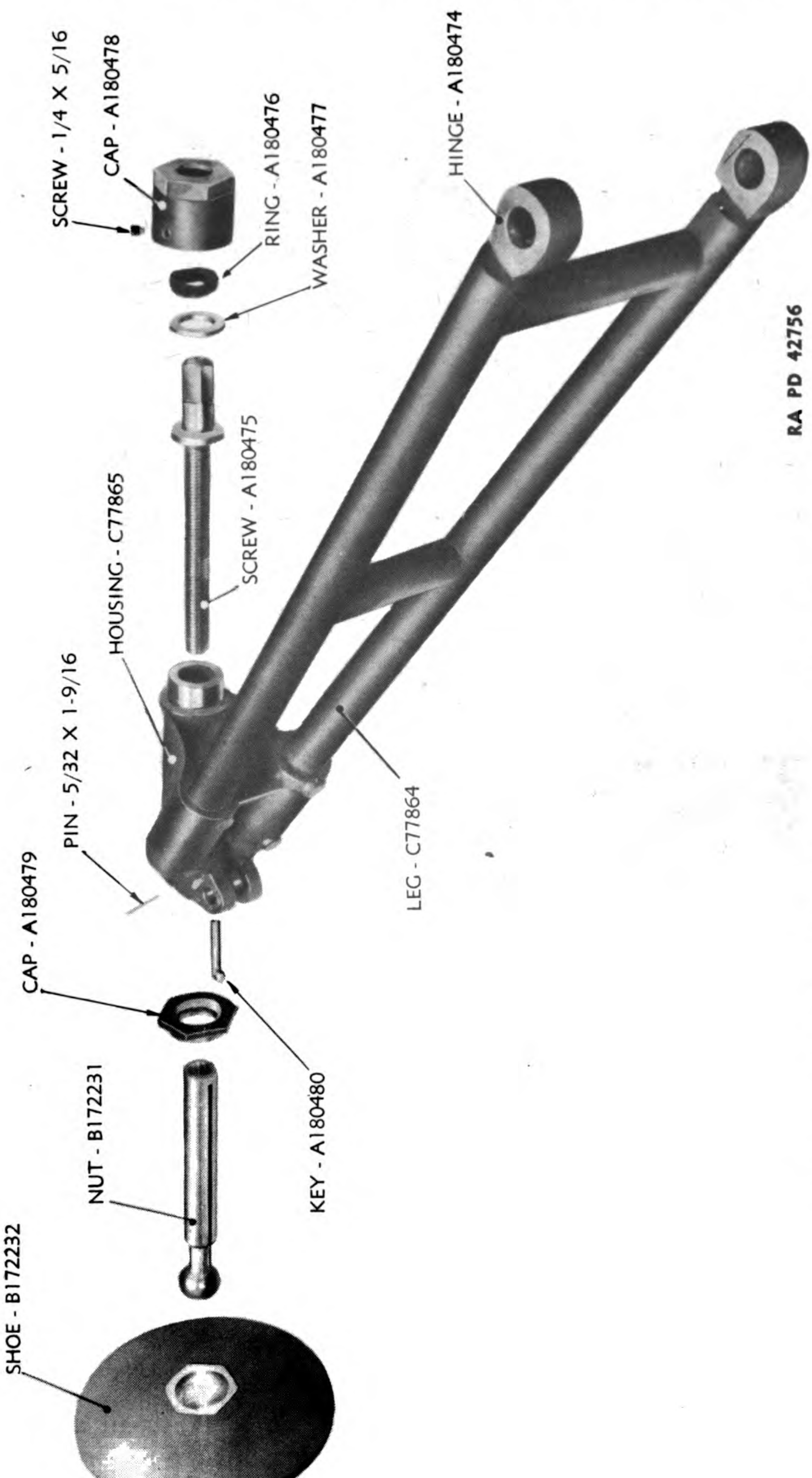

Figure 256 — Tripod Leg Showing Shoe Assembly — Exploded View

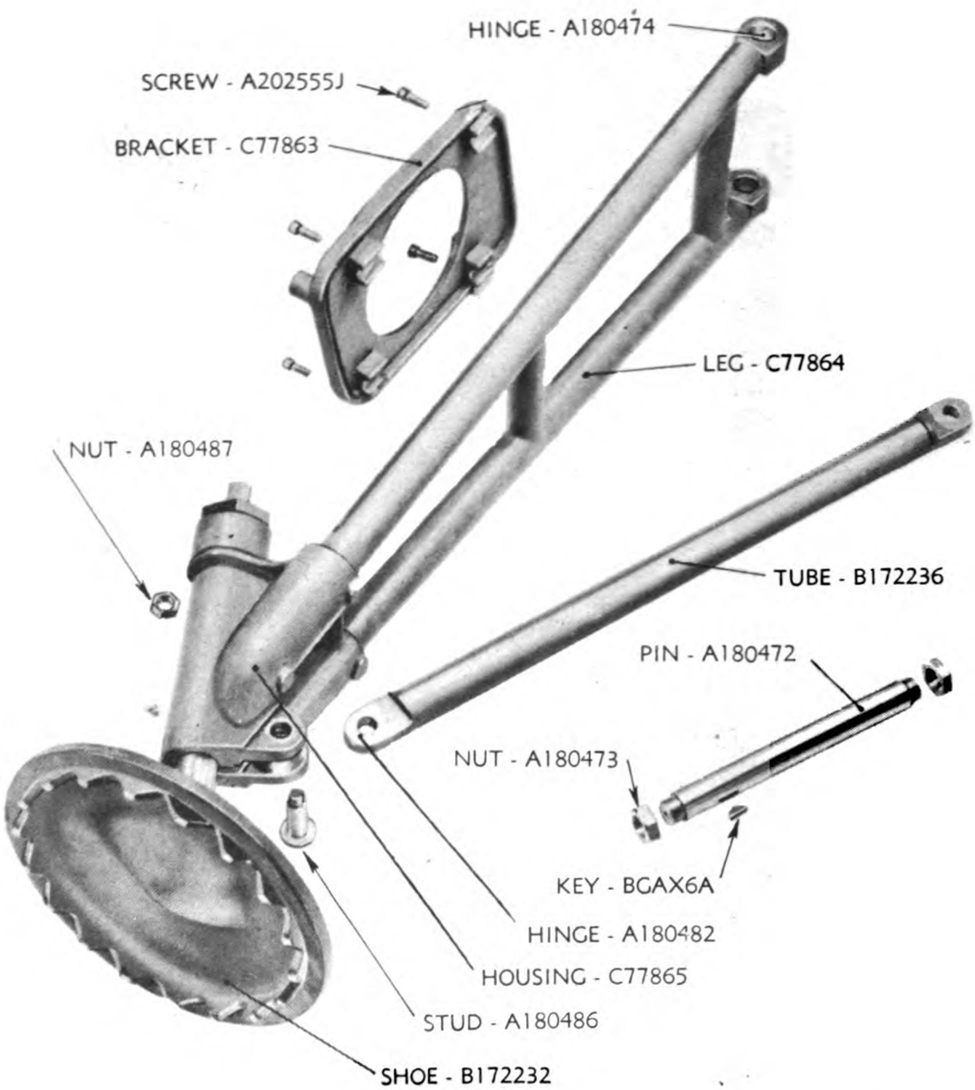

Figure 257 — Tripod Leg Assembly — Partly Exploded View

(1) Drive out the four pins in ring A180485 (fig. 258) and remove this part.

(2) Remove the sleeve C77866.

(3) Drive out the three pins in the hub of the head and, using a round block of wood, drive against the end of tube to force it from the head D43441.

TRIPOD M9 — ADJUSTMENT, DISASSEMBLY, AND REPAIR

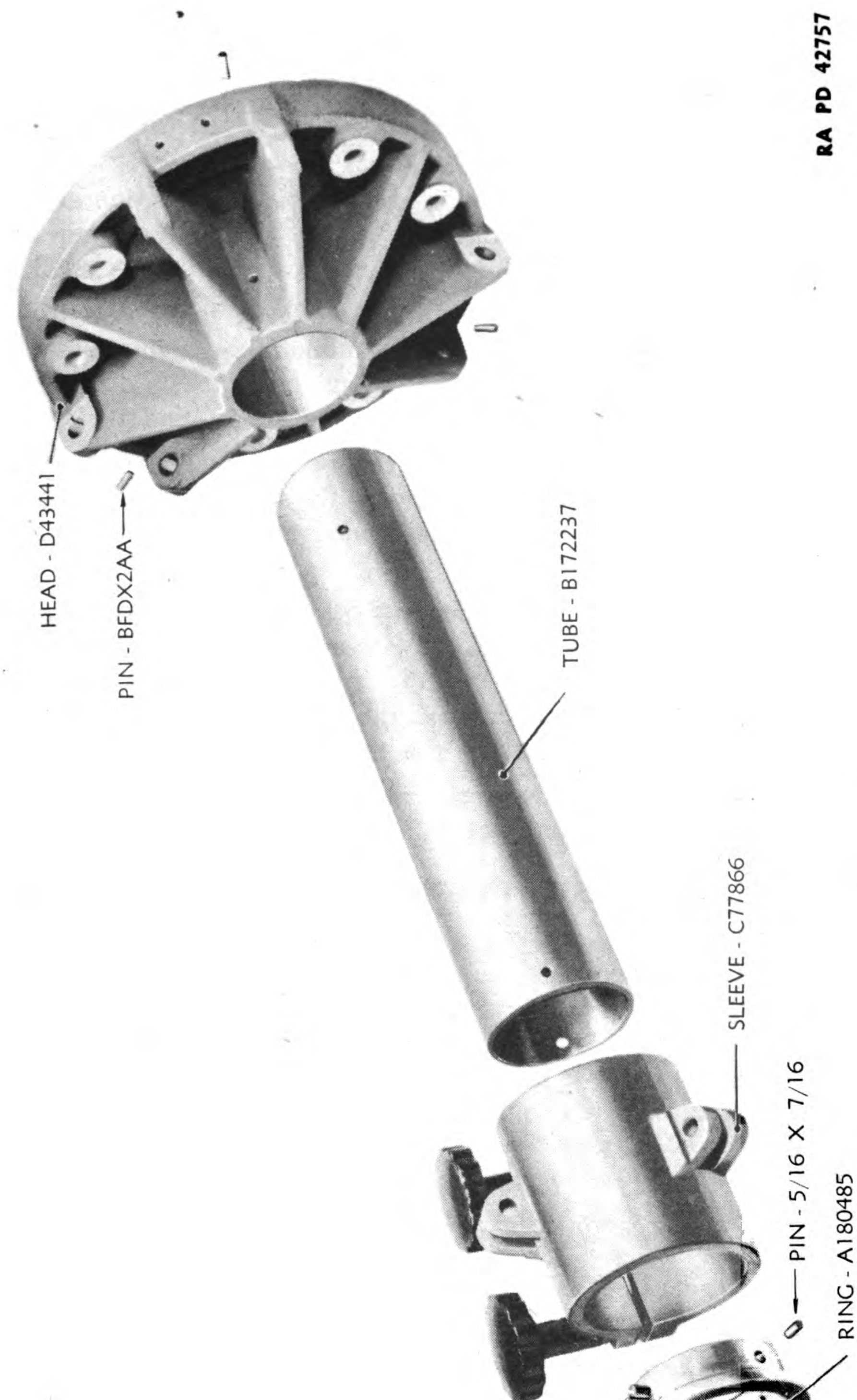

Figure 258 — Tripod Head and Sleeve Assembly — Exploded View

Section XIV

ILLUMINATION AND ELECTRICAL COMPONENTS — ADJUSTMENT AND REPAIR

206. INTRODUCTION.

a. The points of the height finder which receive illumination are: stereo reticles, internal targets, reticles of the two tracking telescopes, measuring drum scale, correction knob scale, and the transmitter dial.

b. In addition to the main junction box (fig. 259) just below the main eyepiece, another box is located on the under side of the cradle. This contains electrical accessories shown in (fig. 254). The diagram (fig. 260) shows the wiring arrangement for the height finder.

c. The need for adjustment arises if the two main reticle fields or the two internal target fields are not equally and uniformly illuminated, or if the reticle fields of the two elbow telescopes are not uniformly illuminated.

d. The electrical system of the height finder is so arranged that adjustment or repair does not involve exposure of any vital part of the instrument. None of the operations described in this section breaks the hermetic seal of the instrument, except the cleaning or replacing of the illumination rods at the main reticles.

e. Illumination adjustment is considered in paragraphs 207 to 210, and illumination failure in paragraph 211.

207. ILLUMINATION ADJUSTMENT OF INTERNAL TARGET SYSTEM.

a. The illumination in both target fields of the internal target system should be equal. The lamp assemblies concerned are on the main tube (front) on either side of the junction box (fig. 261). Since the internal target employs a double-ended collimator, the illumination of the reticle field as seen through the right eyepiece has its source at the left internal target bracket assembly. Likewise, the left eyepiece field is illuminated from the right internal target assembly. This should be remembered in making the following adjustments for equalizing illumination.

(1) Connect the height finder to proper electrical source.

(2) Turn light switch to number 2 position.

(3) Turn transformer-battery switch to "TRANS." if 110-volt power is used.

(4) Remove knurled lamp retainer ring A179909 (fig. 170) and withdraw the entire lamp socket assembly sufficiently to remove set screw BCLX4CT.

ILLUMINATION AND ELECTRICAL COMPONENTS — ADJUSTMENT AND REPAIR

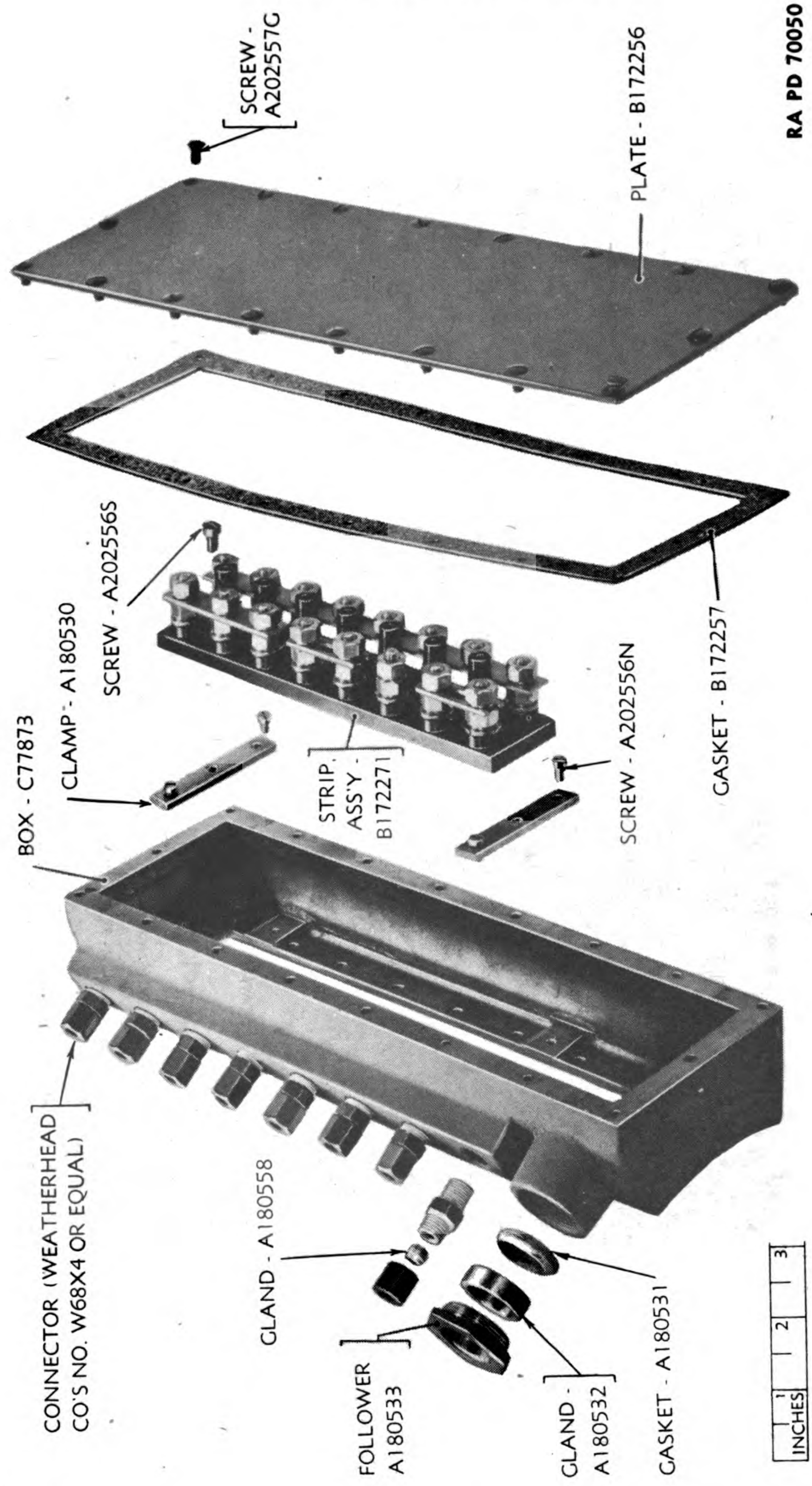

Figure 259 — Illumination Junction Box Assembly — Exploded View

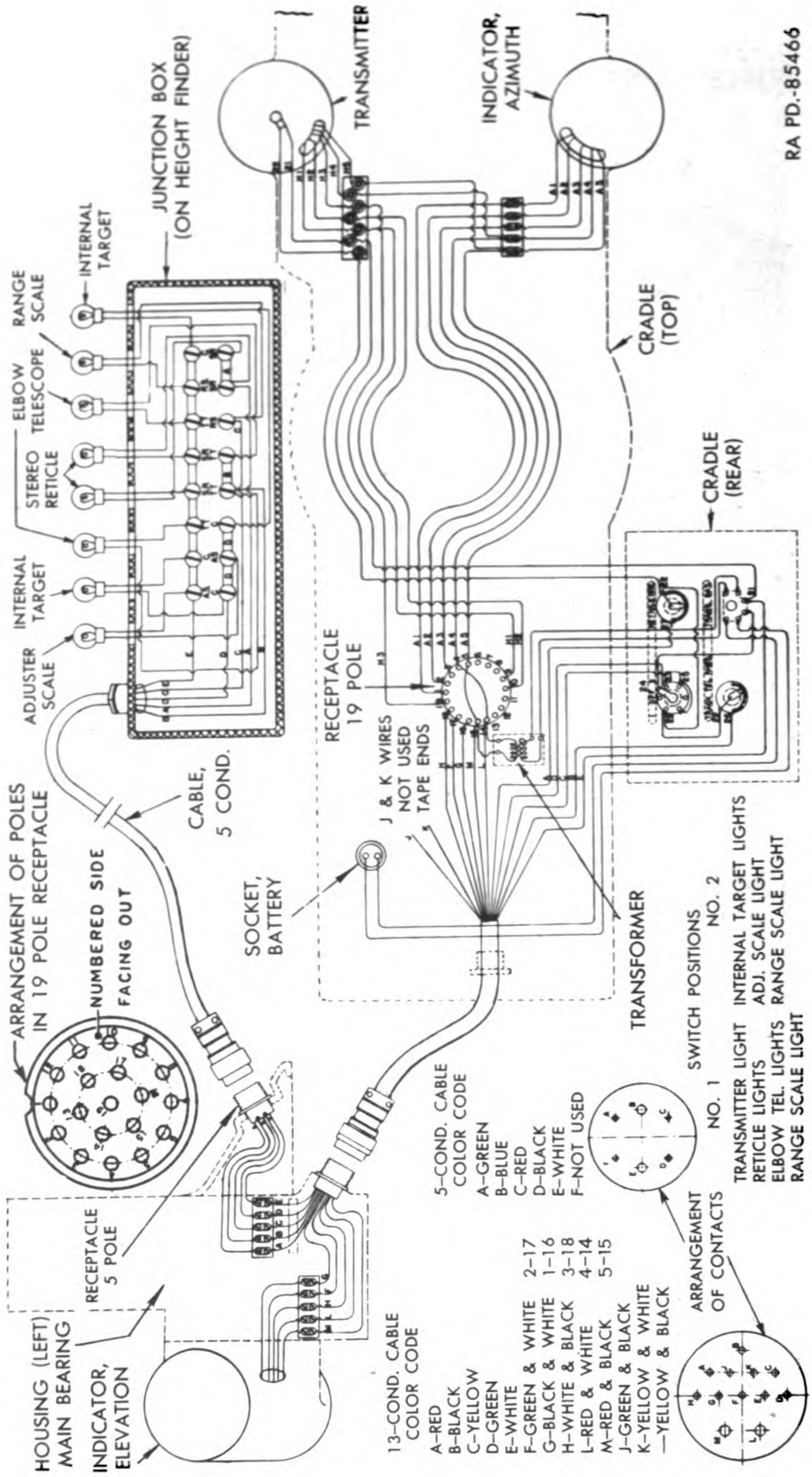

Figure 260 — Height Finder — Schematic Wiring Diagram

ILLUMINATION AND ELECTRICAL COMPONENTS — ADJUSTMENT AND REPAIR

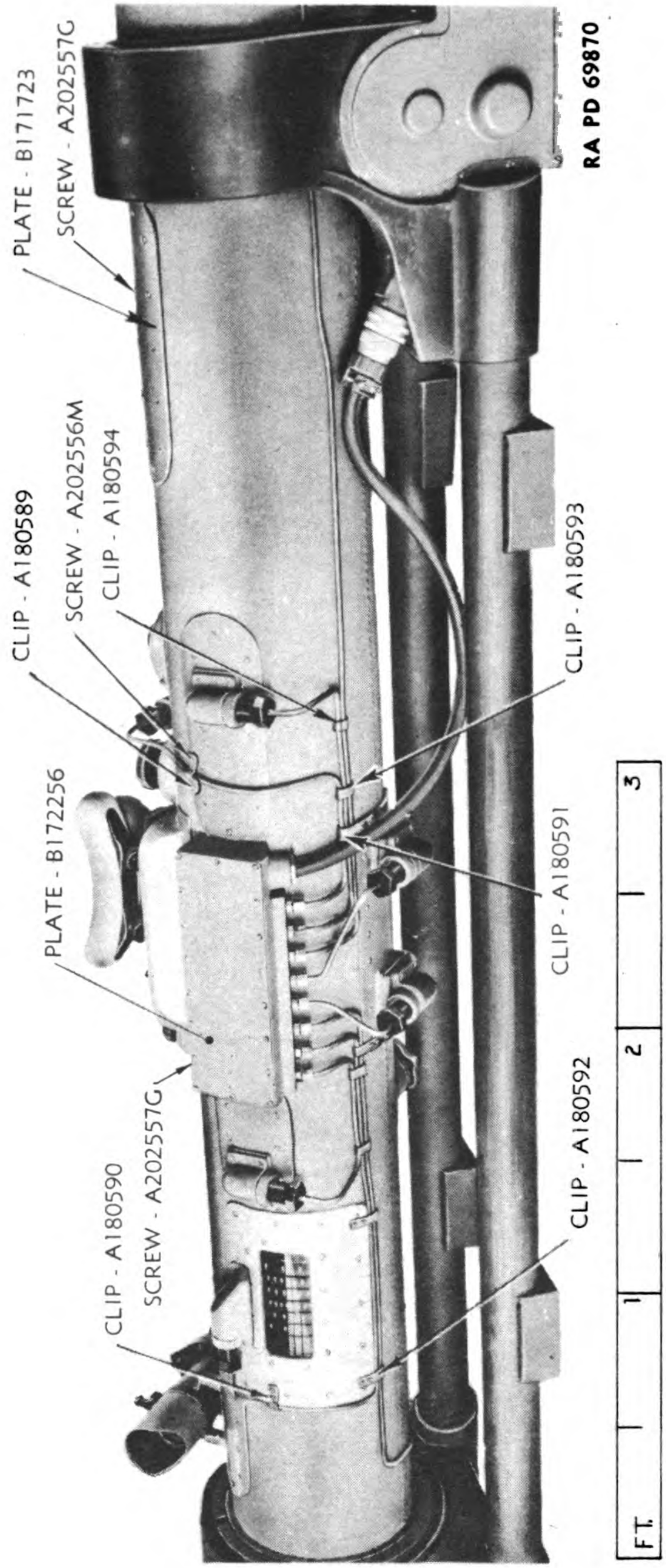

Figure 261 — Height Finder Telescope Showing Junction Box and Illumination Conduit — Front View

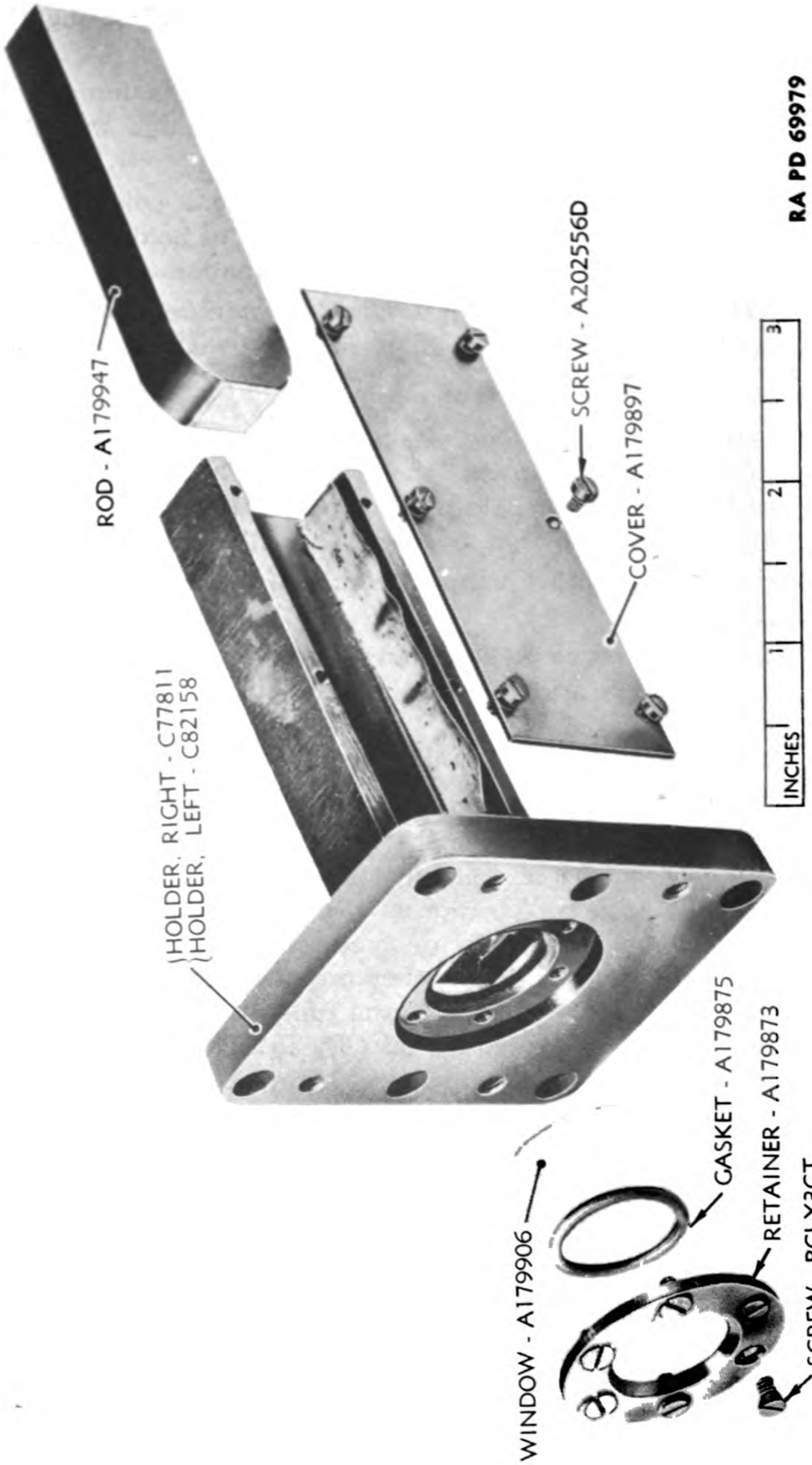

Figure 262 — Reticle Illuminator Rod and Holder — Exploded View

(5) The lamp socket should be pulled out or pushed in slightly, and illumination checked by successive trials.

(6) The correct position will be obtained when maximum brilliance is obtained in the target field as viewed through the main eyepiece.

(7) If the socket has been moved in the housing, it will be necessary to redrill and tap the socket for the set screw to hold the socket to the housing in proper position for best illumination.

NOTE: *If adjusting is done in daylight, it may be necessary to have the observer at the eyepiece cover his head with a dark cloth.*

b. To check the final setting of the lamps:

(1) Loosen the knurled lamp retainer ring A179909, and rotate the lamp housing A180529 so that the greatest light intensity is obtained at the internal target field as observed in the main eyepiece. The lamp filaments should then be parallel to illuminating window.

(2) Repeat for the other lamp assembly, if necessary, to obtain equal brightness.

(3) If the second reticle field cannot be brought to the brightness of the first, readjust the first for lesser illumination.

208. ILLUMINATION ADJUSTMENT OF MAIN RETICLES.

a. It is important that the two stereo reticles be equally illuminated, and that the illumination be centered in each field. The illumination in each field is dependent upon the position of the lamp for brightness, and upon the position of the reticle illumination rods A179947 (fig. 262). These rods are factory-adjusted for centering and will not require attention unless they are dirty or damaged. The lamp assemblies are on the outside of the tube at the center bottom side when the line of sight is horizontal (fig. 261). The reticle field illumination is dependent both upon the lamp adjustment and the adjustment of the illuminator rod below at the reticle mount. First, adjust the position of the lamp as outlined above. If satisfactory illumination cannot be obtained by lamp adjustment alone, it will be necessary to check the reticle illuminating rods, which requires the breaking of the seal of the instrument.

b. Adjust both lamps as described in subparagraph **a**, above.

c. Stereo Reticle Illuminator Rods. Since adjusting the reticle illuminating rods is a delicate job and requires breaking the hermetic seal of the instrument, it is best not to attempt this operation unless the illumination centering is very poor. Equal brightness can generally be obtained by lamp adjustment. If not, and the illuminator rods have to be checked, proceed as follows:

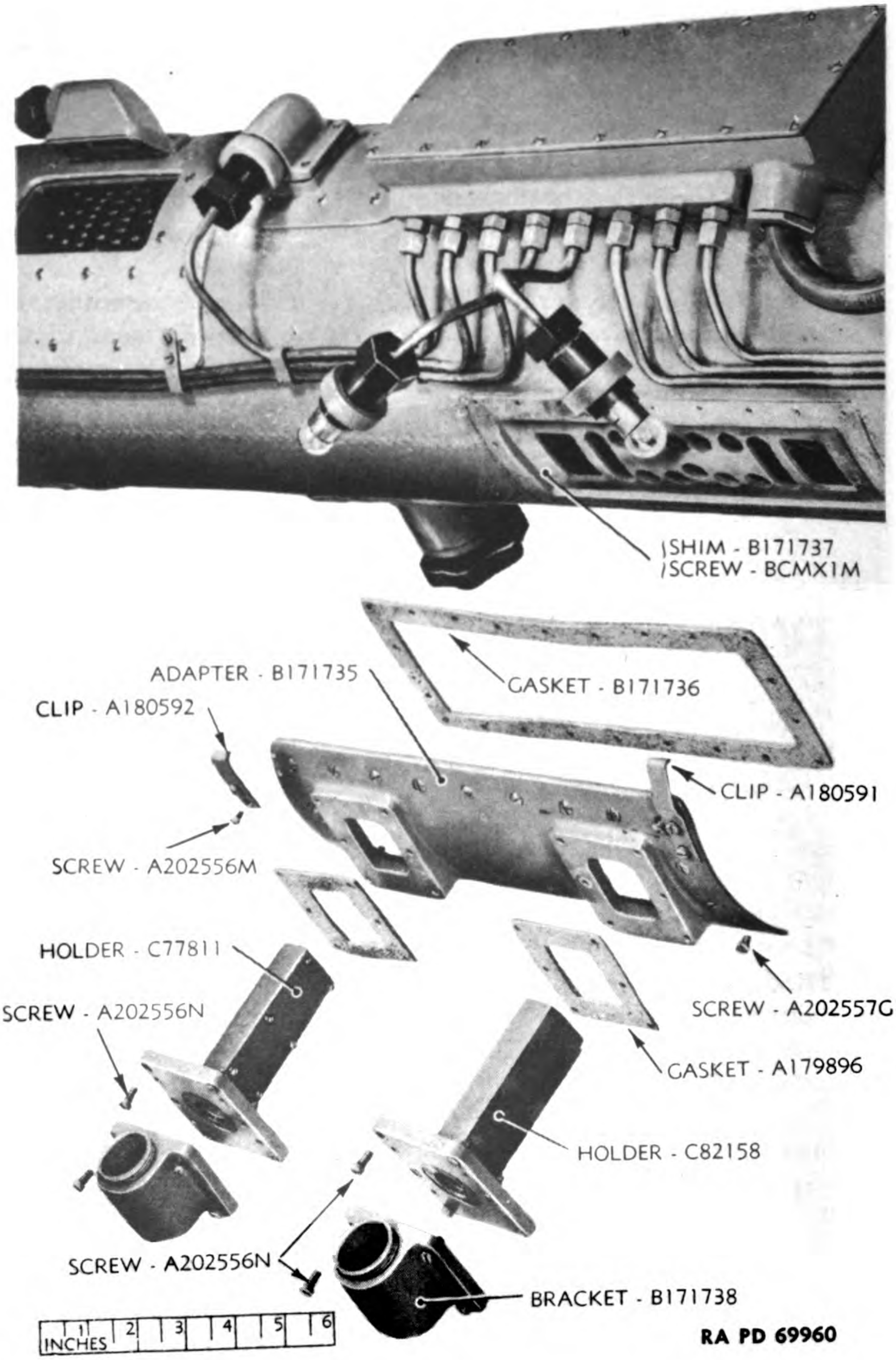

Figure 263 — Removing the Stereo Reticle Illuminators

(1) Remove the screws that hold the illuminator brackets B171738 (fig. 263), and swing the conduit slightly to get these units to one side out of the way.

(2) This allows the windows in the illuminator brackets and those in the holders C77811 and C82158 (fig. 263) to be cleaned.

(3) The screws in the holders should be removed and these units taken out of the adapter B171735 (fig. 263). Remove the screws and take off the adapter and gasket.

(4) Take off holder cover A179897 (fig. 261) and carefully remove the glass rod A179947. If this part requires replacement, make sure that it fits well up into holder at the rounded end by scraping the recess it fits into, if necessary.

(5) Examine the upper end of the holder that fits up into the opening in the under side of the optical bar to make sure this has not been striking. Bevel, if necessary, so that 1/8-inch clearance is obtained when the fine elevation knob is rotated from stop to stop.

(6) Carefully examine the illuminator rod for any imperfection and, if in good condition, carefully clean both unsilvered ends. Wipe off the inner surface of the holder window and replace the rod, making sure that the cork is all in place. Screw on the holder cover.

(7) Reach inside the tube opening and through the bottom of the optical tube and clean the exposed surface of the illuminator segments of the reticle (fig. 160) with the lens tissue on a cleaning stick.

(8) Replace the adapter B171735 and cover the gasket with sealing compound for height finders and screw down securely.

(9) Replace the holders and the illuminator brackets after coating the gaskets with sealing compound for height finders.

NOTE: *It will be observed that 6-candlepower lamps are used for stereo reticle illuminators in most height finders. It has been found that better results are obtained with these than with the 3-candlepower lamp.*

209. ILLUMINATION ADJUSTMENT OF CORRECTION KNOB SCALE.

a. Adjustment of illumination is accomplished by turning the lamp housing and sliding it back or forth in the lamp bracket, in the manner described previously, until the figures and index on the scale are well illuminated.

b. Illumination will be restricted on the correction knob scale if the cork gasket between the scale housing and lamp housing is not properly positioned.

210. ILLUMINATION ADJUSTMENT OF ELBOW TELESCOPES M13.

a. Illumination adjustment is accomplished by turning the lamp housing and sliding it back or forth in the lamp bracket in the manner described in paragraph 207 until the elbow telescope reticle is well illuminated.

b. If the above procedure does not give entirely satisfactory results, it may be found that the light has been cut off in the reticle cell housing. To correct this, proceed as follows:

(1) Loosen the lamp bracket and swing it out of the way.

(2) Look through the light opening in the plate B172265 (fig. 229) and see how much of the reticle glass is visible.

(3) If the opening is restricted, remove the plate A180328 and insert a pin through the clear opening and into the cell B171876. Rotate this cell until the proper area opening is obtained to get maximum illumination. NOTE: *This procedure will disturb the reticle alinement and will have to be finally adjusted* (par. 190).

(4) Replace plate and lamp housing.

211. ILLUMINATION FAILURE.

a. General. When connected to the proper line voltage with the main switch on, illumination failure can be traced to various elements of the electrical system. These elements are described in the following paragraphs and shown in the electrical wiring diagram (fig. 260). Spare lamps, lamp sockets, and screws are included in the accessories of the height finder.

b. Replacement of Lamps.

(1) If lamps are burned out, they can be replaced without breaking the hermetic seal of the instrument. Double contact lamps with bayonet sockets A35189 (Mazda number 82, 6-volt, 6-candlepower) are used at the stereo reticles. All the other lamps are number 64 6-volt, 3-candlepower.

(2) To replace the lamps at the stereo reticles or at the internal targets, unscrew the knurled socket retainer ring, take out the screws, and remove the illuminator bracket. After replacing the lamp, secure the bracket and replace the knurled ring.

NOTE: *On some of the later instruments, the screw holes in the internal target illuminator brackets have been slotted for adjustment.*

(3) To replace lamps at the measuring drum and correction knob, the illuminator brackets must be taken off. The knurled retaining ring should be unscrewed and the illuminator brackets removed back to reach the lamp. Remove the clips where necessary so as not to bend the conduit tubing.

ILLUMINATION AND ELECTRICAL COMPONENTS — ADJUSTMENT AND REPAIR

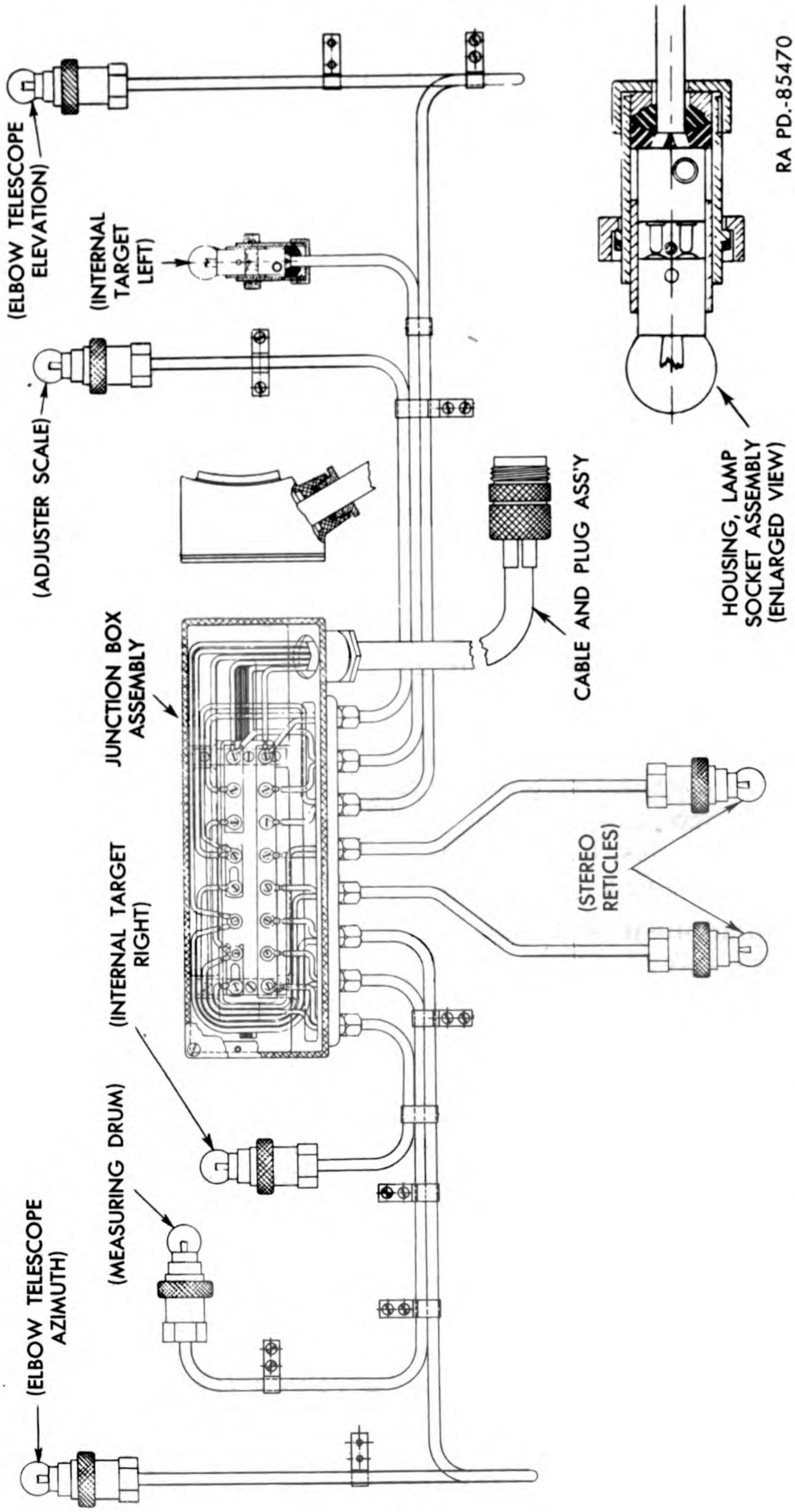

Figure 264 — Wiring Conduits and Junction Box on Height Finder

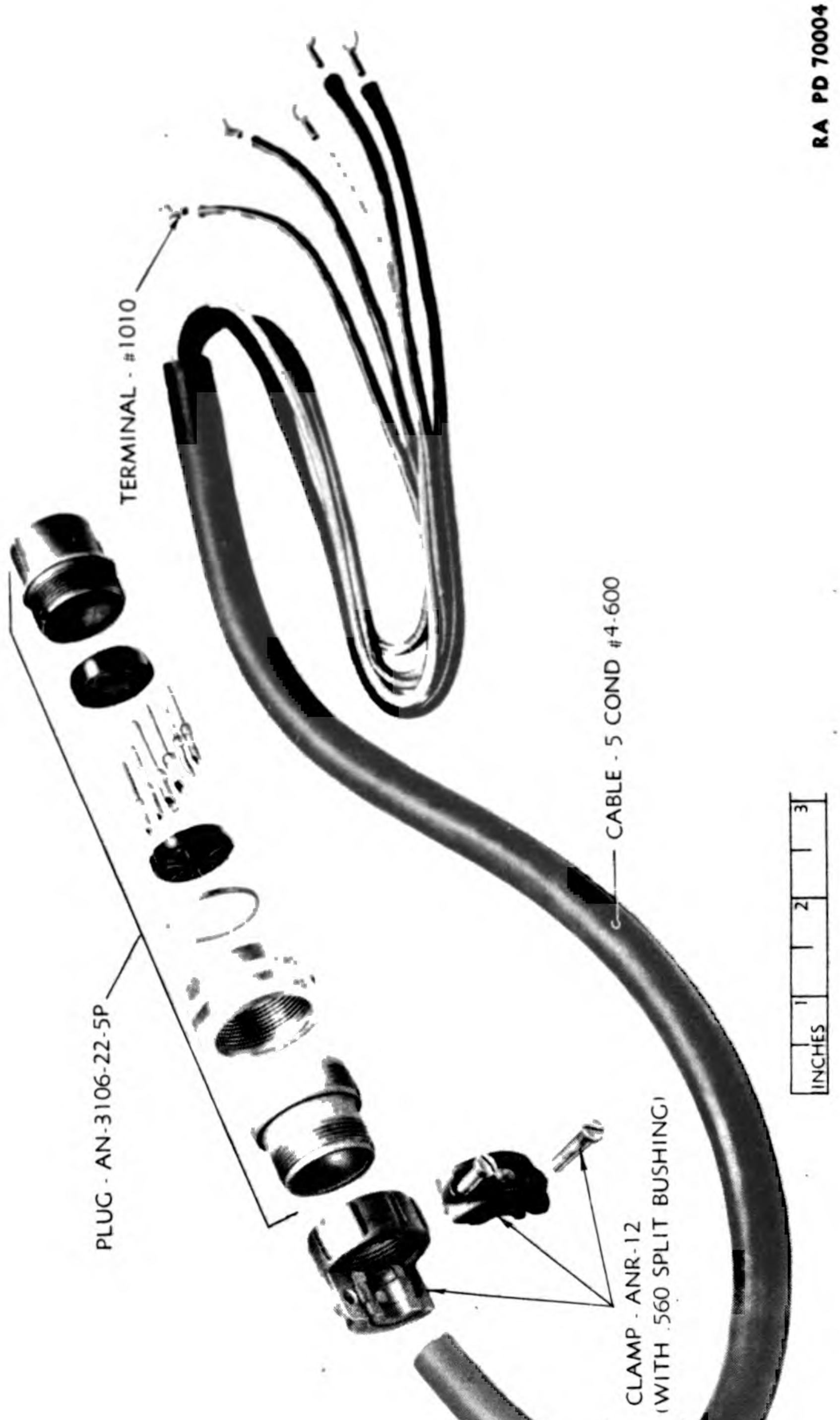

Figure 265 — 6-conductor Illumination Cable Assembly — Exploded View

ILLUMINATION AND ELECTRICAL COMPONENTS — ADJUSTMENT AND REPAIR

(4) The lamp at the transmitter dial can be reached by unscrewing the plug cover of the housing (fig. 246).

c. Height Finder Junction Box and Wiring.

(1) Defective wiring or connections should be checked, using a tester lamp or buzzer and referring to the wiring diagrams shown in figures 254, 260, 264, 265, and 266. Check for continuity and short circuits. Repair according to good electrical practice.

(2) Remove the cover of the junction box (fig. 264) and check the terminal connections of the lamp socket cables (fig. 264).

(3) Check the terminal connections of the cable and plug assembly.

(4) Check the lamp socket assemblies.

(5) If necessary, remove the follower, gasket, and housing of the socket assemblies (fig. 264) and make the required repairs or replacements.

(6) Seal and replace all covers removed in testing. The covers and gland followers should be watertight.

(7) If satisfactory illumination is not obtained in the internal target system, but both lamps are lit, a penta prism may be incorrectly positioned, and adjustment should be made as outlined in paragraph 155.

d. Cradle Junction Box.

(1) Details of the cradle junction box are shown in figure 254. Check for continuity and short circuits; repair where required as follows:

(2) Remove the cover screws and the cover plate C77857 of the junction box (fig. 254).

(3) Loosen the set screws and remove the four knobs, and the clamping nuts and washers of the illumination power switch and rheostats.

(4) If required, disconnect the lead wires at the soldered joints and repair or replace defective switch or rheostats.

(5) Remove, if necessary, the four securing screws, and take out the defective transformer and replace with a new one.

(6) Remove, if necessary, the four securing screws and take out the 19-pole receptacle assembly (fig. 254).

(7) Remove and replace, if necessary, the 13-conductor cable and plug assembly (fig. 254) from the cradle to the receptacle in the left support housing.

(8) Repair and reassemble according to good electrical practice. Instructions for soldering and taping of joints are given in subparagraph e, below.

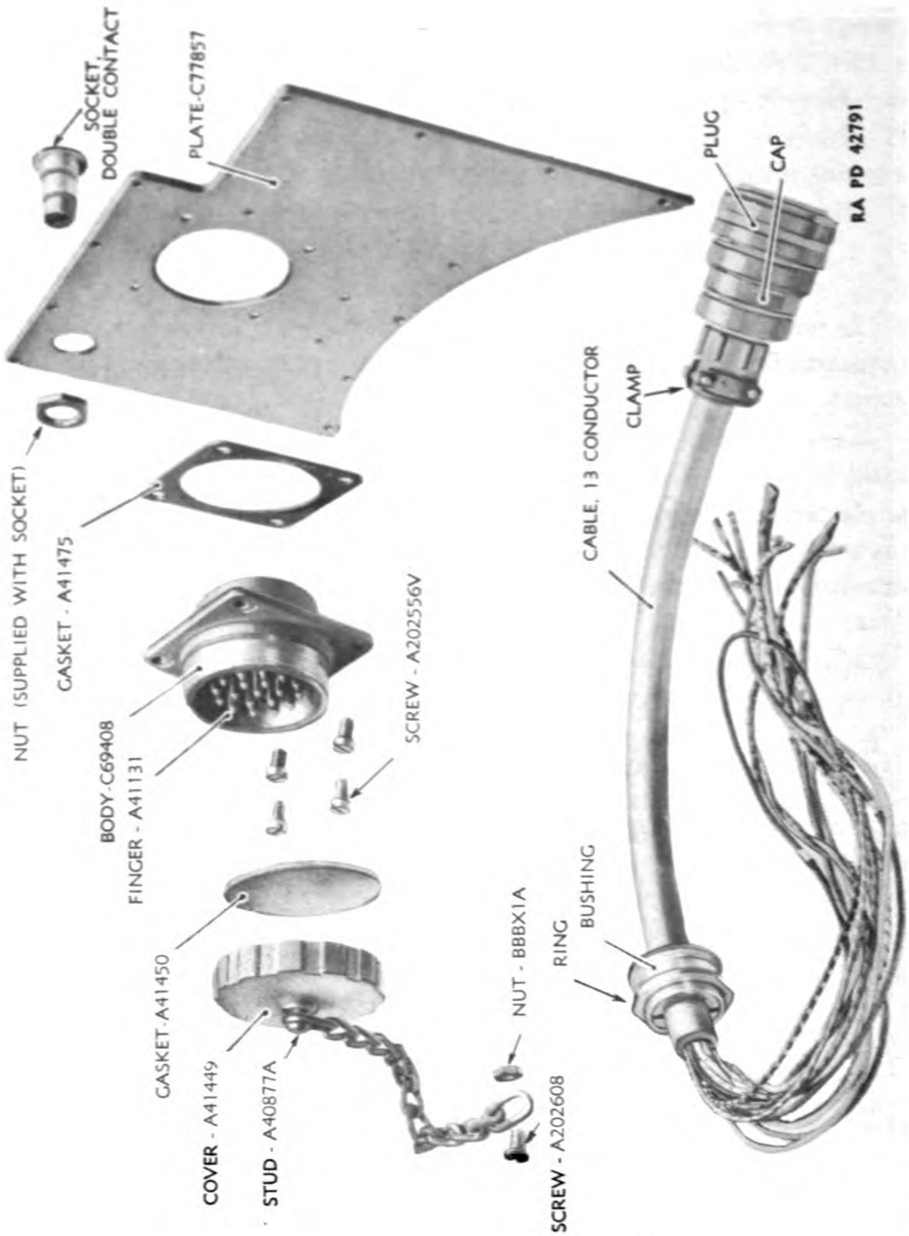

Figure 266 — Cradle Junction Box Plate Assembly and 13-conductor Cable Assembly

e. Soldering and Finishing Electrical Connections.

(1) Grade A solder (tin-lead) should be used.

(2) All lugs should have a hot-tinned finish, and the individually-tinned strands of wire should be twisted at the end, and tinned as a group, by dipping in rosin flux, and then in molten solder.

(3) After soldering, wash the joint very carefully with denatured alcohol to remove all traces of flux, and then coat with clear lacquer to prevent corrosion.

(4) Insulating rubber tape must be used where required, as black friction tape causes deterioration of the insulation. Bind all joints covered with insulating rubber tape with black friction tape.

212. SYNCHRONOUS UNITS — GENERAL.

a. General. The azimuth indicator, the elevation indicator, and the transmitter are adjusted so that dials indicate zero when the units are at electrical zero. This is a standardized reference position at which individual transmitters and repeaters are commonly set to permit maximum interchangeability between synchronous units. This position has been arbitrarily chosen as the position which the unit will assume when the electrical connections are made to an appropriate power source in a certain standardized pattern, the index there being set to read zero on its scale. Whenever a transmitter or repeater has been removed, or disassembly performed, such that the relationship between the motor and disk has been disturbed, it is essential that the synchronous unit be checked for its electrical zero position. The zero position of the dials corresponds to the electrical zero of the synchronous unit. To understand how this electrical zero position is established and its relation to the dials, the following information is outlined:

b. Explanation.

(1) All electric motors are composed of two basic parts: the rotor and the stator. In a synchronous unit, the rotor is wound with a bipolor-phase winding, and the stator is wound with a three-circuit distributed Y-connected winding. Electrically, the unit acts as a transformer. By transformer action, voltages are induced in the three sections of the stator winding. The voltages induced are dependent on the angular position of the rotor in relation to the fields of the stator. If two units are connected together (terminal "1" to "1," "2" to "2," "3" to "3") and one or both rotors are free to turn, the rotors will position themselves so that the induced voltages in both units will be the same. This will occur when both rotors assume the same position in relation to their stators. If one rotor is displaced in relation to the other rotor, their induced voltages will not be the same, and a

flow of current will start in the windings of the stators. This will cause an electro-magnetic field to be built up in the stator, and this magnetic field will react with the magnetic field of the rotors, thereby building up a torque between the rotor and the stator and causing the two units to aline themselves. If the two rotors have an angular displacement of more than 25 degrees for more than a short period of time, the current flow in the stator windings will be high enough to damage the unit due to overheating. The current flow to the rotors of the two units is approximately four times as great at 180-degree angular displacement as it is when the two units are synchronized.

(2) The secondary current flow is zero when the two units are synchronized. When there is an angular displacement, current starts to flow. The greater the angular displacement, the greater will be the flow of current per degree of displacement. The torque developed in the units is nearly proportionate to the angular displacement. It reaches its maximum at 120-degree angular displacement, and then starts to drop until the angular displacement is 180 degrees where the torque developed is zero.

(3) Electrical zero is when the axis of the winding of the rotor is at right angles to the axis of the winding of the field between terminals number "1" and "3." When the rotor of the unit is at electrical zero, there is no induced voltage in fields "1" and "3." This condition also exists at 180 degrees so, to determine the electrical zero from the electrical 180 degrees, proceed as described in paragraph 213.

213. SYNCHRONOUS UNITS—METHOD OF SETTING ELECTRICAL ZERO.

a. Connect terminals number "1," "3," and "5" together, and terminals number "2" and "4" together, then apply power to terminals number "4" and "5." The rotor will then center itself at the electrical zero, due to the fact that the current flow in fields "2" and "3," and "1" and "2," will cause a magnetic field to be built up in the stator which reacts with the magnetic field of the rotor. The magnetic pole of the rotor that is opposite in polarity to the polarity of the center of the two fields will aline itself so it is centered between fields "1" and "2" and fields "2" and "3" and, therefore, at right angles to fields "1" and "3."

NOTE: *When a synchronous unit is electrically zeroed by means of wires connecting terminals number "1"-"3"-"5" and a wire between terminals number "2" and "4," power will be connected for only short periods to prevent overheating and damage to the unit.*

b. With a voltmeter connected to terminals number "1" and "3," and power connected to terminals number "4" and "5," turn either the rotor or stator until the voltmeter reads zero. The unit is then at either the electrical zero or 180 degrees out of electrical zero. Then connect terminals number "1" and "5" and, with power across terminals number "4" and "5," a voltmeter is connected to terminals number "3" and "4." The rotor is then turned in a clockwise direction and, if the voltage decreases, the unit was at the electrical zero. If the voltage increases, the unit was 180 degrees out of electrical zero position. This is due to the fact that the rotor winding and the stator winding of field "1"-"3" are connected in series. Therefore, at 180 degrees from electrical zero, if the rotor is turned clockwise, the induced voltage in the stator winding is in phase with the rotor voltage, and the two voltages add up. At electrical zero, however, if the rotor is turned clockwise, the voltage of the stator and the voltage of the rotor are 180 degrees out of phase, and the stator voltage subtracts from the rotor voltage. The more sensitive a voltmeter is, the more accurate the setting of the electrical zero will be. NOTE: *To prevent overloading a voltmeter, a meter reading higher than the maximum induced voltage must be used first, and the rotor turned until the voltage is below the maximum voltage capacity of the low voltage scale, before connecting to a more sensitive voltmeter.*

c. When the electrical zero position of either the transmitter or the receiver has been established, the dials should be set to correspond with this position.

214. SYNCHRONOUS UNITS — ELECTRICAL ZERO.

a. Azimuth and Elevation Indicators.

(1) The quickest method of electrically zeroing the height finder indicator units is by comparison with an electrical testing instrument for the height finder, or with an antiaircraft director in which the synchronous units have been adjusted in accordance with standard procedure. Any angular position or motion of these standard units should be reproduced on the height finder units. For operation, the 19-pole receptacle on the cradle and the testing instrument are electrically connected by means of a 20-conductor cable, while 115-volt, 60-cycle, a-c power is applied to the testing instrument.

(2) In the absence of a testing instrument, the azimuth and elevation indicators can be electrically zeroed as follows: Connect the terminals of the unit marked "1," "3," and "5" to one side of a 115-volt, 60-cycle, a-c power supply, and the terminal marked "2" and "4" to the other side. When the power circuit is energized, the rotor, if unrestrained, will assume a position within a few tenths of a degree to that defined as the electrical zero position. NOTE: *To avoid disconnecting the cradle wiring, the connections can be made through the 19-pole receptacle by the use of small metal fingers to grip the receptacle prongs. Numbered connections to the receptacle are shown in figure 260.*

(3) To find the electrical zero of the elevation indicator:

(a) Connect terminals "14" and "15" to source of power.

(b) Connect terminals "17" to "14."

(c) Connect terminals "16" and "18" to "15."

(d) Turn power on, and rotor will assume 180 degrees or zero position.

(e) To find zero position, turn off power and mechanically rotate rotor.

(f) Disconnect terminal "17" from terminal "14."

(g) Turn on power, and rotor will assume fixed position.

(h) Connect terminal "17" to terminal "14." If rotor does not jump 180 degrees, the zero position is established. If rotor jumps 180 degrees, the new position of rotor is electrical zero.

b. Transmitter.

(1) To check the electrical zero of the height transmitter when testing fixture or director is not available, electrical zero the azimuth indicator in the manner described under paragraphs 212 and 213.

(2) As the power leads of the azimuth indicator and height transmitter are identical, use the azimuth indicator for testing the transmitter.

(3) Connect terminals "9" to terminal "1," terminal "10" to "2," terminal "19" to terminal "3," and turn power on.

(4) The rotor of the azimuth indicator will move as the height transmitter knob is rotated.

(5) Zero position of transmitter must correspond to zero of azimuth indicator.

(6) Corrections to the transmitter may be made by loosening large-headed nut holding the transmitter center dial, and by tightening the nut when the index and dial are alined at zero. NOTE: *The height correction scale should be set at zero while making this adjustment.*

Section XV

ELECTRIC COVER M405

215. DESCRIPTION.

a. The Electric Cover M405 for the Height Finder M2 is intended to protect and keep the operating mechanisms of the instrument warm enough to function properly in low ambient temperatures. They are issued to units located in climates where temperatures below –15° F may be normally expected. The covers are not necessary in other climates.

b. Each section and piece bears a label which identifies the part. All flaps on the sections are marked relative to the various height finder dials and controls obscured by them. For detailed description of each section, refer to TM 9-624.

c. The heated cover sections are designed to operate on 115-volt, a-c or d-c power supply. Normally they will operate on power supplied to the height finder to energize the data transmission system. The power take-off adapter which is inserted between the main power cable and the 19-pole cradle receptacle furnishes an outlet for connecting the cover.

216. VISUAL INSPECTION.

a. **General.** With all cover sections applied to the height finder and all flaps securely closed, check for over-all fit and general condition. Each cover section should fit snugly. Cover sections which are cut, torn, ripped, unduly stretched, or otherwise mishandled may require minor repairs or replacement in order to avoid excessive heat loss, and to provide maximum protection.

b. **Electrical Data.** The four heated cover sections are connected in parallel and should be tested occasionally for proper electrical operation, and as a check on the heating wires, thermostats, terminal boxes, and connecting cords. An ammeter, voltmeter, and a 110-volt test lamp set can be used for this purpose. The proper electrical values are shown in the following table:

	Volts	Watts Input	Amperes	Ohms Resistance
Complete cover	110	1,279	11.52	9.54
Left tube section	110	192	1.75	63
Right tube section	110	192	1.75	63
Center tube section	110	175	1.6	69.3
Cradle section	110	720	6.54	16.8

NOTE: *Values given are average. Actual readings on individual covers may vary from plus or minus 5 percent for ohms resistance to plus or minus 10 percent for watts input.*

217. OPERATIONAL INSPECTION.

a. To check the operation of the cover, be sure all four heated cover sections are properly connected, and that the thermostat contacts are closed, or the thermostats shorted out of the circuits at the thermostat terminal blocks. (All thermostat contacts should be closed at temperatures below 32° F (0° C).)

b. Complete Cover.

(1) With the cover properly connected to 110-volt, a-c power supply, and the switch on the power adapter at the on position, check the operation of the complete cover, using a voltmeter, ammeter, and test lamp. The heated cover sections are connected in parallel. If the electrical readings are not as shown in the data table, one or more cover sections, a connecting cord, or a thermostat may be at fault. In such a case, each heated cover section should be checked individually to determine the location or cause of the trouble. The value of the electrical readings will be some indication of the probable cover section at fault. If no reading is recorded on the ammeter at the main power cord, either the power supply or power adapter is at fault or the connecting cord is open-circuited. Use a test lamp to check as follows:

(2) First, disconnect the cord from the power adapter and plug the test lamp into the receptacle on the power adapter. If the lamp does not light, either the power supply has failed or an open circuit exists in the adapter, due to broken or burned wiring or failure of the switch or outlet.

(3) If the lamp lights, check the main connecting cord. Remove the cover plate from the terminal box to which the cord is connected and, with the cord plugged into the adapter, check the test lamp across the terminals of the connecting cord. If the lamp does not light, the cord should be repaired or replaced.

c. Individual Cover Sections.

(1) Each cover section may be connected individually to a 110-volt power supply to check its operation. The electrical values for each section are given in the data table in paragraph 216 **b**.

(2) Remove the terminal box cover to which the connecting cord is connected. With the cord plugged into a source of 110-volt power, check with a test lamp across the terminals of the connecting cord. If the lamp fails to light, the connecting cord should be repaired or replaced.

(3) Remove the cover from the thermostat terminal box. Short out the thermostats from the circuit by placing a jumper wire across the leads of the thermostats. Plug the cover into 115-volt power supply, with an ammeter in the circuit. If no current is registered, the heating element is probably open-circuited. Do not attempt to repair a wire or wires in the wired insert. A repaired or soldered joint is not dependable.

d. Operational Thermostat.

(1) The operational thermostats for the three tube sections of the cover are set to maintain a temperature of 36° F (2.2° C) ± 3° F (± 1.7° C), and should not have a differential of more than 1° F

(0.56° C). The operational thermostat for the cradle section is set to maintain a temperature of 38° F (3.3° C) ± 5° F (± 2.8° C), and should not have a differential of more than 5° F (2.8° C).

(2) To check the thermostats, first be sure the temperature of the thermostat is below 32° F (0° C) to insure that the contacts should be closed. With ammeter in the circuit, plug the cord of the cover section into a 110-volt outlet and check the meter reading. If no current is registered, either the contacts of the operational or safety thermostat are open, or the heating element is open-circuited. (Short both thermostats out of the circuit at the thermostat terminal box, to check the heating element.) Place a jumper across the safety thermostat leads at the thermostat terminal box to short it out of the circuit. If the heating element is all right and no current flow is recorded on the ammeter when the safety thermostat is shorted out, the operational thermostat is inoperative and should be replaced.

(3) To check the opening of the contacts, with the safety thermostat shorted out, raise the temperature of the operational thermostat 3° to 5° F, as the case may be, and check the ammeter. Replace any thermostat that does not operate with the limits given.

e. The safety thermostats limit the maximum temperature of the cover and, since they are set much higher, act only to prevent extreme overheating in the event the operational thermostat fails to open. The safety thermostats are set to open at a maximum temperature of 95° F (35° C), and to close at a minimum temperature of 55° F (12.8° C). To check, first be sure the temperature of the safety thermostat is below 55° F to insure that the contacts should be closed. Check as for the operational thermostats. First be sure the heating element is all right. Place a jumper across the terminals of the operational thermostat at the terminal box to short it out of the circuit. If no current is recorded on the ammeter, the safety thermostat is probably inoperative and should be replaced. To check the opening of the contacts, raise the temperature of the safety thermostat up to 95° F (35° C). When the contacts open, no current will be recorded on the ammeter. Replace any safety thermostat that fails to close at 55° F (12.8° C) or to open at 95° F (35° C).

218. MAINTENANCE AND REPAIR — MECHANICAL.

a. Repair of Torn Cover. If the quilted material (outer shell) or the hydrovised sateen material (inner shell) of the cover becomes torn, hand sewing is sufficient to repair a straight tear, cut, or slit, provided the ends are back-sewn for one-half inch and securely fastened. The thread used for the outer shell is 3-cord, olive-drab, soft-finish, cotton, machine, thread number 40, inner shell number 20. If the tear is jagged, a patch sufficient in size should be sewn over it.

NOTE: *In order to prevent further deterioration of cover and the penetration of moisture, be sure to apply a generous coating of canvas leggings and duck, treating compound, to the repaired area, so that it is completely sealed.*

b. Replacement of Cord Locks or Hooks.

(1) All cord locks and hooks are riveted through the outer shell and to a textolite backing plate. These may be replaced by hand sewing through the entire cover. Be careful to avoid the wires in the wired lining insert (heating element).

(2) To rivet, insert the two rivets and position the hook on the section with the rivets protruding through the cover. Turn this assembly over onto a solid metal block which acts as a bucking bar. Place the textolite back plate on the rivets and head them over.

c. Replacement of Grommets. To replace a grommet, use a hole cutter and attaching tools. First, repair the old hole with a suitable patch on both sides and be sure to apply a coating of canvas leggings and duck treating compound. Cut a new hole through the entire cover adjacent to the old one, being careful to avoid the wires in the wired lining insert. Apply the steel grommet.

d. Replacement of Spring Lever Buckles and Turn Button Fasteners.

(1) Spring lever buckles are first attached to a piece of web strap. To replace, correctly position both parts of the buckle on the cover, and hand-sew the web straps through the entire cover section. Care should be exercised to avoid piercing any wire or wires in the wired lining insert.

(2) The turn-button fasteners consist of an eyelet with a washer and a stud with a washer. To replace a turn-button fastener, use an attaching tool number 450 (A198) for the eyelet, and number 171 for the stud, from the United Carr Fastener Co., Cambridge, Mass. If the cover is torn, it should be repaired as described in subparagraph **a**, above, before the new fastener is applied.

(3) Position the eyelet on the outside of the cover and use the attaching tool to cut the center hole and the slits for the four prongs through the entire cover. Apply the eyelet, pushing the prongs through the slits in the cover. Lay the washer inside the four projecting prongs, tight against the inner shell of the cover, and bend the prongs over.

(4) Position the stud on the outside of the cover and use the attaching tool to cut the slits for the two prongs through the entire cover. Lay the washer between the two prongs, tight against the inner shell of the cover, and bend the prongs over. NOTE: *Care should be used to avoid piercing or cutting any wire or wires in the wired lining insert.*

219. MAINTENANCE AND REPAIR — ELECTRICAL.

a. Replacement of Connecting Cord. A connecting cord or a terminal box cover plate may be replaced as follows: Take out the screws holding the cover plate in place, and unsolder and unscrew the connecting cord leads from the bus bar. Apply the new cord assembly by unsoldering the leads and placing the strain relief on the cord inside the terminal box. Replace the terminal box cover plate to the base with the five screws.

b. Replacement of Operational Thermostats.

(1) The thermostat housing is securely attached to the inner surface of the cover section to make intimate contact with the height finder. If the thermostat proves erratic or becomes inoperative, replace as follows.

(2) Remove the stitching along one side of the leather attachment piece which holds the thermostat assembly to the inner shell and which is riveted to the thermostat housing.

(3) Unscrew the terminal box cover plate and cut the threads which bar-tack the thermostat wires to the cover section. It may be necessary to make a slit in the inner shell to facilitate removal and reinsertion of the thermostat leads to the terminal box.

(4) Remove the textolite cover plate from the thermostat housing. Apply enough heat to the housing to melt the zophor wax and pull out the thermostat subassembly with the lead wires attached. CAUTION: *Be sure to protect the fabric of the cover section around the housing with several thicknesses of asbestos paper, or similar material, against excessive heat or burning.*

(5) Insert the new thermostat subassembly and pour in melted zophor wax around the thermostat in order to completely seal it.

(6) Replace the textolite cover plate and bring the wires through the cover section to the terminal box. Bar-tack the wires to the cover section by hand sewing. If slit in the inner shell has been made, resew and coat with canvas leggings and duck treating compound.

(7) Screw and solder the wires to bus bar in terminal box, and replace the cover plate.

(8) Resew the leather attachment piece of the thermostat housing to the inner shell.

c. Replacement of Safety Thermostats.

(1) The safety thermostat is located in a pocket of cotton material which holds the assembly to the inner lining near or adjacent to the thermostat terminal box. Cut a slit in the inner lining of the cover section to expose the thermostat pocket.

(2) Cut the threads which bar-tack the thermostat lead wires to the cover section. Cut the threads on one side of the pocket which contains the thermostat and remove the complete assembly.

(3) Replace the defective thermostat assembly with a Spencer No. C-2851 from the Spencer Thermostat Company, Attleboro, Massachusetts.

(4) Resew the wires to the wiring insert up to the terminal box.

(5) Screw and solder the thermostat wires to bus bar in terminal box, and sew the thermostat pocket closed.

(6) Resew slit which was made in the inner lining of the cover section and coat with canvas leggings and duck treating compound.

d. Replacement of Terminal Box.

(1) To replace a terminal box, first remove the textolite cover plate. Unsolder and unscrew all wires from the bus bars. Untie the strain relief knots and free everything which might interfere with the removal of the wire leads.

(2) Slit the inner shell over the textolite back plate of terminal box, exposing it.

(3) Pull all wires through the back of the terminal box. CAUTION: *Note position of each wire for replacement.*

(4) Break off the textolite back plate, separating it from the base plate of the terminal box.

(5) With a pair of heavy wire cutters, clip off the mushroom end of the rivets and remove the base plate from the cover section.

(6) To replace,, position the new terminal box in the same location as the old.

(7) Insert three number 540 hexagonal nuts in the recess provided on the under side of the base plate. NOTE: *It will be necessary to hold these nuts in place with beeswax.*

(8) Insert the five rivets on top of the base plate.

(9) Position the base plate on the section in the same position, with the rivets protruding through the cover.

(10) Turn this assembly over onto a solid metal block which acts as a bucking bar. Place the textolite back plate on the rivets and head them over.

(11) Reinsert the wires as before, screw and solder all connections, wash soldered joints with denatured alcohol, and apply clear lacquer.

(12) Apply a coating of canvas leggings and duck treating compound over the entire top surface of the base plate.

(13) Replace the textolite cover plate of the terminal box with the three screws provided.

(14) Resew the slip in the inner lining and coat with canvas leggings and duck treating compound.

e. Power Adapter. No attempt should be made to repair the power adapter. It should be replaced as a complete assembly (number D-82646).

Section XVI

REFERENCES

220. PUBLICATIONS INDEXES.

The following publications indexes should be consulted frequently for latest changes or revisions of references given in this section and for new publications relating to materiel covered in this manual:

a.	Introduction to Ordnance Catalog (explaining SNL system)	ASF Cat. ORD 1 IOC
b.	Index (index to SNL's)	ASF Cat. ORD 2 OPSI
c.	Index to Ordnance Publications (listing FM's, TM's, TC's, and TB's of interest to Ordnance personnel, OPSR, FSMWO's, BSD, S of SR's, OSSC's, and OFSB's, and including alphabetical listing of Ordnance major items with publications pertaining thereto)	OFSB 1-1
d.	List of Publications for Training (listing MR's, MTP's, FM's, TM's, TR's, TB's, MWO's, SB's, WDLO's, and FT's)	FM 21-6
e.	List of Training Films, Film Strips, and Film Bulletins (listing TF's, FS's, and FB's by serial number and subject)	FM 21-7
f.	Military Training Aids (listing graphic training aids, models, devices and displays)	FM 21-8

221. STANDARD NOMENCLATURE LISTS.

a.	Cleaning, preserving and lubricating materials; recoil fluids, special oils, and miscellaneous related items ORD 5	SNL K-1
b.	Director, A.A., M4 and M7	SNL F-167
c.	Director, A.A., M9 and M10	SNL F-243
d.	Finder, height 13½-ft., M2	SNL F-189
e.	Harbor defense, railway and antiaircraft artillery sighting equipment and fire control instruments ORD 3	SNL F-2
f.	Major items of antiaircraft artillery ORD 3	SNL D-2
g.	System, cable, M3	SNL F-244
h.	System, remote control, M2	SNL F-207
i.	Telescope, elbow, M17	SNL F-231

j. Tester, stereoscopic, M1 and M1A1	SNL F-168
k. Tool-sets for maintenance of sighting and fire control equipment	SNL F-272
l. Trainer, stereoscopic, M1	SNL F-144
m. Trainer, stereoscopic, M6 and M7	SNL F-193

222. EXPLANATORY PUBLICATIONS.

a. Fire Control Materiel.

Antiaircraft artillery:	
Service of height finders M1 and M2	FM 4-142
Directors M7, M7A1B1, and M7A1B2	TM 9-658
Directors M9 and M10	TM 9-671
Height finder, 13½-ft., M2 and M2A1	TM 9-624
Instruction guide: Director M4	TM 9-2655
Instruction guide: Director M7	TM 9-2658
Instruction guide: Instrument repairman	TM 9-2602
Ordnance maintenance: Director M4	TM 9-1655
Ordnance maintenance: Director M7	TM 9-1658
Ordnance maintenance: Desiccation and helium charging of height finders	TM 9-1622
Ordnance maintenance: Remote control system M2	TM 9-1642
Stereoscopic range and height finding	TM 4-250

b. Gun Materiel.

4.7-inch gun M1 and 4.7-inch antiaircraft gun mount M1	TM 9-380
90-mm antiaircraft gun materiel M1 and M1A1	TM 9-370
90-mm gun M2 and 90-mm antiaircraft gun mount M2	TM 9-372
Antiaircraft artillery: 90-mm antiaircraft gun on M1A1 mount	FM 4-126
Antiaircraft artillery: Formations and inspections	FM 4-120
Antiaircraft artillery: Gunnery	FM 4-110
Antiaircraft artillery: Organization and tactics	FM 4-100

c. Lubrication.

Cleaning, preserving, sealing, lubricating and related materials issued for Ordnance materiel	TM 9-850

d. Miscellaneous.

Decontamination	TM 3-220
Defense against chemical attack	FM 21-40

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