TM 9-1623

WAR DEPARTMENT TECHNICAL MANUAL

ORDNANCE MAINTENANCE

Height Finders, 13½-Ft., M1 and M1A1

RESTRICTED DISSEMINATION OF RESTRICTED MATTER—The information contained in restricted documents and the essential characteristics of restricted materiel may be given to any person known to be in the service of the United States and to persons of undoubted loyalty and discretion who are cooperating in Government work, but will not be communicated to the public or to the press except by authorized military public relations agencies. (See also paragraph 18 b, AR 380-5, 28 September 1942.)

WAR DEPARTMENT • 27 NOVEMBER 1943

FOR ORDNANCE PERSONNEL ONLY

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*** This manual supersedes TM 9-1623, dated 1 August 1942, and such portions of TB 1623-4, 1624-4, dated 2 August 1943 as pertain to Height Finder M1.**

WAR DEPARTMENT
Washington 25, D. C., 27 November 1943

TM 9-1623, Ordnance Maintenance: Height Finders, 13½-ft., M1 and M1A1, is published for the information and guidance of all concerned.

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G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
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Major General,
The Adjutant General.

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

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Section I

INTRODUCTION

Paragraph
General 1

1. GENERAL.

a. Purpose.

(1) This manual is published for the information and guidance of ordnance maintenance personnel. The list of requirements in each paragraph on adjustment and repair shows whether or not the operation is possible with the means at hand. No operation should be undertaken unless duly authorized.

(2) This manual is supplementary to TM 9-623, which should be consulted for information on operation, adjustment, and maintenance normally performed by the using arms.

b. Scope.

(1) This manual covers the description, principles, inspection, adjustment and repair, disassembly, and assembly of the 13½-ft. Height Finder M1. The 13½-ft. Height Finder M1A1 is identical with the Height Finder M1 except that it also includes the helium retention device. The operations described in this manual may be performed by authorized ordnance personnel only, with the exception of certain field adjustments and inspections.

(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 locally.

c. Changes from Previous Edition. The present edition differs from the previous edition of this manual chiefly in the inclusion of much additional information and in the presentation of improved methods of adjustment and repair. Of particular importance is the new procedure for a systematic basic inspection to allow analysis of the probable cause of any trouble. Another important addition is the procedure for reassembly and adjustment of an instrument which is badly out of adjustment or which has been disassembled. The detailed instructions for charging with helium, and for desiccating the instrument, which are covered in TM 9-1622, have been omitted.

INTRODUCTION

d. The Use of This Manual.

(1) Sections III and IV are intended primarily for those unfamiliar with the optical principles of the instrument. They also contain reference data. Section V describes the accessories.

(2) Section VI outlines the method of setting up and adjusting the instrument for performance tests, inspections, and adjustments.

(3) Section VII gives a routine for complete inspection of the instrument. This systematic inspection is particularly valuable as an aid in diagnosing the cause of any trouble. This section also includes a summary of inspections and tolerances.

(4) Section VIII is to some extent a duplication of section VII, but it approaches the question from the standpoint of diagnosis of trouble encountered, rather than from a systematic inspection. This may save time and unnecessary inspection in some cases.

(5) Section IX describes the tools and testing equipment needed for maintenance and repair operations. It also covers the routine maintenance operations such as cleaning and lubrication.

(6) Section X includes the adjustment and repair, disassembly and assembly of all optical and mechanical subassemblies which are accessible without a complete disassembly. The requirements for each operation are given, though ordinary mechanic's tools and tools supplied with the instrument are not listed.

(7) Section XI covers the disassembly of the height finder telescope into the various subassemblies and the complete assembly and adjustment. It also covers in detail, the disassembly and assembly of the optical tube.

(8) Section XII includes all adjustment, repair, disassembly, and assembly information on the Elbow Telescope M7. Section XIII includes similar information on the Cradle M1, and section XIV on the Tripod M6.

(9) Section XV covers the adjustment and repair of illumination and electrical components. The wiring, lamps, and some electrical trouble shooting are included, as well as the electrical connections for the transmitter and receivers.

(10) Section XVI covers the maintenance of the Electric Cover M404.

e. References. The publications pertaining to the materiel described herein are listed at the end of the manual.

Section II

GENERAL DESCRIPTION

Paragraph
The purpose of the height finder M1 2
External appearance 3

2. THE PURPOSE OF THE HEIGHT FINDER M1.

a. The Height Finder M1 is an optical instrument which can locate the exact position of an aircraft in flight, and can follow the aircraft's movements continuously. It indicates the height of the aircraft above the level of the height finder, which is its main function. It can also measure the slant range or direct distance from the height finder to the aircraft, the azimuth angle or horizontal angle from north or some other fixed reference, and the elevation angle or angle above horizontal. Slant range and elevation angle are combined to give a direct reading of height (fig. 1). The height information is transmitted semiautomatically to the antiaircraft director of the antiaircraft battery with which the height finder is associated. The range drum scale reads from 550 to 50,000 yards, and the height transmitting system reads up to 10,000 yards. The Height Finder M1 can also be used as a range finder.

b. The height finder is kept sighted on the aircraft by two operators or "trackers," who follow the aircraft through azimuth and elevation tracking telescopes fixed to the height finder. The azimuth tracker operates a handwheel to swing the instrument as a whole around the tripod on which it is mounted. The elevation tracker rotates the instrument on its horizontal axis, to keep his telescope sighted on the aircraft. The angular settings so obtained are indicated on two dials, and are used to insure that the height finder and antiaircraft director are sighted on the same target. For this purpose, the azimuth and elevation settings of the antiaircraft director telescopes are transmitted to the height finder dials. But the most important function of the trackers is to keep the height finder centered on the aircraft, for the stereoscopic observer's benefit.

c. The principle involved in range finding is the measurement of the small angle between two rays of light arriving from the aircraft at two widely separated points on the height finder. This measurement is merely a 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 serves the purpose of optically separating the observer's eyes by 13.5 feet.

d. The two rays entering the height finder are used to create two images of the aircraft, one for each eye of the stereoscopic observer. The two images are fused stereoscopically so as to appear as an apparently

GENERAL DESCRIPTION

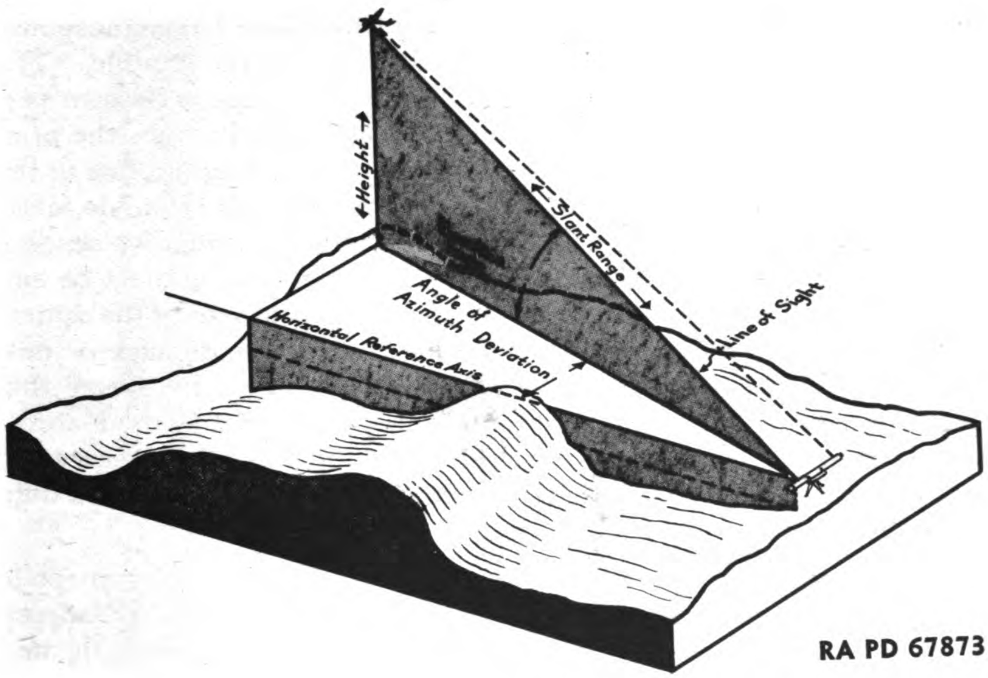


Figure 1 — Measurements Possible with Height Finder

single aircraft image floating in space. The observer turns a knob to adjust the apparent distance of this image, until it matches that of a line of marks which also appear to float in space. This adjustment operates a scale, which then shows either height or range as desired. This scale is read by another observer, who sets the value in on the dial of the range transmitter which transmits the height or range automatically to the antiaircraft director.

e. When the instrument is set for height measurement, range and elevation settings are combined automatically. The stereoscopic observer adjusts for changes in height only, and a direct reading of height results. Since the aircraft's height is more constant than its range, height measurements can be made more deliberately and precisely.

f. Since angle between two beams entering height finder is small (max. 28 minutes), and changes in angle for different ranges are still smaller, the height finder must measure small angles with great accuracy. For this reason, the height finder is of necessity a somewhat complicated optical instrument, built and adjusted to extreme precision. Slight displacement of some of its parts will result in a faulty response to the angle, and hence to 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 instrument has a number of devices built into it to check its own performance. Locating trouble can be done systematically once the principles of the instrument are understood and the check-up is done in the specified manner. Some adjustments and repairs can be made while the instrument is on location. More serious difficulties involve sending the instrument back to the base repair shops. One thing must be emphasized above all: because of the delicacy of adjustment of the optical and mechanical parts, it is all too easy to add to the damage or misalinement by doing the wrong thing. 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.

g. 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 training of the crew utterly worthless. Thus, inaccurate functioning of the height finder endangers the entire gun battery.

3. EXTERNAL APPEARANCE.

a. The height finder is composed of three major units, the Height Finder Telescope M1 including the Elbow Telescopes M7 (575 pounds), the Cradle M1 (160 pounds), and the Tripod M6 (185 pounds). These units are packed separately in steel boxes for transportation; the total combined weight when packed is 2,160 pounds. The major units are shown in relation to each other in figure 2, as seen from the front side (which faces the target). The base length (distance between entering rays) is 13.5 feet. The fronts of the tracking telescopes (Elbow Telescopes M7) and their eye shields can be seen on top of the horizontal tube either side of center.

b. Some of the controls and other details on the observer's side of the instrument are indicated in figures 3 and 4. The central eyepiece assembly is for the stereoscopic observer. The measuring knob (fig. 3) to the right of these eyepieces is operated by the stereoscopic observer to alter the apparent distance of the stereoscopic image relative to the reticle marks. The elevation adjustment knob to the left (fig. 4) is also operated by the stereoscopic observer, and serves as a fine adjustment to position the aircraft image vertically in the eyepiece field, the elevation tracker having brought the aircraft vertically into the field. The change-of-magnification crank 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

GENERAL DESCRIPTION

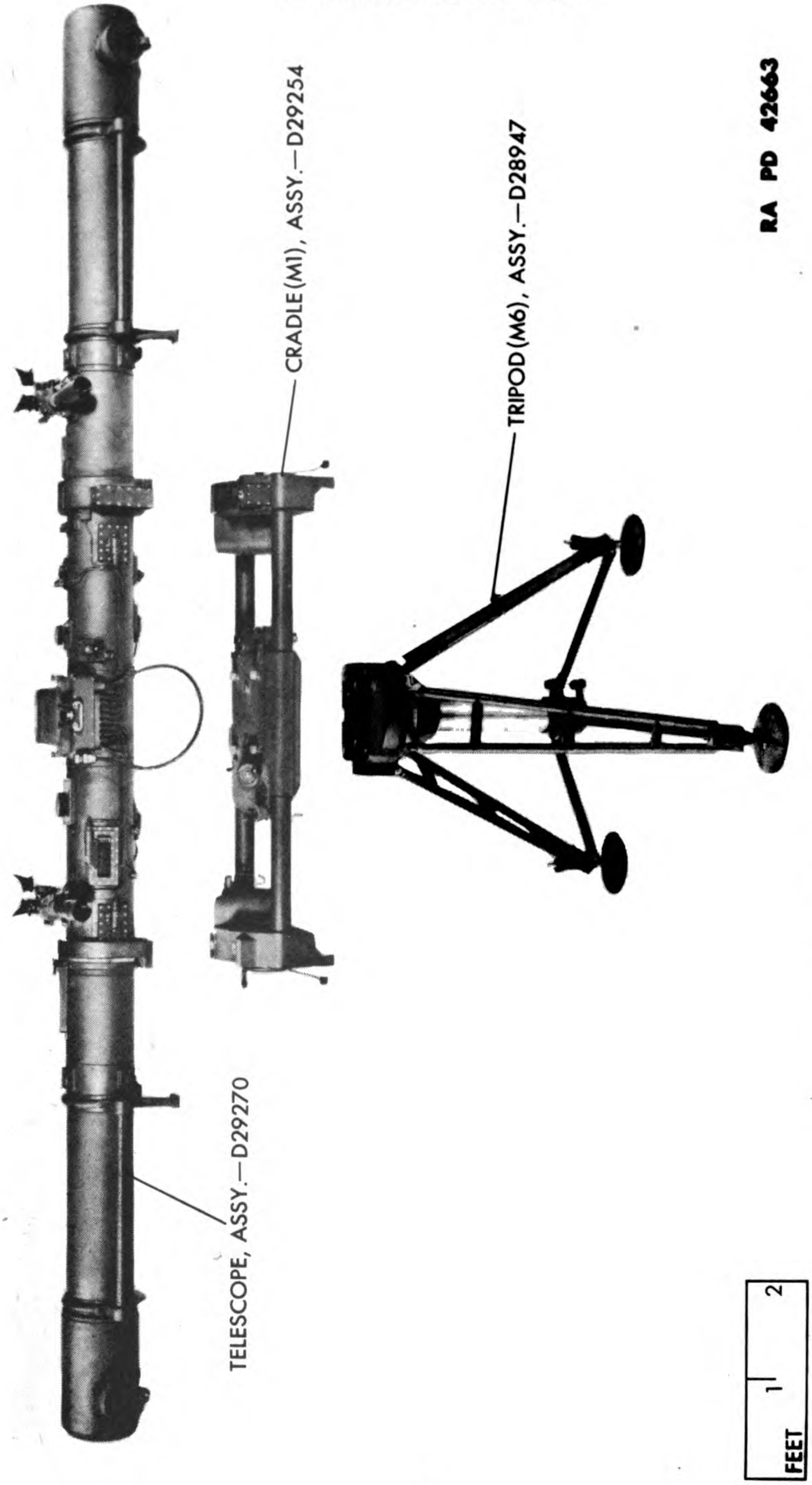
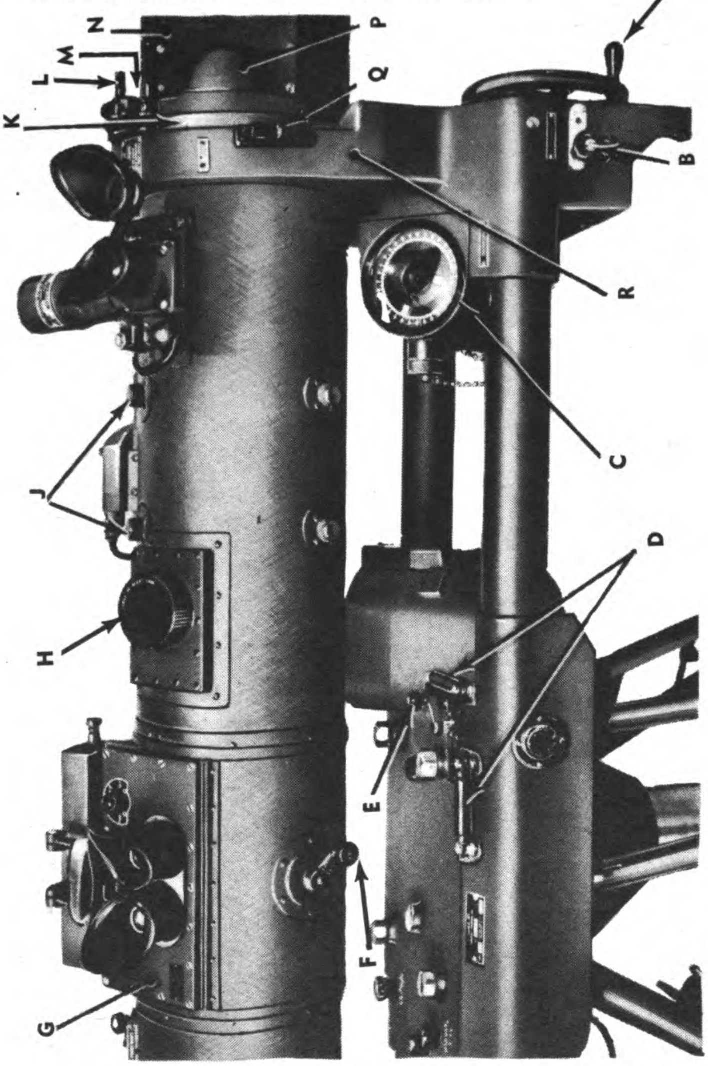


Figure 2 — Tripod, Cradle, and Telescope — Exploded View



A — TRAVERSING HANDWHEEL
B — CHANGE OF SPEED CRANK *(TRAVERSING)*
C — AZIMUTH INDICATOR
D — LEVEL ASSEMBLIES *(CRADLE)*
E — AZIMUTH RELEASE LEVER
F — CHANGE OF MAGNIFICATION CRANK
G — EYEPIECE ASSEMBLY
H — MEASURING KNOB
J — MEASURING DRUM BEARING CAPS
K — MAIN BEARING RACE
L — HEIGHT RANGE LEVER
M — RANGE POSITION FOR HEIGHT RANGE LEVER
N — MEASURING WEDGE HOUSING
P — HEIGHT RANGE SHAFT AND BEVEL PINION COVER
Q — HEIGHT POSITION FOR HEIGHT RANGE LEVER
R — RIGHT MAIN BEARING HOUSING

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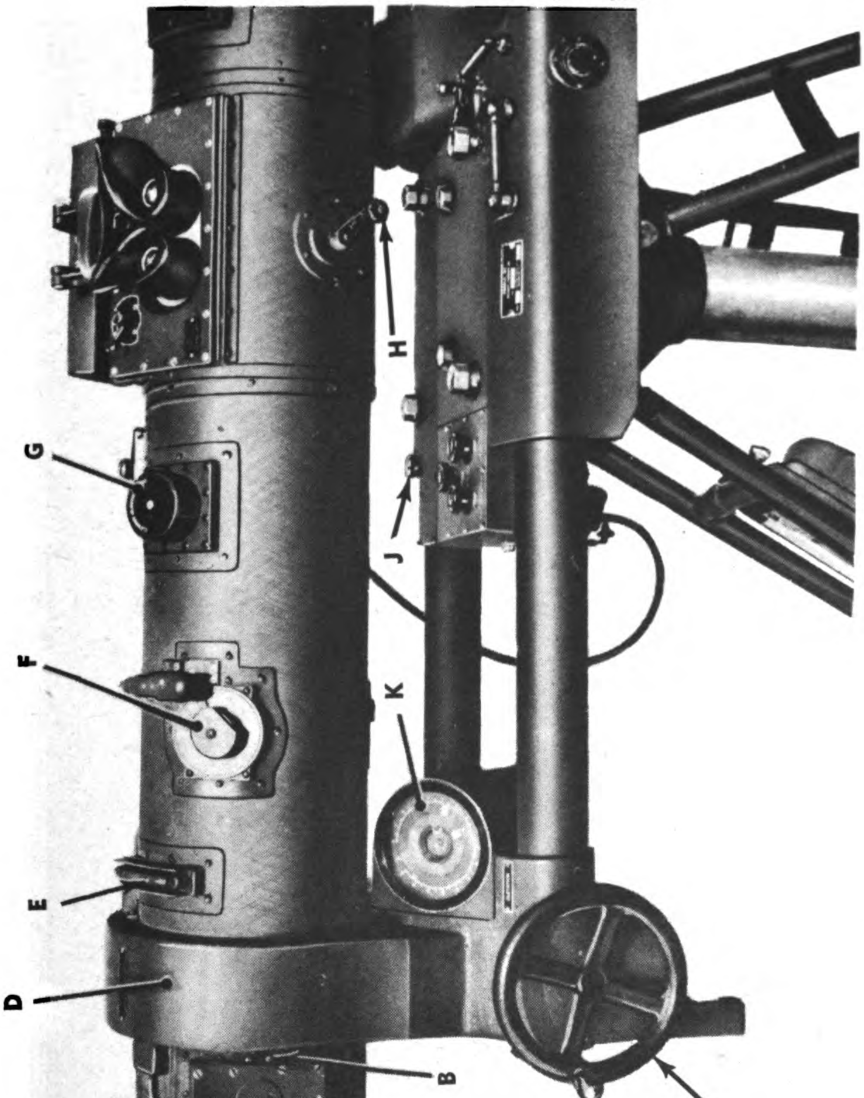
Figure 3 — Rear of Height Finder M1 — To the Right of Center

GENERAL DESCRIPTION



A — ELEVATION HANDWHEEL
B — LOCATION OF ELEVATION INDEX
C — INTERNAL ADJUSTER CORRECTION WEDGE BRACKET
D — LEFT MAIN BEARING HOUSING
E — LEVEL ASSEMBLY *(TELESCOPE)*
F — INTERNAL ADJUSTER CORRECTION KNOB
G — ELEVATION ADJUSTMENT KNOB
H — CHANGE OF MAGNIFICATION CRANK
J — LIGHT SWITCH
K — ELEVATION INDICATOR

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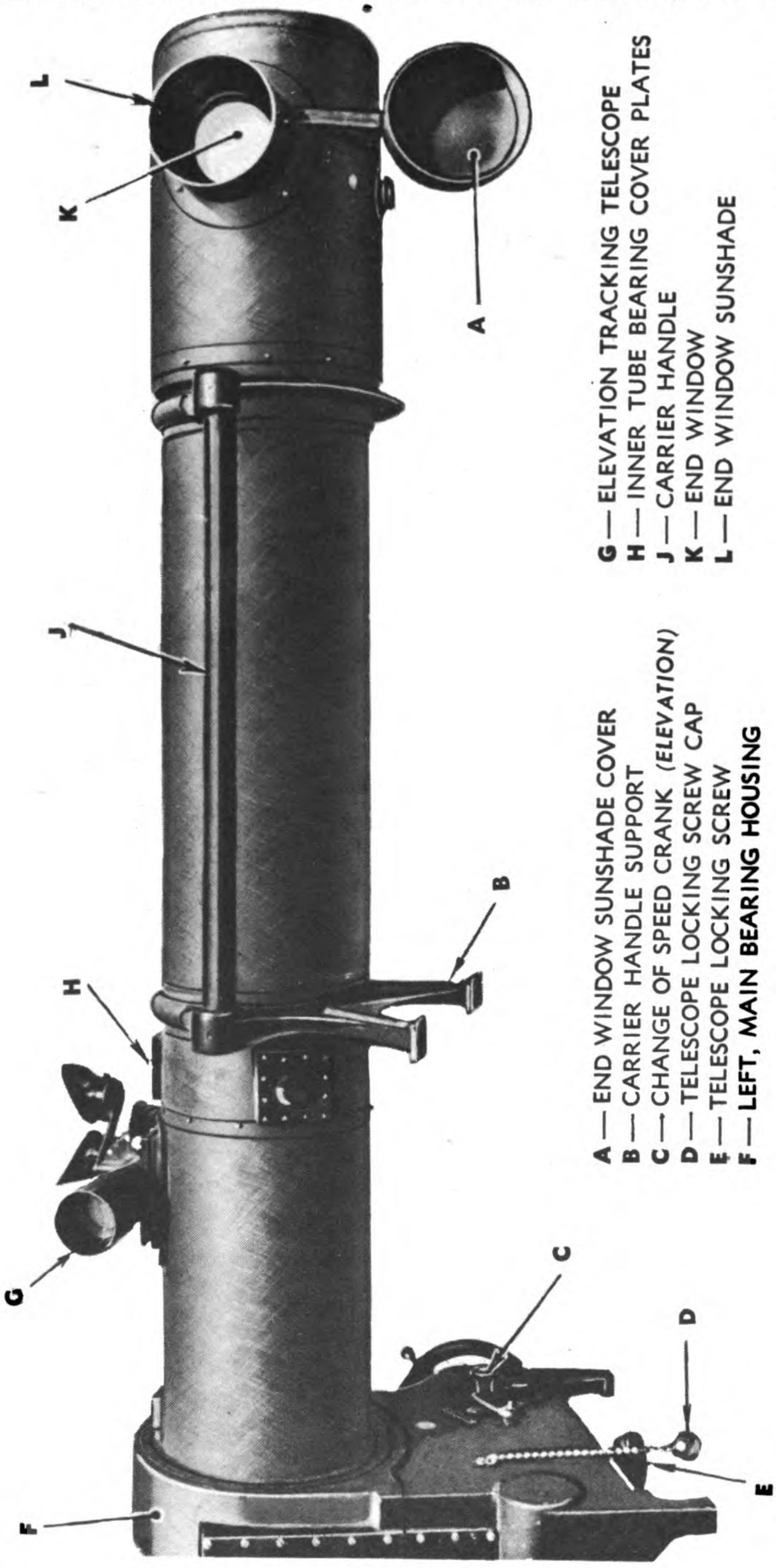
Figure 4 — Rear of Height Finder M1 — To the Left of Center



A — END WINDOW SUNSHADE COVER
B — CARRIER HANDLE SUPPORT
C — CHANGE OF SPEED CRANK (ELEVATION)
D — TELESCOPE LOCKING SCREW CAP
E — TELESCOPE LOCKING SCREW
F — LEFT, MAIN BEARING HOUSING

G — ELEVATION TRACKING TELESCOPE
H — INNER TUBE BEARING COVER PLATES
J — CARRIER HANDLE
K — END WINDOW
L — END WINDOW SUNSHADE

RA PD 15422

Figure 5 — Front of Height Finder M1 — Left End

A — MAIN JUNCTION BOX
B — INTERNAL TARGET PRISM SHIFT CRANK
C — ELEVATION ADJUSTMENT KNOB
D — INTERNAL TARGET ILLUMINATION LAMP
E — LEVEL ASSEMBLY (TELESCOPE)
F — LEFT MAIN BEARING HOUSING
G — LEFT MAIN BEARING WORM HOUSING
H — ELEVATION DRIVE BRACKET
J — HEIGHT ADJUSTER KNOB
K — RETICLE ILLUMINATION LAMP
L — CRADLE LOCKING BOLTS
M — CRADLE TELESCOPE CABLE

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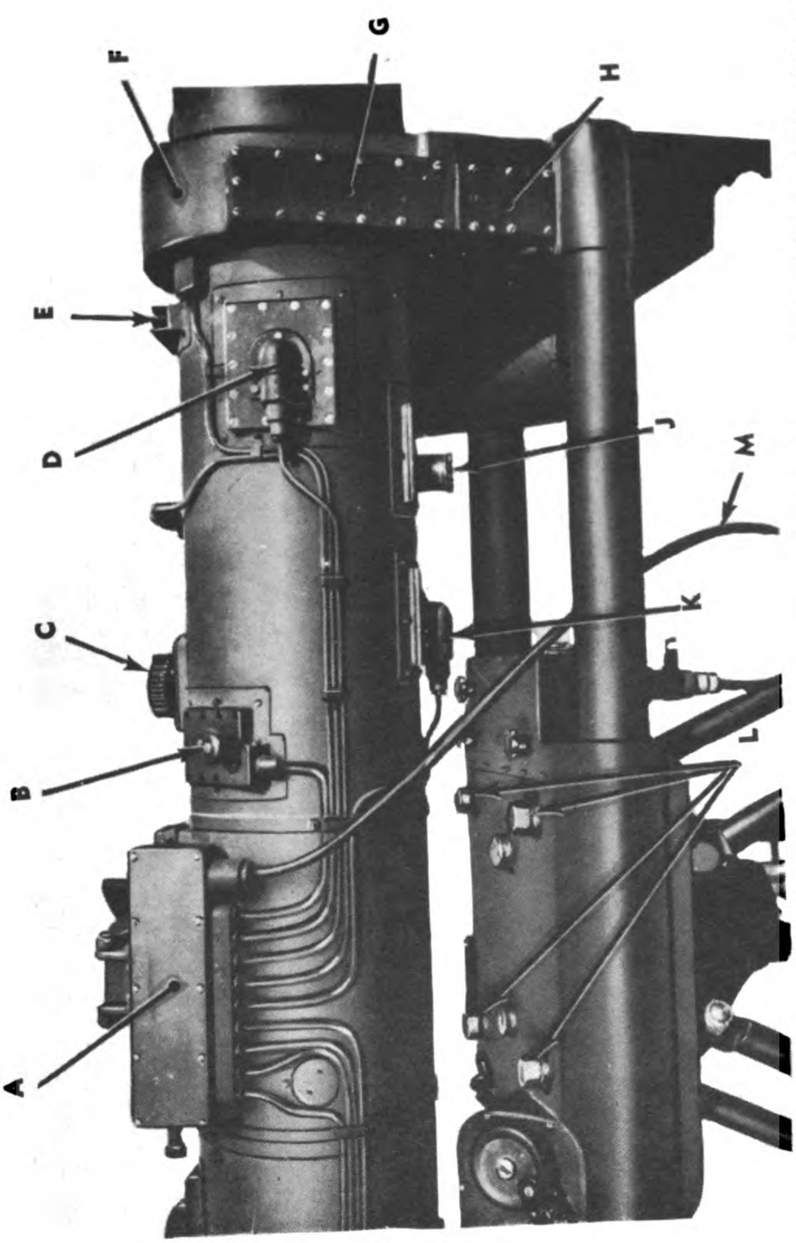
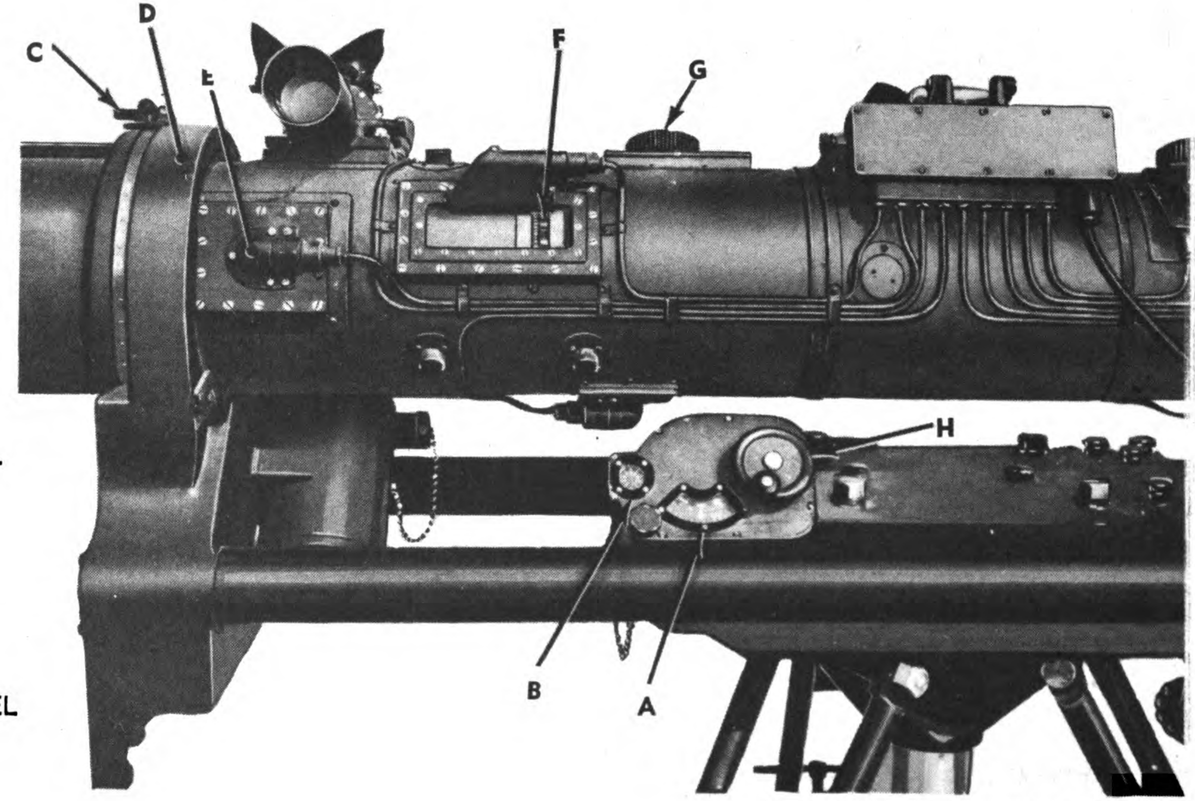


Figure 6 — Front of Height Finder M1 — To the Left of Center



A — TRANSMITTER SCALES
B — VERTICAL PARALLAX DIAL
C — HEIGHT RANGE LEVER
D — {RIGHT MAIN / BEARING HOUSING}
E — {INTERNAL TARGET / ILLUMINATION LAMP}
F — MEASURING SCALE
G — MEASURING KNOB
H — TRANSMITTER HANDWHEEL

Figure 7 — Front of Height Finder M1 — To the Right of Center

tracking telescope (fig. 3) is the height-range lever latched in position for range measurement. Another setting is provided for height measurement.

c. The azimuth tracking telescope appears in figure 3. The azimuth tracker operates the traversing handwheel to swing the instrument around the tripod, at either of two speeds as selected by the change-of-speed crank. The elevation handwheel and change-of-speed crank appear in figures 3 and 5. The elevation tracker revolves the main telescope by the handwheel. The azimuth and elevation indicators (figs. 3 and 4) show the azimuth and elevation settings for both the height finder and the antiaircraft director with which it is associated.

d. Some of the controls, adjustments, lamps, and other details on the front side of the instrument are shown in figures 5, 6, and 7. One of the height finder crew reads the height indicated on the measuring scale (fig. 7) and operates the transmitter handwheel to make the transmitter scale read this same value, to be transmitted electrically to the antiaircraft director. The vertical parallax dial is set to correct the height value transmitted, to allow for altitude differences between height finder and antiaircraft director, or for other minor corrections. The director crew is informed when to accept the transmitted data by means of a signal light located on the director. This signal light is operated from a push button on the height finder.

e. **Production Differences by Serial Numbers.** Height Finders M1, serial numbers 1 to 32 inclusive, differed from later production in two respects: The tracking telescopes were different and lacked the adjustable alinement feature on later instruments. The packing chest for the height finder telescope, as provided for these early instruments, lacked the desiccating valve which is on later chests. Minor changes have occurred since serial number 33, but these do not affect any of the instructions in this book except where noted.

f. **Height Finder M1A1.** When a helium retention apparatus is attached to the Height Finder M1, its designation is changed to Height Finder M1A1. This apparatus consists of a bellows, a tank of helium, and a control panel, which are permanently attached to the height finder telescope. Valves which are part of the equipment regulate the helium pressure within the height finder so it does not fall to a point where moist air can leak into the instrument from the outside. Maintenance and repair of the helium retention is not described in this manual, but will be included in a revision.

Section III

PRINCIPLES OF OPERATION

Paragraph

Explanation of lenses and prisms 4

How the height-finding system works 5

4. EXPLANATION OF LENSES AND PRISMS.

a. The height finder is one of the most complex optical instruments with which military personnel must deal. Many types of optical elements are represented in this instrument; it will therefore aid in a more thorough understanding if the functions of these individual elements are understood.

b. **Lenses.**

(1) The most important property of a lens is its ability to form an image of an object. All so-called positive lenses, whether simple or very complex, have this property. Light rays from the object reach all parts of the lens, which is shaped so that all the rays from each part of the object are bent to converge on the corresponding part of the image (fig. 8). This image is formed on the opposite side of the lens from the object and at a certain distance from the lens. One of the rays from each part of the object passes through the optical center of the lens and proceeds in the same straight line* to the corresponding part of the image. Therefore, the image is upside down in respect to the object. An image can be seen and understood readily this 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 about where the film would come. Only part of this image can be seen at one time, that part being limited by the size of the lens and the iris of the eye, because light travels in straight lines from the lens to the eye. 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.

(2) 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. Actually, the focal plane is an imaginary plane at a fixed distance from the lens and parallel to it.

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* This discussion intentionally ignores the nodal points.

The distance to this plane from a fixed point in the lens is called the focal length. The actual focal length is determined by the construction of the lens.

(3) 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. This shift in image for nearby objects is one factor which affects the shortest range which can be measured by the height finder. The image of nearer objects falls in the wrong place.

(4) 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.

(5) 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 at right angles to the face of the lens is called the lens axis. The mechanical and optical axes are the same if the lens has been properly mechanically centered. It will be appreciated that any mounting which decenters the optical center of the lens would throw the image sideways by a slight angle.

(6) The type of image so far described is called a "real" image. 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. 9). 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 focal length to image size relation 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.

c. Types of Lenses.

(1) OBJECTIVE. Different type 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.

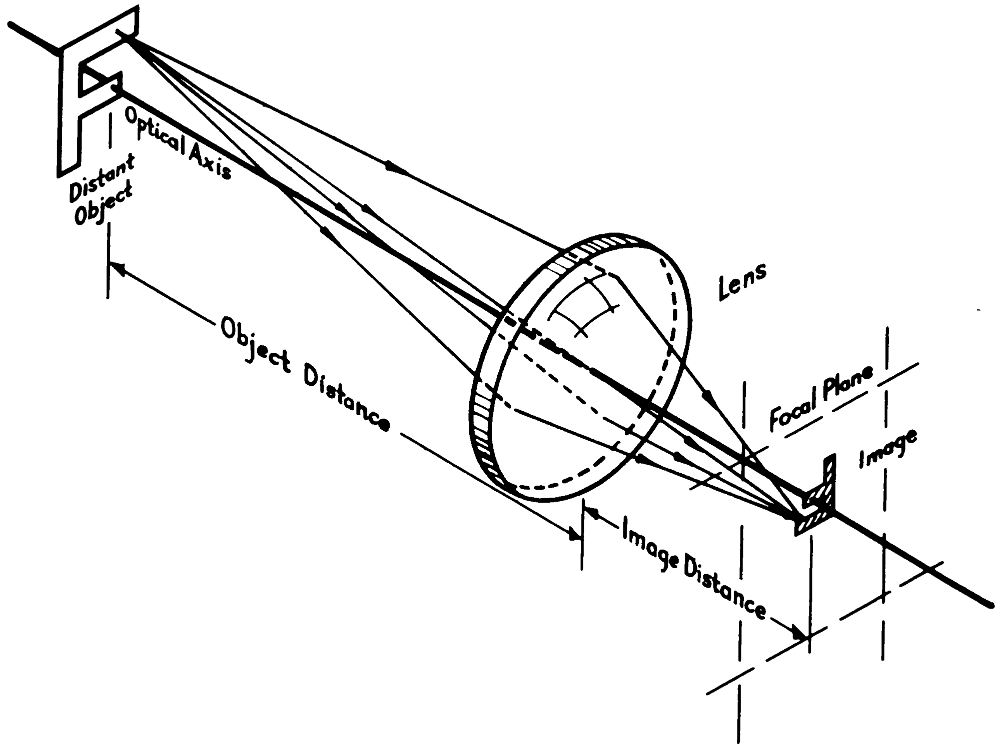

Figure 8 — Formation of a Real Image by a Lens

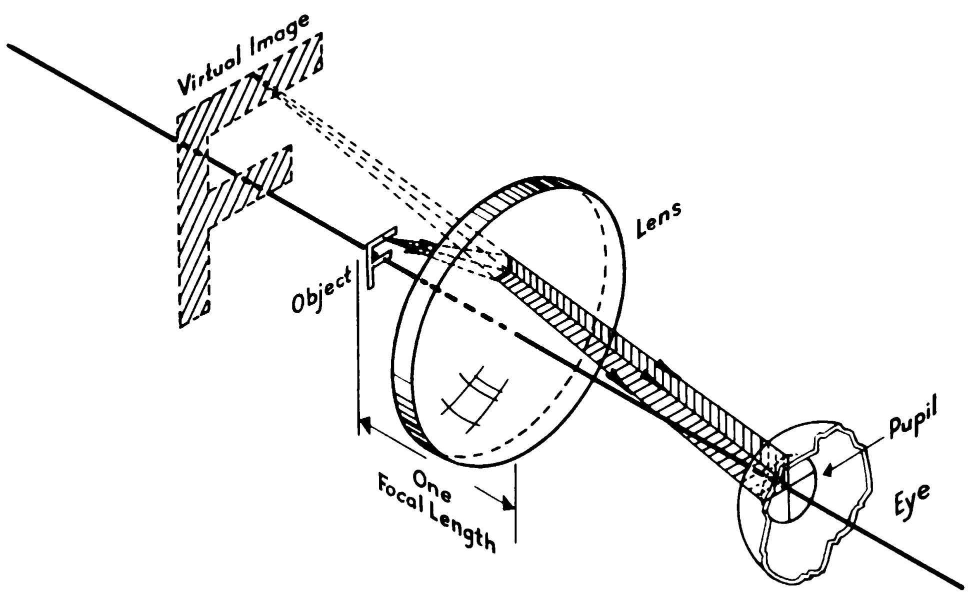

Figure 9 — A Virtual Image Seen Through a Lens

(2) FIELD LENS. The term "field lens" refers to a lens which is placed in the same plane as this image. This lens converges the beam which has formed the image, so that the rays will all enter the next lens in the system. Thus the whole image within the field lens can be seen. In the absence of a field 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 field lens does the same thing as the ground glass, but with no loss of light.

(3) ERECTING LENS. An "erector lens" or "erecting lens" is one which creates a second image of the first image formed by the objective, for the purpose of 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 usually comes at the eyelens, so the observer sees an erect image.

(4) EYELENS. The term "eyelens" 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. Eyelenses are short in focal length to give a magnified image.

(5) COLLIMATING LENS. 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) The terms "eyepiece" or "ocular" are applied to the combination of the field lens and eyelens, usually within a cell. This combination is moved towards, or from the objective to accommodate the observer's eye.

d. Reflecting Prisms and Mirrors.

(1) 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 without distortion complicated reflections which would be impractical with mirrors.

(2) 90-DEGREE OR RIGHT-ANGLE PRISM. The simplest reflecting prism is the ordinary "90-degree prism" or "right-angle prism" in which the beam of light enters one face, is reflected at 90 degrees by the long face of the prism, and comes out the other face (A and B, fig. 10).

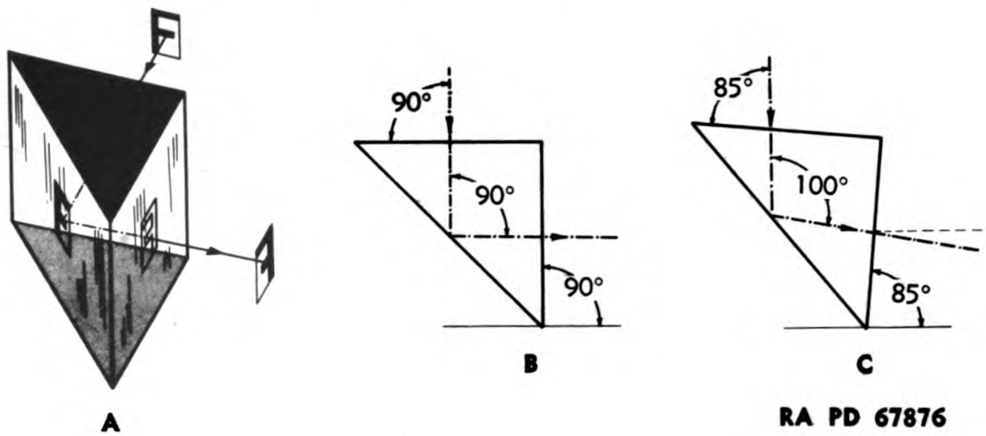

Figure 10 — Reflection by a 90° Prism

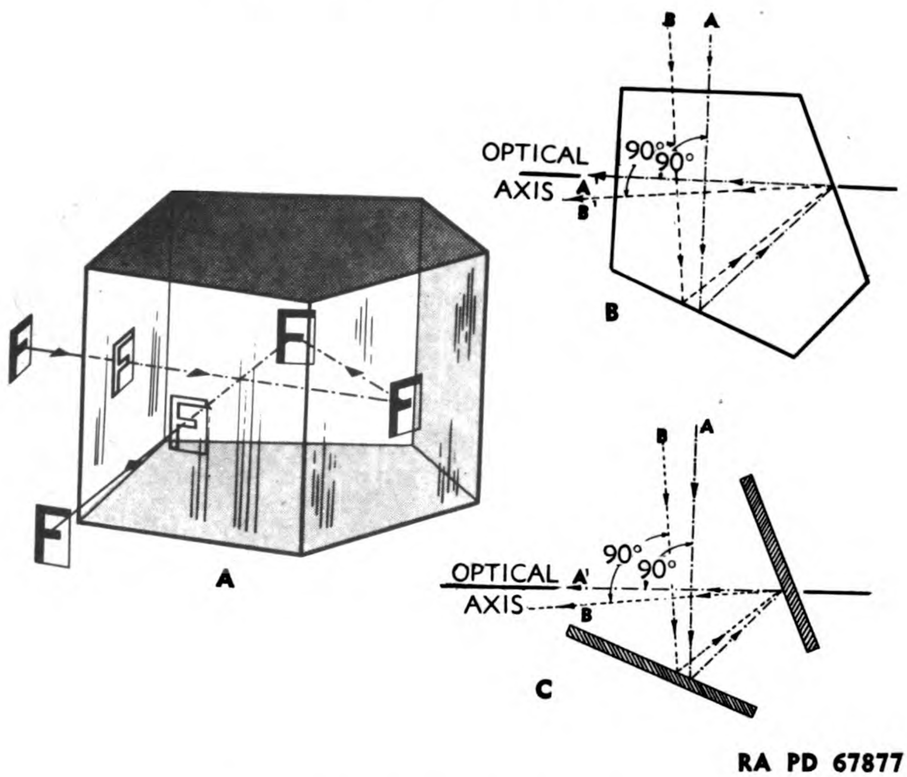

Figure 11 — Reflection by a Penta Prism

Image forming light rays so reflected are reversed, so that the image is reversed right to left. If the right-angle prism is turned in the plane of the rays, the angle of the reflected light ray turns twice as much (C, fig. 10). Mounts for such prisms must therefore be adjusted accurately.

PRINCIPLES OF OPERATION

(3) Another very simple type of prism is the *penta prism;* two of these are used in the internal target system of the height finder. The penta prism shown in A and B, figure 11, reflects the light ray through an angle of 90 degrees just as the right-angle prism does, but by two reflections as shown. Because of the arrangement of these two reflections, turning the prism in the plane of the light rays does not turn the reflected light ray. Therefore, this type of prism is not so sensitive in its mounting adjustment. For this reason, this type is used in the internal target system where the angle of reflection between the ray entering and the ray leaving must remain absolutely constant. Penta prisms would be used in the ends of the height finder to reflect the incoming rays from the aircraft at 90 degrees, 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 (C, fig. 11). 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, just as the mounting of a right-angle prism is.

(4) 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 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. For this reason, some optical mirrors 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, etc. It is, however, subject to scratch.

(5) Getting back to prisms, another type is the *double right-angle prism* or *ocular prism,* which consists theoretically of two right-angle prisms joined with two short faces in contact. It reflects a beam of light twice, the first time at right angles, the second time at right angles to the plane of the original beam and its first reflection (fig. 12). The image remains correct right to left. Such a prism is used in the range finder system to turn the beam out 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 for observer's convenience.

(6) In a *rhomboid prism* (A and B, fig. 13), 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 image remains correct right to left. The rhomboid prism and any optics which follow it can be rotated about the axis of the incoming light ray.

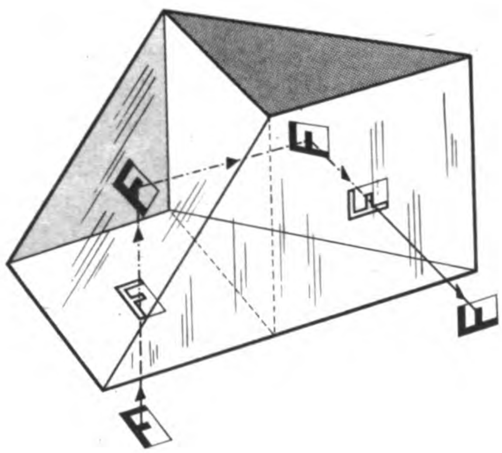

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Figure 12 — Two Reflections by a Double 90° Prism

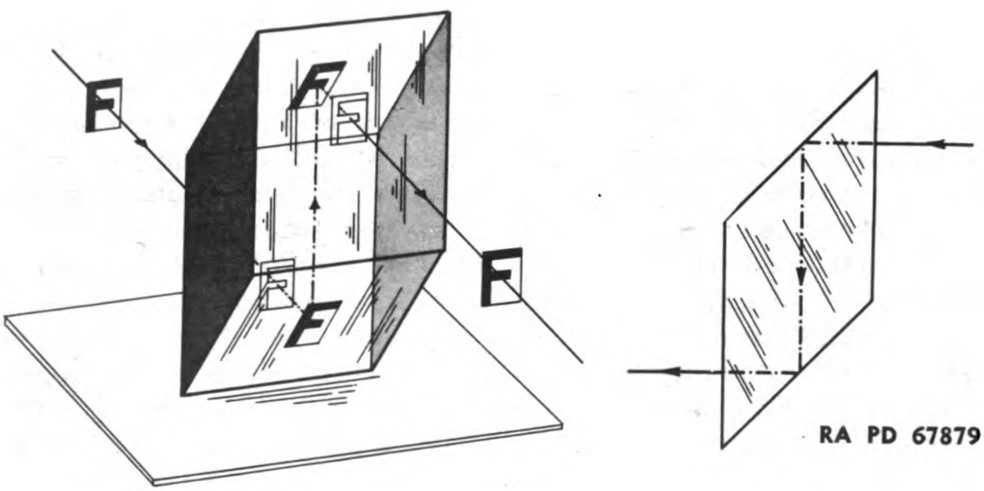

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Figure 13 — Two Reflections in the Same Plane by a Rhomboid Prism

This principle is used in the interpupillary adjustment of the height finder so that the two rays which have come through the height finder up to the eyepiece, and which up to this point are fixed in separation, can be varied in separation in order to match the separation of the observer's eyes.

(7) A *roof prism* can 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, not reversed, 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 raised into a roof (fig. 14). 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, and is reflected upwards obliquely, 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.

(8) 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 seen correctly.

e. Refracting Plates and Wedges.

(1) 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 changed ray makes a smaller angle with the "normal," an imaginary line inside the glass which is at right angles to the 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" where the ray leaves (A, fig. 15). 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 paralled shift of light rays in the height-of-image adjustment.

(2) 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.

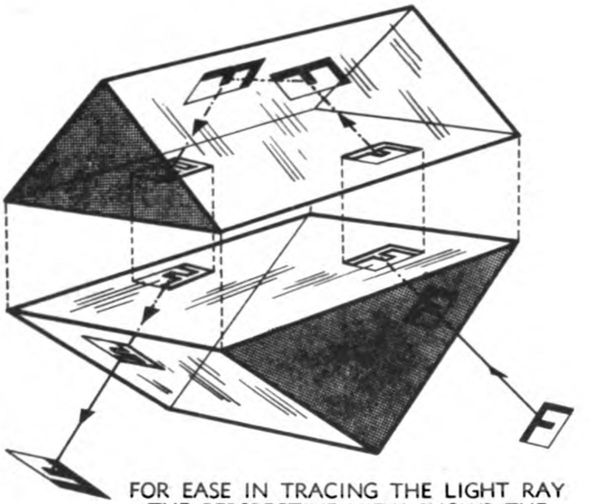

Figure 14 — Ray Reflected Twice by Roof Prism

Such a device is called a refracting prism or wedge (B, fig. 15). 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 (C, fig. 15). 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. 15). 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.

5. HOW THE HEIGHT-FINDING SYSTEM WORKS.

a. The Basis of Range Finding.

(1) 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 A, figure 16, 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

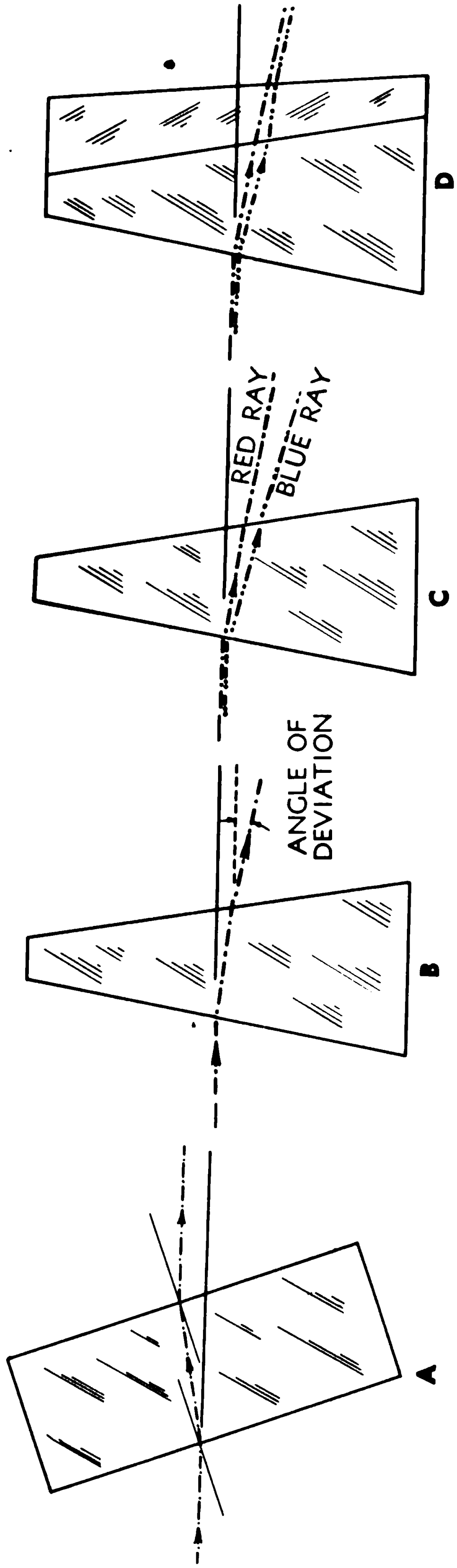

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Figure 15 — Displacement of a Ray by a Parallel Glass Plate and Deviation by a Wedge

distant object (in the case of the M1 by two trackers with their telescopes) 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 EA and DC increases as the object gets closer to the range finder.

(2) 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 the use of a glass wedge arrangement of variable angle. 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, figure 16, the wedge is shown at Q deviating the 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 power of the wedge so that the scale reads distance directly.

(3) The problem comes up: How can we tell when the light from D has been deviated sufficiently so that it does coincide with A? The method used is shown in C, figure 16. 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 exerted by the wedge.

(4) 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 16. 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 L, which creates 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 reticle. The image

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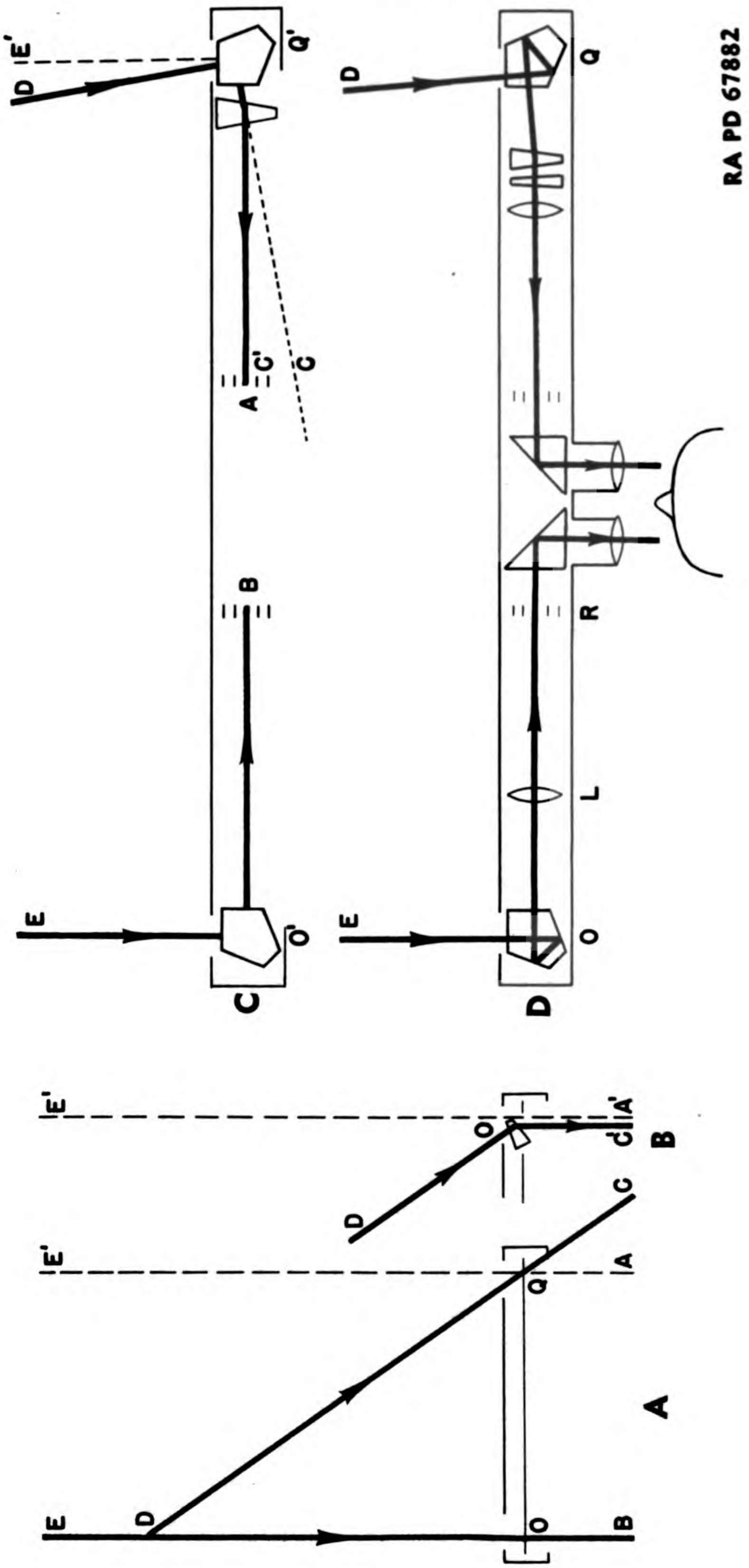

Figure 16 — Path of Ray of Light Through a Simple Range Finder

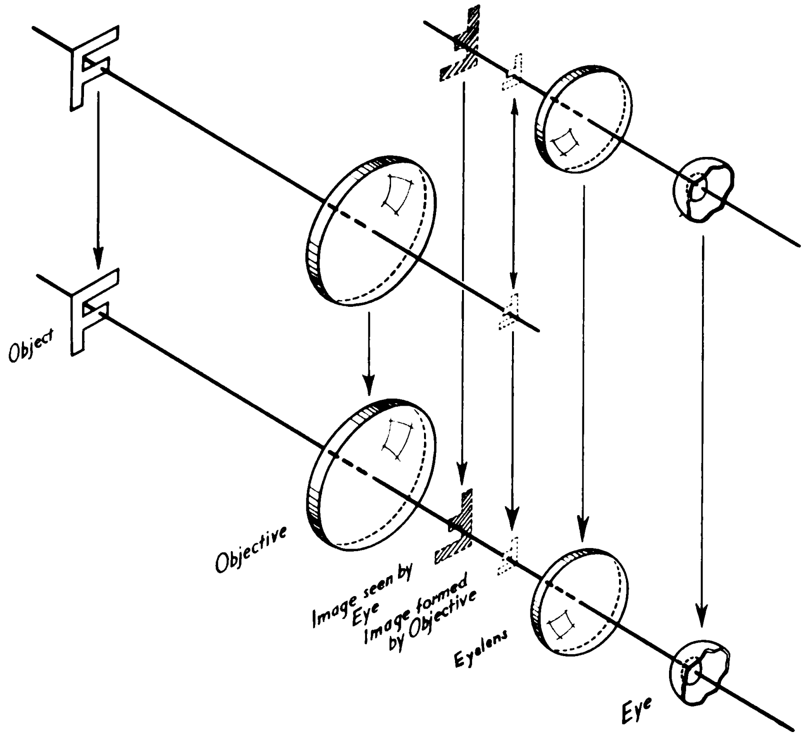

Figure 17 — Optics of a Simple Telescope Which Produces an Inverted Image

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.

b. The Image-forming System.

(1) 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 17. A distant object is imaged by the objective in an inverted manner, and the reticle is located at the image position. The eyelens acts as a magnifier to present an enlarged virtual image of this inverted image to the eye.

(2) Seeing a distant target inverted is not at all convenient in range finding, or even possible 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 18

PRINCIPLES OF OPERATION

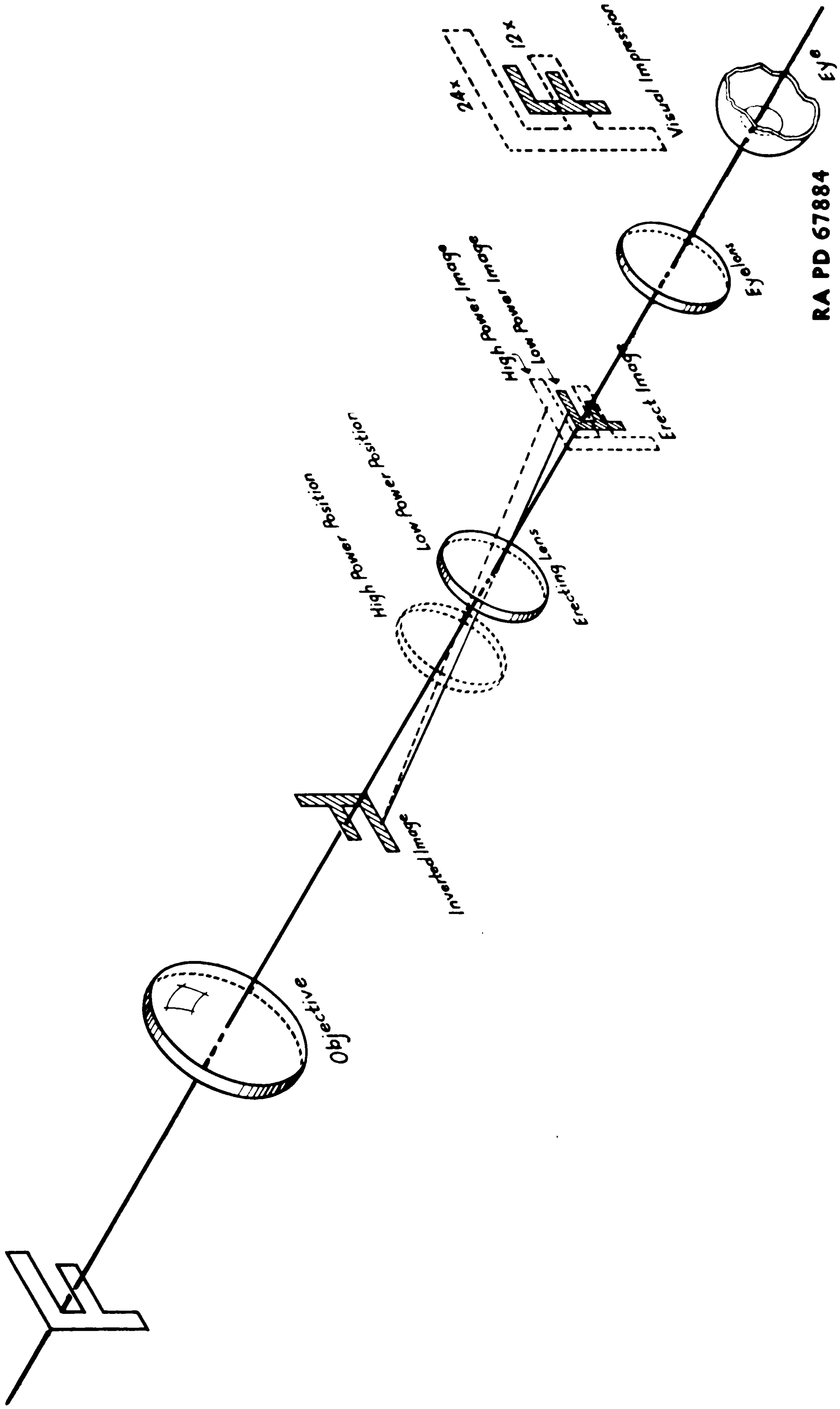

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Figure 18 — Addition of Erecting Lens to Telescope — The Two Positions of This Lens Offer a Choice in Magnifying Power

shows the erecting lens placed at a suitable distance in back of the inverted image so it creates an erect image still farther back. In the case of the Height Fender M1, the erecting lens serves to carry the image out of the optical tube into the ocular. The focal length of the erecting lens is such that, when in the position shown dotted, the erect image is larger than the inverted image. The eyelens 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 shown in figure 17.

(3) 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. Therefore, the erecting lens allows a change of power or magnification (12x or 24x). This is desirable because the high magnification usually yields high precision in range or height measurements. Since a wider angle of the sky is included at low power, the 12x setting may be used for preliminary ranging while the trackers are approaching their proper adjustment. 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.

(4) The most important function of the erecting lens is this: Without this lens the reticle would have to be out close to the ocular, which would add to the chances of misalinement between reticle and objective. The erecting lens permits mounting both reticles and objectives solidly in the same optical tube.

(5) Returning now to the telescope system, the system shown in figure 18 is not yet practical, because the rays from the objective which go to the outside edges of the system would pass by the erecting lens, as shown by the dotted lines in figure 19. In this case, only the rays from the center part of the image would enter the erecting lens, and therefore only the center part of the image could be seen. For this reason, a field 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 lens. 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 the flat face of this field lens.

(6) The question naturally comes up: 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,

PRINCIPLES OF OPERATION

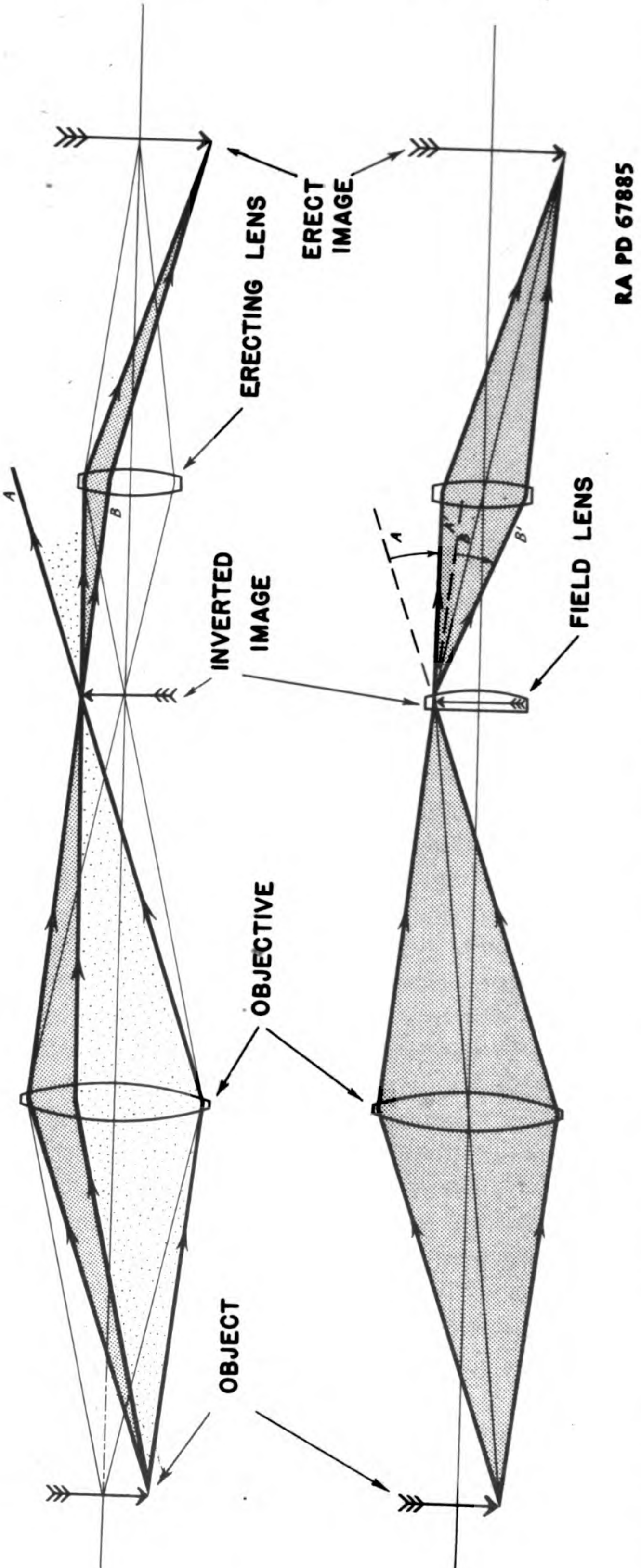

Figure 19 — The Field Lens Deviates Beams, Such as AB to A'B' to Enter the Erecting Lens and Hence Form the Edges of the Erect Image

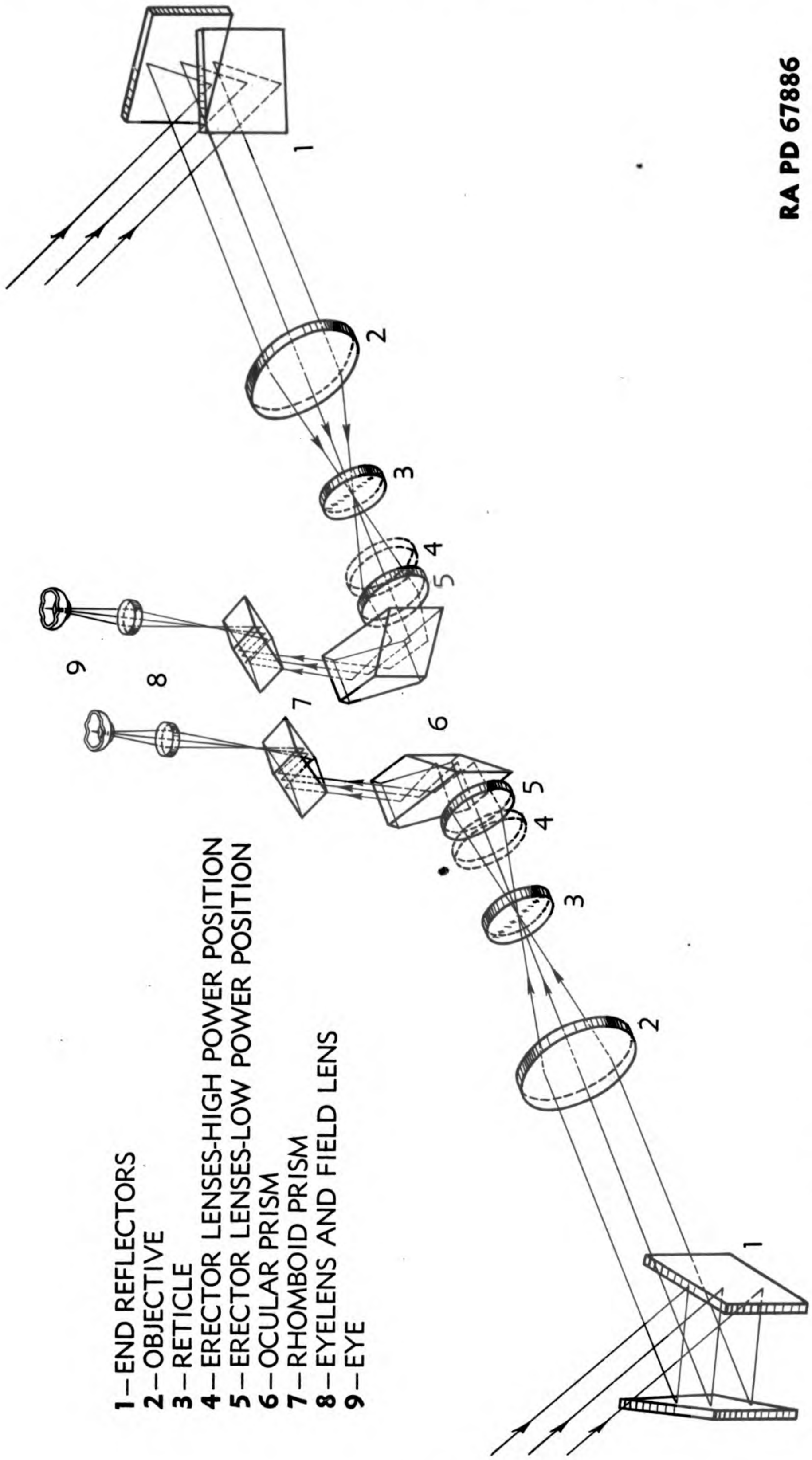

Figure 20 — Perspective of Simplified Image-forming Elements of Height Finder M1

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.

(7) Figure 19, then, represents the image-forming elements actually used in the Height Finder M1. The light is of course reflected at right angles at several places, notably at the end reflectors and in the prism system which brings the light rays out into the eyepiece. But the number and nature of these reflections has been chosen not to affect the appearance of the image. It is right side up and correct left to right when seen in the eyepiece. Figure 20 shows a schematic perspective drawing of the image-forming system, including all the reflectors and prisms.

c. The Reticles and Stereoscopic Vision.

(1) As stated before, the Height Finder M1 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 the images fall at the corresponding points in the two fields or not. 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 21 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 21 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.

(2) Therefore, if the row of lines in figure 21 is 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.

(3) 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.

(4) 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 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 22 that the mark to the right and above the central mark is relatively farther to the right in the right 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, shown in figure 23. The observer can see whether the image of an aircraft is in the plane of the farthest pair of marks,

PRINCIPLES OF OPERATION

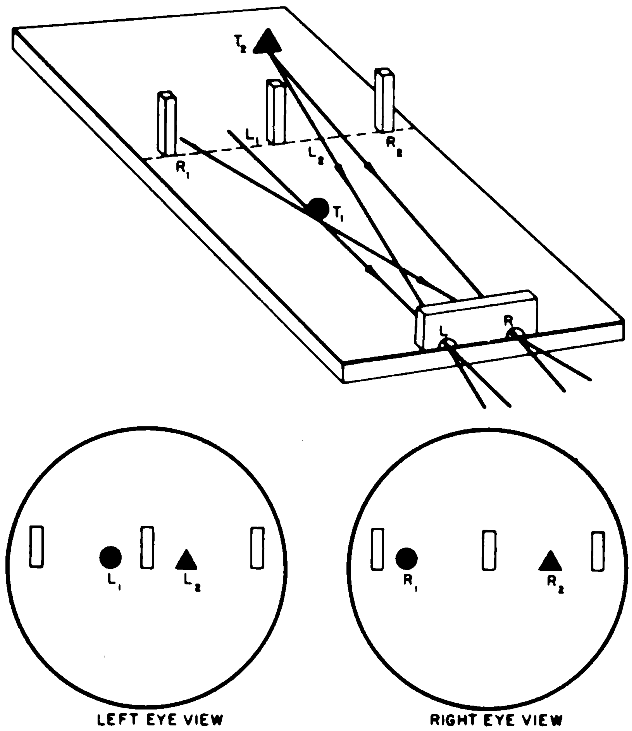

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Figure 21 — Differences Between Right and Left Eye Views in Stereoscopic Vision

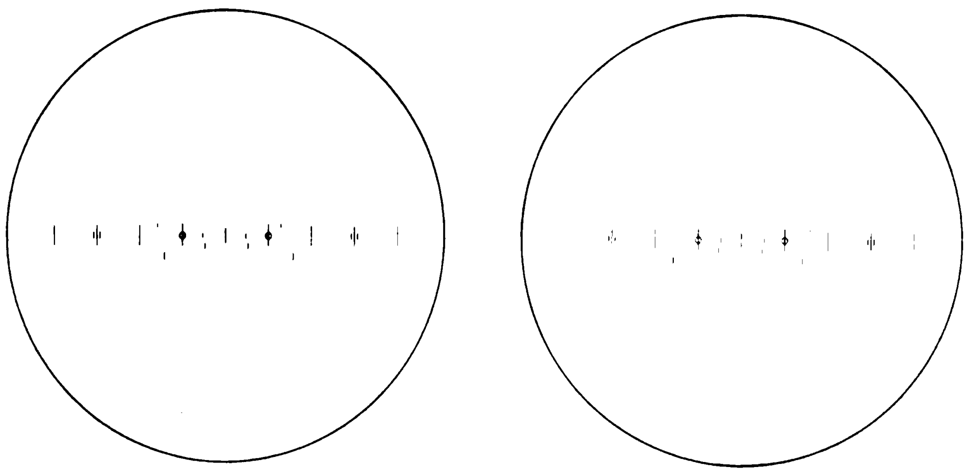

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Figure 22 — Appearance of Left and Right Eye Reticles from Ocular Side

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, using these marks, to locate shell bursts in terms of yards behind or in front of the aircraft.

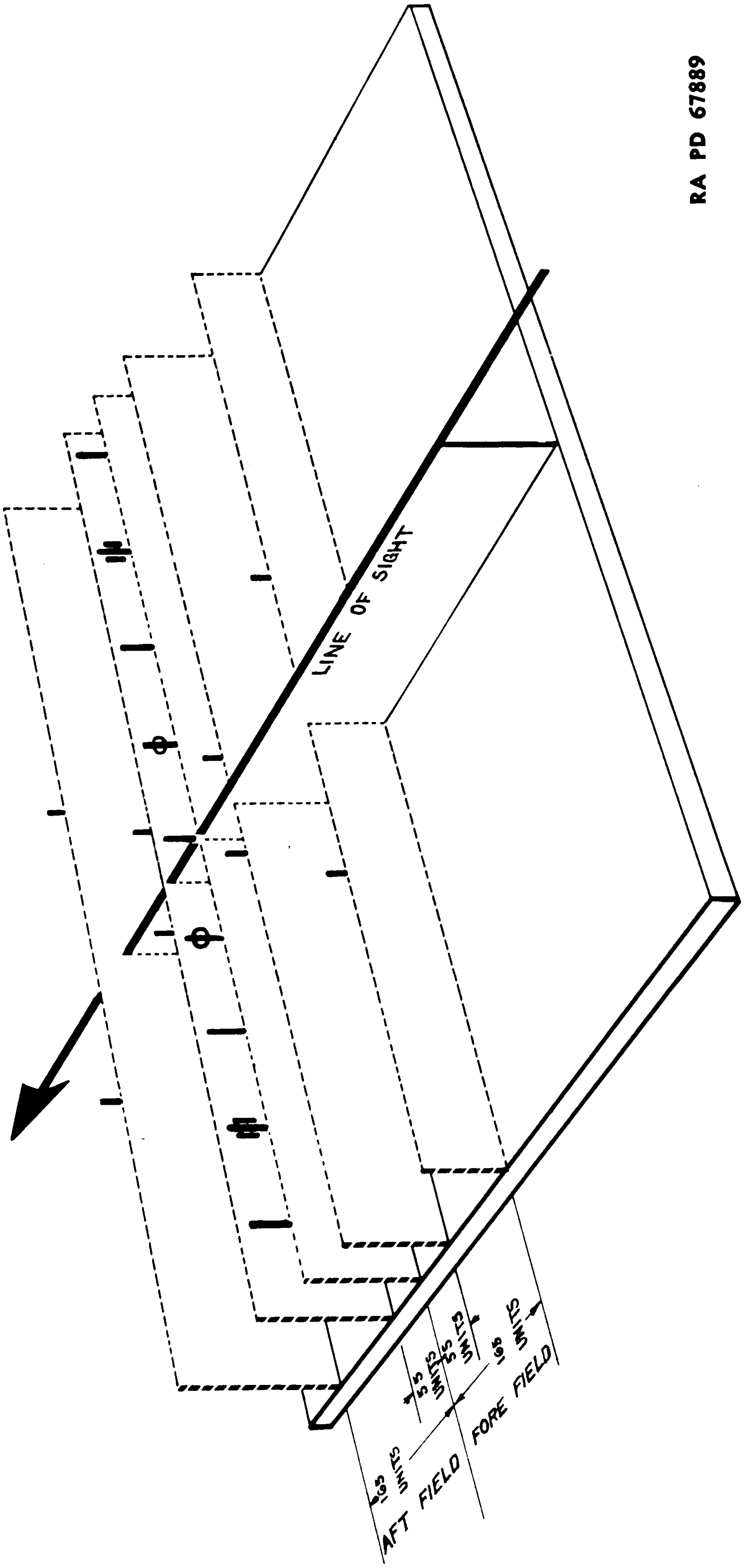


Figure 23 — Stereoscopic Impression of Reticle Markings

d. Compensator Wedges (Measuring Wedges).

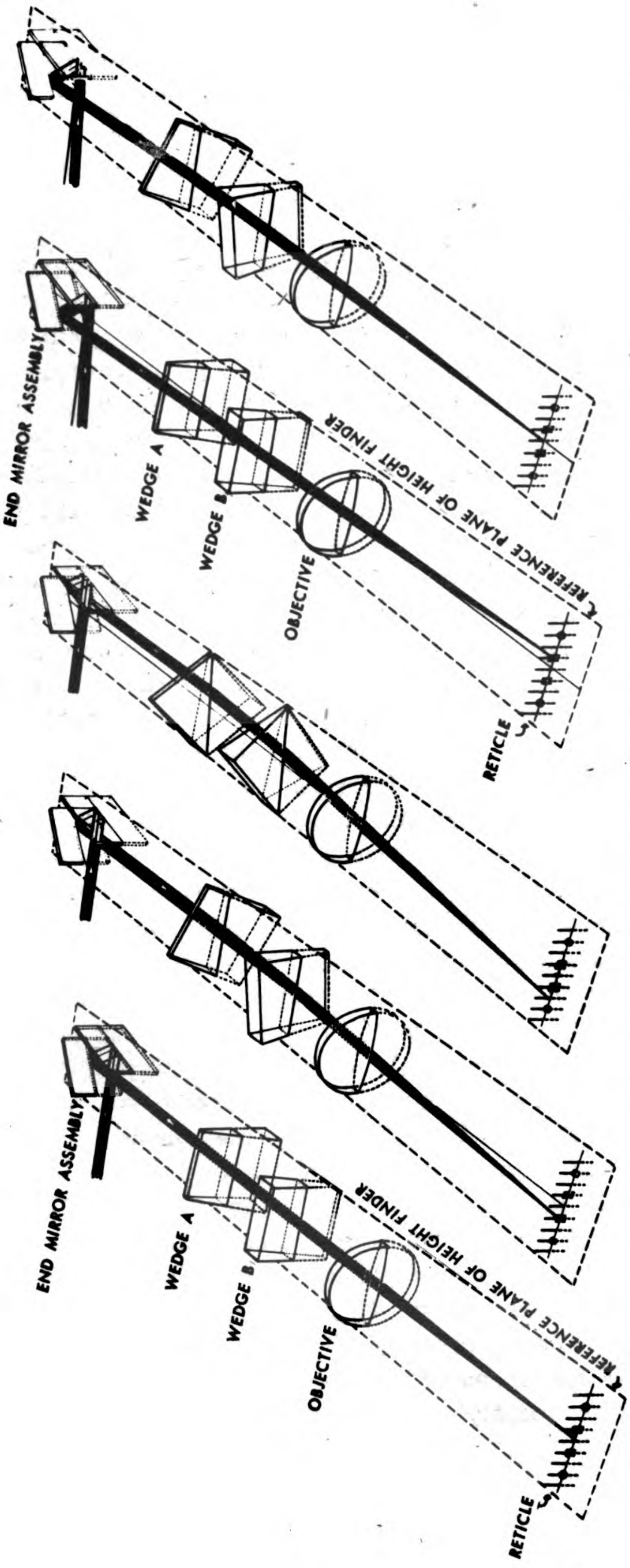
(1) The ability to displace or deviate one image, which is required to bring the two images of the target into stereoscopic contact with the reticle marks, is offered by the compensator wedges. While the compensator wedge unit actually contains four individual wedges, each composed of two pieces of glass 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.

(2) 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.

(3) 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. 24).

(4) 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. 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 directly the range 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.

(5) MEASUREMENT OF HEIGHT. In antiaircraft fire control, it is the height or altitude of the target that is determined by the height



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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.

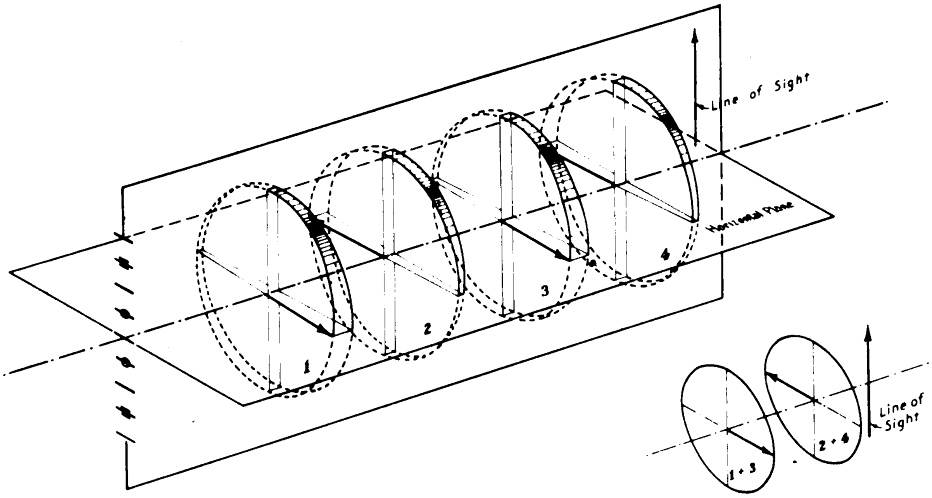
Figure 24 — Action of Two Wedges Operating for Range Measurement

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 directly 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.

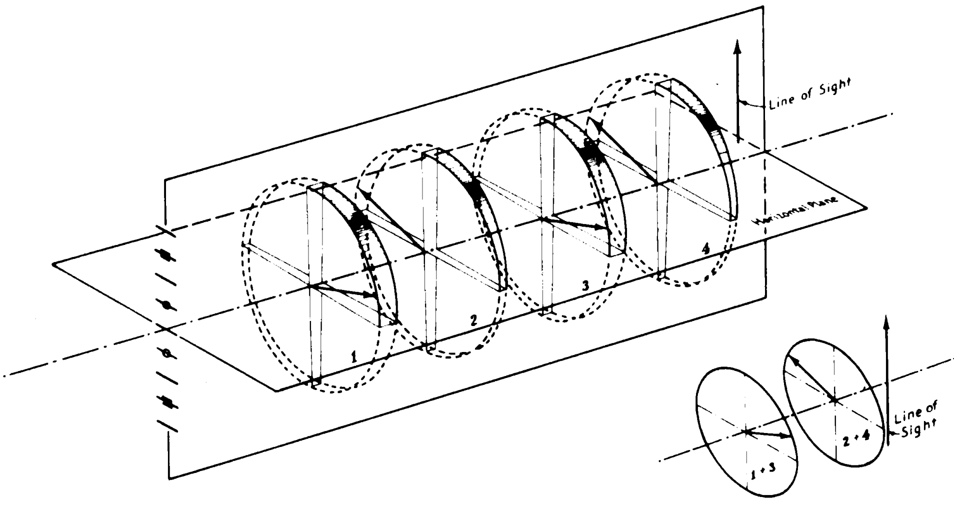
(6) The height conversion mechanism is put into operation by lifting the height-range lever from the "range" position, and rotating the height-range conversion ring around the height finder tube to allow the lever to be locked in the "height" position.

(7) 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 is rotated to the position which shows the height in yards, the deviation actually produced by the wedges corresponds to the range of the target.

(8) 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 25, 26, and 27. This reduces the effective deviating power of each pair, as explained in subparagraph d (3), above, by the proper amount to compensate for the difference between the range and the height of the target. In figure 25, the line of sight is vertical and the wedge pairs act the same for height as for range. When the line of sight is inclined (fig. 26), wedge 1 is rotated away from 3, and 2, away from 4, so that the combined deviating effect is reduced. When the line of sight is horizontal (fig. 27), and the height range is set for height, wedge 1 opposes 3, and 2 opposes 4, and each pair produces zero deflection.



A — COMPENSATOR SET FOR HEIGHT INFINITY



B — COMPENSATOR SET FOR MEDIUM HEIGHT

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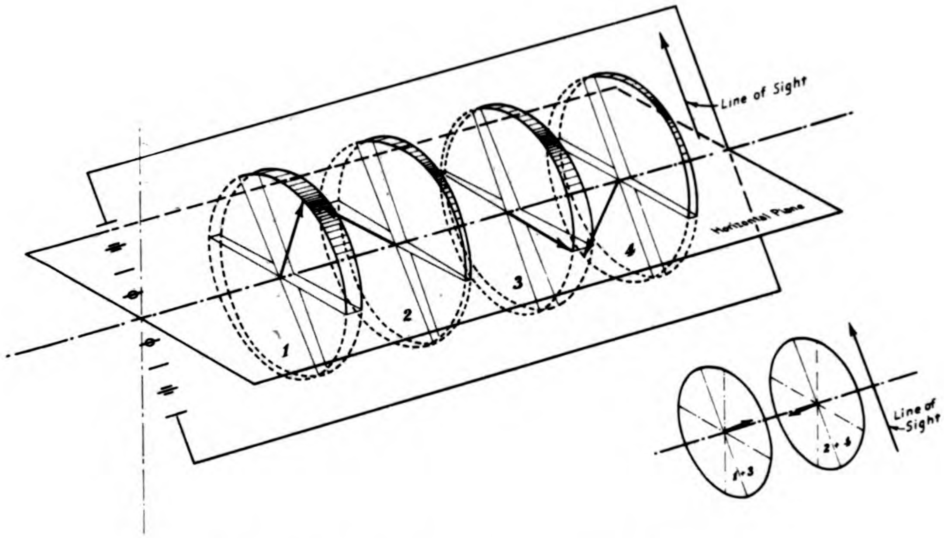
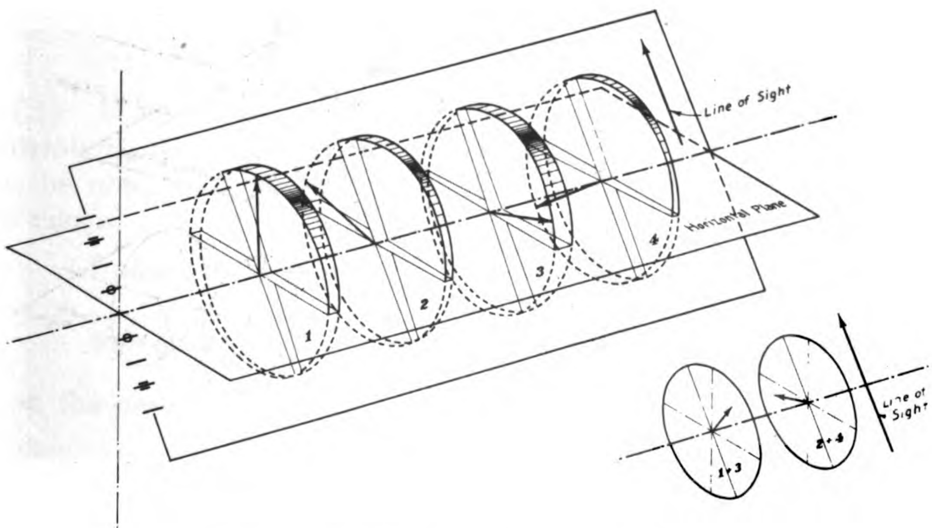
Figure 25 — Action of Measuring Wedges — Line of Sight Vertical

PRINCIPLES OF OPERATION



A — COMPENSATOR SET FOR HEIGHT INFINITY



B — COMPENSATOR SET FOR MEDIUM HEIGHT

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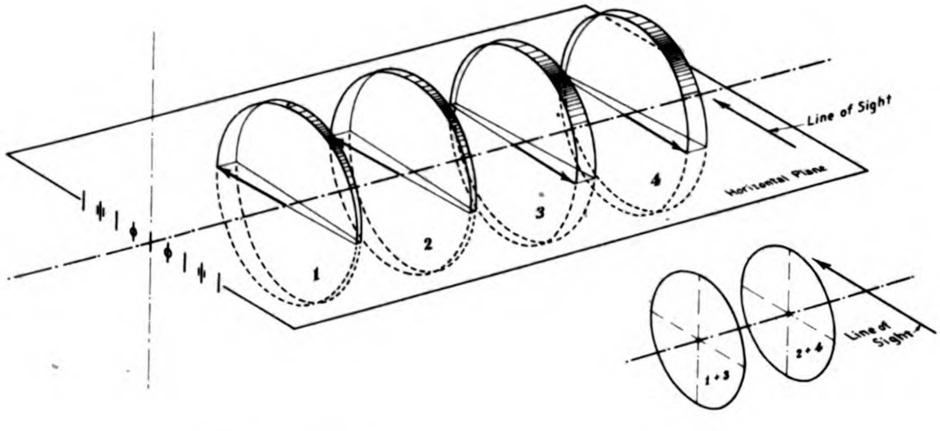
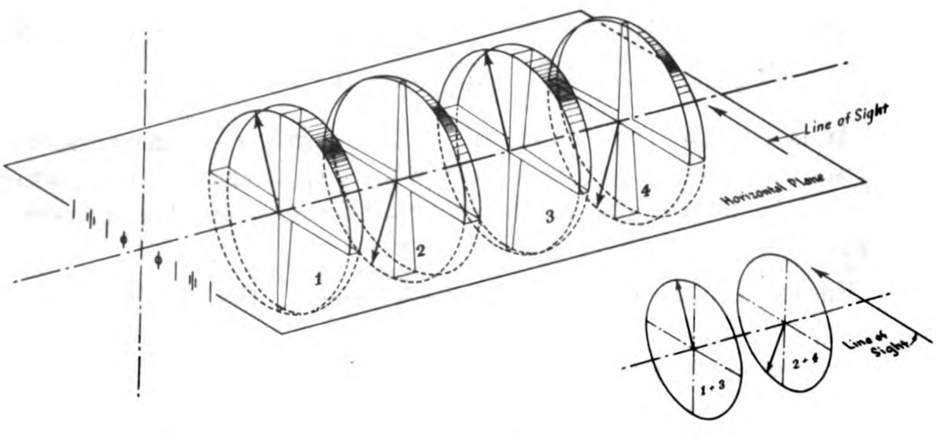
Figure 26 — Action of Measuring Wedges — Line of Sight Inclined



A — COMPENSATOR SET FOR HEIGHT INFINITY



B — COMPENSATOR SET FOR MEDIUM RANGE

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

PRINCIPLES OF OPERATION

e. Accuracy — The Unit of Error (UOE).

(1) 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 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.

(2) As mentioned above, the ranging error in yards, based on the uncertainty of observation, can be calculated from the formula

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

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 crank. Example: What is the probable error (PE) in ranging a target at 5,000 yards, using a magnification of 24?

$$PE = \frac{.0000582 \times 5000^2}{4.5 \times 24} = 13.5 \text{ yards}$$

(3) 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.

$$\text{Factor for 12 power } (F_{12}) = \frac{.0000582}{4.5 \times 12} = .00000108$$

$$\text{Factor for 24 power } (F_{24}) = \frac{.0000582}{4.5 \times 24} = .00000054$$

Now, the previous calculation becomes

$$5000^2 \times .00000054 = 13.5 \text{ yards}$$

NOTE: Recent research confirms that the power-of-magnification formula does not operate as a linear function in practice due to other factors which affect the observer's judgment. Therefore, an observer will not read twice as well at 24x as at 12x. To avoid this and other factors which may be confusing, a different approach which refers to UOE as a change in the range-finding triangle is advanced in TM 4-250. For example, a UOE is there defined as one four-hundredth of a mil error in estimating the convergence angle in the range finding triangle.

(4) 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 .54 respectively as multipliers for the square of the first significant figures:

$$5^2 \times .54 = 13.5 \text{ yards}$$

(5) Now, since these factors approximate one and one-half respectively, a sufficiently accurate (within 10 percent) result can be obtained mentally by squaring the figure representing thousands of yards when low power is used, or taking one-half the square when high power is used.

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

(6) 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 as low elevation angles.

Section IV

DETAILED DESCRIPTION

	Paragraph
Mechanical supports of the optical units	6
Optical units of the height-finding system	7
Tracking telescopes (elbow telescopes M7)	8
Cradle M1	9
Tripod M6	10

6. MECHANICAL SUPPORTS OF THE OPTICAL UNITS.

a. The main structural elements of the Height Finder Telescope M1 consist 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 directly supports some of the optical units. It also supports the inner tube, which in turn supports the optical tube and the rest of the optical units. The inner tube also permits rotating all the central optical units and end reflectors, thereby providing an elevation fine adjustment. The outer tube is covered with a layer of heat-insulating material of hair felt covered with canvas to further retard temperature changes in the height finder and for protection against denting and rough handling.

b. The instrument is hermetically sealed* and filled with desiccated helium, to prevent the optical parts (except the eyepiece assembly) 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. The eyepiece assembly, which has several moving parts, is mounted in a well having circular glass windows cemented 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, cadmium-plated to prevent corrosion.

c. **Outer Tube.**

(1) The outer tube (5, fig. 28) serves as a housing for the instrument proper, and supports the inner tube without strain. The outer tube turns in elevation on two ball bearings, one on each side of the center of the tube. The outer races (15, fig. 28) are attached to the cradle or support for the height finder when the instrument is set up, while the inner races (16, fig. 28), are attached to the tube, permitting the height finder telescope to be rotated freely in elevation.

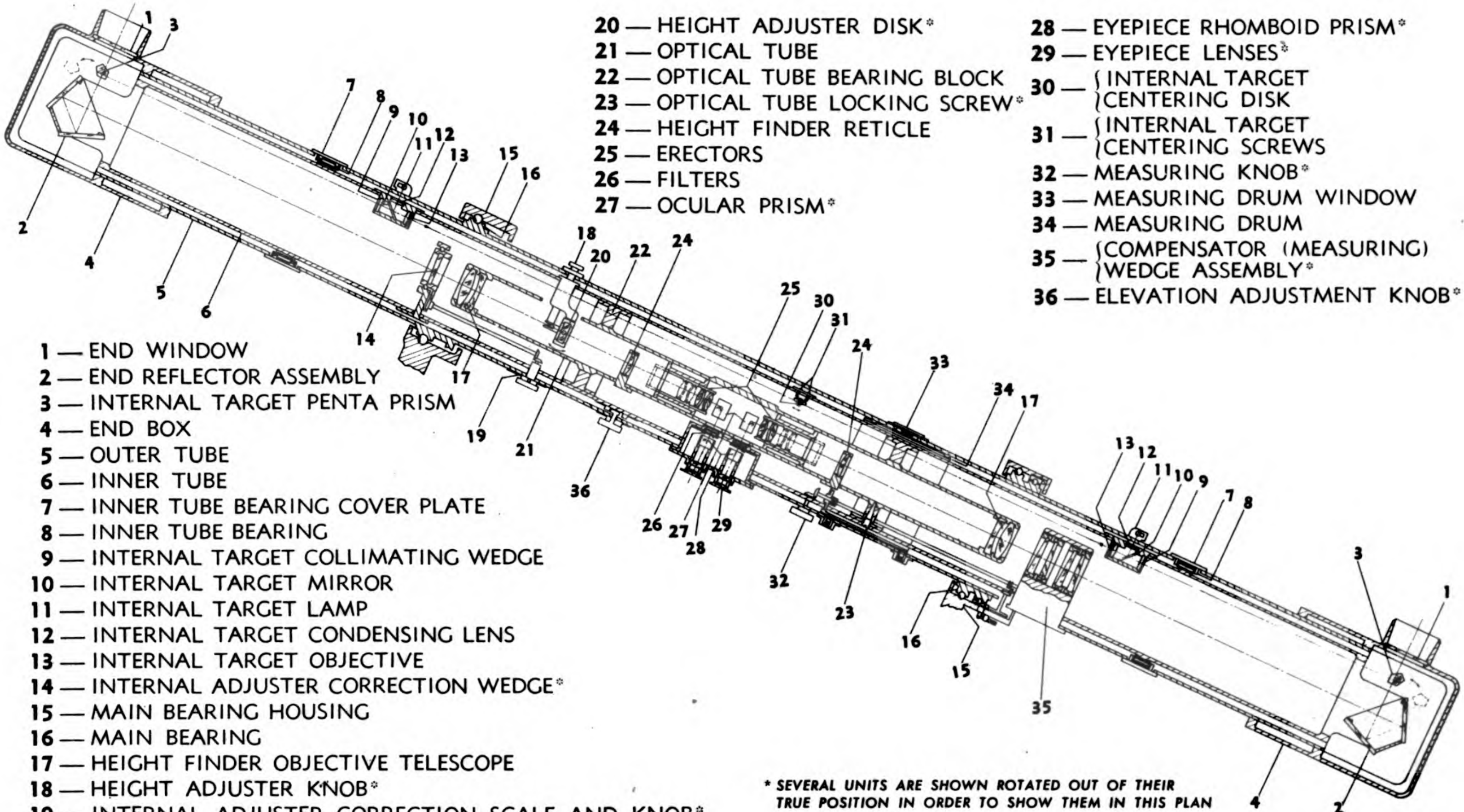
(2) Carrier handles mounted near the ends of the tube provide hand grips for eight men or more when the instrument is being lifted on or off its cradle. Feet below the carrier handles support the tube when it is necessary to set it on the floor or ground.

d. **Inner Tube.** The inner tube (6, fig. 28) is encased by the outer tube, and cannot be reached without breaking the hermetic seal of the instrument. The inner tube carries the end reflectors and other sensitive optical parts of the height finder that should 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 is not affected by minor deformations of the outer tube. The two bearings (7, fig. 28) on which the inner tube is supported are located so that the tube is 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 elevation adjustment knob. This adjustment does not affect the height conversion gear system.

e. **Optical Tube.**

(1) The optical tube carries the objective lenses and the reticles (fig. 28), the rigidity of which determines the precision of the entire

* Due to unavoidable leakage, periodic desiccation is needed.



1 — END WINDOW
2 — END REFLECTOR ASSEMBLY
3 — INTERNAL TARGET PENTA PRISM
4 — END BOX
5 — OUTER TUBE
6 — INNER TUBE
7 — INNER TUBE BEARING COVER PLATE
8 — INNER TUBE BEARING
9 — INTERNAL TARGET COLLIMATING WEDGE
10 — INTERNAL TARGET MIRROR
11 — INTERNAL TARGET LAMP
12 — INTERNAL TARGET CONDENSING LENS
13 — INTERNAL TARGET OBJECTIVE
14 — INTERNAL ADJUSTER CORRECTION WEDGE*
15 — MAIN BEARING HOUSING
16 — MAIN BEARING
17 — HEIGHT FINDER OBJECTIVE TELESCOPE
18 — HEIGHT ADJUSTER KNOB*
19 — INTERNAL ADJUSTER CORRECTION SCALE AND KNOB*
20 — HEIGHT ADJUSTER DISK*
21 — OPTICAL TUBE
22 — OPTICAL TUBE BEARING BLOCK
23 — OPTICAL TUBE LOCKING SCREW*
24 — HEIGHT FINDER RETICLE
25 — ERECTORS
26 — FILTERS
27 — OCULAR PRISM*
28 — EYEPIECE RHOMBOID PRISM*
29 — EYEPIECE LENSES*
30 — {INTERNAL TARGET CENTERING DISK
31 — {INTERNAL TARGET CENTERING SCREWS
32 — MEASURING KNOB*
33 — MEASURING DRUM WINDOW
34 — MEASURING DRUM
35 — {COMPENSATOR (MEASURING) WEDGE ASSEMBLY*
36 — ELEVATION ADJUSTMENT KNOB*

* SEVERAL UNITS ARE SHOWN ROTATED OUT OF THEIR TRUE POSITION IN ORDER TO SHOW THEM IN THIS PLAN

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Figure 28 — Schematic Plan Section Showing All Principal Optical Parts and Mechanical Supports

DETAILED DESCRIPTION

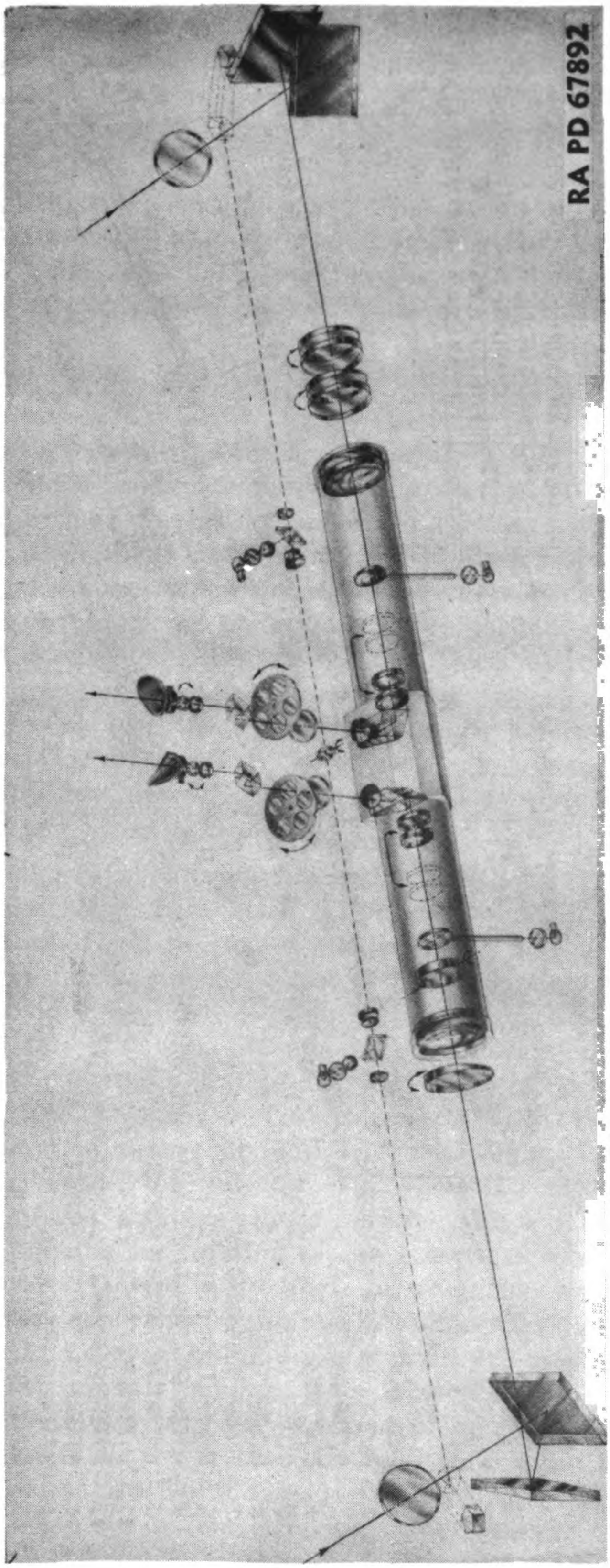

Figure 29 — Schematic Perspective of the Main Optical System and Internal Target System

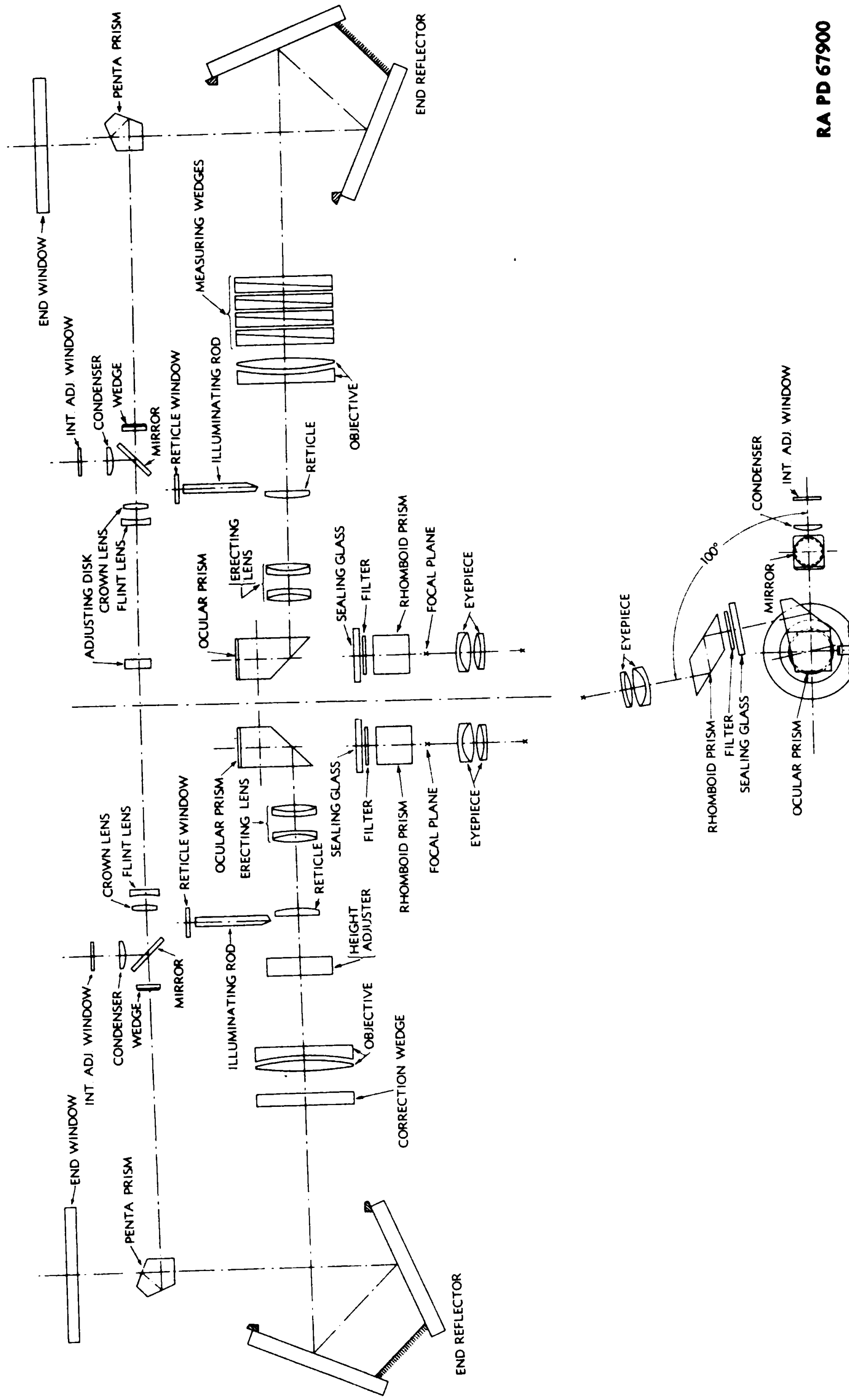

Figure 30 — All Optical Parts of the Main Optical System and Internal Target System

instrument. The optical tube also carries the erecting lenses and central prisms. Therefore, it is the most important mechanical part of the instrument and is made with the greatest degree of precision. A forging of special composition having a low coefficient of expansion is used for this purpose.

(2) The optical tube is supported in the inner tube on three-point bearings at two places only, and is held longitudinally by a single screw (23, fig. 28). This permits the optical tube to have freedom so that it is positioned but not restrained by the inner tube.

7. OPTICAL UNITS OF THE HEIGHT-FINDING SYSTEM.

a. **End Windows.** The end windows (figs. 28, 29, and 30) serve two purposes: first, they form a transparent seal for the tube; second, they provide an adjustment for the manufacturer or an optical repairman for adjusting 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 accumulate 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.

b. **End Reflectors.** In order to maintain acceptable accuracy, it is essential that the rays entering the end windows be reflected at right angles to the 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 are designed like penta prisms; they contain two reflecting surfaces very rigidly mounted with an included angle of 45 degrees. With this type reflector, as discussed in paragraph 4 d (3), 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. 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 mounted to a 1-piece steel block. The mirrors have accurately ground and polished plane surfaces, and are of sufficient thickness to retain their shape, but not so thick that changing temperatures are likely to cause distortions. The block is made from a solid piece of steel having an expansion coefficient approximately the same as that of the glass. The mirrors are mounted at 45 degrees to each other, and each mirror rests on three raised spots which are accurately finished and polished. A steel spring plate with three cork pads holds each mirror firmly to the steel block, yet leaves it free to dilate. This permits expansion and contraction due to temperature changes without producing any strain or stress in the reflectors. The inside of the block is scored to reduce the possibility of reflections being picked up from the walls. The block has a 3-point bearing on a bracket fastened to the end of the height finder inner tube. 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 subparagraph j (2), below.

c. **Objectives.** The objective lenses which form images of the target on the reticles must have as nearly as possible the same focal length (approx. 463 mm); 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. Since the surfaces of the wedges, end reflectors, end 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. 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.

d. **Reticles.**

(1) The reticles carry the reference markings with which the positions of the images formed by the objectives are compared. Therefore, they must be mounted with the markings 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 markings. Each reticle is mounted in a bracket which allows rotation about the central axis as well as movement in any direction perpendicular to the optical axis of the instrument. Thus the reticle can be rotated to make the markings appear level, and the center mark can be alined with the axis of the erector lens. Either reticle mount can be removed without disturbing the adjustment of the height finder, although the hermetic seal must be broken.

(2) The reticles are engraved on plano-convex lenses which also serve as field lenses to converge the image rays into the erector

lenses so that the whole field will be imaged by the erectors in the focal plane of the eyepiece. The reticle markings are etched into the plane surface, 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 Lucite rods to the edges of the reticles. The light enters the reticle glass and is reflected from the inner surfaces of the filled lines. The placing of the "fore and aft" marks differs for the right- and left-hand reticles, in order to produce the stereoscopic separation, as described in paragraph 5 c (4). 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.

e. Erecting Lens System.

(1) The beams from the image at the front surface of the reticle-field lens are converged by the convex surface of the lens into the erecting lens system.

(2) Each erecting lens consists of two cemented achromatic lenses with an air space between, mounted on the erector tubes (fig. 31) which fit into the optical tube, and it can be moved along its axis by the links connected to the change-of-magnification disk which the observer turns with the change-of-magnification crank. As the disk is rotated, the links draw the erector tubes toward the central ocular prisms or push them away from these prisms. Two spring detents hold the disk on 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 object distance (reticle to erector lens) for one position is equal to the image distance (erector lens to eyepiece) 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.

f. Central Ocular Prisms.

(1) The two ocular prisms at the center of the optical tube turn the rays away from the axis of the instrument, so that the images formed by the erecting lenses are brought 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

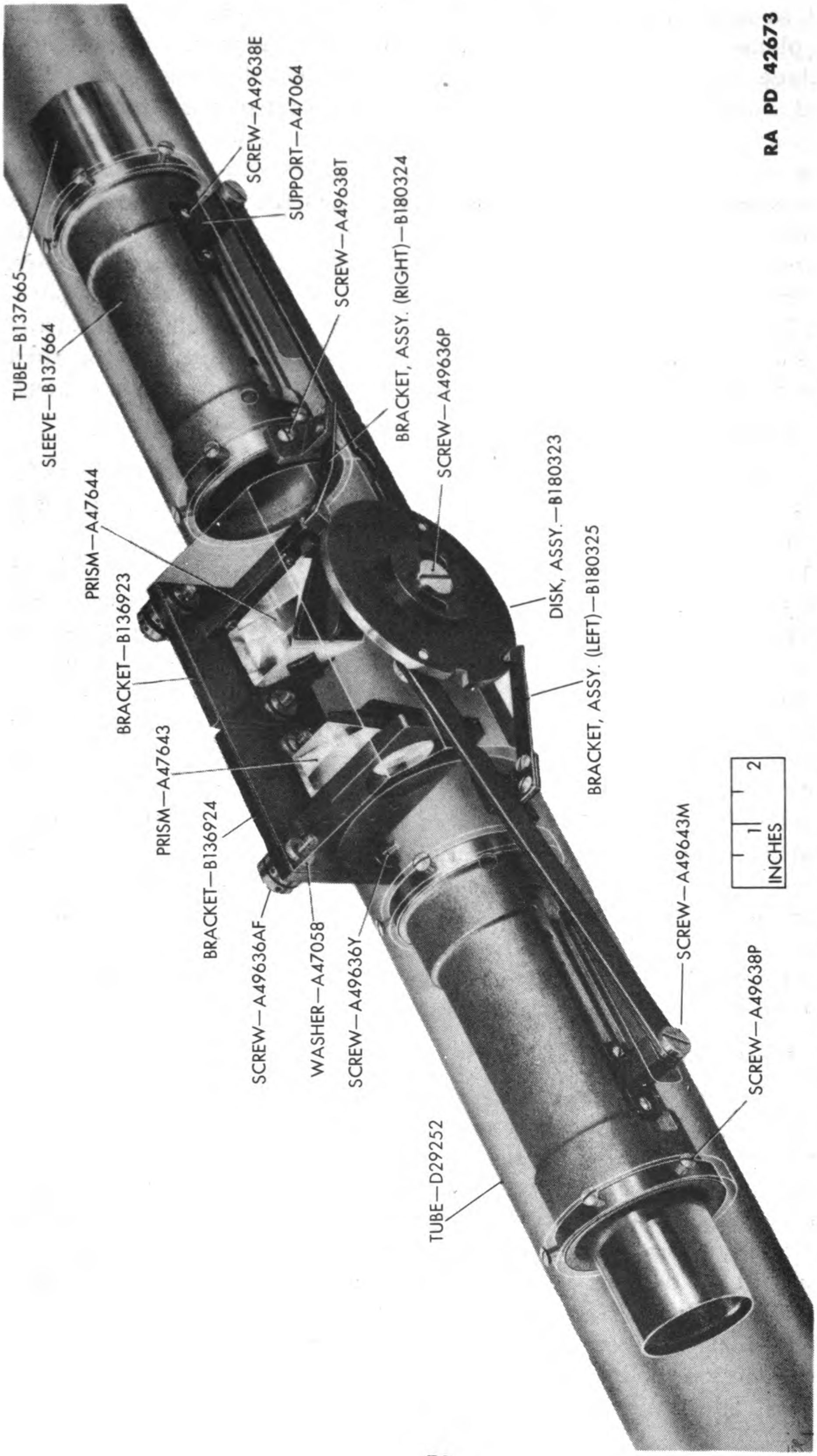

Figure 31 — Phantom View of Change-of-magnification Mechanism

the rays from the center line of the tube enough to allow insertion of the rhomboid prisms in the eyepiece unit.

(2) The ocular prisms are held securely in brackets (fig. 31) which are screwed and pinned to the optical tube.

g. **Eyepiece Unit** (fig. 32).

(1) The rays reflected from the central prisms pass out to the eyepiece assembly through windows sealed to the outer tube. The eyepiece assembly contains two sets of ray filters, two rhomboid prisms, and two eyepieces.

(2) Each eyepiece is made up of two cemented achromatic lenses 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.

(3) The rhomboid prisms 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 central ocular prisms, the distance between the two eyepieces can be adjusted to fit the separation between the observer's eyes. This movement is effected through a lever operated by a handle which indicates the interpupillary setting on an external scale calibrated in millimeters.

(4) The filters or colored glasses are used for sighting against a brilliant sky, through haze, and on camouflaged targets. Red, amber, blue, neutral, and clear filters are provided. These filter glasses are arranged and mounted so that turning a single knob brings a glass of the same color into the field of each eye.

(5) 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 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, the cover is removed and attached to one tripod leg.

(6) 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.

h. **Compensator (Measuring) Wedges.**

(1) The compensator or measuring wedge assembly (fig. 33) is located between the right-hand objective and end reflector. Thus it is not sensitive to any slight shifts in position, and, since it must be geared to the height conversion ring around the outer tube, the assembly is

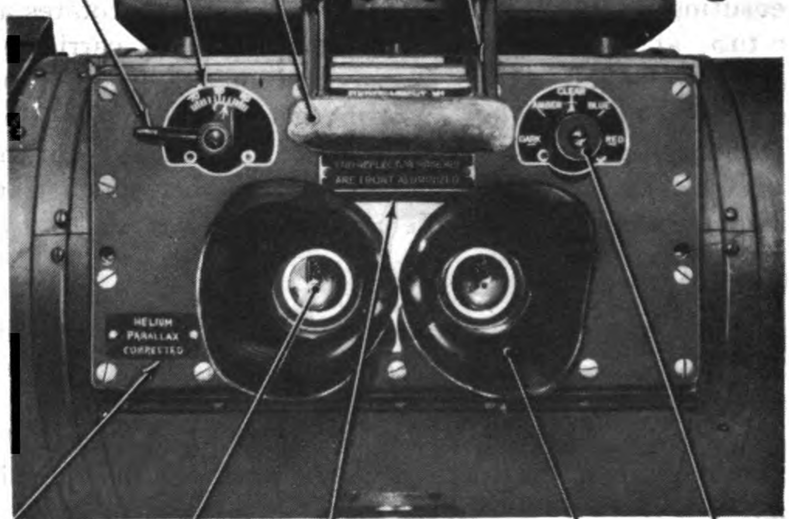

Figure 32 — Eyepiece Assembly

mounted on the outer tube. The achromatic wedges are circular in form, and are mounted in cells in the four large gears. These gears are supported in ball bearings and are rotated by pinion gears driven through the planetary gear system by the height conversion mechanism and the measuring knob. The gear train is spring-loaded to eliminate backlash. In figure 33, the gear at lower left is actuated by the height conversion ring on the outer tube. The shaft at middle left connects with the measuring knob and drum. The gear assemblies on top are spring-loaded and remove backlash from the system. The large ring gears are attached through the black adjusting rings to the individual wedge mounts. The planetary gear system appears below the large ring gears.

(2) The range scale is engraved on the measuring drum (fig. 34), which rotates just inside the outer tube, so that the scale is visible through a window at the front of the tube. The measuring drum is calibrated in yards from 550 yards to 50,000 yards. The infinity mark for calibration by internal target system or other means is shown by the asterisk (*). The gear teeth in the right end engage a gear on the measuring knob shaft assembly. The measuring knob, mounted on the outer tube in a convenient position for the right hand of the observer, is geared to the range drum and, through a shaft, to the com-

pensator wedge assembly (fig. 35). Thus, when the measuring knob is turned, both the scale and the wedges are rotated the proper relative amounts.

i. Height Conversion Mechanism. The height conversion motion of the measuring wedges is controlled by a ring which rotates around the outer tube at the right main bearing. This ring carries a lever which can be swung to the right (range position) to engage a bracket on the outer tube, or to the left (height position) to engage a bracket on the bearing housing which is fastened to the cradle. On the side of the ring is a gear which engages a bevel pinion, which transmits the height conversion motion to the compensator wedges.

j. Height-of-image Adjustment.

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

(2) The height-of-image adjustment is accomplished by means of a thick glass plate (20, fig. 28) with parallel surfaces. This glass plate is mounted in a metal frame which can be tilted mechanically about 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.

k. Elevation Fine Adjustment. The purpose of the elevation fine 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 elevation fine 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 elevation movement is introduced by an eccentric motion which is turned by the elevation adjustment knob. The elevation adjustment knob is attached to a shaft which bears an eccentrically mounted ball bearing operating in an opening in the inner tube to drive it with respect to the outer tube. The total movement amounts to approximately one degree of rotation. This adjustment does not affect in any way the elevation angle setting or the height conversion mechanism.

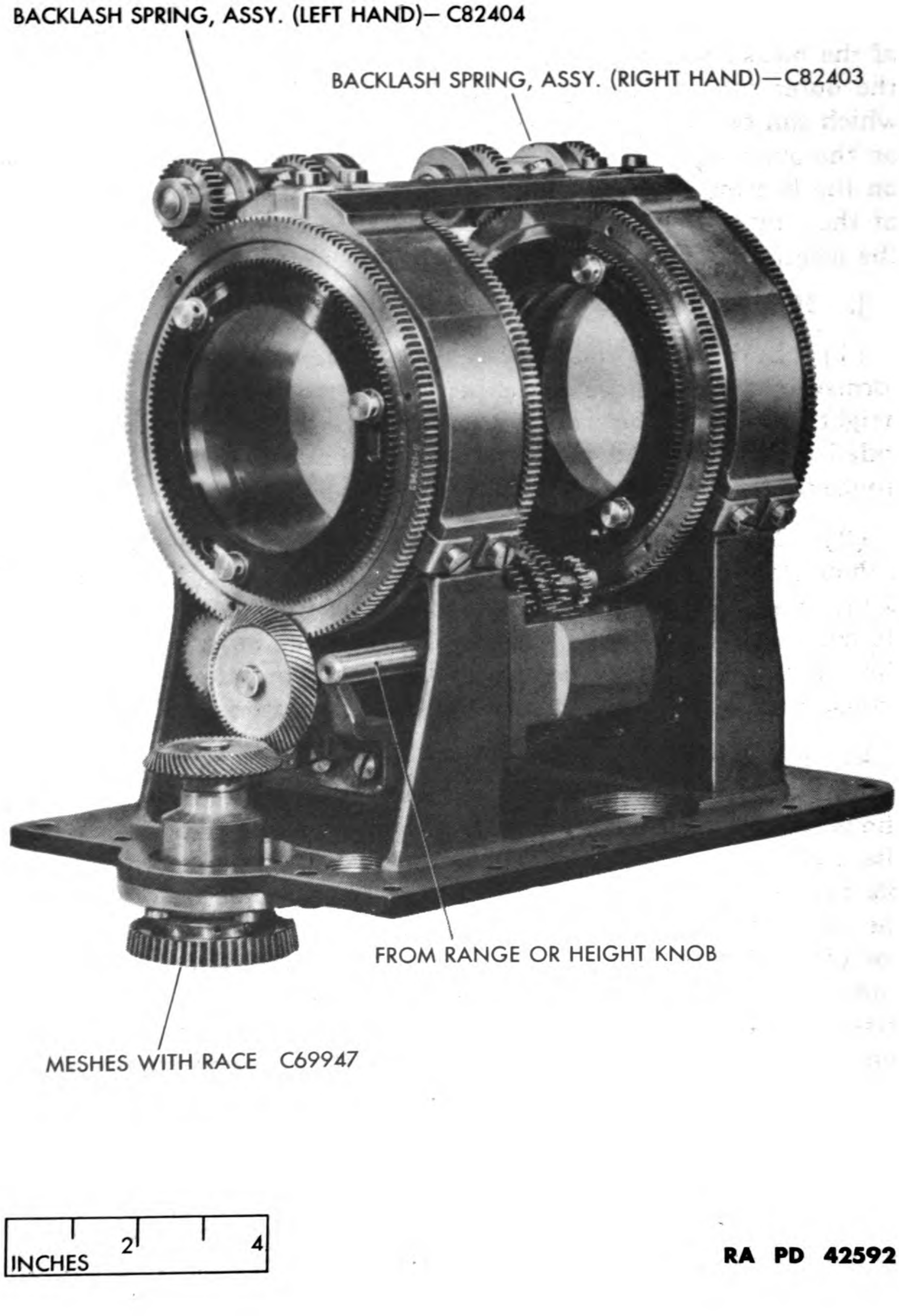

Figure 33 — Compensator Wedge Assembly

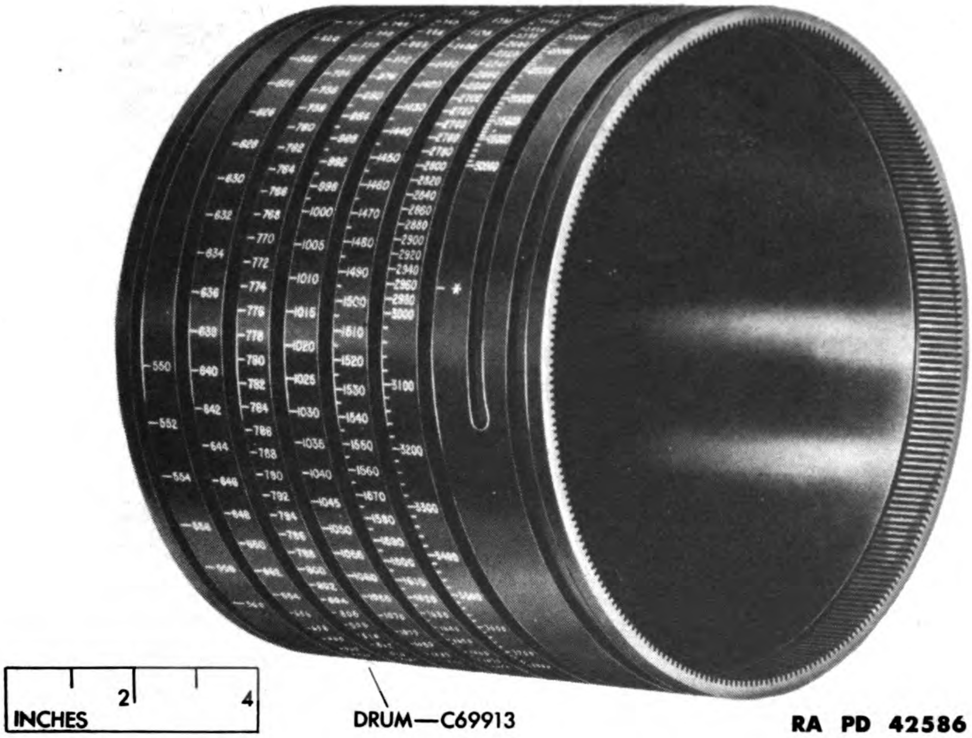

Figure 34 — Measuring Drum — Readings in Yards

l. Internal Target System.

(1) The operation of the height finder depends on the precise measurement of the very small angle between the lines of sight from the two end windows to the target. Therefore, the accuracy of the readings will be affected by any changes in the optical alinement, which can easly be caused by temperature variations in the instrument. The correction wedge mounted in front of the left objective provides a means of compensating for any such changes in alinement. Rotation of this wedge moves the image in a short arc across the left reticle, thus making it possible to establish stereo contact between the target image and the reticle marks when the range drum is properly set for the known distance of the target. The drum is set at infinity (engraved *) when moon or stars are used, or when the internal target system is employed.

(2) In field use, well-defined targets of accurately known range are seldom available for testing, and celestial objects, such as the moon or stars, are not visible during the day or in bad weather. Therefore an internal target system is incorporated in the height finder to furnish an artificial target at infinity. In order for this internal target to be effective, complete assurance is required that the internal target will not be subject to the same errors in optical alinement that occur in the main optical system of the height finder. This condition is satis-

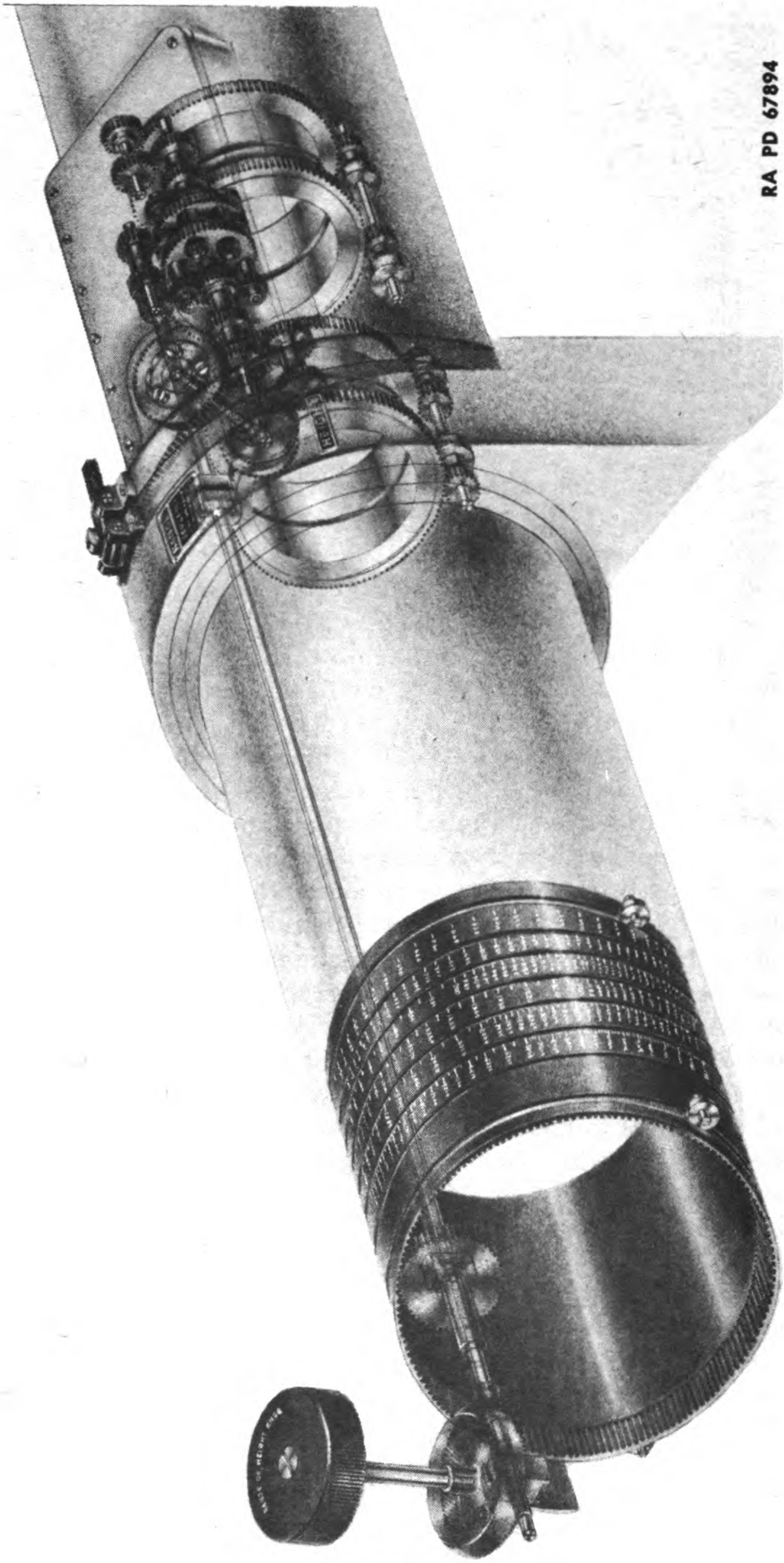

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Figure 35 — Relationship Between Measuring Knob, Measuring Drum, and Compensator Unit

DETAILED DESCRIPTION

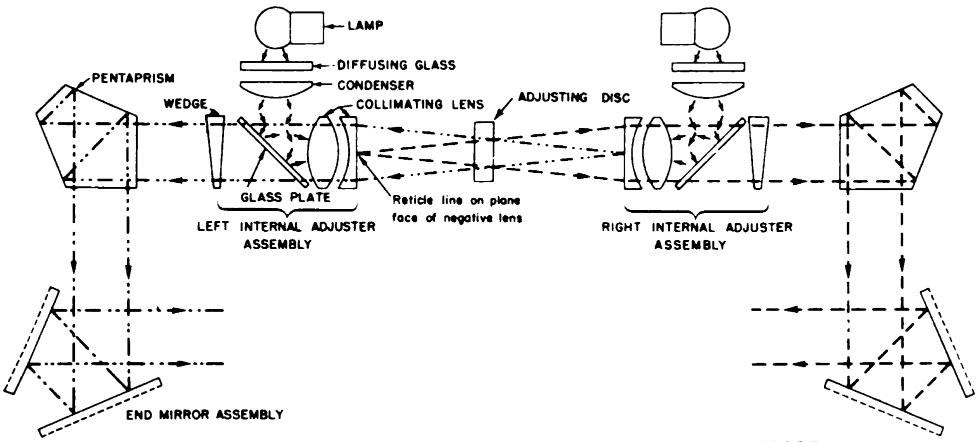

Figure 36 — Diagram of the Self-collimating Internal Target System

fied by a double-ended collimating system which gives out parallel rays and which is not sensitive to slight errors in mechanical mounting or alinement.

(3) The principle of the double objective, self-collimating system is shown in figure 36. Each objective has a line, which is the infinity target for the other objective, engraved on its plane face, axial with and close to its optical center. The objectives are mounted so that each plane face is at the principal focus of the other objective. Thus each objective produces a virtual image at infinity of the mark on the other objective, and these two images are located at opposite ends of the line passing through the optical centers of the two objectives. In use, each objective is illuminated by the light reflected from its adjacent lamp, so that the images of the lines stand out in black against the light background of the reflectors. These reflectors are of optical glass, so each transmits the major portion of the light coming from the other reflector and objective. The images of the target lines are reflected by the small end penta prisms into the end reflectors of the main height finder system. Thus the infinity line on the left internal target objective is seen by the right eye, and that on the right objective by the left eye of the observer.

(4) The rays emerging from both ends of the internal target system maintain their direction relative to each other regardless of any likely distortion of the height finder. If variations occur in the optical alinement of the height finder, the internal target lines will not appear at the same depth relation in space as do the main reticle marks, when the compensator wedges are turned to the infinity range setting. This is readily corrected by turning the adjuster scale to rotate the correction wedge until stereo contact between the internal target lines and the reticle marks is restored. This adjustment changes the range finder system, not the internal target system (fig. 38).

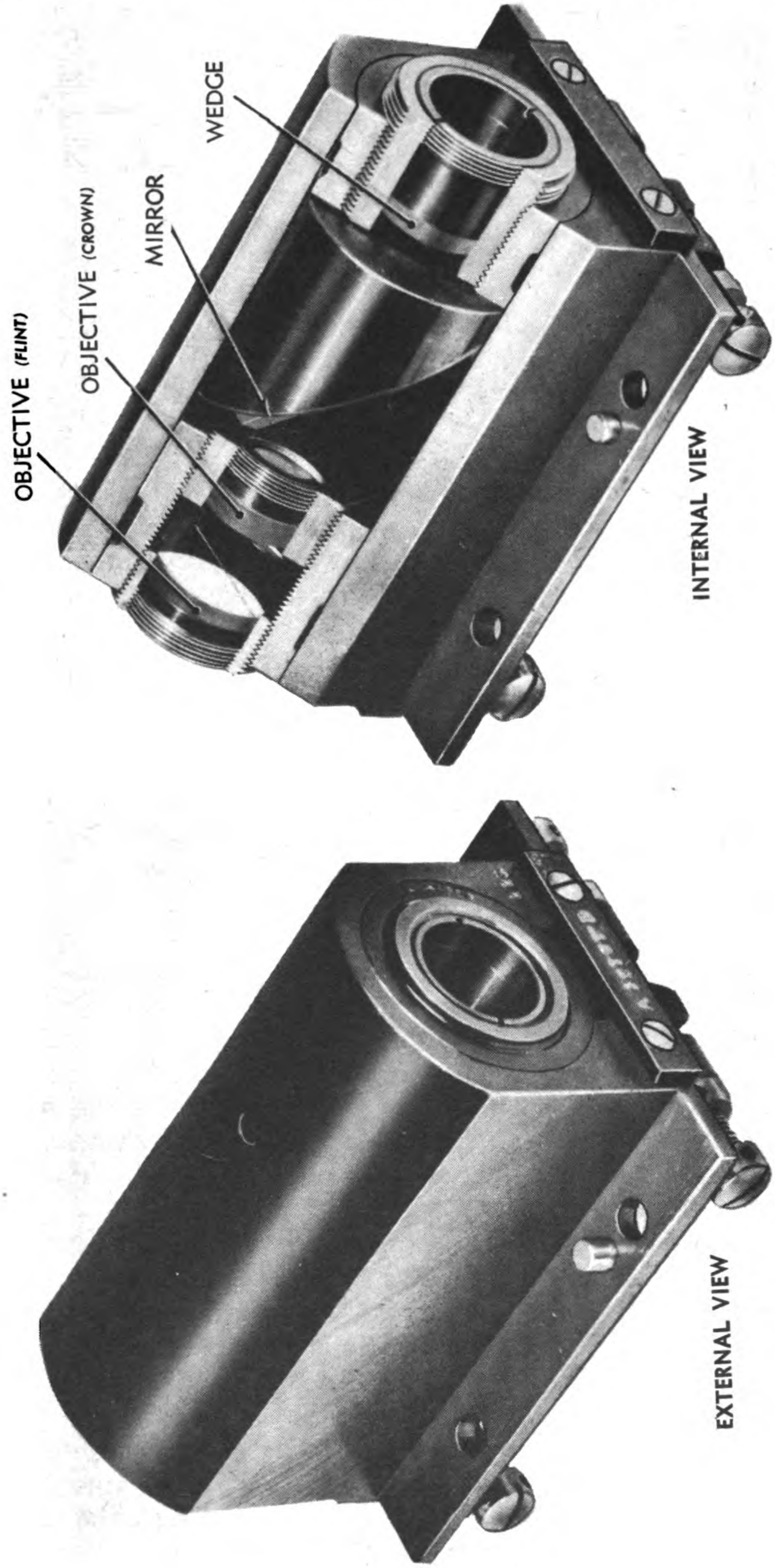

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Figure 37 — Internal Target Bracket Assembly

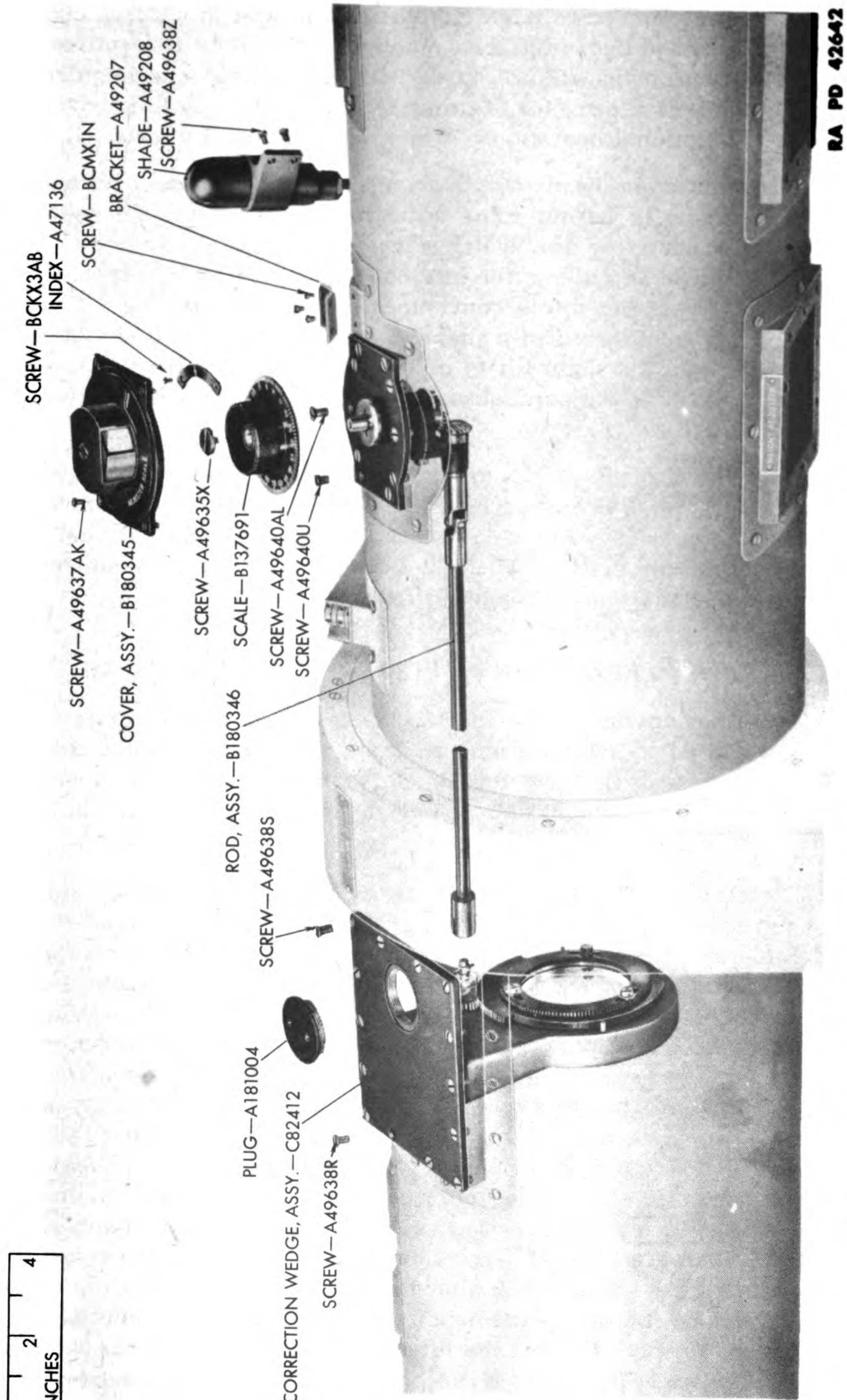


Figure 38 — Internal Adjuster Correction Wedge, Connecting Rod, and Adjuster Scale — Phantom View

(5) The adjuster scale 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 adjuster scale is equal to ½-second angular change, or one unit of error for 24x magnification. The rotating cover prevents unintentional operation. A lamp illuminates the scale.

(6) In addition to the main optical units, the internal target system contains elements to permit some adjustments to the system itself (fig. 36). The centering disk, which is located approximately midway between the objectives, allows the internal target lines to be displaced the internal target lines into a convenient position for reading. The centering disk is composed of a plane parallel glass plate, and when it is tilted it imparts a slight tilt to the axis of the internal target system without affecting the parallelism of the rays coming from the two end penta prisms.

(7) Since the penta prisms and other parts of the internal target system may not be optically perfect, collimating wedges are mounted next to the objectives 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.

8. TRACKING TELESCOPES (ELBOW TELESCOPES M7).

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 are mounted on the height finder telescope to enable the elevation and azimuth trackers to keep the height finder alined on the target. These two telescopes are identical except for the reticle markings and name plate. Construction of the telescopes and arrangement of the optical parts on Height Finders M1 with serial numbers 33 and up are shown in figure 39. A roof prism is mounted in the triangular compartment below the eyepiece. Light rays from the objective enter the front face of this prism, undergo reflection at the two roof surfaces, and emerge through the second face toward the eyepiece. The reticle is mounted just above the prism, in the focal plane of the eyepiece. The inverted image of the target formed by the objective is again inverted in its passage through the roof prism, as described in paragraph 4 d (7), so that an erect image of the target is seen through the eyepiece. A filter holder mounted just in front of the prism can be rotated by means of a knob at the side of the telescope to place any one of three color filters or a clear window in the path of the light rays. The eyepiece can be focused to suit the observer's

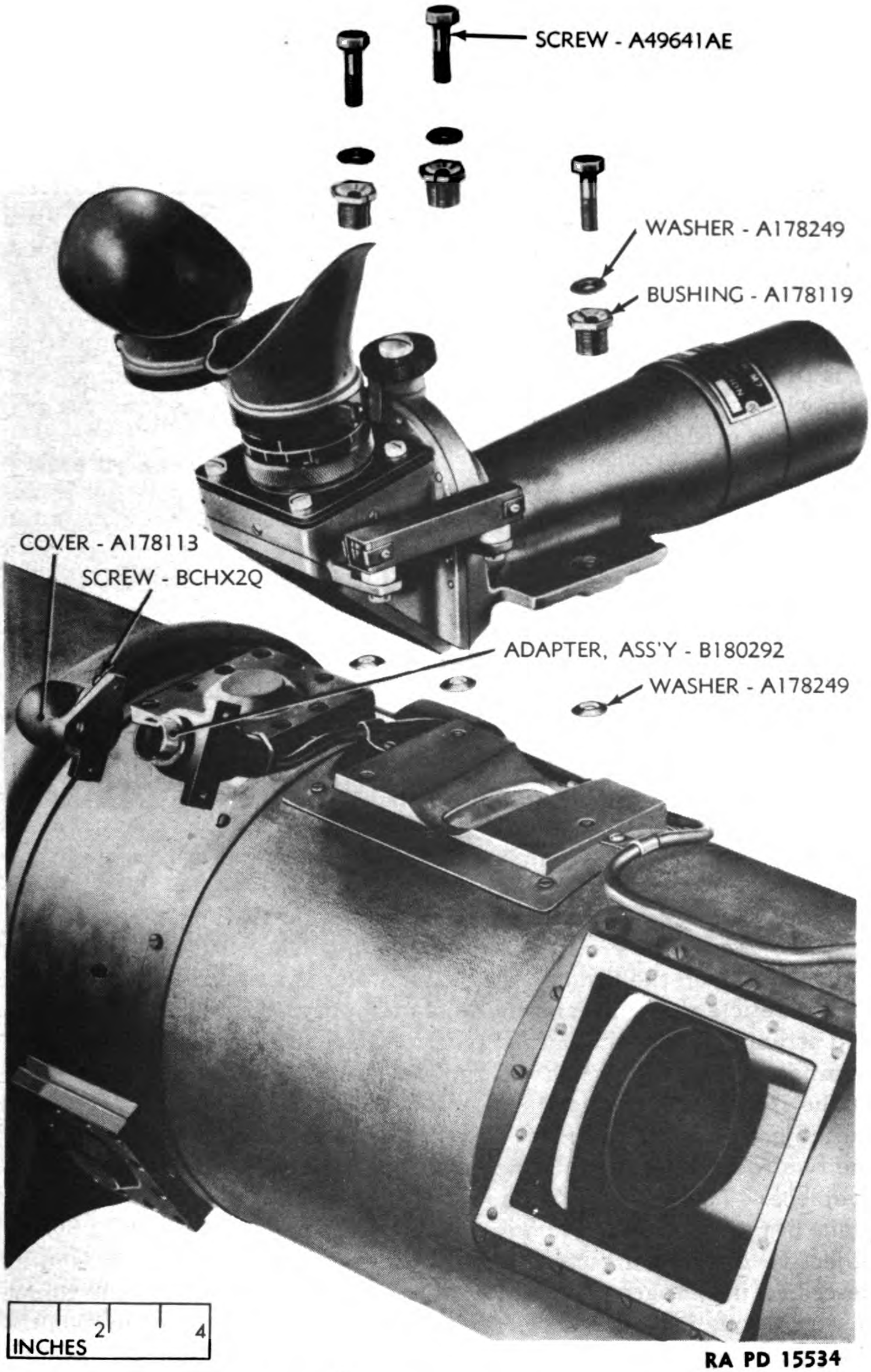


Figure 39 — Elevation Tracking Telescope Removed from Height Finder

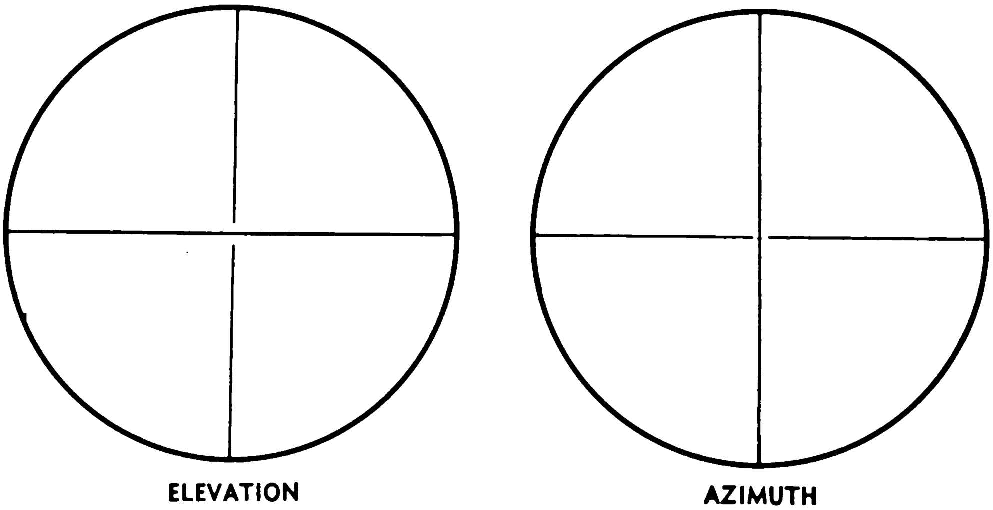


Figure 40 — Appearance of Tracking Telescope Reticles

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.

c. The magnification of the telescopes is 8x and the field of view is 6 degrees.

d. In the azimuth tracking telescope, the vertical line of the reticle is continuous and the horizontal line is broken at the center, while the reverse is true for the elevation telescope (fig. 40). A lamp at the side of the telescope illuminates the reticle markings for night observations.

e. In order to help the trackers bring the target initially into the field of view, each telescope is equipped with an open collimator sight. This consists of a tube with an eyelens at the rear end and a sight with a triangular opening at the front end, at the focal plane of the eyelens. A ground glass window in front of the sight illuminates the opening with diffused skylight. When the eye is placed back of the tube, it sees a virtual image of the triangular sight opening at infinity, and, since the rays from the ocular are parallel, the apparent direction of this image is not affected by variations in the eye position. In use, the target is sighted over the top of the sight, and the height finder is rotated in azimuth and elevation until the top point of the sight triangle touches the target. Further observation is continued through the tracking telepscope. Use of the open collimator 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.

9. CRADLE M1.

a. The Cradle M1 (fig. 41) supports the Height Finder Telescope M1 and contains the driving mechanism for traversing the height finder in elevation and azimuth. It also carries the electrical data transmission and receiving system necessary for use with an antiaircraft director, as well as the electrical controls for the illumination in the height finder.

b. **Controls.**

(1) The main bearing housings of the height finder telescope rest on flat bearing plates at the ends of the cradle, and are held down by clamping screws. Caps for protecting these screws when the instrument is dismounted are chained to the ends of the cradle. The elevation handwheel at the left end of the cradle operates, through gearing and shafts enclosed in the cradle and housing, a vertical shaft which engages a clutch on the elevation worm wheel shaft in the left bearing housing. The change-of-speed crank allows a choice of either 20 or 80 mils change in elevation angle per revolution of the handwheel. The handwheel at the right of the cradle operates in a similar manner the azimuth traversing drive in the tripod top. The change-of-speed crank provides either 10 or 40 mils 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 in the tripod head.

(2) A release lever is included near the center of the cradle to disengage the clutch of the azimuth drive when the cradle is to be removed from the tripod. A system of stops keeps the lever in the disengaged position when the cradle is not in position on the tripod. It should be noted that the clutch must always be disengaged before dismounting the instrument.

(3) Two levels mounted on the cradle at right angles to each other help in leveling the tripod when the instrument is set up.

c. **Azimuth and Elevation Indicators.** The two target designating indicators at either end of the cradle are equipped with "follow the pointer" dials. The inner or electrical index of each indicator is fastened to the rotor and is positioned electrically by the antiaircraft director. The other or mechanical index of the elevation indicator is geared to the driving mechanism and indicates the elevation angle on the fixed outer scale. The mechanical index of the azimuth indicator is connected, through gearing, to the stationary part of the tripod so that it will show the proper azimuth reading regardless of whether the instrument is traversed by the mechanical drive or by slewing. An orientation clutch knob on the side of the azimuth indicator, which is covered by a chained cap when not in use, allows the mechanical

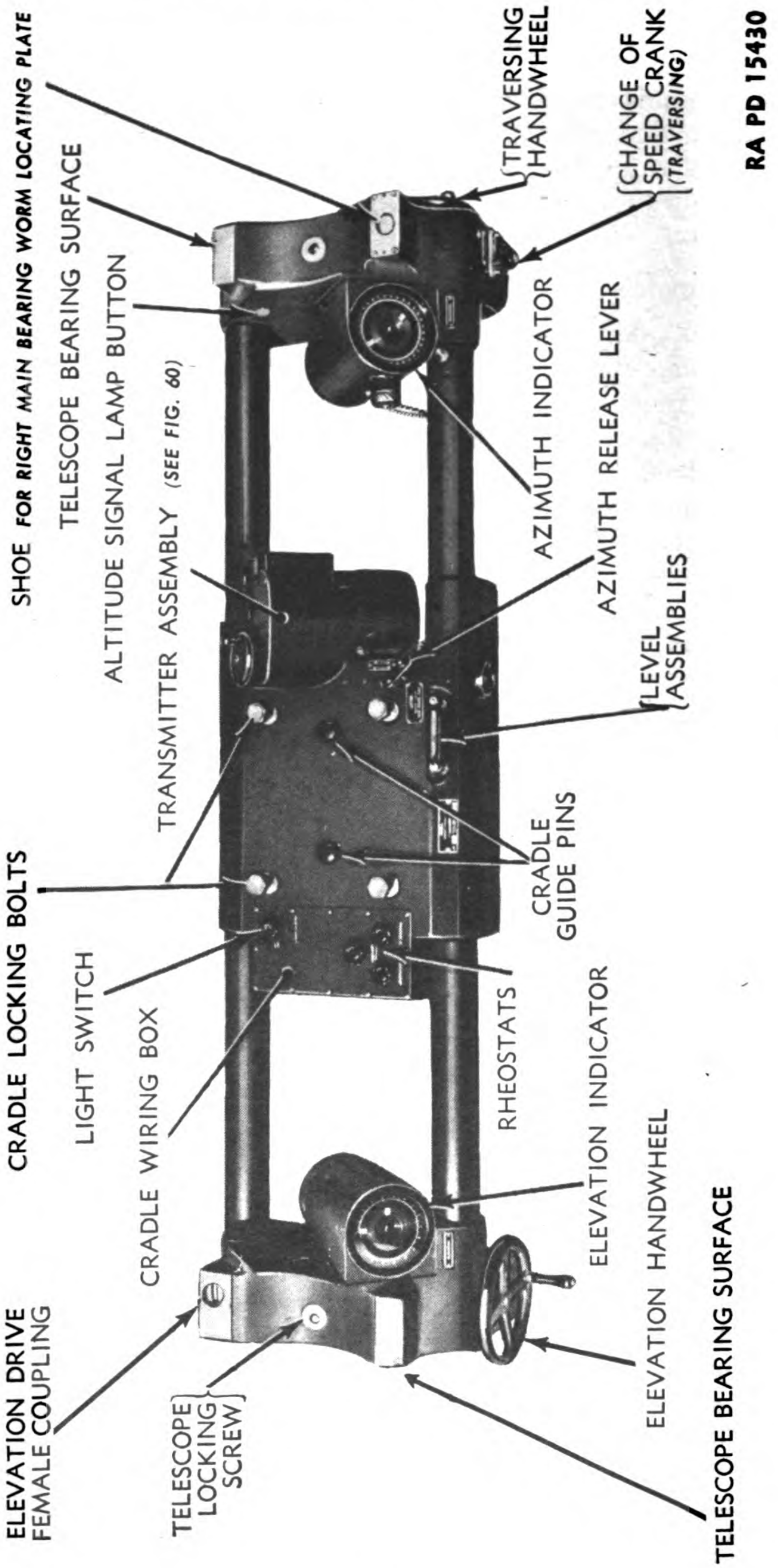


Figure 41 — Cradle M1

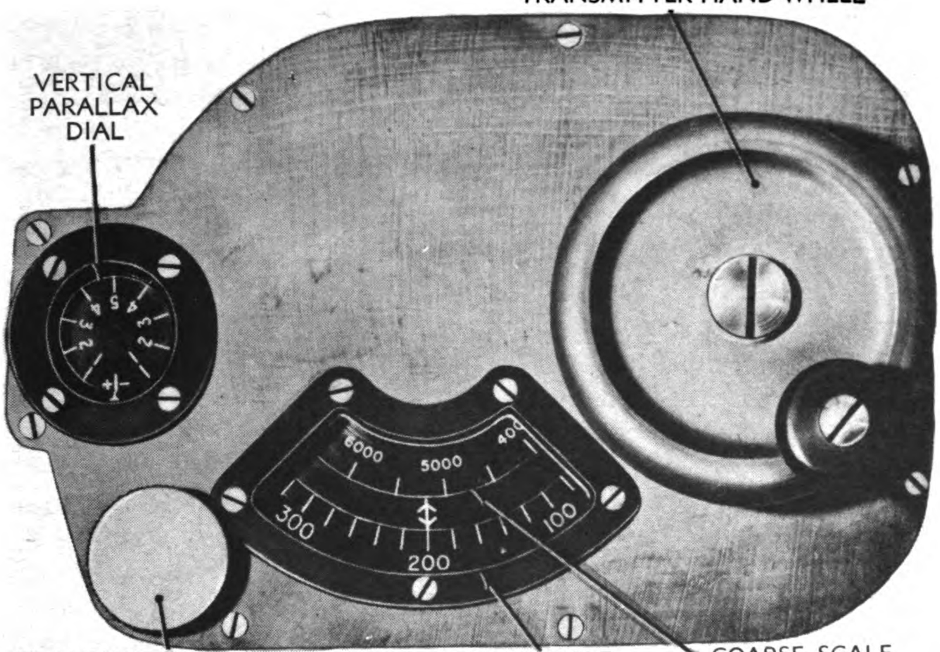


Figure 42 — Face of Transmitter

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. 42) is mounted at the front of the cradle, below and 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 handwheel at the right. The outer scale, which is graduated from 0 to 1,000 with marks for every 20 yards, rotates ten times as fast as the inner 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, so that, when the reader sets the scales to agree with the range drum reading, the data are 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 small round cover at the lower left.

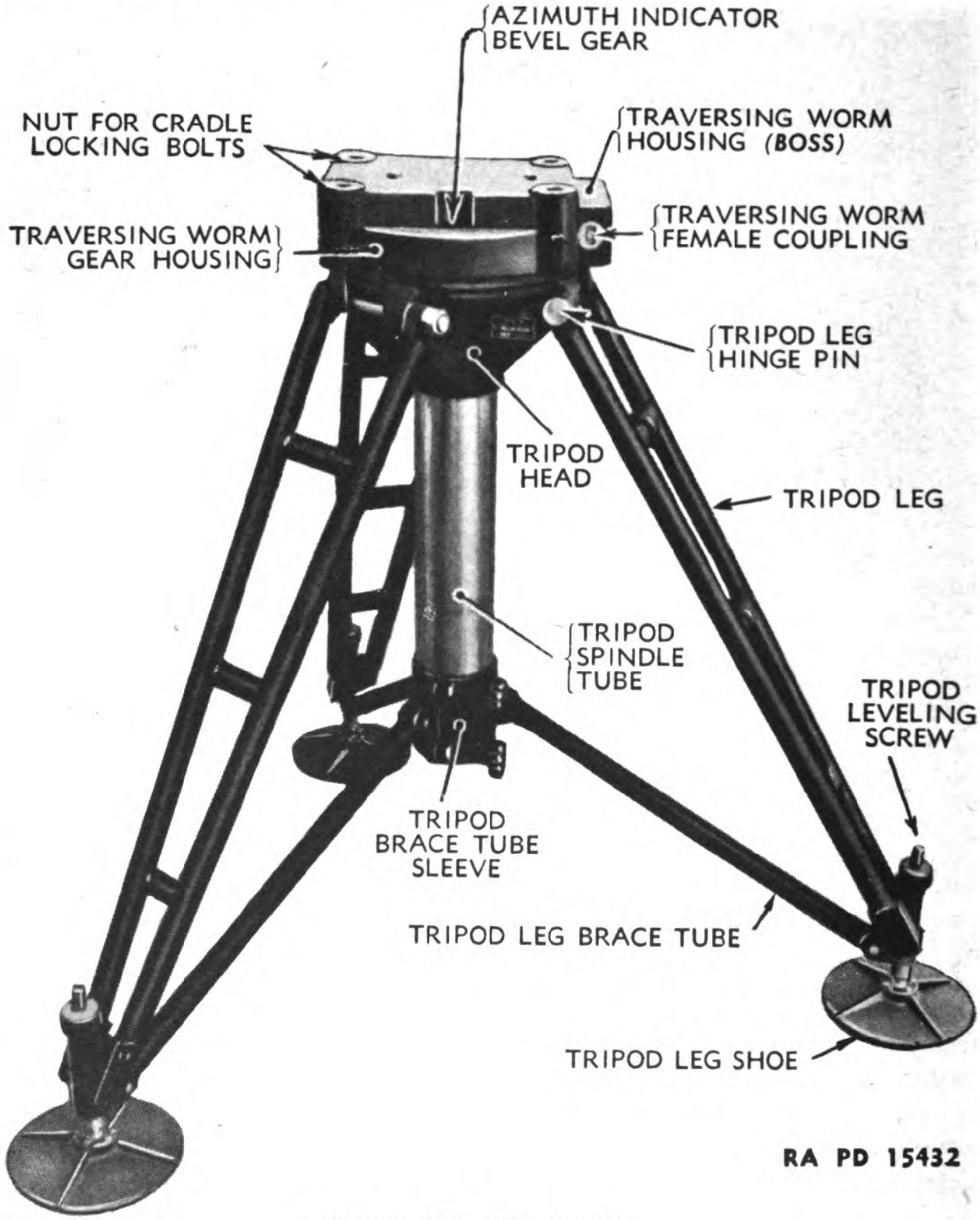


Figure 43 — Tripod M6

e. **Electrical Units.** The electrical junction box near the center of 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; a 6-volt receptacle to allow a 6-volt battery source of current to be used for the illumination; a lighting switch with three positions, "110-volt line," "6-volt battery," and "off"; rheostats to control the intensity of illumination; and a 6-pole receptacle to enable connections to be made between the cradle and the height finder telescope. The cable and plug fitting this receptacle is fastened to the height finder telescope, and all illumination leads for the instrument are included in this cable. The points which receive illumination are: stereoscopic marks on main reticles, internal target lines, range drum scale, adjuster scale, and reticle marks of the tracking telescopes. In addition, a lamp is provided to illuminate the scales of the range-height transmitter.

10. TRIPOD M6.

a. The Tripod M6 (fig. 43) supports the cradle and height finder telescope in a firm and rigid manner. A spindle, supported by ball bearings in the fixed head and central tube, carries the mounting surface for the cradle and the worm wheel of the azimuth drive. This worm engages a ring gear which can turn on the fixed head but is restrained by a friction lining. This allows the height finder to be turned in azimuth either by the mechanical drive or, for more rapid motion, by slewing. The friction between the gear and the fixed head is adjustable.

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.

Section V

ACCESSORIES

	Paragraph
Packing chests	11
Organization tools and spare parts	12

11. PACKING CHESTS.

a. The cylindrical metal packing chest for the Height Finder Telescope M1 is shown in figure 44, with the instrument partly withdrawn. When the height finder telescope is fully inserted in the chest, the traveling carriage is locked in position by hand clamps on the inside wall of the chest. The end rings carry rubber gaskets to produce an airtight seal when the end plates are tightened by the hinged clamping bolts. The socket wrench in the cradle packing chest fits the nuts on these bolts. Charging valves are supplied in packing chests for Height Finders M1, serial numbers from 33 on. The charging valves enable the using personnel to desiccate the interior of the case and thus insure long and safe storage. The hand grips are provided to facilitate carrying the chest or loading it upon a truck.

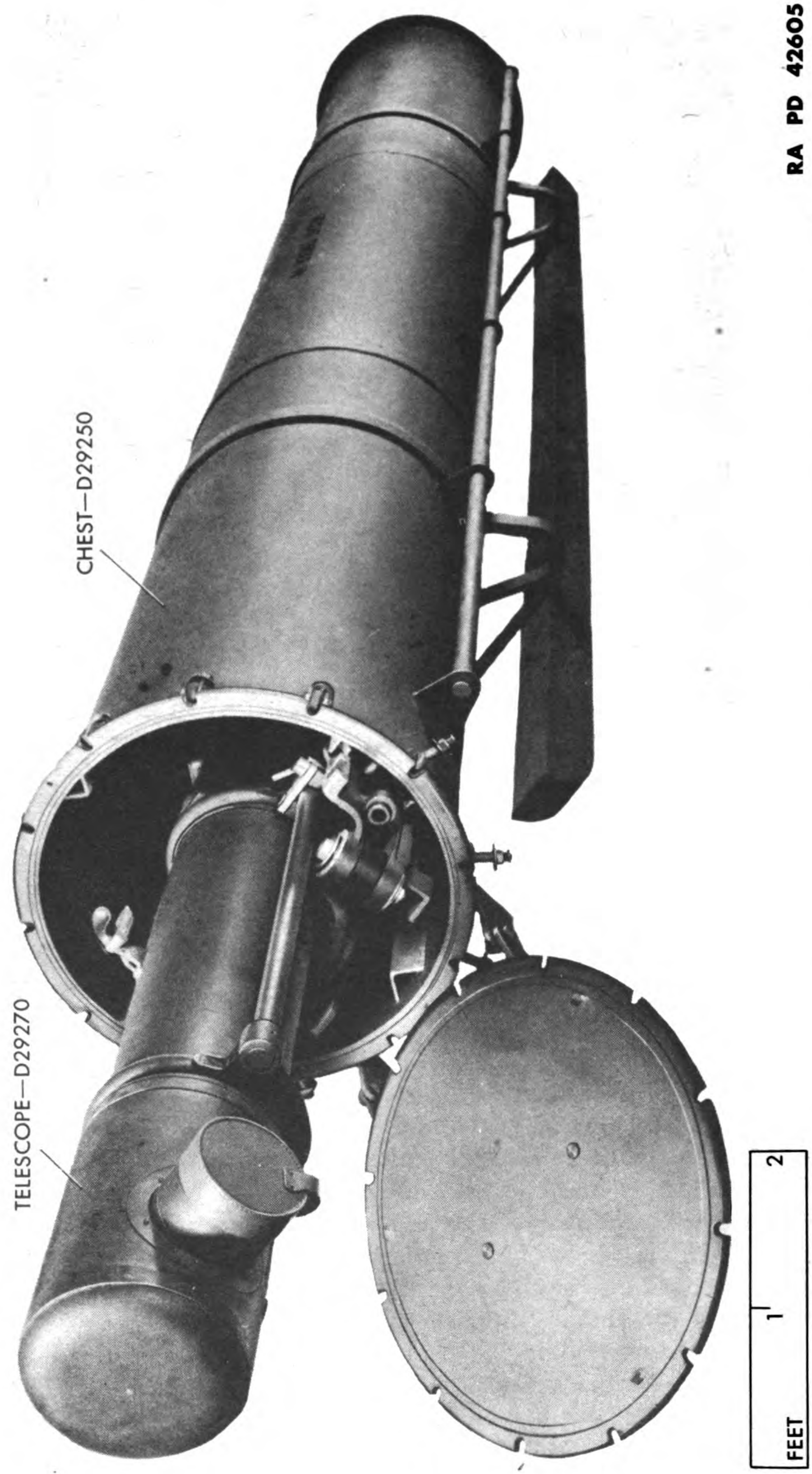


Figure 44 — Height Finder Telescope Partly Removed from Its Packing Chest

ACCESSORIES

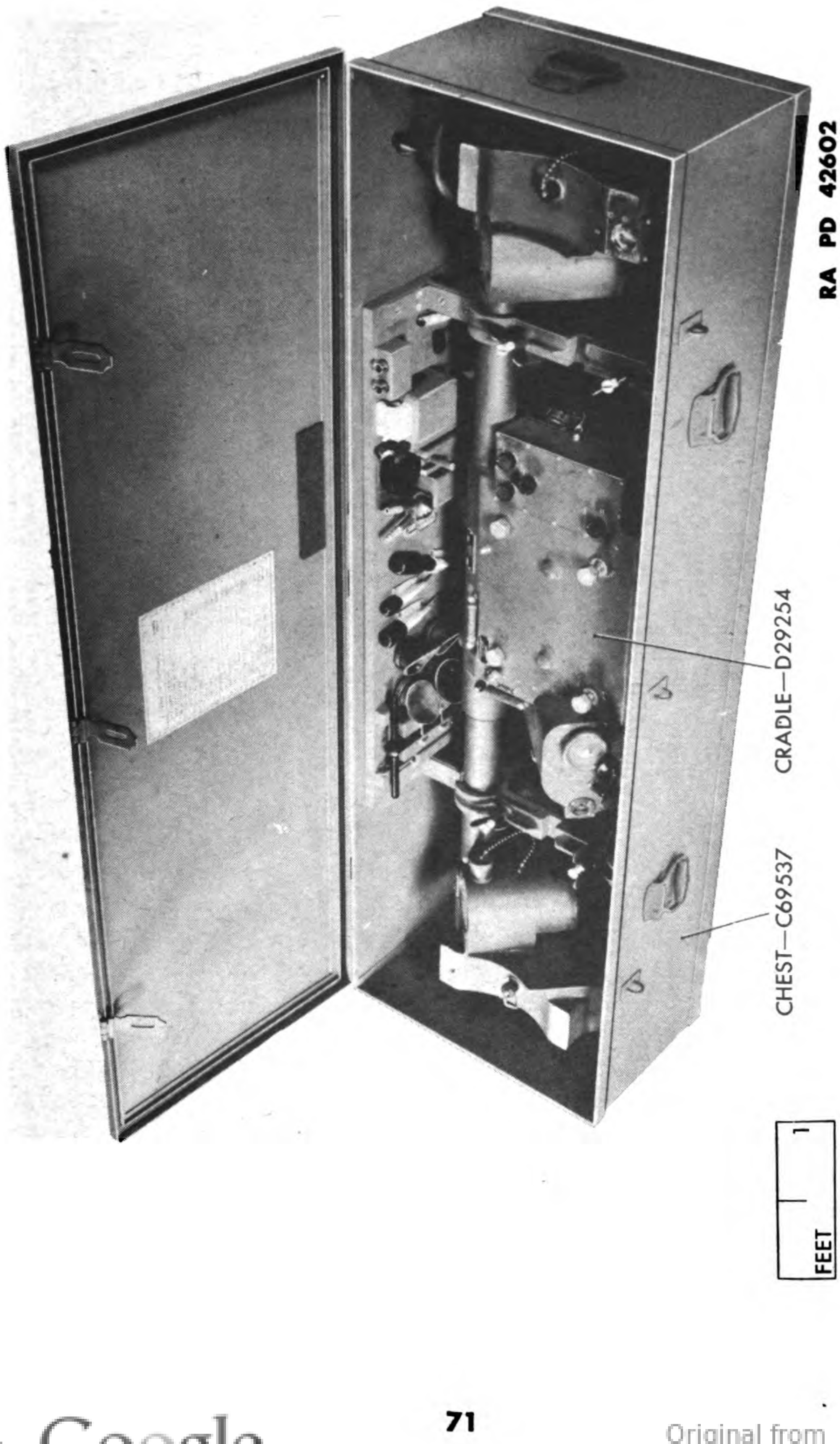


Figure 45 — Cradle Chest Containing Cradle M1 and Accessories

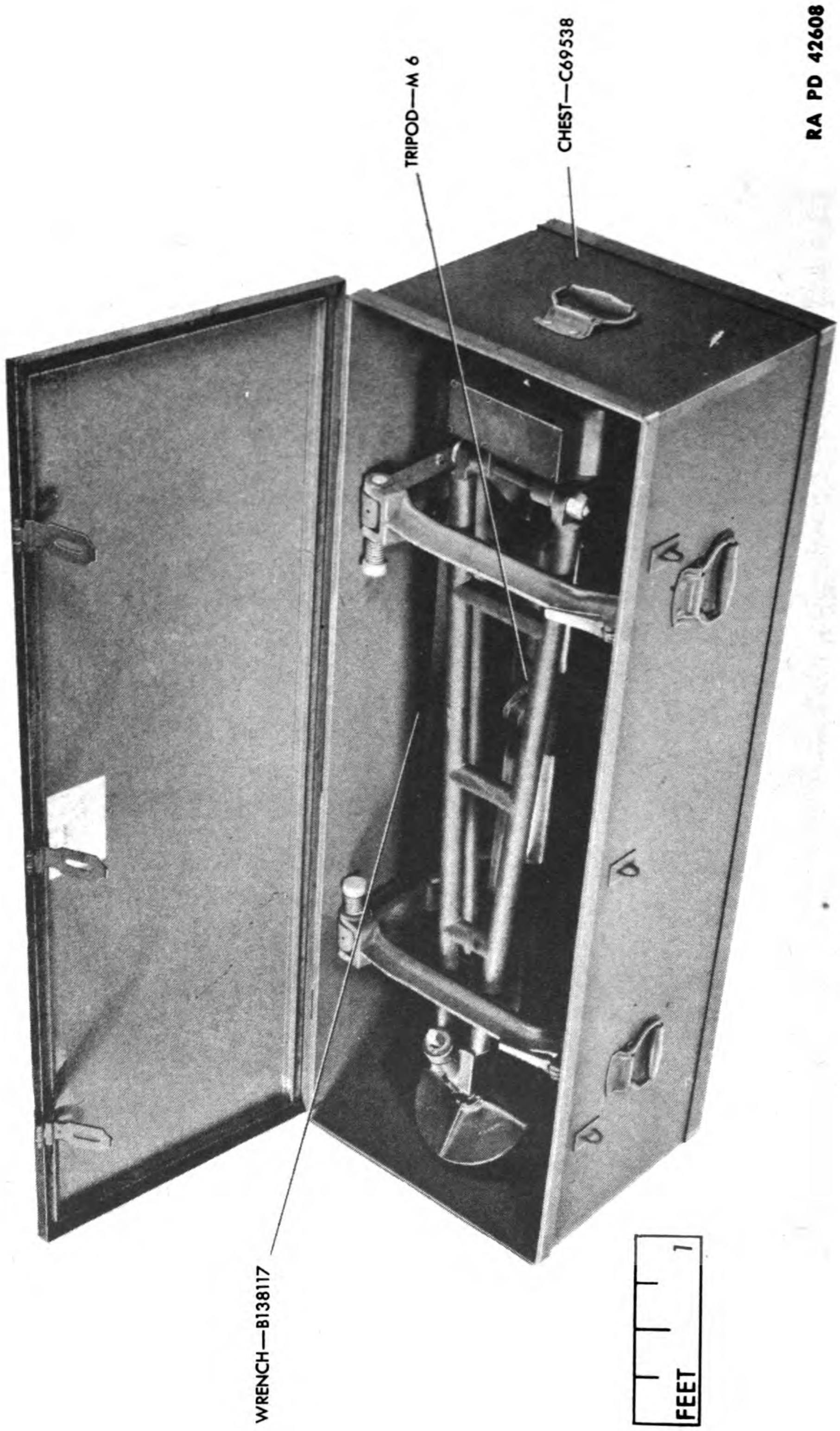


Figure 46 — Tripod Chest with Tripod M6 in Place

b. The metal packing chest for the Cradle M1 is shown in figure 45. The lid is raised to show the cradle clamped in position and the board rack for the spare parts, tools, and accessories.

c. The metal packing chest for the Tripod M6 is shown in figure 46, with the cover lifted and the tripod clamped in storage position. The hand wrench for adjusting the leveling screws is shown in its traveling position in the back of the case. The lids of both chests have rubber gaskets to provide a watertight seal.

12. ORGANIZATION TOOLS AND SPARE PARTS.

a. Accessories and spare parts for Height Finder M1, delivered with each instrument, are described in TM 9-623.

Section VI

SETTING UP AND PRELIMINARY ADJUSTMENT

	Paragraph
Setting up	13
Orientation	14
Synchronization	15
Preliminary adjustments	16
Dismantling and packing	17

13. SETTING UP.

a. Site for Inspection and Adjustment.

(1) When the Height Finder M1 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 be 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 M1 is to be checked with an antiaircraft director or equivalent, an ordinary 110-volt a-c power supply with a thin, 2-pronged receptacle is adequate power for all testing needs. The 110-volt receptacle will fit the two prongs numbers 4 and 5 of the 19-pole plug (fig. 222). A 6-volt line can also be employed using the 2-prong, 6-volt receptacle at the front of the cradle.

(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 level, as described in TM 9-623.

14. ORIENTATION.

a. The orientation of the height finder should be checked and adjusted, as described in TM 9-623.

15. SYNCHRONIZATION.

a. The synchronization of the height finder should be checked and adjusted as described in TM 9-623.

16. 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 the 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 9-623.

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

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

(2) OPTICAL ADJUSTMENT.
(a) Wedge adjustment (any of main system).
(b) Realinement of internal target system.
(c) End window adjustment.
(d) Fine elevation knob stops (focus change).
(e) Readjustment eyepiece assembly and replaced optics.

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

17. DISMANTLING AND PACKING.

a. The height finder should be dismantled and packed as described in TM 9-623.

Section VII

INSPECTION

	Paragraph
Introduction	18
Check the instrument for completeness	19
Optical check — basic performance	20
Optical check — basic performance (cont'd)	21
Optical check — final performance	22
Electrical check	23
Mechanical check	24
Summary of inspections and tolerances	25

18. INTRODUCTION.

a. Purpose.

(1) The systematic basic inspection procedure provides a means for determining whether 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. This check should be made during the basic inspection just before making the optical check. Reference should be made to the results obtained by the height finder crew in checking the instrument by the Oliver method (TM 9-623). If these tests indicate excessive leakage or if the instrument has not yet been charged with helium, a pressure test (TM 9-1622) should be carried out to locate any leaks. The leaks can be repaired while the instrument is disassembled for other repairs or adjustments. The pressure test should be repeated after completion of all repairs requiring breaking of hermetic seal, to insure that all adapters have been mounted properly.

b. Requirements.

(1) The inspection tests should be made by a trained stereoscopic observer whose speed is not over 2 UOE in 10 readings and, where practical, should be checked by a second observer. The instrument must be set up in a suitable location as described in paragraph 13. The instrument should be under stable temperature conditions (no temperature change greater than 3 deg per hr), 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 (less than 4,000 yd); intermediate (5,000 to 10,000 yd); and long (over 12,000 yd) ranges. A distant target with a sharply defined reference point or line exactly level with the height finder is also needed (par. 21 i).

(2) The following tools and items of testing equipment (par. 34) are required for making the complete inspection: double collimator, collimating telescope, dioptometer, bumping machine or steel-wheel truck, interpupillary distance template (or ground glass, wood blocks, and millimeter scale), Pupil loupe (or hand magnifier), reading microscope (or scriber and hand magnifier).

c. **Tolerances.** Tables of the tolerances which should be met in all of the inspection tests are given in paragraph 25.

19. 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 and note any damaged or missing parts.

b. **Height Finder Telescope.** Check the instrument for M7 Telescopes, adjusting knobs, carrier handles, eye shields, lamps, etc.

c. **Cradle.** Check the cradle for elevation and azimuth indicators, height transmitter, traversing and elevation handwheels, levels, 19-pole receptacle, 6-pole receptacle, etc. Note presence of nicks or burs on mating surfaces.

d. **Tripod.** Check the tripod for friction ring adjustment, adjustable feet, ease in setting up, etc.

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

20. OPTICAL CHECK — BASIC PERFORMANCE.

a. The basic performance test will determine whether or not the optical elements in the height finder are in proper adjustment for taking accurate height and range readings.

b. **Levels.**

(1) 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 recticle field, and that the height readings, which are dependent on the angle of elevation, will give true values.

(2) 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. 13). Check the positions of the bubbles with respect to the engraved marks on the vials.

INSPECTION

INSPECTION OF HEIGHT OF INTERNAL ADJUSTER MOONS

STEP 1 — SET HEIGHT ADJUSTER FOR EXTERNAL TARGET.

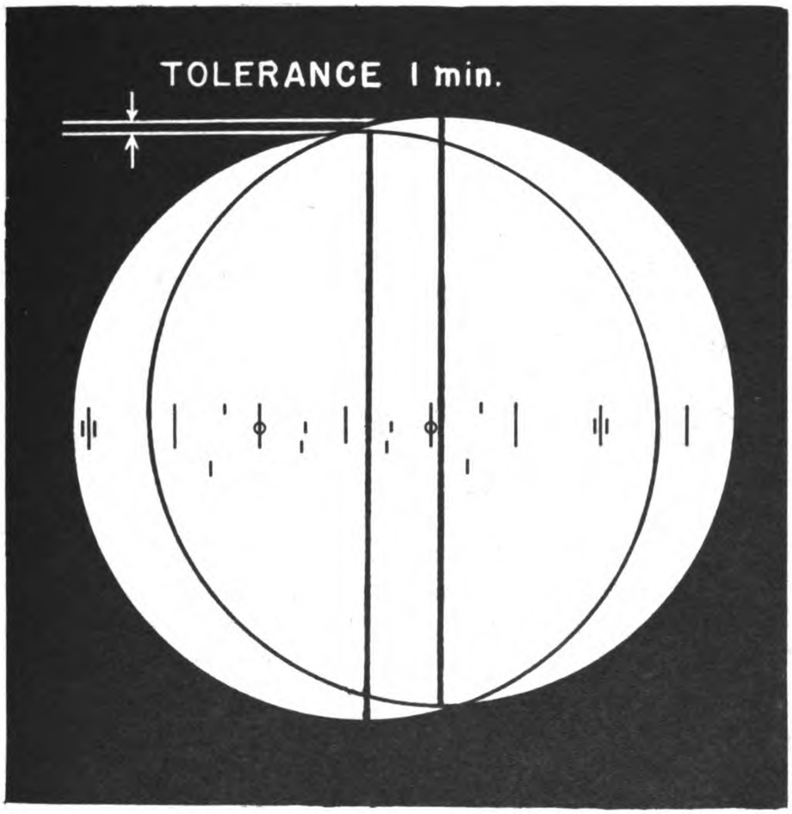
STEP 2 — TURN ADJUSTER PRISM SHIFT FOR INTERNAL READINGS.

STEP 3 — OBSERVE THROUGH LEFT EYEPIECE AND NOTE POSITION OF INTERNAL TARGET MOON IN RETICLE FIELD.

TOLERANCE: MOON SHOULD BE CENTERED UP AND DOWN WITH RESPECT TO RETICLE MARKS WITHIN ONE MINUTE. *(CIRCLE ON BALL MARK IS ONE MINUTE IN DIAMETER; CENTER LINE OF RETICLE IS THREE MINUTES LONG.)*

CORRECTION: TO CENTER MOON WITHIN TOLERANCE, ADJUST LEFT PENTA PRISM. *(PAR. 57)*

STEP 4 — SIGHT THROUGH BOTH EYEPIECES AND ROTATE RANGE KNOB TOWARD NEAR RANGE UNTIL RIGHT AND LEFT MOONS ARE SEEN AS SEPARATE OVERLAPPING FIELDS AND NOTE RELATIVE HEIGHTS.



TOLERANCE: RIGHT MOON SHOULD NOT BE MORE THAN ONE MINUTE HIGHER OR LOWER THAN THE LEFT MOON.

CORRECTION: TO LEVEL RIGHT MOON, ADJUST RIGHT PENTA PRISM. *(PAR. 57)*

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Figure 47 — Height of Image Adjustment

(3) Turn the elevation handwheel to center the bubble in the level on the height finder telescope. Check the movement of the height conversion ring (outer main bearing race) as follows:

(a) Set the height-range lever in "height" position and scribe a fine line on the bearing housing exactly opposite the upper edge of the zero-degree engraved line on the ring. (If a reading microscope is available, mount it so that its horizontal reticle line is superimposed on the upper edge of the zero degree mark.)

(b) Move the height-range lever to "range" position and check the position of the upper edge of the 90-degree line with respect to the scribed index mark. Use a hand magnifier to check the position of the scribed mark with respect to the two lines on the ring.

(4) If the cradle and telescope levels are not within tolerance, adjust them (par. 41) before proceeding further with the inspection.

c. Height Adjuster for Height of Image.

(1) 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.

(2) Set height adjuster for an external target by making a height-of-image adjustment (par. 16). Shift the height finder prism shift crank for internal target readings, and note the relative positions of the illuminated circles or "moons" in the reticle fields (fig. 47).

(3) ANALYSIS.

(a) If it is impossible to bring the external field into adjustment, it is an indication that an end reflector support has become loose and shifted, or that the right main inner tube adapter has shifted. Check by leveling the height finder and sighting on a target at the same height as the height finder with the height adjuster knob and the elevation adjustment knob set at midposition. Look for the trouble on the side of the height finder through which the target is not visible. Make the necessary adjustment as in paragraph 42 c.

(b) If the height adjustment for the internal field is not the same as for the external field, check the alinement of the internal target penta prisms and other elements (par. 57 c).

d. Internal Target and Main Optical Systems.

(1) 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.

(a) Set the height-range lever at "range," the measuring drum at "infinity (∞)," and the adjuster prism shift for "internal target" readings. Make five internal target readings and set the median value on the adjuster scale. (When a group of numbers is arranged so that

the numbers are ordered in size from the smallest to the largest, the median is the middle number in the series. When such a series contains an even number of numbers, the median is taken as the average of the middle two numbers.) Shift the prism crank shaft for outside readings and make five readings on a target at a known distance of between 2,500 and 5,000 yards.

(b) In some cases, it may be impossible to obtain stereo contact between the internal target line and the center line of the main reticle. In such cases, obtain stereo contact on either of the fore or aft marks in the reticle field. If the internal target is adjusted to the fore or aft marks, obtain stereo contact with the outside target on the same fore or aft marks. (Always recheck the measuring drum infinity (*) setting if stereo contact cannot be made with the internal target.

(c) 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.

(2) ANALYSIS. For outline, see Table I.

(a) 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 48 to 52 adjuster reading by adjusting the internal target collimating wedges and the end windows (pars. 58 and 60 **c**).

(b) 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. 60 **c**).

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

1. End reflectors. These may not be properly seated on bosses. End mirror support may be loose or there may be dirt or burs on a pressure pad. Correct as in paragraph 42.

2. Measuring wedges. These might be out of adjustment. Check as in subparagraph **e**, below.

3. Correction wedge. This might be out of adjustment. Check as in paragraph 21 **d**.

4. Objective cells. These may have been decentered, clamping rings or locking rings may be loose, or the lens may be loose in its cell. Check these points, and, if necessary, make adjustment as instructed in paragraph 45.

TABLE I

	TOLERANCE OF READINGS		CONDITION	
	External Target	Internal Target	Main Optical System	Internal Target System
1.	In	In (20 to 80)	O. K.	O. K.
2.	Out	In (20 to 80)	End windows out	O. K.
3.	In	Out (20 to 80) but can obtain reading at center or on "fore and aft marks"	Out	O. K.
4.	Out			
	a. Can range in with adjuster scale (20 to 80)	Out (20 to 80) Can or cannot obtain reading on "fore and aft marks"	O. K.	Out
	b. Cannot range in with adjuster scale (20 to 80)		Out	Out

(d) 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 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.

(e) Possible To Obtain Contact on Outside Target with Adjuster Scale. Carefully inspect the internal target system to locate the difficulty. Set the prism shift crank for internal readings. Note the relative position of the internal target moons which should be superimposed upon each other and centered about the height finder reticle lines (fig. 47). Also note the relative position of the internal target line in the height finder reticle field with the adjuster scale set at 50. Both lines should be in the same relative position in both fields (fig. 124). Also check for "tilt" and "lean" of the target line, both in stereo and through each eyepiece individually (fig. 121). 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, possibly either an internal target collimating wedge cell or a crown objective has moved. Either one of these will affect both the

position of the target line and the position of the moons. (If the target line, viewed through the right eyepiece, is out of position, make sure the range drum has not shifted from the infinity setting.) If no "tilt" or "lean" is noticeable but the moon viewed through one eyepiece is decentered and the target line in the same eyepiece is out of position, reset the internal target collimating wedge cell affecting this target line (par. 57). It should be possible to bring the internal target into stereo contact and the moon into a centered position with this adjustment. Make one complete turn of the wedge in order to try all positions for both bringing the reading in and centering the moons. If the moon becomes further decentered when the target line is in position, it is because the internal target crown objective and not the wedge is out of adjustment, in which case turn the wedge cell to its original position and make adjustments on the crown objective. If "tilt" and "lean" are noticeable and the moons are centered, it is because the flint objective is in need of adjustment. In making minor adjustments to the internal target system, never touch the right internal target objectives. If the individual adjustments (par. 58) do not bring the internal target system into adjustment, it will be necessary to reset the entire system (par. 57).

(f) Impossible To Range on Outside Target with Adjuster Scale. If it is impossible to obtain stereo contact on the outside target, it is 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 57 and 67. (The main optical system must be adjusted first.)

e. Check Compensator (Measuring Wedge) Unit for Accuracy (Range-infinity, Height-infinity, Height-900).

(1) 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.

(2) CHECK FOR BACKLASH IN WEDGE UNIT.

(a) Set height-range lever at "range." Turn measuring drum to about 3,000, 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 turn carefully back to infinity and take five more internal target readings. Compare the medians of the two sets of readings.

(b) Analysis. If the readings are not within tolerance, there is backlash in the compensator unit, and the following points should be checked and corrected (par. 49):

1. Backlash between the range shaft and the planetary gear coupling.

2. Backlash in the range shaft and spur gear coupling.

3. Gears hit air tubes.

4. Backlash springs broken or sticking.

5. Backlash springs not wound to proper tension.

6. Play between measuring knob spur gear and measuring drum.

(c) Check for Backlash between Bevel Pinion and Height Conversion Race.

1. Set measuring scale at 550 and height-range lever in "height" position.

2. Depress telescope from about 200 mils, until telescope bubble is *exactly* centered and take five IACS readings.

3. Depress telescope to its lower limit, elevate until the telescope bubble is *exactly* centered and take five IACS readings.

4. Compare the medians of the two sets of IACS readings for tolerance (par. 25).

(3) CHECK "RANGE-INFINITY" AND "HEIGHT-INFINITY."

(a) Carefully level the cradle and height finder telescope, and take five internal target readings with 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.

(b) 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 48 **c**.

(4) CHECK "RANGE-INFINITY" AND "HEIGHT-900."

(a) Check that the height finder and cradle are properly leveled. Take five internal target readings with the height-range lever at "range" and the measuring drum at infinity. Put the height-range lever at "height" and turn the measuring drum to "900," and again take five internal target readings. Compare the median of the readings at both settings of the drum.

(b) Analysis. If "height-infinity" and "height-900" readings are not within tolerance, it is a sign that the bevel gear of the compensator unit is not properly meshed and adjusted with the height conversion ring. Adjust it according to paragraph 48 **d**.

f. Divergence.

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

(2) Check tightness of eyepiece plate screws. Place the double collimator (divergence tester) on the eyepiece unit and check the

INSPECTION

INSPECTION OF EYEPIECE UNIT FOR ALINEMENT OF OPTICAL AXES
(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 LEFT MAIN RETICLE IS AT POSITION SHOWN IN SKETCH.

STEP 3 — NOTE POSITION OF IMAGE OF CENTER LINE OF RIGHT MAIN RETICLE. A POSITION TO THE RIGHT OF THAT OF THE LEFT RETICLE INDICATES DIVERGENCE, A POSITION TO THE LEFT INDICATES CONVERGENCE, A POSITION ABOVE OR BELOW INDICATES DIPVERGENCE.

TOLERANCE: THIRTY MINUTES DIVERGENCE, NO CONVERGENCE, TEN MINUTES DIPVERGENCE *(UP OR DOWN)*.

CORRECTION: FOR CONVERGENCE OR EXCESSIVE DIVERGENCE ROTATE RHOMBOID PRISM AS INDICATED. TRY TO SET AT ABOUT 15 MINUTES DIVERGENCE. FOR DIPVERGENCE TWIST EYEPIECE UNIT ON ITS ADAPTER AS INDICATED *(PARAGRAPH 43)*.

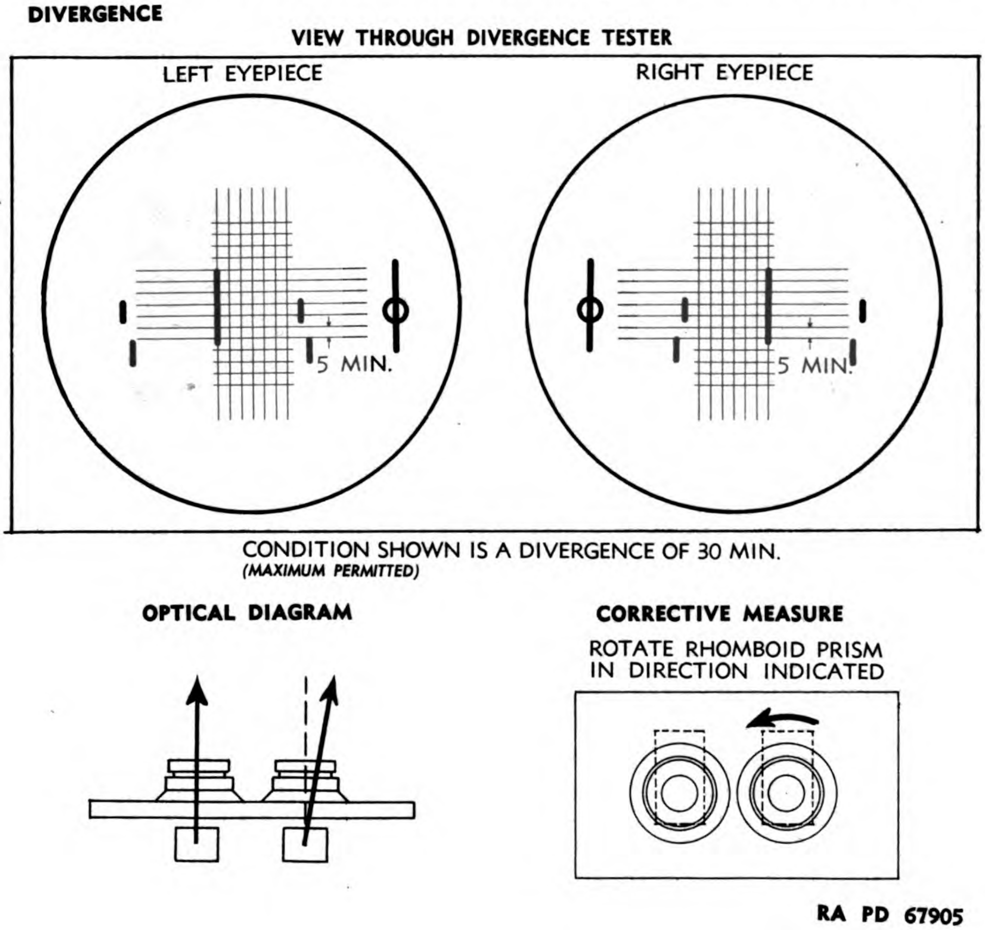
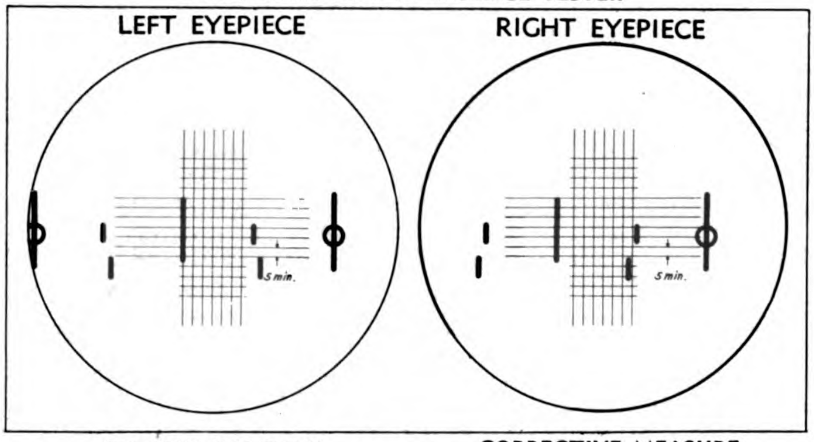


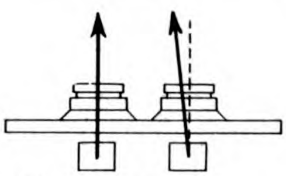
Figure 48 — Inspection of Eyepiece for Divergence

CONVERGENCE

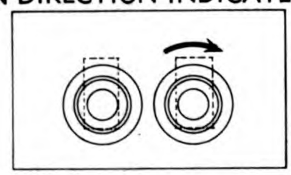
VIEW THROUGH DIVERGENCE TESTER



OPTICAL DIAGRAM

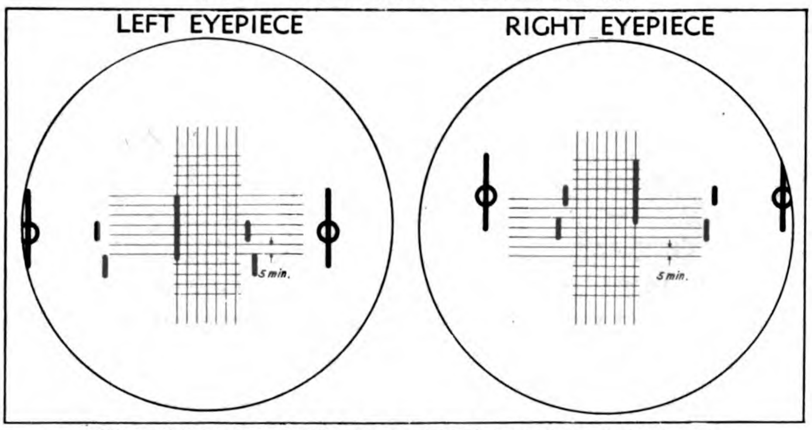


CORRECTIVE MEASURE
ROTATE RHOMBOID PRISM
IN DIRECTION INDICATED



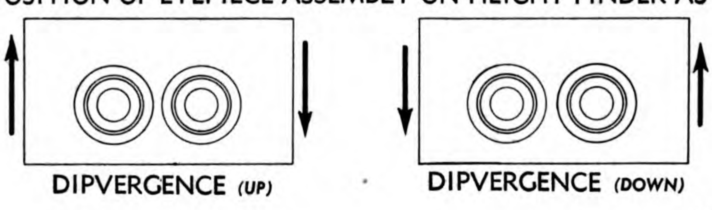
DIPVERGENCE

VIEW THROUGH DIVERGENCE TESTER



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

CORRECTIVE MEASURE
SHIFT POSITION OF EYEPIECE ASSEMBLY ON HEIGHT FINDER AS INDICATED



RA PD 15433

Figure 49 — Inspection of Eyepiece for Convergence and Dipvergence

divergence as in figures 48 and 49. Shift the interpupillary distance lever through its travel from 58 to 72 mm with the instrument in both high and low power. Note the change in position of the center reticle lines with respect to each other at any setting.

(3) If the dipvergence is not within tolerance:

(a) 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 twisting eyepiece on adapter (fig. 49).

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

1. If the change in dipvergence is more than 5 minutes on changing from low to high power, reduce by centering one (or both) of the reticles and then twisting eyepiece assembly to correct dipvergence.

2. If change in dipvergence occurs when moving IPD from 58 to 72 mm, difficulty lies in mechanical misalinement in the eyepiece assembly.

(4) If the divergence is not within tolerance:

(a) 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 0 to 30 minutes by rotating the right rhomboid prism bracket (figs. 48 and 49).

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

1. If the change in divergence is more than 5 minutes upon changing from low to high power, reduce by centering one (or both) of the reticles and then rotating right rhomboid prism bracket.

2. If change in divergence occurs when moving IPD from 58 to 72 mm, difficulty lies in rhomboid prisms and cannot be eliminated unless prisms are replaced.

g. Parallax Test (Focus of Height Finder Objectives).

(1) 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.

(2) Train the height finder on a target at least 5,000 yards distant and inspect for parallax by moving the head back and forth above the eyepiece (figs. 50 and 51), or check the focus with a collimating telescope as follows:

(a) Place the collimating 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.

(b) 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.

(c) Repeat substeps *(a)* and *(b)*, above, for the left eyepiece.

(3) ANALYSIS. If the parallax is more than allowable, refocus the objectives as in paragraph 45. (If the diopter setting for the target image is negative with respect to the setting for the height finder reticle, it indicates "with" parallax and vice versa.)

h. Cross Field Readings.

(1) The purpose of comparing readings made at several points across the reticle field is to check the match of the optics on both sides of the height finder for equality of magnification at the reticle. This test can be made on an outside target at a distance greater than 5,000 yards.

(2) Make five readings with the target image in each of three positions across the reticle field, as in figure 52. If the median readings for the three positions do not agree, calculate the UOE difference (par. 25). Cross field tests are difficult to make, and it is wise to have a second observer check the readings of the first observer. If the two observers do not agree, a further check should be made by taking readings at the ends of the reticle field, both with the head held straight in the eyepiece and with the head tilted considerably.

(3) ANALYSIS.

(a) If the readings are high at one side and low at the other side of the field, it indicates that the optics, from the reticles to the end windows, are not exactly matched on the two sides of the instrument so that there is a slight difference in the sizes of the two target images. This can be corrected by replacing one objective with another of different focal length (par. 45), or by replacing the end windows with others of different power (par. 60). If replacements are not available, interchanging the end windows (or the objectives) between the two ends of the instrument may be helpful, or it may make the readings worse.

(b) If the cross field readings are irregular, for instance, high at the ends and low in the middle, it indicates that there is distortion in one or both images, possibly caused by surface irregularities or strain in the end reflectors (par. 42 d), or by strain or decentering in the mounting of the objective lenses.

i. Bump Test.

(1) 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.

(2) 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:

(a) The height finder telescope can be carried on a steel-wheel truck and rolled over cobble stones or equivalent for a distance of

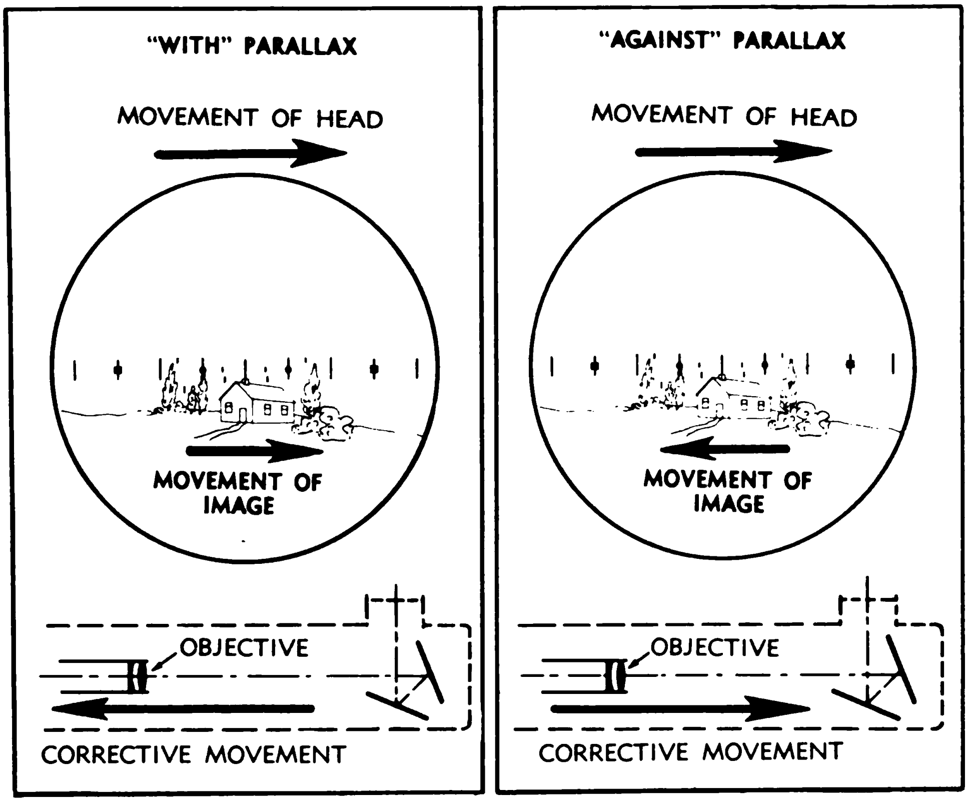
INSPECTION

PARALLAX TEST FOR FOCUS OF OBJECTIVE LENSES

STEP 1 — TRAIN HEIGHT FINDER ON 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: AT CENTER OF FIELD THE MOVEMENT OF THE TARGET SHOULD NOT BE GREATER THAN THE WIDTH OF THE CENTER RETICLE LINE.

CORRECTION: FOCUS RIGHT OBJECTIVE BY MOVING IN DIRECTION INDICATED *(PAR. 45)*.

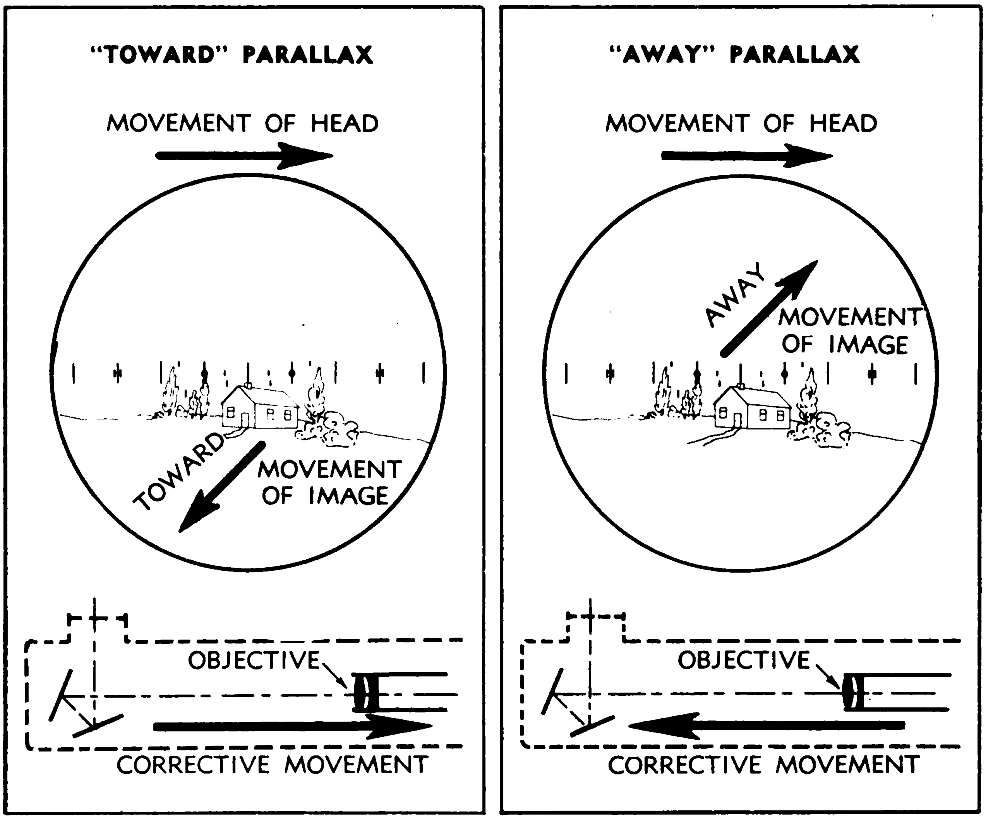
RA PD 67911

Figure 50 — Test of Objectives

PARALLAX TEST FOR FOCUS OF OBJECTIVE LENSES *(CONTINUED)*

STEP 4 — INSPECT FOR PARALLAX MATCH *(SIMILARITY OF PARALLAX ERROR IN BOTH EYEPIECES)*. INSPECT TARGET IMAGE IN STEREO WHILE MOVING HEAD BACK AND FORTH ABOVE EYEPIECES. LACK OF PARALLAX MATCH IS INDICATED BY MOVEMENT OF THE TARGET IMAGE TOWARD OR AWAY FROM THE OBSERVER.

STEP 5 — CHECK STEREO PARALLAX BY BRINGING TARGET IMAGE INTO STEREO CONTACT BY USE OF THE ADJUSTER SCALE WITH THE HEAD FIRST AS FAR TO THE LEFT AND THEN AS FAR TO THE RIGHT AS THE TARGET CAN BE SEEN THROUGH THE EYEPIECES.



TOLERANCE: AT CENTER OF FIELD THE MOVEMENT OF THE TARGET SHOULD NOT CAUSE MORE THAN TWO UNITS OF ERROR DIFFERENCE IN ADJUSTER SCALE SETTINGS FOR LEFT AND RIGHT HEAD POSITIONS.

CORRECTIONS: FOCUS LEFT OBJECTIVE BY MOVING IN DIRECTION INDICATED. (PAR. 45).

RA PD 67912

Figure 51 — Test of Objectives (Continued)

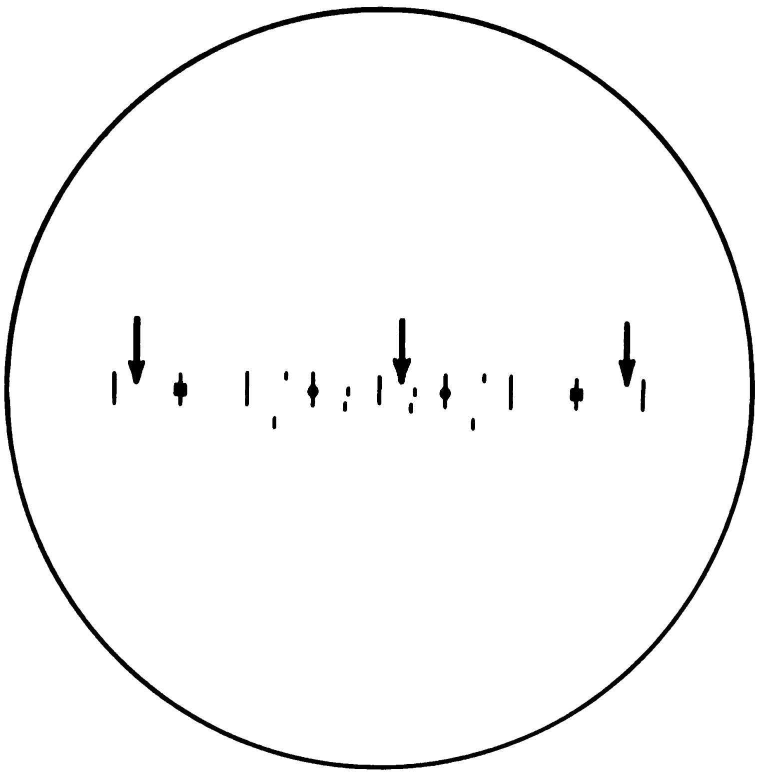
INSPECTION

CROSS FIELD TEST FOR EQUALITY OF MAGNIFICATION OF IMAGE AT RETICLES

STEP 1 — TRAIN HEIGHT FINDER ON DISTANT TARGET
(CORRECT I.P.D. AND EYEPIECE FOCUS IS IMPORTANT IN THIS TEST.)

STEP 2 — SET RANGE-HEIGHT LEVER AT "RANGE" AND RANGE DRUM TO BRING TARGET INTO STEREO CONTACT.

STEP 3 — MAKE FIVE RANGE SETTINGS FOR STEREO CONTACT AT EACH OF THE THREE 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 2-1/2 UNITS OF ERROR.

CORRECTION: SEE DISCUSSION IN PAR. 20g.

RA PD 67913

Figure 52 — Test for Equality of Magnification

100 yards. The truck body and carriage should be rigidly connected and the truck should embody no cushioning devices.

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

1. Check the divergence at 65-mm setting of the interpupillary distance.

2. Check the parallax and parallax match.

3. Check the internal target readings.

4. Check the outside range reading.

5. Check the shift of focus.

6. Check the height of image with the height adjuster.

NOTE: The bump test should be made only after a complete disassembly and assembly, or after disassembly and assembly of mirror block, internal target assembly, or end mirror supports.

(3) 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.

21. OPTICAL CHECK — BASIC PERFORMANCE (CONT'D).

a. Check Interpupillary Distance.

(1) Set the interpupillary distance with an IPD template (par. 39 b), 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 59.

(2) ANALYSIS. If the scale reading is outside of tolerance, reset the indicating index (par. 43).

b. Check Eyepiece Focus.

(1) 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 crank 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 dioptometer over the eyepiece and focus it for zero parallax between the height finder reticle and the dioptometer reticle. Note the median of five readings of the dioptometer. Repeat this procedure at +2, –2, and –4 diopters on the diopter scale. Switch the power shift lever from high to low power, and again measure the diopter setting at the four points mentioned above. Recheck by another observer. If a dioptometer is not available, use a collimating telescope and determine the eyepiece settings for zero diopters.

(2) ANALYSIS.

(a) If the diopter reading is not within tolerance, adjust the setting of the diopter scale as outlined in paragraph 43.

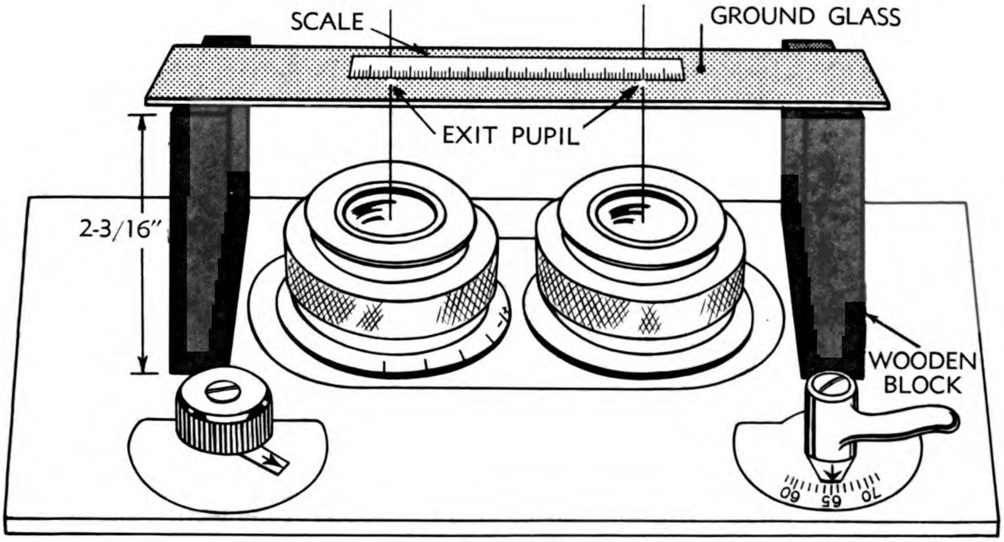
(b) If the shift of focus is outside tolerance, readjust the movement of the erector lenses (par. 54).

INSPECTION

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 EYESHIELDS.

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.



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 72-MM SCALE SETTINGS.

TOLERANCE: THE INTERPUPILLARY DISTANCE AS MEASURED SHOULD CORRESPOND TO THE SCALE SETTING WITHIN 1-MM.

CORRECTION: SHIFT INDEX TO BRING SETTING WITHIN TOLERANCE. (PARAGRAPH 43d)

RA PD 67914

Figure 53 — Inspection of Interpupillary Distance Scale

INSPECTION OF CENTERING OF RETICLES

STEP 1–DIRECT HEIGHT FINDER AT BRIGHT SKY OR DIRECT LIGHT INTO EACH END WINDOW.

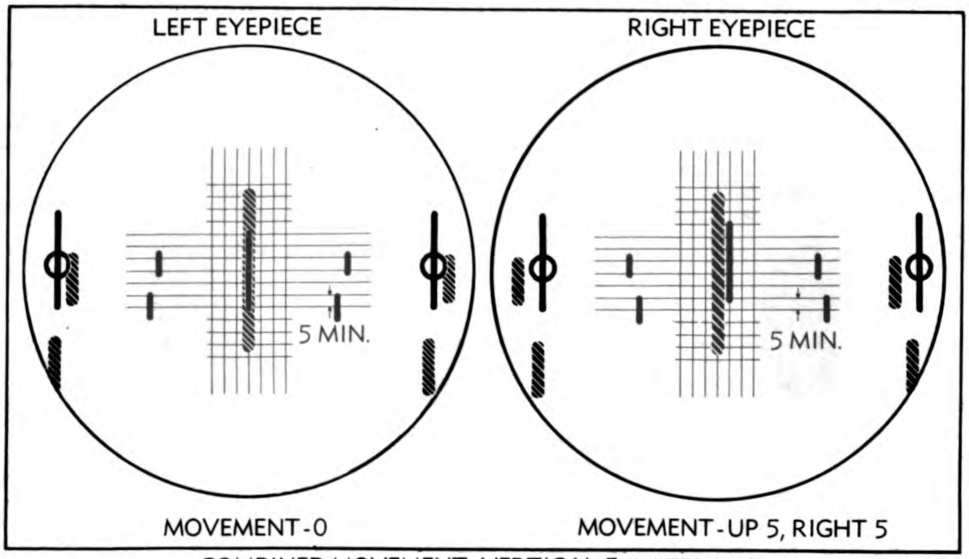
STEP 2–SET UP DIVERGENCE TESTER OR DIOPTOMETER ON EYEPIECES AND FOCUS ON HEIGHT FINDER RETICLE. ALINE AT 24X SO THAT CENTER RETICLE MARK IS CENTERED IN TESTER GRATICULE. *(BROKEN IMAGE IN SKETCH.)*

STEP 3–SHIFT POWER TO 12X AND NOTE POSITIONS OF CENTER RETICLE MARKS FOR BOTH EYEPIECES.

TOLERANCE: COMBINED MOVEMENTS OF RIGHT AND LEFT CENTER RETICLE MARKS MUST NOT EXCEED FIVE MINUTES SIDEWAYS AND UP OR DOWN.

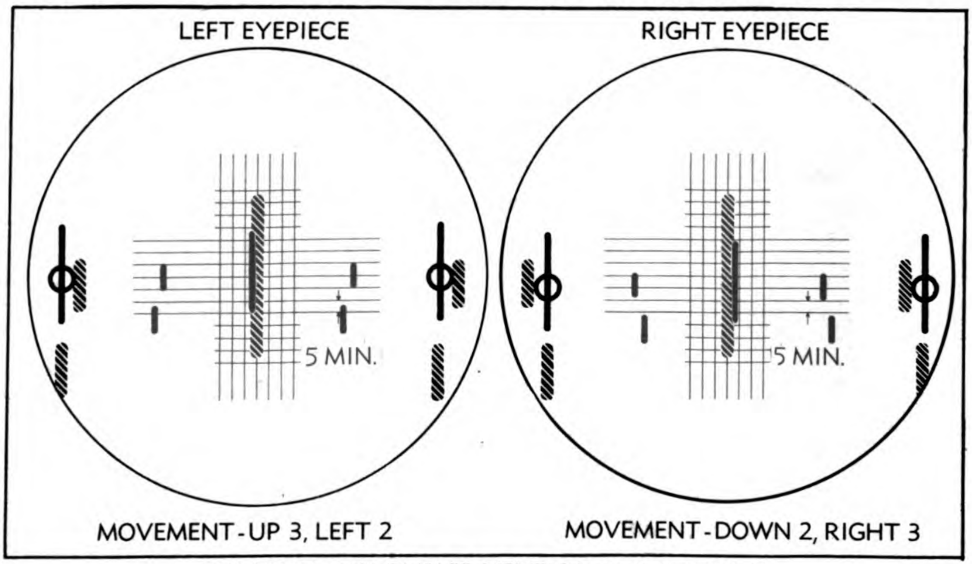
CORRECTION: CENTER RETICLES TO BRING JUMP WITHIN TOLERANCE. *(PAR. 53b)*

CASE 1 RETICLE JUMP IN ONE EYEPIECE ONLY



COMBINED MOVEMENT-VERTICAL 5, LATERAL 5

CASE 2 RETICLE JUMP DIVIDED BETWEEN BOTH RETICLES



COMBINED MOVEMENT-VERTICAL 5, LATERAL 5

RA PD 67940

Figure 54 — Inspection of Centering of Reticles

c. Check Filters.

(1) 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.

(2) ANALYSIS. If not within tolerance, adjust or replace, according to instructions in paragraph 44 d.

d. Calibrate Internal Adjuster Correction Wedge (Value of Adjuster Scale Divisions).

(1) The internal adjuster correction wedge (range correction wedge) calibration is tested by determining the value of the adjuster scale divisions in terms of units of error. 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, 25, 50, 75, and 100; and determine the median 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 median values of the range readings in the following formula:

$$\text{Units of error per division} = \frac{R_2 - R_1}{0.5386 \left(\frac{R}{1000}\right)^2 \times 25}$$

where R_1 and R_2 are the median values for a successive pair of readings, such as those for the 0 and 25, or the 25 and 50 settings of the adjuster scale, and R is the true range.

(2) ANALYSIS. If the value of the scale divisions is outside tolerance at either end of the scale, the adjuster wedge is improperly mounted and should be reset in an "image up" position (par. 46 c). 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.

e. Check Height Adjuster Disk.

(1) 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 crank 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.

(2) ANALYSIS. If not within tolerance, reposition the height adjuster assembly on its adapter on the inner tube (par. 55).

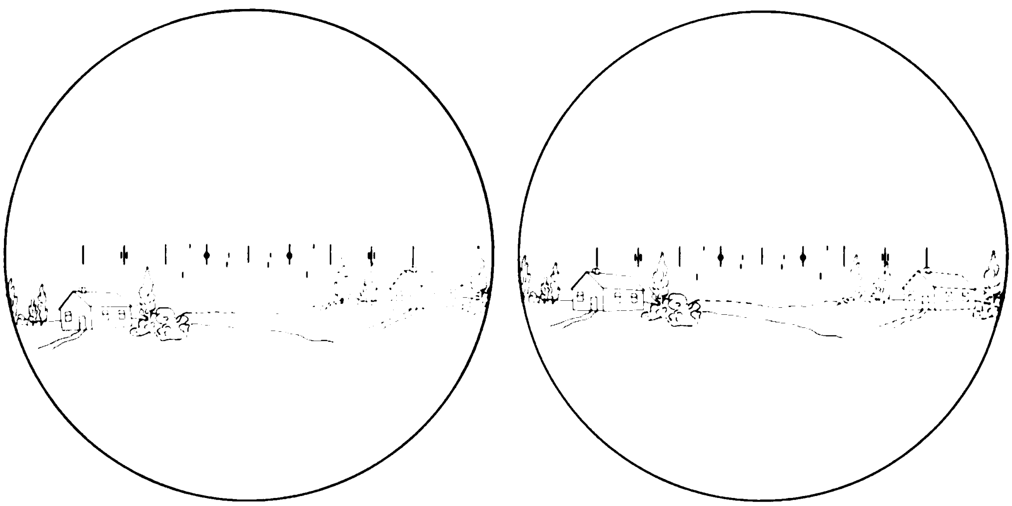
INSPECTION OF RETICLES FOR TILT OF FIELD

STEP 1 — LEVEL CRADLE AND ALINE HEIGHT FINDER SO THAT TARGET IMAGE IS SEPARATED BY ONE LINE WIDTH FROM TOP OR BOTTOM OF END RETICLE LINE. *(DOTTED IMAGE IN SKETCH)*

STEP 2 — TRAVERSE HEIGHT FINDER AND NOTE HEIGHT OF TARGET WITH RESPECT TO RETICLE LINE AT OPPOSITE SIDE OF FIELD.

TOLERANCE: TARGET IMAGE SHOULD FALL AT SAME HEIGHT AT BOTH ENDS OF RETICLE FIELD WITHIN ONE-HALF WIDTH OF A RETICLE LINE.

CORRECTION: ROTATE RETICLES TO BRING WITHIN TOLERANCE. *(PAR. 53)* ADJUST RIGHT RETICLE FIRST, THEN ADJUST LEFT RETICLE TO MATCH *(ANY DEVIATION FROM LEVEL SHOULD BE SAME AMOUNT IN SAME DIRECTION).*



RETICLE TILTED   RETICLE LEVEL

RA PD 67915

Figure 55 — Inspection of Reticles for Tilt of Field

INSPECTION

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

(Change-of-magnification crank 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 top and bottom, 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 knob.</th><th>Rotates upon changing interpupillary distance</th><th>Relative position of pupil loupe for sharp focus (Exact distance will vary for different loupes)</th><th>Dirt is on this element.</th></tr>
<tr><td rowspan="5">YES</td><td colspan="6">YES</td><td>End Window or End Mirrors</td></tr>
<tr><td rowspan="4">NO</td><td colspan="5">YES</td><td>Wedge Units</td></tr>
<tr><td rowspan="3">NO</td><td colspan="3">YES</td><td>1 mm down from Wedge</td><td>Erector</td></tr>
<tr><td rowspan="2" colspan="3">NO</td><td>1 mm up from Wedge</td><td>Objective</td></tr>
<tr><td>6 mm up from Exit Pupil</td><td>Halving Disk</td></tr>
<tr><td rowspan="5" colspan="4">NO</td><td colspan="3">YES</td><td>Filter</td></tr>
<tr><td rowspan="4">NO</td><td rowspan="3">NO</td><td>At Pupil</td><td>Ocular Prism 1st Surface</td></tr>
<tr><td>2 mm up from Pupil</td><td>Ocular Prism Last Surface</td></tr>
<tr><td>2 mm down from filter</td><td>Eyepiece Box Window</td></tr>
<tr><td colspan="2">YES</td><td>Rhomboid Prism 1st 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 rowspan="3" colspan="2">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 Mirror</td></tr>
<tr><td>NO</td><td>Internal Adjuster Condenser or Mirror</td></tr>
</table>

RA PD 15441

Figure 56 — Chart for Position of Dirt on Optics

f. Check Reticles for Centering and Tilt.

(1) This test is to determine the accuracy of centering of the reticles and of alinement of the reticle field with respect to the image of the external field

(2) CENTERING.

(a) 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 54.

(b) ANALYSIS. If the reticle jump is outside tolerance, center the reticles (par. 53).

(3) TILT.

(a) 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 figure 55.

(b) *Analysis.* Square up tilted reticles as described in paragraph 53.

g. 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 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.

(2) ANALYSIS. Determine the position of the dirt with the aid of the chart (fig. 56). Clean the dirty element as outlined in paragraph 36.

h. Illumination of Reticles.

(1) RETICLES—HEIGHT FINDER.

(a) 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.

(b) Analysis. Stray light is generally caused by light entering around the shutters on the internal target penta prism bracket. Unequal brightness can be corrected by making adjustments on the reticle illuminating rod in the reticle mount or by making adjustments as to the positioning of the reticle illumination lamp. If the illumination in either reticle field is not properly centered, make adjustments on the reticle illuminating rod (par. 82). Shifting the internal target condenser lens in or out may improve illumination.

(2) M7 TELESCOPE RETICLES. Check the reticle illumination of the M7 Tracking Telescope by turning on the reticle switch 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 paragraph 82.

(3) INTERNAL TARGET.

(a) The illumination of the two internal target moons should be of equal intensity so that readings will be more easily made. Check the illumination by setting the prism shift crank for internal target readings and turning the rheostat switch to full brightness. Check one internal target moon against the other for equal brightness by offsetting the moon by means of the height adjuster knob.

(b) Analysis. If the internal target moons are not equally bright, check the positioning of the internal target lamps in their brackets (par. 57). If it is impossible to bring the illumination up to the desired intensity in one of the moons, check the penta prism aperture for full transmission. This can be done by using a pupil loupe as in checking for dirt (subpar. g, above) 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 the internal target collimating wedge and crown lens both being set in an "image up" or "image down" position, thereby deflecting the light too far upward or downward. To correct, change the "image up" or "image down" position of one of these units.

i. Check the M7 Tracking Telescopes.

(1) RETICLES.

(a) Check the tracking telescope reticles for the position of the solid line in the reticle field.

(b) Analysis. If the reticle lines are not according to specifications, reverse the tracking telescopes so that the reticle lines are as specified. If both telescopes have reticles of the same type, turn the reticle of one of the telescopes through 90 degrees (par. 73).

(2) FOCUS OF OBJECTIVE.

(a) 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 5,000 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.

(b) Analysis. If the parallax is outside of tolerance, refocus the objective (par. 70).

(3) ALINEMENT AND TILT.

(a) It is necessary that the tracking telescopes be properly alined in elevation, *primarily* in relation to the compensator when in adjustment at zero mils angular height and when the height range ring travels exactly 90 degrees, and *secondarily,* and less exactingly, with respect to the main optical system, so that all three elements will be trained on the same target (pars. 41 **b** and 71). To check or adjust tracking telescopes for proper alinement in *azimuth,* set the range scale at approximate range. Superimpose the center reticle on the azimuth point at approximately 5,000 yards, and while so alined, adjust the tracking telescopes so that the verticle hairlines pass through the point (par. 71) (fig. 155).

(b) To check the alinement of the M7 Tracking Telescopes in elevation, substep *(a),* above, it is *first* necessary to establish an accurate level point preferably at 1,000 yards or more by surveying methods. An accurate procedure is as follows: With the foot leveling screws of the height finder at approximately midpoint, set an accurately leveled transit adjacent to the height finder elevation tracking telescope, so that with transit and height finder approximately level, the objectives of the transit and tracking telescope are centered with respect to each

other. Slew the height finder out of the way, and with the transit, locate a distant well-marked point at the same height as the transit. Invert or plunge the transit telescope, relevel it, and read again. A point which is vertically halfway between the two marks establishes a true horizontal line of sight for the transit, and, if properly done, will be not over 1/10 mil or one hairline width off true level for the height finder. A checkerboard on this point will be excellent for future use. *Secondly,* check cradle bubbles for looseness, let them temperature-stablize, and level exactly. *Thirdly,* elevate the height finder to the position which will allow the height-range ring to turn exactly 90 degrees. (It is assumed that the wedges check at range-infinity and height-900 within tolerance in this position.) *Fourthly,* check to see that the M7 Telescope *horizontal* cross hairs pass through the level point. If they do not, proceed as in paragraph 71.

(c) 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.

(d) *Analysis.* If out of tolerance, realine the telescope (par. 71).

22. 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 19, 20, and 21, 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 aline them as accurately as possible on a target at a known distance of between 5,000 and 10,000 yards, as described in paragraph 60. After this has been done, proceed with the final optical check.

b. Check Range Finding.

(1) ACCURACY.

(a) 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.

(b) 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.

(c) Make 5 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 5,000 and 10,000 yards, and 10 readings on a target at a distance greater than 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 1 UOE, set the second reading on the adjuster scale and repeat the range readings.

(d) 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.

(e) *Anaylsis.* 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.

(2) REPEATABILITY—HIGH AND LOW POWER.

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

(b) 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 the range readings and the deviation of each of these readings from true range. Obtain the median of the range readings, and the median of the deviations and note. Repeat the above test with the instrument at high power.

(c) *Analysis.* If not within tolerance, repeat the basic performance tests.

c. Check Height Finder.

(1) ACCURACY.

(a) The purpose of this test is to determine the performance of the height conversion mechanism by setting in fictitious angles of elevation on the height conversion ring. To perform this test, set the instrument level and the height-range lever in height position. Attach a 4-power reading microscope to the height conversion ring housing, as described in paragraph 41, and check the zero position as against the scribing on the conversion ring. The test is made on targets at three distances and at the same level as the height finder. Make five internal target readings, and set the median value on the adjuster scale. With the height finder at zero elevation, make five range readings on the target. With the height finder still at zero elevation, rotate the height conversion ring to the angles specified below. Make five readings at each of these points. This procedure 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 0° Elevation
Less than 4,000 yards	10°, 30°, 50°, 70°, 85°
5,000 to 10,000 yards	10°, 30°, 50°, 70°, 80°
Greater than 12,000 yards	10°, 30°, 40°, 60°

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

Height = Range x 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 range-infinity and height-900 as set forth in paragraph 20.

d. Check Internal Adjuster.

(1) ACCURACY.

(a) 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. Focus the eyepiece for an outside target and switch the prism shift crank for internal target readings. Set the instrument at low power and take five readings on the adjuster scale, making the final setting of each reading, turning the adjuster scale in a clockwise direction. Repeat this test with the instrument at high power.

(b) *Analysis.* If the spread of the adjuster scale readings is outside of tolerance, check the internal target optical system (par. 57).

(2) BACKLASH.

(a) This test is performed to determine the accuracy at which readings can be made when the final settings are made in either direction. The instrument is set for internal target readings and on high power. Take five readings on the internal target, making the final setting in a counterclockwise direction. Take five more readings on the internal target, but make the final settings in a clockwise direction. Repeat this procedure by again taking five more readings of each direction.

(b) *Analysis.* If the spread of the two medians is outside of tolerence, check the correction wedge and adjuster scale for backlash, and correct (par. 46).

(3) ELEVATION.

(a) The purpose of this test is to check the accuracy of the instrument at various positions through its elevation. Hang a 50- to 100-pound weight on each of the rear carrier handles. Set the instrument for internal target readings and set the height-range lever at "range." With the elevation dial at zero and the height finder level, make five internal adjuster readings. By turning the elevation handwheel, elevate the instrument to an angle of 30 degrees and make five more internal target readings. Repeat this performance up the scale at 60 degrees and 90 degrees, and down the scale at 60 degrees, 30 degrees, and zero.

(b) *Analysis.* If the instrument is not within tolerance, the following are probable causes:

1. Lack of helium purity; check again after 4 hours at constant temperature.

2. Change-of-magnification crank pins jam against change-of-magnification disk when instrument is elevated to 90 degrees. This usually produces an error of about 25 UOE. Loosen the screws holding the change-of-magnification crank assembly to check. If this affects the readings, check for loose inner tube bearings; if necessary, shorten shoulder of the change-of-magnification shaft by about $\frac{3}{16}$ inch and compensate by inserting a washer under the crank on the outside.

3. Loose wedge or crown lens in the internal target system. Usually indicated by an error of about 5 to 10 UOE.

23. 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, or M9. 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 110-120-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 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 0 to 10,000 yards, noting the relative readings of 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 0 to +500 yards and 0 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 84.

(2) ANALYSIS. If these units are not within tolerance, reset the dials as instructed in paragraph 84.

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 83.

24. 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 tubes and that the etch and fill are satisfactory and the cover action smooth. Make any replacements or changes in the levels as outlined in paragraph 41.

(2) HEIGHT FINDER TELESCOPE. Check level on the height finder telescope to see that the vial is tight in its tube and that the etch and fill are satisfactory and the cover action smooth. Make any replacements or changes on the height finder level as in paragraph 41.

c. Check Mechanical Operation. To check the mechanical operation of the various mechanical parts of the M1 Height Finder, go through the check list in paragraph 25. In making repairs to any parts, refer to the appropriate paragraph on disassembly and assembly.

d. Check Carrier Handles. During transit, the M1 Height Finder rests entirely on the carrier handles. Therefore it is important that the carrier handles be parallel. Check this by leveling the height finder on its cradle, and using an ordinary level across the feet of the carrier handle supports. Check the deviation from the horizontal. If necessary, partially elevate the height finder to bring one carrier handle support to a level position and check this against the second support.

e. Pressure Test. Test the instrument for retention of pressure (TM 9-1622).

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.

25. SUMMARY OF INSPECTIONS AND TOLERANCES.

a. Completeness — Check for Missing Parts.

Test	Requirements
(1) Telescope.	Complete with M7 Telescopes, adjusting knobs, carrier handles, eye shields, lamps, etc.
(2) Cradle.	Complete with elevation and azimuth indicator, height transmitter, traversing and elevation handwheels, levels, 19- and 6-pole receptacles, etc.

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Test	Requirements
(3) Tripod.	Complete with friction ring adjustment, adjustable feet, etc.

b. Optical Check — Basic Performance.

Test	Requirements
(1) Levels.	
(a) Cradle.	Bubble to be centered within 1 minute (1/3 of space between engraved marks) throughout 360 degrees traverse.
(b) Telescope.	When bubble is centered, movement of height conversion ring to be 90 degrees within one-third width of engraved line.
(2) Height adjuster.	In shifting from the external to the internal system, the relative height of the images in each eyepiece should shift no more than 2 minutes.
(3) Internal and main optical systems.	
(a) Internal target readings.	The median of 5 internal target readings to fall between 20 and 80 on the internal target scale.
(b) Range readings.	The median of 10 range readings on a target of known distance should be within 1½ UOE of the true range.

TABLE II

ERROR IN YARDS EQUIVALENT TO 1.5 UOE AT 24

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	10,000	81	14,500	170
				15,000	182

If the range being used is between two consecutive ranges, then the tolerance will lie proportionally between the two ranges. (This is not precisely true, but is close enough.) The error values in the table are based on the following relation:

1½ UOE $\doteq$ 1.5 x 0.0000005386 x $(\text{Range})^2$ or 0.808 x $(\text{Range} \div 1{,}000)^2$.

NOTE: 1 UOE = 0.5386 x $(\text{Range} \div 1{,}000)^2$.

Test	Requirements
(4) Check Wedge Unit.	
(a) Backlash.	Adjuster scale readings for up-scale drum setting and down-scale drum setting to agree within 1 unit of error. Adjuster scale reading for elevation-depression of instrument with height-range lever at "height" to agree within 3 UOE (par. 20 e (2) *(c)*).
(b) Range-infinity—height-infinity.	Adjuster scale reading to agree within 2 UOE at both positions.
(c) Range-infinity—height-900.	Adjuster scale reading to agree within 1 UOE at both positions.
(5) Divergence.	
(a) Divergence and convergence.	Permissible divergence 0 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.
(b) Dipvergence (up-and-down divergence).	The permissible up-and-down divergence is 10 minutes at any point throughout 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.

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Test		Requirements
(6)	Parallax.	Movement of the image in the reticle field not to exceed one-half reticle line thickness at the center of the field.
		With collimating telescope, difference between settings for target and reticles not to exceed ¼ 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 ⅛ diopter for right and left eyepieces.
(7)	Cross field readings.	The median of five readings at any point across the reticle field not to vary from the median at the center of the reticle field by more than 2½ UOE.
(8)	Bump test.	After the bump test, the performance of the instrument must remain within tolerance.

c. **Optical Check — Basic Performance — Continued.**

(1)	Interpupillary distance.	58 mm to 72 mm ±1 mm at any setting.
(2)	Eyepiece focus.	±¼ diopter at any setting in high or low power. No more than ¼ diopter change with shift from high to low power.
(3)	Filters.	The same color filter in each eyepiece at each setting of the filter knob.
(4)	Adjuster correction wedge.	Adjuster scale divisions within 12 percent of true unit of error for high magnification (par. 22).
(5)	Height adjuster disk.	Adjuster scale readings at extreme ends of the travel of the height adjuster disk to be within 2 UOE.

Test	Requirements
(6) 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.
(7) Dirt on optics.	
(a) Reticles.	No dirt, scratches, or smears noticeable.
(b) Eyelenses and end windows.	Inner surface clean and free from scratches.
(c) 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.
(8) Illumination of reticles.	
(a) Height finder.	No stray light. Equal brightness. Illumination centered.
(b) M7 Tracking Telescopes.	No stray light. Illumination centered.
(c) Internal target.	Equal brightness. Prism shift switch O.K.
(9) M7 Tracking Telescopes.	
(a) Reticles.	Elevation — solid horizontal line. Azimuth—solid vertical line.
(b) Focus of objective.	Parallax must be reduced to a minimum in both telescopes.
(c) Alinement and tilt.	
1. Alinement in azimuth.	Center of target within nine line widths of vertical reticle line for both telescopes.
2. Alinement in elevation.	At 0-degree elevation — center on target within one line width of horizontal reticle line.
3. Tilt.	Reticle tilt must be reduced to a minimum in both telescopes.

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d. Optical Check — Final Performance.

Test	Requirements
(1) Range finder.	
(a) Accuracy.	The median of 10 range readings on each of 3 targets should be within 1½ UOE of true range.
(b) Repeatability.	
1. High power.	Median deviation of 10 readings from median range to be not more than 1½ UOE.
2. Low power.	Median deviation of 10 readings from median range to be not more than 2 UOE.
(2) Height finder.	
(a) Accuracy.	The median of five height readings at any elevation and distance to be within 2½ UOE of calculated height.
(3) Internal target.	
(a) Accuracy.	
1. Low power.	The spread of five readings in low power not to exceed 2 UOE.
2. High power.	The spread of five readings in high power not to exceed 1 UOE.
(b) Backlash.	The median of 10 up-scale internal adjuster settings not to differ from the median of 10 down-scale adjuster settings by more than 1 UOE.
(c) Elevation (in the shade).	The median of five adjuster scale readings at any degree of elevation to be within 2½ UOE of the median at any other point.

e. Electrical Check.

(1) Indicators and transmitter.	Must read to within one-half width of index line at all points on scale.
(2) Illumination of scales and dials.	Illumination on range drum, height transmitter scale, and internal target scale suitable for night reading.

f. Mechanical Check.

Test	Requirements
(1) Levels.	
(a) Cradle.	Vials tight in tube. Etch and fill satisfactory. Cover action snug. Level parallel to "release" arrow, no tolerance; other bubble, one-half division.
(b) Height finder, telescope.	Vials tight in tube. Etch and fill satisfactory. Cover action snug. Tolerance one-half line width (see par. 41 d (4)).
(2) Mechanical operation.	
(a) Change - of - magnification crank.	Action smooth and easy. Stops operate at 12 and 24 power.
(b) Height conversion mechanism.	Snug fit, no high spots. Stops operate for travel beyond 0 degrees and 90 degrees.
(c) Elevation adjustment knob.	Action smooth, no optical jump. Stops operate for a ½- to 1-degree travel.
(d) Prism shift mechanism.	Action smooth. Both stops to make contact at the same time.
(e) Measuring knob.	Action free from high spots. Stops operate for full travel (550 at bottom of window and "*" at top of window at extreme ends of range from travel).
(f) Internal adjuster correction scale.	Action smooth, no backlash, no high spots. Stops operate for full travel (0 to 100). Cover action snug.
(g) Height adjuster knob.	Action satisfactory — no binding through travel at all positions of fine elevation knob. Length of travel — 8 turns of knob.

INSPECTION

Test	Requirements
(h) Eyepiece.	
1. Focusing.	Work smoothly — no backlash or high spots.
2. Interpupillary lever.	Covers full scale (58 mm to 72 mm), works smoothly.
3. Filter knob.	Action smooth. Stops operate to position filters at eyepiece.
(i) Elevation gearing.	No backlash or high spots. Stop operates properly for full travel 0 to 1600 mils.
(j) Azimuth gearing.	No backlash or high spots. Full travel 0 to 6400 mils, no stops.
(k) Height transmitter handwheel and scale.	No backlash or high spots.
(l) Height transmitter correction knob and dial.	Action snug — no binding. Stops operate for full travel from beyond +500 yards to beyond –500 yards.
(m) Tripod.	
1. Feet.	Action firm.
2. Friction ring.	Tight enough so that it does not slip on turning the azimuth handwheel, but loose enough to allow slewing.
(n) M7 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.	Rotates on adapter without causing adapter to turn.
(3) Carrier handles.	Must be parallel to within 3 minutes.
g. Miscellaneous.	
(1) Pressure retention.	Starting with 4 pounds of air pressure, loss not to exceed 1 pound in 8 hours.
(2) Painting and protection.	All exposed metal surfaces and corners to be painted. No fractures in canvas covering.

Test	Requirements
(3) Accessories and tools.	None to be missing.
(a) Height finder telescope.	
1. Traveling carriage.	
2. Storage case.	
(b) Cradle M1.	
1. Storage case.	
2. Tools.	
3. Accessories.	
(c) Tripod M6.	
1. Storage case.	
2. Tools.	
3. Accessories.	

Section VIII

TROUBLE SHOOTING

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26. 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. Included is a set of check questions for use in the field and shops during tests and adjustment.

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.

27. 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 height finder level is centered when the elevation scale reads zero and the index on the left bearing housing matches its mark?

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?

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 tube to the cradle connected properly?

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

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

28. 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
(a) Eyepiece focus incorrectly set.	Make proper focus adjustment (par. 16).
(b) Change-of-magnification crank not firmly in position.	Turn crank until click is heard.
(c) Moisture on eyelenses or end windows.	Clean according to instructions in paragraph 36.
(d) Visibility not good.	Refer to TM 4-250.
(e) Parallax (not a probable cause unless excessive).	See paragraph 45 **c**.
(f) Development of strains within an optical part.	Release external pressure on part or replace defective part. See paragraph 65 **b**.

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

(a) See (1), *(a)*, *(b)*, *(c)*, *(d)*, and *(e)*, above.	See corresponding remedies.
(b) Incorrect spacing of crown and flint elements of internal target objective.	See paragraph 57 **c**.

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

(a) Wrong filter in use.	Select proper filter.
(b) Internal target prism shift incorrectly positioned.	Set shift crank in correct position.
(c) Moisture on external optical surfaces.	Clean according to instructions in paragraph 36.
(d) Condensation on optical surfaces within the instrument.	Desiccate. See TM 9-1622.
(e) Film or excessive dirt on optical surfaces.	Same as substep *(c)*, above.
(f) Visibility not good.	Refer to TM 4-250.

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

	Possible Cause	Possible Remedy
(a)	See (3) *(a)*, *(b)*, *(c)*, *(d)*, and *(e)*, above.	See corresponding remedies.
(b)	Illumination failure.	See paragraph 83.
(c)	Prism shift crank does not operate internal target switch.	See paragraph 83 c.
(d)	"Cut-out" due to *both* the internal target collimating wedge and crown set "image up" or *both* set "image down."	Check with pupil loupe. If image of penta prism aperture is not rectangular and almost square, reset internal target crown to bring all the light through the penta prism (par. 57).
(e)	"Cut-out" due to loosened spring in the tube spring assemblies.	Check with pupil loupe. If wire can be seen entering the internal field, remove tube spring assembly and repair.
(f)	"Cut-out" due to internal target mirror gib extending into field.	If gib cuts into field, remove internal target unit and position gib correctly.

29. ILLUMINATION FAILURES.

a. Main Field.

(1)	No input voltage.	Connect to proper voltage source.
(2)	Main switch incorrectly positioned.	Reposition switch.
(3)	Cable from height finder to cradle not connected.	Plug in at proper receptacle.
(4)	Rheostat incorrectly positioned.	Reposition rheostat.
(5)	Defective rheostat.	Replace.
(6)	Defective main switch.	Replace.
(7)	One or more lamps burned out.	Replace.
(8)	One or more lamps incorrectly positioned.	Reposition lamp which is at fault.

Possible Cause	Possible Remedy
(9) Wrong filter in use.	Select correct filter.
(10) Reticle illuminating rods incorrectly positioned.	Refer to paragraph 82 **b**.
(11) Defective wiring or connections.	Check for continuity and short circuits. Repair according to good electrical practice (par. 83).

b. Internal Target.

Possible Cause	Possible Remedy
(1) See **a** (1), (2), (3), (4), (5), (6), (7), (8), (9), and (11), above.	See corresponding remedies.
(2) Internal target prism shift not in proper position.	Set crank firmly in position at stop.
(3) Prism shift switch defective.	Repair or replace (par. 83 **c**).
(4) Internal target penta prism incorrectly positioned.	Refer to paragraph 57 **c**.
(5) Internal target reflector broken or missing.	Refer to paragraph 57 **c**.

30. STEREO FAILURES.

a. Reticle Cannot Be Fused into Stereoscopic Pattern (TM 4-250).

Possible Cause	Possible Remedy
(1) Interpupillary distance incorrectly set for observer.	Reset to correct distance (par. 16).
(2) One or both eyepieces incorrectly focused for observer.	Set to correct focus (par. 16).
(3) Tilted or off-center reticle.	See paragraph 53.
(4) Broken reticle.	Replace (par. 53).
(5) Reticle incorrectly positioned upon reassembly.	Reposition (flat surface faces objective).
(6) Observer is at fault.	Change observer.

TROUBLE SHOOTING

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

	Possible Cause	Possible Remedy
(1)	Height of image incorrectly set.	Reset (par. 16).
(2)	Range-height lever in "height" with low angle of elevation.	None. Instrument will not read altitudes less than 550 yards.
(3)	Range of target less than 550 yards.	None. Instrument will not read ranges less than 550 yards.
(4)	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.
(5)	Observer is at fault.	Change observer.

c. Internal Target Line Split into Two Images.

(1)	Range scale at incorrect setting.	Reset to infinity.
(2)	Range-height lever at incorrect angle of elevation.	Reset to "range."
(3)	Tube at incorrect angle of elevation.	See note * below.
(4)	Compensator badly out of adjustment for range and/or height conversion.	See paragraph 48 **c** and **d**.

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

(1)	Incorrect interpupillary distance set for observer.	Reset to correct distance (par. 16).
(2)	One internal target lamp burned out.	Replace left lamp if right field is dark, and vice versa.

*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, i.e., the height finder and cradle must be level.

Possible Cause	Possible Remedy
(3) Range-height lever at incorrect position.	Reset to "range."
(4) Range scale at incorrect setting.	Reset to infinity.
(5) Tube at incorrect angle of elevation.	See note, under subparagraph c (3), above.
(6) Collimating wedge in internal target mount incorrectly positioned.	See paragraph 57 c.
(7) Compensator badly out of adjustment for range and/or height conversion.	See paragraph 48 c and d.
(8) Observer is at fault.	Change observer.

31. RANGE OR ALTITUDE ERRORS.

a. Incorrect Range on Fixed Targets.

Possible Cause	Possible Remedy
(1) Incorrect internal adjuster scale setting (RCS).	See TM 4-250.
(2) Range-height lever not in "range."	Set lever in "range."
(3) Compensator not in adjustment for range and/or height conversion.	See paragraph 48 c and d.
(4) End windows not in adjustment.	See paragraph 60.
(5) Instrument in unstable condition.	See paragraph 35.
(6) Observer is at fault.	Change observer.
(7) Instrument in need of arsenal overhaul.*	Request instructions from officer authorized to order instrument shipped to base shop or arsenal.

*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

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

	Possible Cause	Possible Remedy
(1)	Incorrect internal adjuster scale setting (RCS).	See TM 4-250.
(2)	Height-range lever not set at proper displacement.	See paragraph 22.
(3)	Computed altitude not correct.	See paragraph 22.
(4)	Compensator not in adjustment for range and/or height conversion.	See paragraph 48 c and d.
(5)	End windows not in adjustment.	See paragraph 60.
(6)	Instrument in unstable condition.	See paragraph 35.
(7)	Observer is at fault.	Change observer.
(8)	Instrument is in need of arsenal overhaul.	See subparagraph a (7), above.

c. Incorrect Altitude on Aerial Targets.

(1)	Height-range lever not set in "height."	Set lever in "height."
(2)	Cradle not level.	Level cradle correctly (par. 41).
(3)	Elevation tracking telescope not properly alined with height finder optical system.	See paragraph 71.
(4)	Incorrect internal target scale setting (RCS).	See TM 4-250.
(5)	Compensator not in adjustment for range and/or height conversion.	See paragraph 48 c and d.

	Possible Cause	Possible Remedy
(6)	End windows not in adjustment.	See paragraph 60.
(7)	Altitude as computed by other means incorrect.*	Improve method of computing altitudes.
(8)	Inaccurate tracking in elevation.	Train elevation tracker to keep target on horizontal cross line.
(9)	Instrument in unstable condition.	See paragraph 35.
(10)	Stereoscopic observer at fault.	Change observer.
(11)	Helium content low.	Change to 95 percent.

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

(1)	Backlash spring broken.	Replace.
(2)	Backlash spring stuck.	Remove, clean, and oil.
(3)	Backlash springs not wound up properly.	Wind up #1 and #2 four turns; #3 and #4 three turns (#1 is at the bevel gear end of the wedge unit).
(4)	Wedge unit gears hit air tubes.	Remove air tube and flatten.
(5)	Backlash between range rod and spur gear of range knob.	Correct backlash, or replace and fit new range rod assembly.
(6)	Backlash between range rod and the planetary gear coupling.	Same as step (5), above.

*Altitudes computed by tracking the target with other instruments, 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.

e. Altitudes Taken while Elevating Instrument Differ from Those while Depressing.

Possible Cause	Possible Remedy
(1) Backlash between bevel gear and height conversion gear.	Loosen screws and move compensator unit closer to conversion gear. Check three screws holding bevel gear to shaft. Check that the race retainer ring in elevation bearing housing has not unscrewed slightly.

f. Noticeable Halving Error of Target when Range Drum Is Traversed from 550 Yards to Infinity.

(1) 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. 67 e).

Section IX

GENERAL MAINTENANCE

	Paragraph
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Tools and special equipment	34
The need for helium charging	35
Care and handling of optical parts	36
Cleaning and painting	37
Lubrication	38
Improvised accessories	39
Maintenance of packing chests	40

32. GENERAL.

a. Scope.

(1) This section describes the testing instruments and special tools, pressure tests, precautions in handling optical parts, cleaning, lubrication charts, painting and repair information on packing chests.

(2) The information given in section X 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 XI, beginning at paragraph 65. Disassembly of the individual units is included in the adjustment and repair section for each.

b. General Handling of the Height Finder.

(1) 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.

(2) 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.*

(3) 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.

c. Repair Parts. Inasmuch as this type of instrument is fabricated by several manufacturers, the components or parts are not necessarily interchangeable. It is therefore extremely important to give the following data when ordering spare parts or requesting information: Name of manufacturer and serial number of instrument. For complete information concerning replacement parts and replacement assemblies, see SNL F-171, Finder, height, 13½-ft. M1.

d. Repair Shop Location and Temperature Conditions.

(1) 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.

(2) Visibility of distant targets and other considerations frequently require that the instrument shop be located 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.

(3) 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 adjuster 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.

e. Hermetic Seal.

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

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

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

(c) 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 COMPOUND, sealing, for height finders, between the contact surfaces of the outer tube and the adapter or the unit cover plate. One-half pint cans of COMPOUND, sealing, for height finders, are furnished maintenance groups.

(d) End windows and sealing glasses are sealed into their mounts with a sealing compound. If a new window has to be installed, the window must be sealed into its mount with COMPOUND, sealing, Navy black.

(e) The packing glands of the height adjuster shaft, measuring knob shaft, 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 GRAPHITE, amorphous, and then coated with GREASE, graphited, light.

33. 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.

34. TOOLS AND SPECIAL EQUIPMENT.

a. **Tools with Height Finder.** 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 usual mechanic's tools. A few special jigs 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. For checking alinement of main eyepieces. Consists of two low-power telescopes with reticles. Adapted to fit eyepiece plate.

(2) PUPIL LOUPE. A magnifier for examining the image of various optical parts as created by the eyepiece lenses. Fits the individual eyepieces.

(3) COLLIMATING TELESCOPE. For checking focus of main objectives, also objectives of M7 Tracking Telescopes. Also used for checking eyepiece diopter scales at zero diopter.

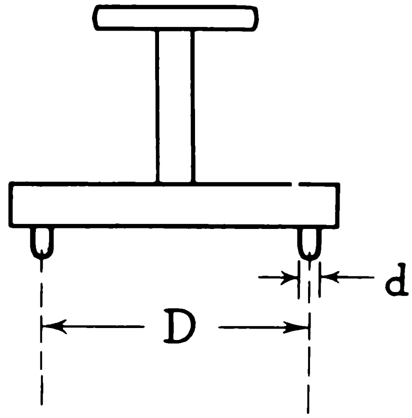
NOTE: The above three items are standard equipment issued for height finder work. The next two items are available in some repair shops, as they have other uses.

(4) AUTOCOLLIMATOR. Useful in setting up ocular prisms in the optical tube. Needs adapter to fit seat of objective cell (fig. 143). A graduated reticle is desirable.

(5) 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.

c. **Jigs and Fixtures.**

(1) BASE LENGTH FIXTURE (fig. 151). For adjusting end reflectors for accurate base length. Pipe or I-beam with 1/64-inch vertical slots 13 feet 6 inches apart. Lamps with filaments horizontal.



PART TO BE FITTED		WRENCH DIMENSION		
NAME	NO.	D	d	
A. END WINDOW *(RING)*	A47040	3.420	.078	#43
B. CHARGING VALVE	B136922	.560	.156	5 32"
C. WEDGE PLUG *(LARGE)*	A181004	.750	.125	#30
D. WEDGE PLUG *(SMALL)*	A178061	.406	.078	#43
E. FOLLOWER	A49413	.531	.093	#41
F. INDICATOR WINDOWS	A47479	*(SUPPLIED)*		
G. END WINDOW *(FRAME)*	B136921	3.850	.062	1 16"

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Figure 57 — Special Wrenches — Bezel Type

(2) SURFACE PLATE. An 8- by 10-inch flat steel plate for holding compensator fixture and other fixtures.

(3) COMPENSATOR FIXTURE. Holds compensator on a surface plate so that surface of compensator housing is 42 degrees to horizontal. Fixture can be made as a casting or built up from steel plates.

(4) PRISM ALINING FIXTURE (fig. 145). For locating prism brackets. Clamps to back of optical tube, fitted with four bracket alining screws.

(5) PRISM BRACKET CENTERING PLUG (fig. 146). Locates prism bracket with reference to internal diameter of erector tube.

(6) EYEPIECE ADAPTER (fig. 147). Holds eyepiece unit correct distance from optical tube. Clamps on optical tube.

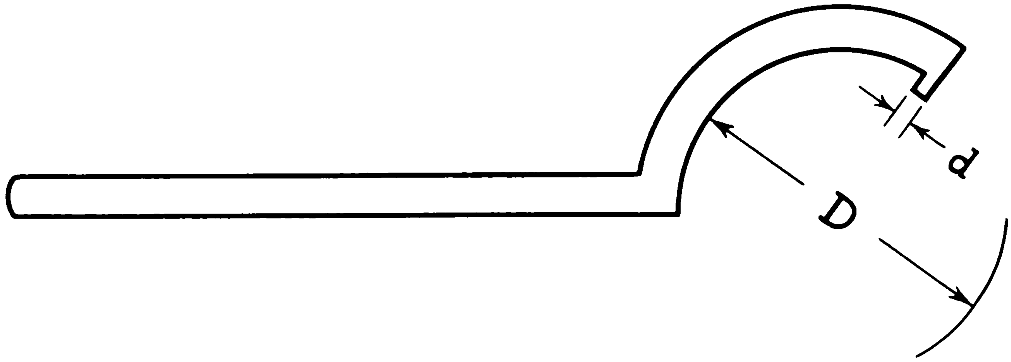
(7) V-BLOCKS. Wood blocks to hold inner tube or optical tube.

(8) HELIUM TANK, PRESSURE REGULATOR, PURITY TESTER, HOSE, ETC. (See TM 9-1622.)

(9) ERECTOR TUBE PULLER (fig. 142). For withdrawing erector tube from optical tube. Fits thread in end of erector tube. Has a handle 30 inches long.

(10) 45-DEGREE ANGLE TEMPLATE (fig. 150). To position end reflector assemblies.

(11) BEVELED GEAR CLAMP (fig. 83). Small right-angle clip to lock bevel gear of compensator.



PART TO BE FITTED		WRENCH DIMENSION		
NAME	NO.	D	d	
A. OBJECTIVE CELL	A49178	3.034	.070	#49
B. OCULAR PRISM BUSHINGS	A47060	.687	.078	#43
C. LEVELS	A47322	.437	.070	#49

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Figure 58 — Special Wrenches — Spanner Type (120°)

(12) ADAPTER FOR AUTOCOLLIMATOR (FIG. 143). Its outside diameter fits the end of the optical tube. Inside diameter is snug fit for autocollimator.

d. Miscellaneous Tools.

(1) LEVEL. Type used on height finder mounted on 4- by 1½-inch plate, or master level issued to ordnance maintenance companies.

(2) CLEANING MATERIALS. PAPER, lens, tissue; CLOTH, batiste; SOLVENT, dry-cleaning; SOAP, liquid, lens cleaning; ALCOHOL, ethyl; SOAP, castile; BRUSH, artist, camel's-hair; and vacuum nozzle (fig. 98).

(3) RANGE SHAFT COUPLING WRENCH. $^3/_{16}$-inch square socket, 5-inch handle. To loosen range shaft coupling screw.

(4) CABLE PACKING NUT WRENCH.

(5) SLOTTED ⅝-INCH HEXAGONAL BOX WRENCH. For junction box packing nuts. Slotted to slip over conduit.

(6) SPECIAL HEIGHT ADJUSTER WRENCH (fig. 109). Operates height adjuster without need for replacing the knob adapter.

(7) RANGE DRUM BEARING CAP WRENCH. To fit notches in sides of bearing cap. Is of retaining ring type (fig. 59) with center relieved.

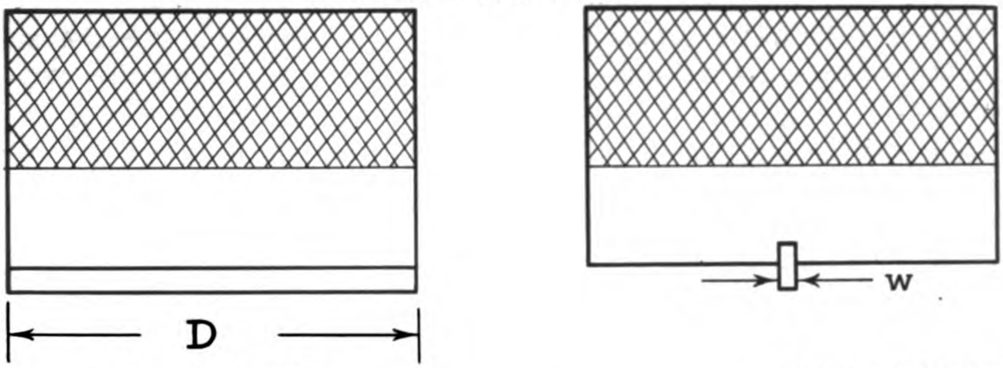
(8) 10-DEGREE METAL WEDGE. For use in adjustment of height finder levels (par. 41 d (7)).

e. Special Wrenches. See figures 57, 58, and 59.

35. 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



PART TO BE FITTED NAME	NO.	WRENCH DIMENSION D	W
A. OBJECTIVES & WEDGES	A49179	2.580	1/16
B EYELENS & FIELD LENS	A46929	1.028	1/32
C. INTERNAL TARGET RETICLES AND CONDENSERS	A49156	.770	1/32
D. INTERNAL TARGET CROWN AND WEDGE	A46989	.668	1/32
E. ERECTOR LENS	A178030	1.262	1/32
F. MAIN RETICLE	A46948	1.180	1/16

RA PD 67945

Figure 59 — Special Wrenches — Retaining Ring Type

of the instrument, and to minimize the effects of unstable temperature conditions. Dry air or dry nitrogen has been used, and these were satisfactory in the prevention of condensation but gave 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 (par. 45) will have parallax if helium purity diminishes.

(2) The M1 Height Finder is fitted with valves for the purpose of gaseous charging, and cylinders of helium and appropriate control 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 for ordnance personnel are given in TM 9-1622. The Oliver method, described in TM 9-623, may be used by ordnance personnel when lack of a purity indicator makes it impossible to charge by the purity indicator method.

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 soapsuds 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.

36. CARE AND HANDLING OF OPTICAL PARTS.

a. Precautions.

(1) It must be remembered at all times that these 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; 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 the fingers.

(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 materials in the field is not permitted. To remove dust, brush the glass lightly with a clean camel's-hair artist 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 SOAP, liquid, lens cleaning or ALCOHOL, ethyl, sparingly with a clean camel's-hair 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 paper. Repeat as necessary until the surface is clean.

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

c. Handling of Optical Parts.

(1) It must be remembered at all times that optical glass surfaces are delicate and easily damaged. Therefore special care is required 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 surfaces 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.

(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.

d. Cleaning Internal Optical Parts.

(1) In height finders of recent manufacture the surfaces of some of the interior optical parts have been specially treated to increase light transmission and to reduce internal reflections. Surface-treated parts are generally identifiable by the slight tinge of color seen by reflected light. Since the number of parts which have been treated will vary with different instruments, all interior optical parts should be handled as though they had these delicate surfaces. *No water, not even from the breath, should be used.* Coated surfaces must not be touched unless absolutely necessary. If it becomes necessary to remove optical parts from their mounts, handle lenses by their edges and prisms by uncoated surfaces.

(2) To clean, wipe gently with lens tissue paper.

(3) Remove dust with a clean camel's-hair artist brush.

(4) If a solvent is necessary to remove finger marks or oil or grease, except on front aluminized mirrors, apply ethyl alcohol sparingly with a clean camel's-hair artist brush, and dry gently with lens tissue paper. Take care to prevent the alcohol from seeping around the edge of the glass into the mount.

(5) After cleaning a mounted or unmounted optical element, wrap it with clean lens tissue paper and put in a safe place until reassembly in the instrument. Do not leave any optical part unmounted for any longer than necessary.

(6) Special precautions in handling and cleaning reticles and front aluminized mirrors are described in paragraphs 42 and 53.

37. 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 36. The other surfaces can be cleaned with castile soap and warm water. All soap should be thoroughly rinsed off with clean water and the surfaces dried quickly. Care must be taken to prevent water from penetrating under the various control knobs and levers. For details of painting, see TM 9-850.

(2) Cement, sealing or plugging, is required above some screwheads, when a flush surface is desired, or to prevent unauthorized adjustment of the screw.

b. Cleaning and Painting Chart.

Part	Operation and Remarks	Suggested Frequency in Moist Climates
Gland, measuring knob.	Repack, test for helium leak.	Semiannually.
Glands, others.	Repack, test for helium leak.	When needed.
Seals, *all*.	Repair, 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. 36 **b**).	When needed.
Internal optics.	Clean (par. 36 **d**).	When needed.

38. LUBRICATION.

a. There are two lubricants prescribed for the height finder:

(1) OIL, lubricating, for aircraft instruments and machine guns. Apply lightly wherever oil is prescribed. Excess oil collects dust and dirt.

(2) GREASE, lubricating, special. Apply sparingly wherever grease is prescribed.

b. SOLVENT, dry-cleaning, will be used to clean parts which must be dried thoroughly before lubricating.

c. Instructions for lubricating and cleaning are given in Tables I, II, III, and IV.

NOTE: *Avoid getting oil and grease on the optical parts.*

TABLE I

Cleaning and Lubrication Chart for Tripod

Part	Operation and Remarks	Suggested Frequency in Moist Climates
Tripod leg shoes.	Clean and oil lightly. Remove each shoe and clean to prevent wear due to dirt or sand. Oil the ball and socket joint.	Twice a week.
Leveling screw assemblies.	Clean and oil. Remove the small plate on the outer side of each assembly. Back off the set screw and remove the retaining ring around the top of the leveling screw. Remove the screw itself. Clean all parts with dry-cleaning solvent, and oil. Reassemble.	Twice a week.
Spindle tube.	Clean with dry-cleaning solvent and grease lightly.	Twice a week.
Brace tube sleeve clamping screws.	Remove. Clean with dry-cleaning solvent. Grease.	Twice a week.
Tripod leg hinge pins and tripod leg brace tube hinge pins.	Clean and oil.	Weekly.

TABLE I — (Con't)

Part	Cleaning and Lubrication Chart for Tripod Operation and Remarks	Suggested Frequency in Moist Climates
The four nuts for the cradle locking bolts.	Clean thoroughly with dry-cleaning solvent. Grease.	Weekly.
The two holes for the cradle guide pins.	Clean and grease.	Weekly.
Traversing female worm coupling, traversing worm and traversing worm gear.	Clean and grease *very lightly*. Remove the worm coupling by taking out the large screw in the center. Take off the traversing worm housing. Clean the worm with a wiping cloth and grease lightly. Grease the traversing worm gear with *no more than one pinhead of grease per tooth*. Slew the tripod head to expose all teeth.	Monthly.
Cradle locking bolts.	Remove. Clean with dry-cleaning solvent. Grease.	Weekly.

TABLE II

Cleaning and Lubrication Chart for Cradle

Telescope locking screws.	Clean and grease.	Weekly.
The four telescope bearing surfaces.	Clean with dry-cleaning solvent and grease lightly to prevent rusting.	Weekly.
Change of speed crank shafts.	Oil (1 drop).	Weekly.
Level vial covers.	Oil (1 drop) and wipe dry.	Weekly.
Underneath side of cradle.	Clean cavity, gears, guide pins, azimuth male coupling and springs. Coat lightly with oil by using a cloth dampened in oil.	Weekly.
Rheostats and light switch.	Remove the knobs. Clean and grease the shafts and screws.	Monthly.

GENERAL MAINTENANCE

Part	Operation and Remarks	Suggested Frequency in Moist Climates
Elevation mechanism.	Clean (if necessary) and grease. Remove the left cradle body cover and the telescope locking screw. Rotate the elevation handwheel and inspect the elevation mechanism. If any sand has gotten into it, clean by wiping with a wiping cloth. Grease while rotating the elevation handwheel. *Do not take the elevation mechanism apart.*	Monthly.
Traversing mechanism.	Grease. Remove the right cradle body cover and the telescope locking screw. Grease while rotating the traversing handwheel. *Do not take the traversing mechanism apart.*	Monthly.
Traversing mechanism.	*Ordnance job:* Clean, grease, and adjust.	Every 3 months.

TABLE III

Cleaning and Lubrication Chart for Telescope

Eyepiece face plate.	Wipe the sliding surfaces clean.	Twice a week.
Eyepiece cells and tracking telescope eyepiece cells.	Clean and oil *very lightly.* Set each eyepiece at the highest possible plus focus. Clean and wipe the eyepiece cells and oil lightly.	Weekly.
Level vial cover.	Oil (1 drop) and wipe dry.	Weekly.
Headrest holder pivots.	Oil (1 drop on each pivot) and wipe dry.	Weekly.
Threaded holes for telescope locking screws.	Clean with dry-cleaning solvent. Grease.	Weekly.

TABLE III — (Con't)

Cleaning and Lubrication Chart for Telescope

Part	Operation and Remarks	Suggested Frequency in Moist Climates
Threads of end window sunshades and of tracking telescope sunshades.	Remove the sunshades and clean the threads. *Use no lubricant.*	Weekly.
The four bearing surfaces which rest on the cradle.	Clean with dry-cleaning solvent and grease lightly.	Weekly.
Internal adjuster correction scale cover.	Remove, clean and replace. *Use no lubricant.*	Monthly.
Pivot for tracking telescope dummy eye shield.	Remove screw, clean and replace. *Use no lubricant.*	Monthly.
Height-range lever.	Work 1 drop of oil into pivot.	Monthly.
Springs in height-range lever retaining brackets.	Remove springs. Clean, oil and replace.	Monthly.
Main bearing race and bevel pinion.	Clean and oil *lightly*. Remove the cover over the bevel pinion. Clean and oil the bevel pinion and the teeth on the side of the race.	Monthly.
Elevating worm and gear segment.	Clean and grease. Set the telescope on the ground. Swing the left main bearing housing up on the front side of the telescope. Remove the elevation coupling by taking out the large screw in the center. Remove the left main bearing worm housing. Wipe the worm clean. Grease the worm and the worm gear segment.	Every 3 months.

GENERAL MAINTENANCE

Part	Operation and Remarks	Suggested Frequency in Moist Climates
Right main bearing and left main bearing.	*Ordnance job.* Remove the bearing housing. Clean and grease the balls and the race. Readjust.	Every 6 months.
Eyepiece assembly.	*Ordnance job.* Remove, clean and grease. Reseal and realine, using a double collimator.	Every 6 months.
Eyepiece face plate.	*Ordnance job.* Clean by removing the eyepiece cell assemblies. Use grease.	Every 6 months.
Inner tube bearings.	*Ordnance job.* Remove the cover plates. Grease the bearings. Reseal the telescope.	Once a year.

TABLE IV

Cleaning and Lubrication Chart for the Packing Chests

Telescope packing chest.	Grease the threads of the 12 bolts which are used to clamp the hinged end of the chest.	Weekly.
Hinges and hasps on all chests.	Clean and oil.	Monthly.
All chests.	Wash and dry.	Monthly.
Telescope carriage.	Wash the carriage. Clean and grease the rollers.	Every 6 months.

39. IMPROVISED ACCESSORIES.

a. Scope. Certain accessories have been found to increase the accuracy obtained from the height finder. They are approved or may be approved shortly. Where they are not yet supplied, they can be improvised. These accessories include sunshades for the top of the height finder telescope, sunshade boxes for the internal target mounts, and end window stops to provide a 1-inch aperture at the end windows. Construction of these is described in TM 9-623. Details for the construction of an interpupillary distance template follow.

b. Interpupillary Distance Template. One factor in obtaining the highest precision from the height finder is to have the interpupillary

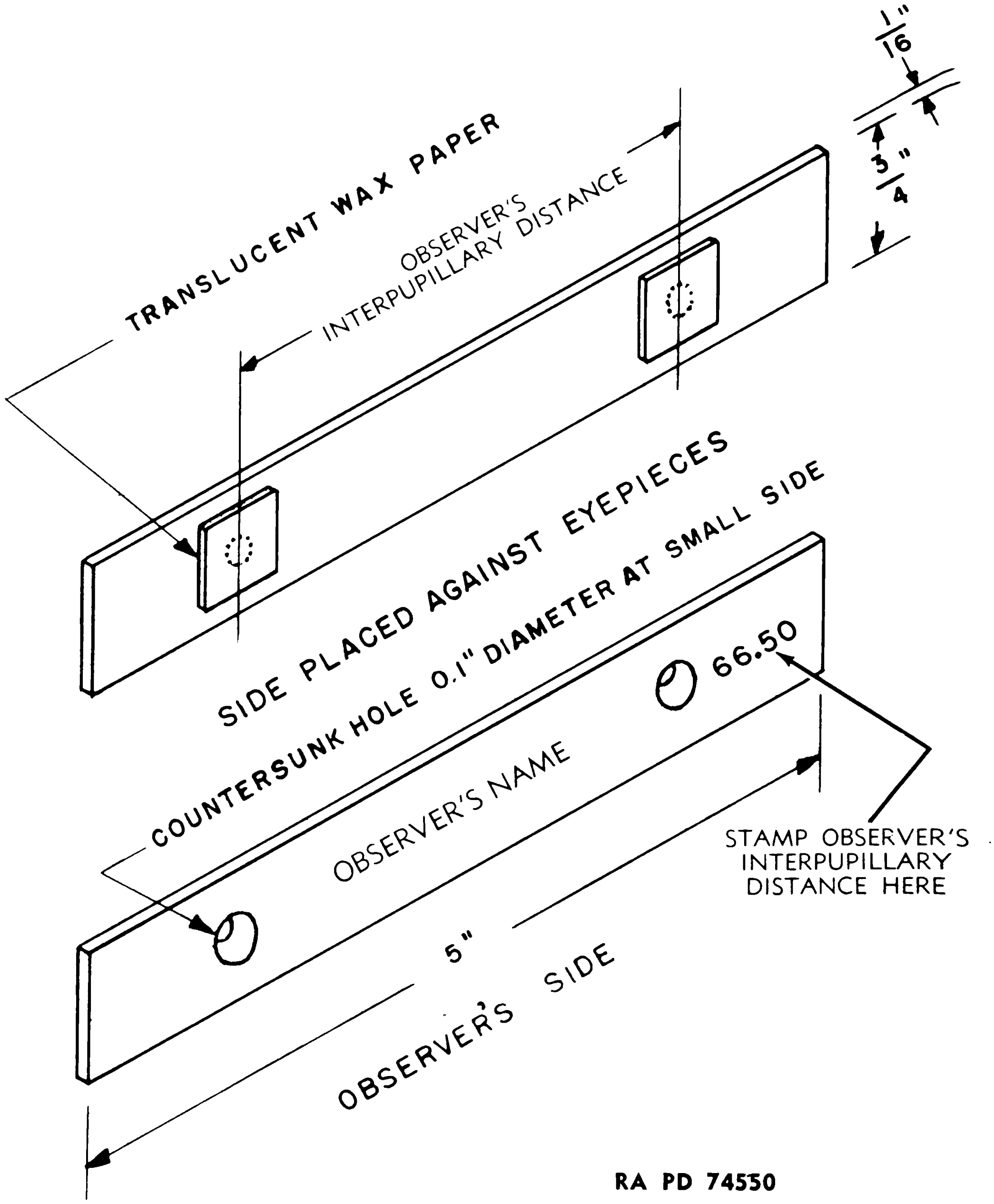


Figure 60 — Interpupillary Distance Template

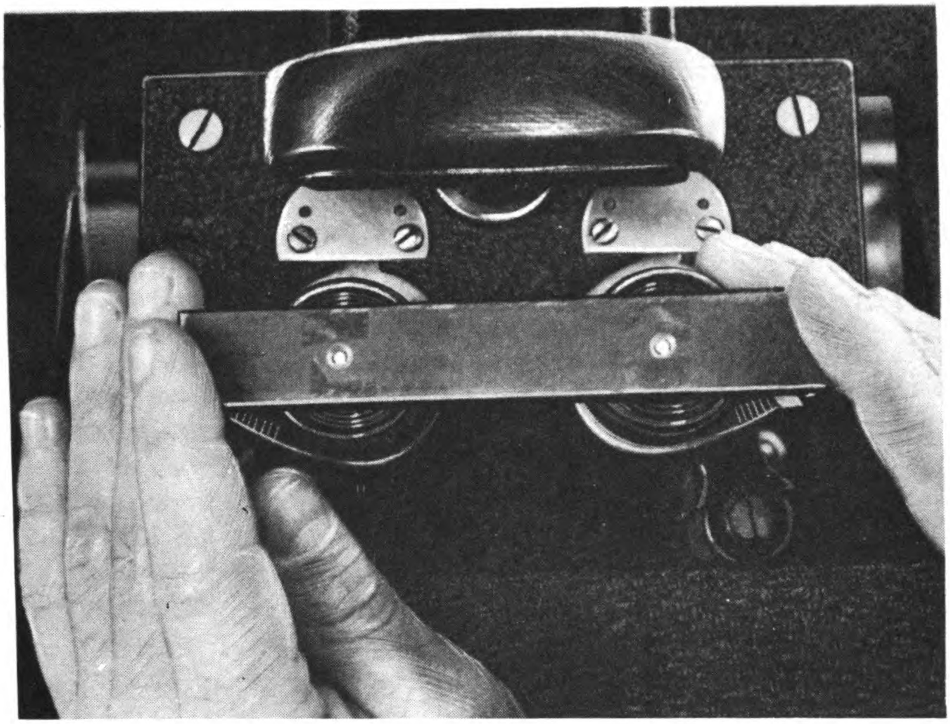


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Figure 61 — Interpupillary Distance Template in Use

distance setting correct for the individual observer within one-quarter of a millimeter. Since the interpupillary distance scales are not calibrated to this accuracy, it is desirable for each observer to procure an interpupillary distance template to fit his own eyes and to make the interpupillary distance setting using this template. The construction of such a template is shown in figure 60. The template is made from a strip of steel $\frac{1}{16}$ inch thick, $\frac{3}{4}$ inch wide, and 5 inches long. Two perforated holes are drilled in this template as shown. The holes are 3 mm in diameter (No. 32 drill). The value for the distance between centers of the two holes is found by measuring the interpupillary distance between the observer's eyes on an interpupillometer of an approved design. Having obtained this template, the observer marks it with his own name and the interpupillary distance, and thereafter uses the template to set the interpupillary distance on any height finder on which he must observe. This setting is made by pointing the height finder at the open sky and adjusting the interpupillary distance lever so that the two exit pupils fall exactly centered in the two holes of the template.

40. 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 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 contents are shown in figures 44, 45, and 46.

c. Chest Maintenance Chart.

Part	Operation and Remarks	Suggested Frequency in Moist Climates
Chest, packing, telescope.	Grease thread of 12 lock bolts.	Weekly.
Carriage, telescope.	Clean and grease roller, wash carriage.	Semiannually.
Chest, hinges, hasps.	Clean and oil.	Monthly.
Chests.	Wash all chests and dry.	Monthly.

Section X

HEIGHT FINDER TELESCOPE—ADJUSTMENT AND REPAIR

	Paragraph
Adjustment and replacement of levels	41
End reflectors	42
Eyepiece unit—adjustment	43
Eyepiece unit—removal and disassembly	44
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Measuring drum	52
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Height adjuster disk (height of image adjustment)	55
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Internal target system—cleaning and adjustment of individual units	58
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End boxes 61
Right main bearing and height conversion ring 62
Left main bearing housing 63
Carrier handles 64

NOTE: Preliminary adjustments must be carefully made before starting work described in this section (par. 16).

41. ADJUSTMENT AND REPLACEMENT OF LEVELS.

a. Explanation. The height conversion mechanism is controlled by the angle of elevation of the height finder telescope with respect to the cradle and elevation tracking telescope. 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 tracking telescope the level on the height finder tube should be accurately alined with the height conversion mechanism.

b. Requirements. Checking, adjusting, and replacing the cradle and height finder levels can readily be done in the field. Extra level tube assemblies are supplied with the spare parts in the cradle packing chest. The tripod feet should be solidly set on a firm foundation when the levels are being checked and adjusted. A specially mounted reading microscope is desirable for observing the scale graduations on the height conversion ring for setting the height finder tube at exactly 90 degrees from the vertical position, but a scriber and hand magnifier can be used. To get height performance these relationships must be established in the sequence below:

(1) The bearing surfaces between cradle and telescope must be clean.

(2) The cradle must be leveled accurately.

(3) The height-range ring must travel exactly 90 degrees.

(4) The wedges must be in adjustment in the zero mils angular height position.

(5) The horizontal hairline of the elevation tracking telescope must be alined on a known exact level point preferably at least 1,000 yards distant if visibility is such that no refractive effects are introduced. (If tests, using inverted transit or reversed level, indicate refractive change of level point since last tested, a new point is permissible as close as 500 yards, if work is done with extreme care.)

(6) The height finder telescope level must be centered when the instrument is at zero mils angular height as determined by training the elevation tracking telescope on the level point.

(7) The elevation adjustment knob stops and/or the end reflector assemblies may need adjusting to cause the known level point to appear in the center of the field of view of the main optical system when the elevation tracking telescope is on the level point.

c. **Cradle Levels.**

(1) If the cradle levels are outside tolerance, adjust them as follows:

(a) Make sure vials are not loose in their sleeves.

(b) If bubbles are heated locally by hands they must cool uniformly before final adjustments.

(c) 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.

(d) 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.

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

(f) With a pencil, mark the position of the edge of the bubble on the vial or on the cover.

(g) Turn the level adjusting nuts with the adjusting pin (fig. 62) to bring the bubble back one-half the distance between the pencil mark and the center engraved mark.

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

(i) Traverse the height finder through 180 degrees and again note the position of the bubbles. (They should stay centered within tolerance, 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.)

(j) Fully tighten the nuts on the cradle levels and recheck the setting by traversing the instrument through 360 degrees. If the levels are found to be within tolerance, apply a small quantity of shellac to the joining surfaces of the nut and stud as a seal.

d. **Height Finder Level.**

(1) The height finder level (fig. 63) can be reset in the following manner, using an elevation microscope:

(a) Level the cradle accurately.

(b) Mount the elevation microscope on the height-range conversion gear housing in place of the screw just in front of the range bracket.

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Figure 62 — Turning Level Adjusting Nut with Adjusting Pin

1. Set the height-range lever in range position.

2. Adjust the microscope so that its horizontal reticle line is superimposed on the upper edge of the 90-degree engraved line on the conversion gear.

3. Shift the height-range lever to height position.

4. Turn the height finder in elevation, using the elevation adjustment handwheel on the cradle, until the horizontal reticle line of the microscope is superimposed upon the upper edge of the 0-degree engraved line. See subparagraph **b**, above, for zero mils adjustment relationships before proceeding further.

(c) Set the adjusting nuts A47322 of the height finder level to bring the bubble into midposition within one-half the width of the etched line on the level.

(d) Check tightness of the leveling nuts and recheck the position of the bubble in the height finder level. The height finder is considered to be level when the movement of the height-range conversion gear from range position to height position is 90 degrees to within one-third the width of the engraved line on the conversion ring. If the microscope is not available, any index precise to one-third line width will do, such as a prick-punch mark or scribed line on the gear housing opposite the 90-degree engraved mark.

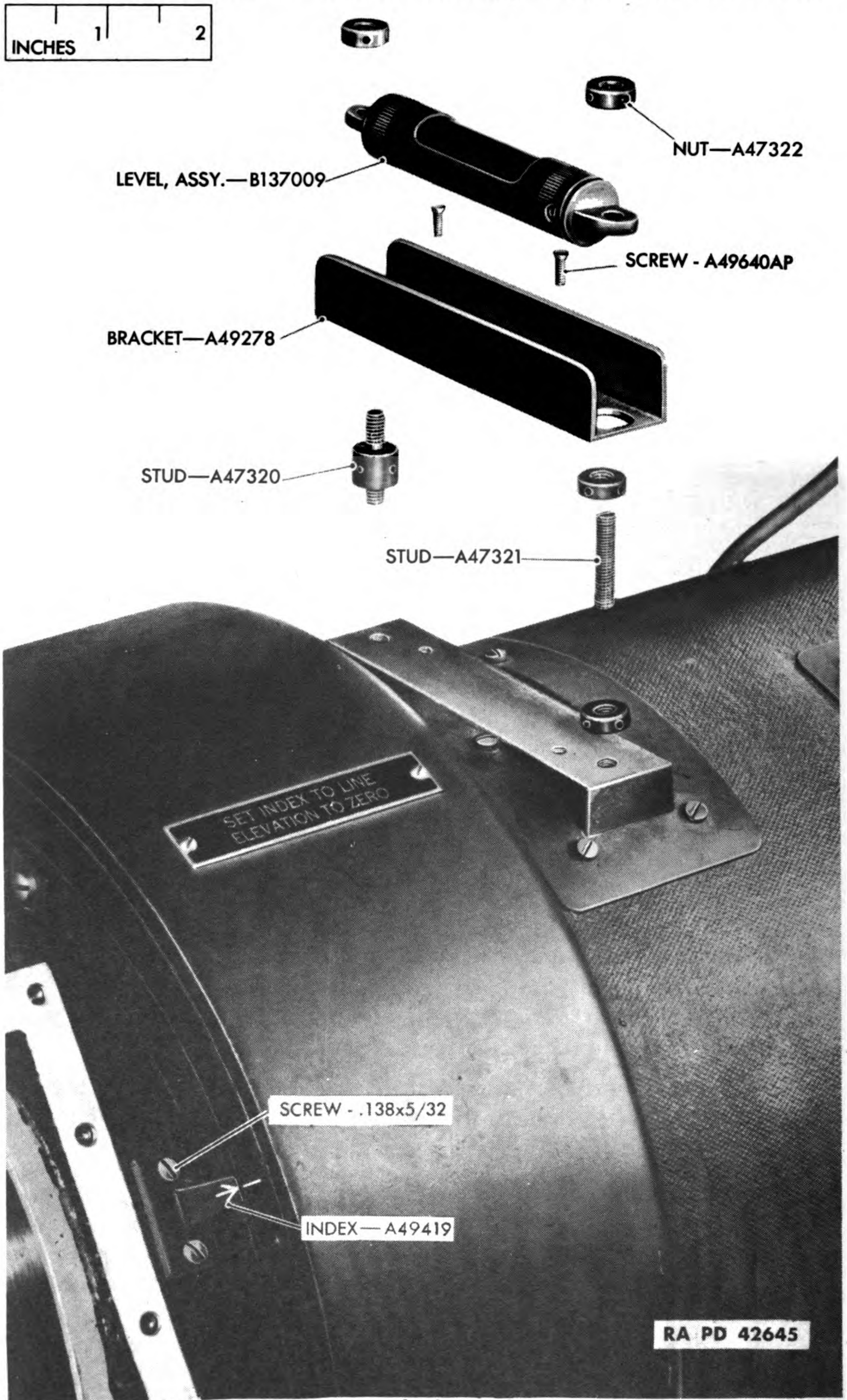

Figure 63 — Removal of Height Finder Level

(e) Check the range-infinity, height-900 internal target settings and the vertical alinement of the tracking telescopes on the known level point.

(f) If it is desired to tentatively set the height finder level before the 90-degree height-range conversion gear is pinned, or if the range or height stops have been damaged, it can be done in the following manner:

1. Level the cradle carefully, and place a 10-degree metal wedge or gunner's quadrant set at 10 degrees on the flat surface of the eyepiece assembly with the base of the wedge toward the back of the height finder.

2. Place a test level on the 10-degree wedge and rotate the height finder in elevation by rotating the elevation handwheel until the bubble of the test level is in midposition.

3. Turn the adjusting nuts on the height finder level until the bubble is in midposition within one-half the width of the level vial graduations.

4. Tighten the screws and recheck the position of the bubble, which should be within 2 minutes of 10 degrees from the eyepiece adapter seat.

NOTE: If this latter procedure is followed, the 90-degree travel of the height conversion ring must be checked and adjusted. The compensator unit must be adjusted and the vertical alinement of the tracking telescopes checked and adjusted on the known level point.

e. Replacement of Levels. If a level should become damaged or broken, it can be replaced by one of the spare level assemblies B137009 (fig. 65) packed in the cradle case. Unscrew the two top clamping nuts (fig. 64), remove the old assembly, put on the new assembly, and replace the clamping nuts. Whenever a level is replaced, it should be checked and, if necessary, adjusted as described above.

42. 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. Dirt or irregularities on the contact surfaces of the mount will probably change the adjuster scale readings, possibly beyond the range of the scale. Excessive pressure from the clamp may cause poor definition or a change of focus, as well as irregular cross field readings. The reflec-

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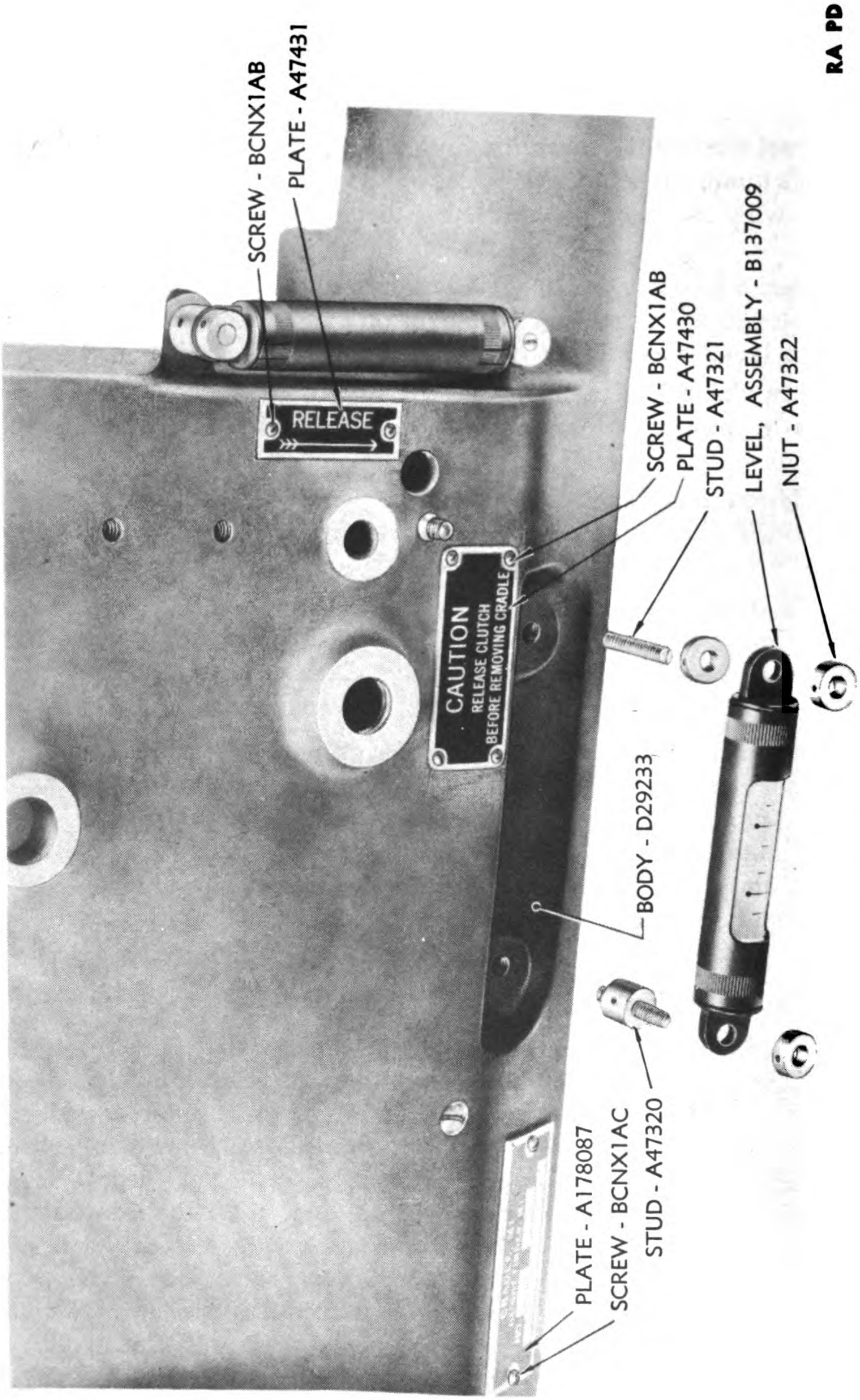

Figure 64 — Removal of Cradle Level Assembly

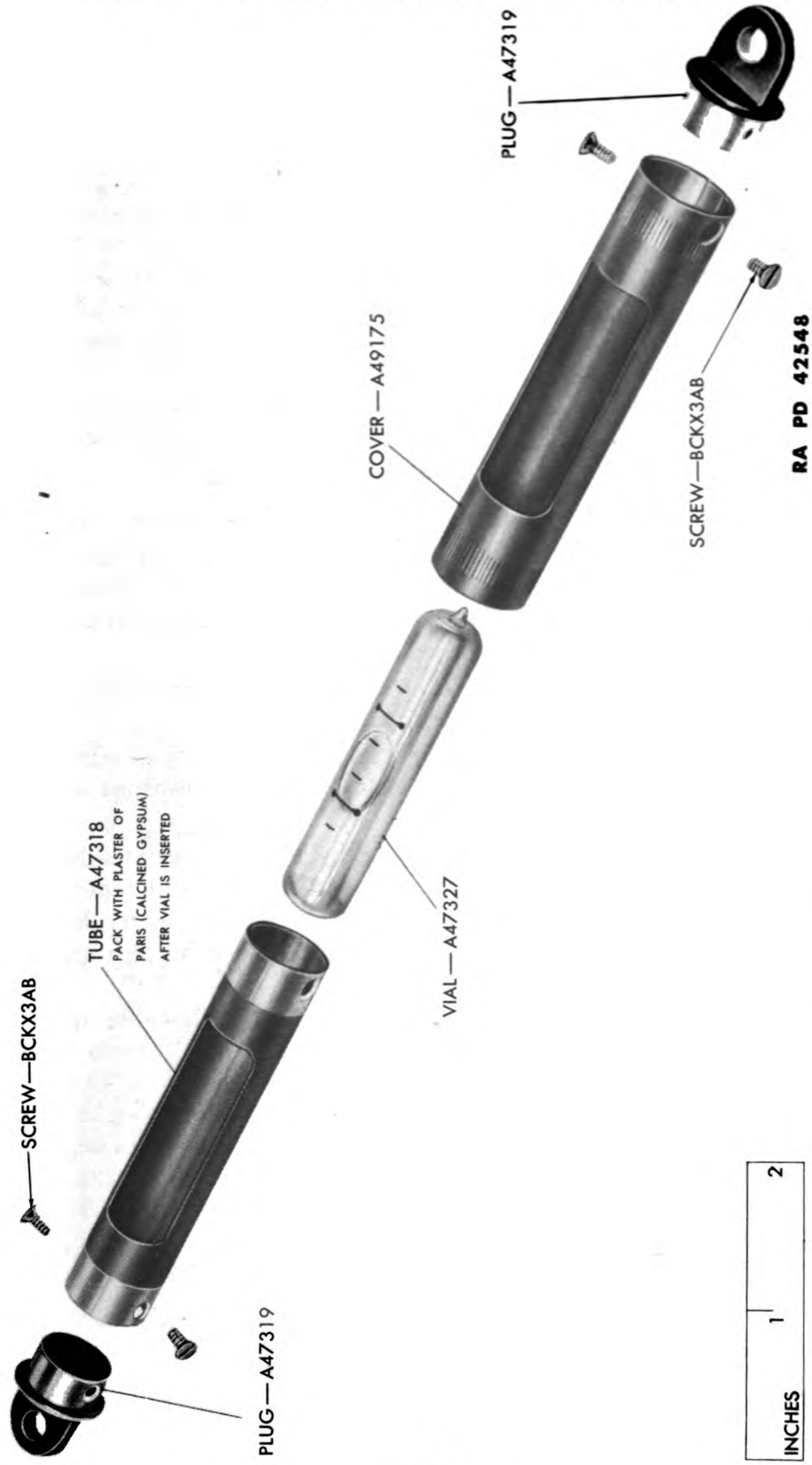

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Figure 65 — Level Assembly — Exploded View

tor supports are mounted to the inner tube by screws, and the screw holes are slightly oversize to allow a slight rotation of the bracket in originally lining up the reflectors. Any subsequent shifting of the bracket will cause misalinement.

b. Requirements.

(1) 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 will be needed for testing. The installation of new reflectors requires the use of special fixtures for setting the base length and mounting angles as described in paragraph 67.

CAUTION: The front aluminized mirrors are easily damaged and must be handled with extreme care. *Do not touch the reflecting surfaces.*

c. Adjustment of End Reflectors for Misalinement. If the height adjuster cannot bring the images in both fields to the same height, and the inspection (par. 20 **c**) indicates that the difficulty is in the end reflectors, determine which reflector is at fault and correct it as follows:

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

(2) Set the height adjuster at the midpoint of its travel and look through the left and right eyepieces, noting relative positions of the target image in the two reticle fields.

(3) If one image is decentered, possibly completely outside the field, check and adjust the corresponding end support and reflector.

(a) Remove the end box as described in paragraph 61 **b** and loosen the eight hexagonal-head screws which hold the support assembly to the inner tube (fig. 66).

(b) Rotate the support assembly through its allowable movement, and note the effect on the target image in the reticle field. Rotation of the support affects the tilt of field as well as the up-and-down alinement of the image. If the image can 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 can be corrected by rotating the reticle (par. 53 **g**).

(c) When the image is alined, tighten the eight screws and seal them with VARNISH, shellac.

(d) Check the internal target moons and, if necessary, reset the penta prisms (par. 57 **c**).

(e) Check tilt of reticle (par. 53 **d**).

(4) Replace end box (par. 61 **b**).

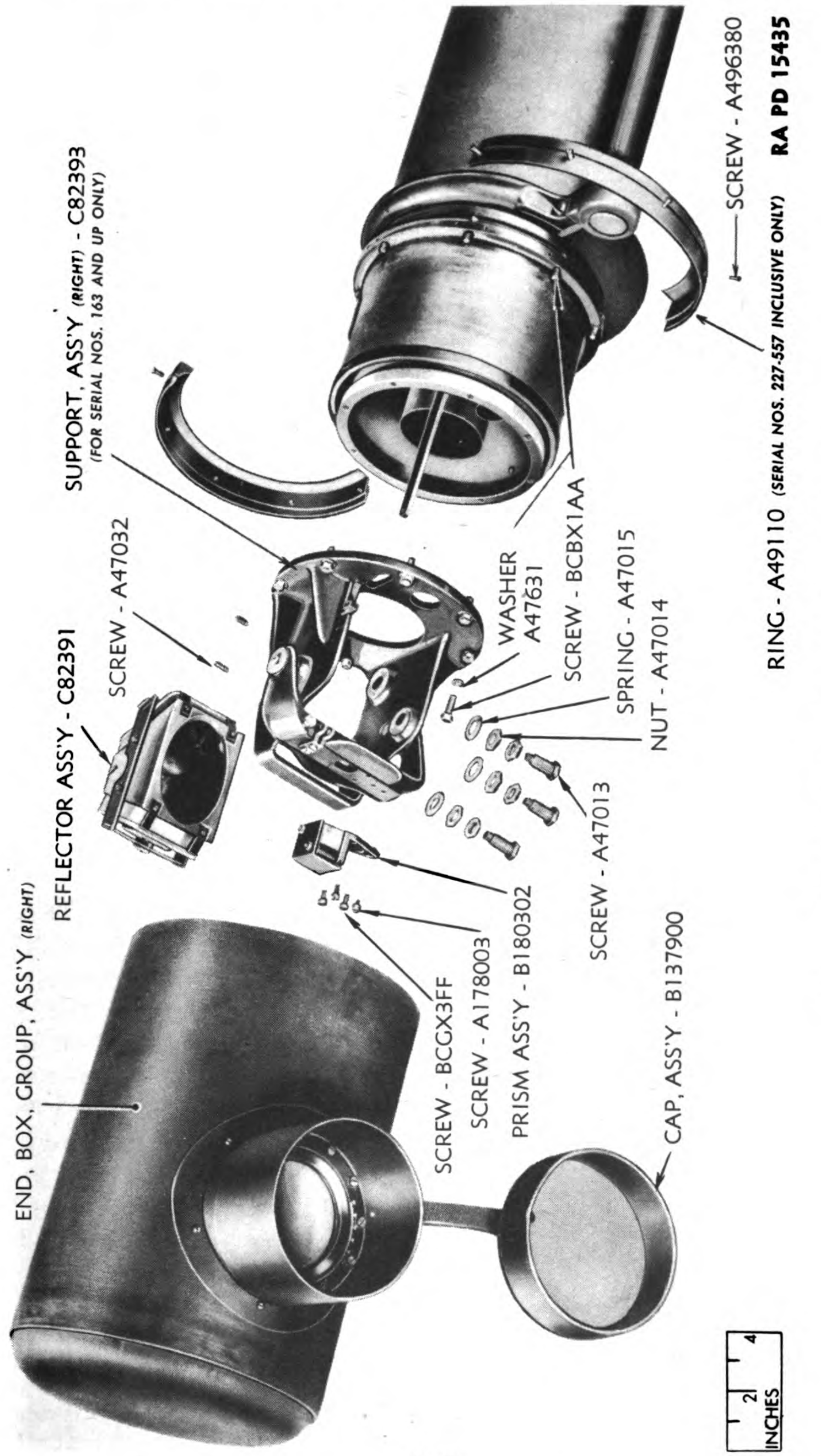

Figure 66 — Removal of End Reflector Support

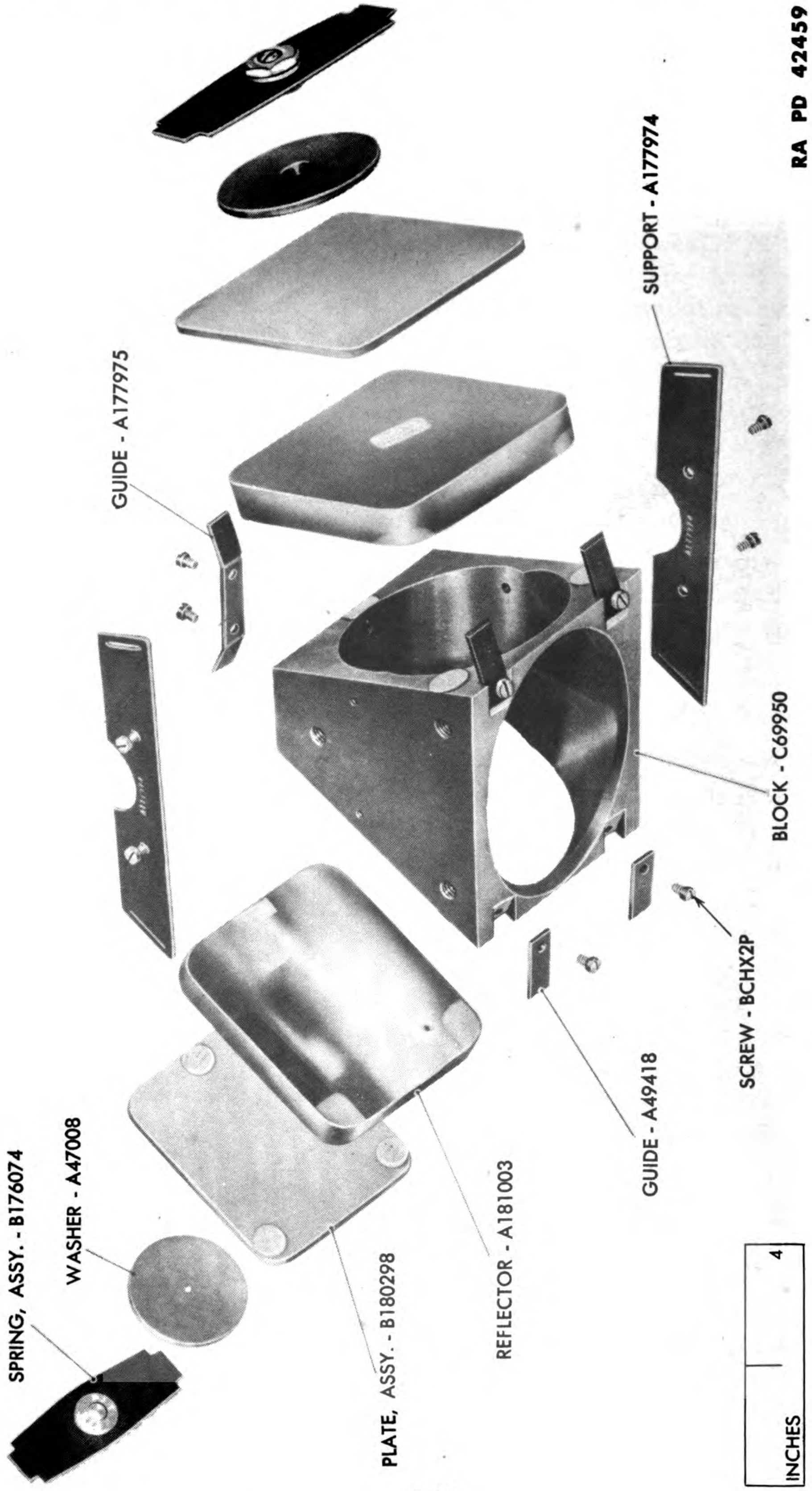

Figure 67 — End Reflector Assembly — Exploded View

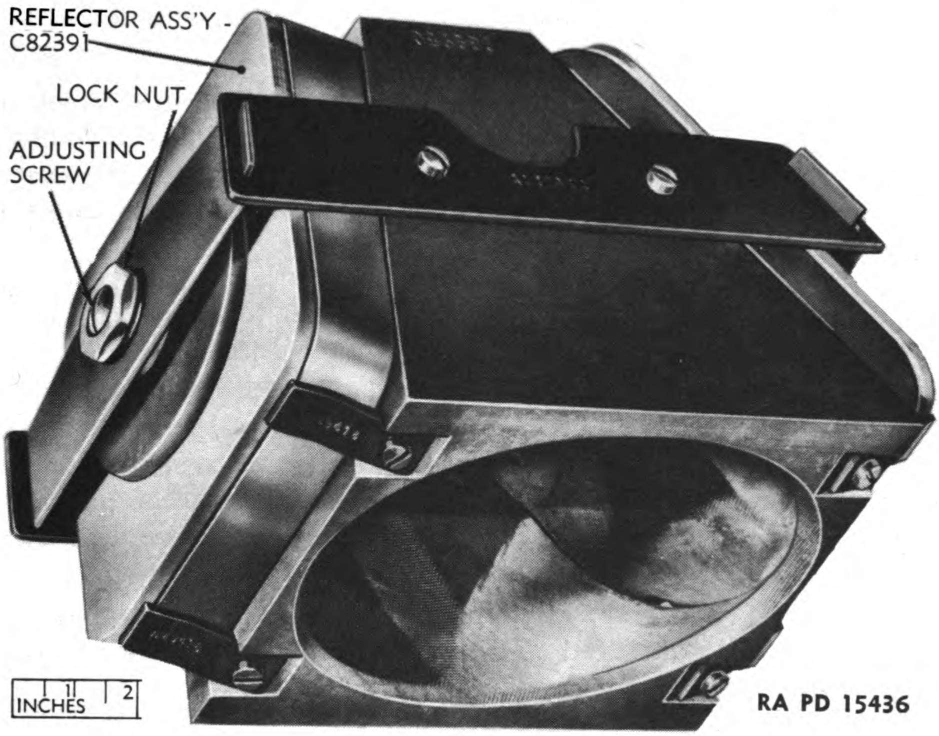

Figure 68 — End Reflector Assembly

d. Irregular Cross Field Readings Due to End Reflectors.

(1) If there is difficulty in obtaining uniform readings across the reticle field, and the difficulty is traceable to the end reflectors, as outlined in paragraph 20 **h,** check the end reflectors as follows:

(2) Remove the end boxes as instructed in paragraph 61 **b.**

(3) Relieve pressure on the mirrors as follows:

(a) Loosen the lock nuts and back off the adjusting screws in the mirror clamping spring assemblies (fig. 68). If these screws are too tight, the mirrors may become slightly warped, which will affect the cross field readings. If the difficulty is found therein, draw up the screws as snugly as possible without affecting the cross field readings but enough to keep the mirrors securely mounted on the block.

(b) Check to see whether there is any contact between the mirrors and the edges of the bosses which support the mirror assembly. If so, it will be necessary to remove the mirror assembly and file the edge of the boss to avoid the contact.

(4) Check the bearing surfaces.

(a) Loosen the lock nuts A47014, remove screws A47013, and lift out the reflector assembly (fig. 66).

(b) Check for burs and foreign matter between the contact surfaces of the block and bosses. If any are found, remove them, replace

block as described in subparagraph e (6), below, and recheck the cross field readings.

(5) Check the contact surface between the reflector block and bosses, using a flat plate and PRUSSIAN BLUE, over the combined surfaces of the bosses. The contact surface should be at least 75 percent. If it is less than this, it will be necessary to rescrape the support as described in paragraph 67.

NOTE: Rescraping should be avoided if possible. Do it only after all other corrective means have failed, including the use of other end reflectors, if available.

e. Removal for Cleaning or Replacement.

(1) If an end mirror has been damaged so as to require replacement, or if it needs more cleaning than can be accomplished by gentle use of a camel's-hair brush, it can be removed from its mount as follows:

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

(a) Remove the end box as instructed in paragraph 61 **b.**

(b) Loosen the lock nuts A47014, remove screws A47013, and lift out the reflector assembly (fig. 66).

(c) Release mirror as follows:

1. Loosen the lock nut and back off the adjusting screw to release the tension on the spring A47009 (fig. 68).

2. Repeat for the opposite mirror on the block.

3. While holding the mirrors with one hand, loosen the two clamping screws sufficiently to allow the support A177974 to be lifted off the spring assemblies (fig. 67). Then carefully remove the mirrors.

(d) When reassembling the mirrors to the block, make sure that all points of contact are free from dirt or grit. Set the pressure on each mirror at about three-quarters to one turn of the adjusting screw A47016.

(e) Remount the reflector assembly as follows:

1. Place the reflector block in position on the support, with the scribed marks on the bottom centered in the holes through the bosses.

2. Turn the lock nuts as close to the heads of the mounting screws A47013 as possible and turn the screws into the reflector block with the fingers until snug. Take care not to move the block.

3. Tighten two of the nuts against the support to prevent the block from slipping.

4. Tighten the third screw into the block; then tighten the lock nuts.

5. Loosen the nuts on one of the other screws, tighten the screw, and retighten the nuts.

6. Repeat for the third screw.

7. Apply VARNISH, shellac, to nuts and screws.

f. Cleaning the End Reflectors.

CAUTION: Do not attempt to clean a front aluminized mirror with lens tissue paper.

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

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

g. Removal of End Reflector Supports.

(1) The end reflector supports need not be removed except for replacement or for a major disassembly of the height finder (removal of the inner tube). It is not necessary to remove the end reflector assembly or the penta prism mount assembly from the support in order to remove the end support.

CAUTION: Take care to avoid touching the surfaces of the end reflectors.

(2) Remove the end box as described in paragraph 61 **b.**

(3) Mark the position of the support with relation to the inner tube by scribing a line across the joining surface.

(4) Remove pivot screw to disconnect the prism shift link from the penta prism bracket. Do not disturb the penta prism stop or the stop screw.

(5) Remove the eight hexagonal-head mounting screws and remove the support asesmbly.

(6) For disassembly of the support, see figure 69.

(7) When remounting the support assembly on the inner tube, make sure that it is properly tilted so that the scribed lines match.

43. EYEPIECE UNIT — ADJUSTMENT.

a. Introduction.

(1) Light rays reflected by the ocular prisms pass to the eyepiece unit (figs. 70, 71, and 72) through windows sealed in the eyepiece housing, which is assembled to the outer tube. The eyepiece unit contains two eyepieces, two rhomboid prisms, and two sets of filters.

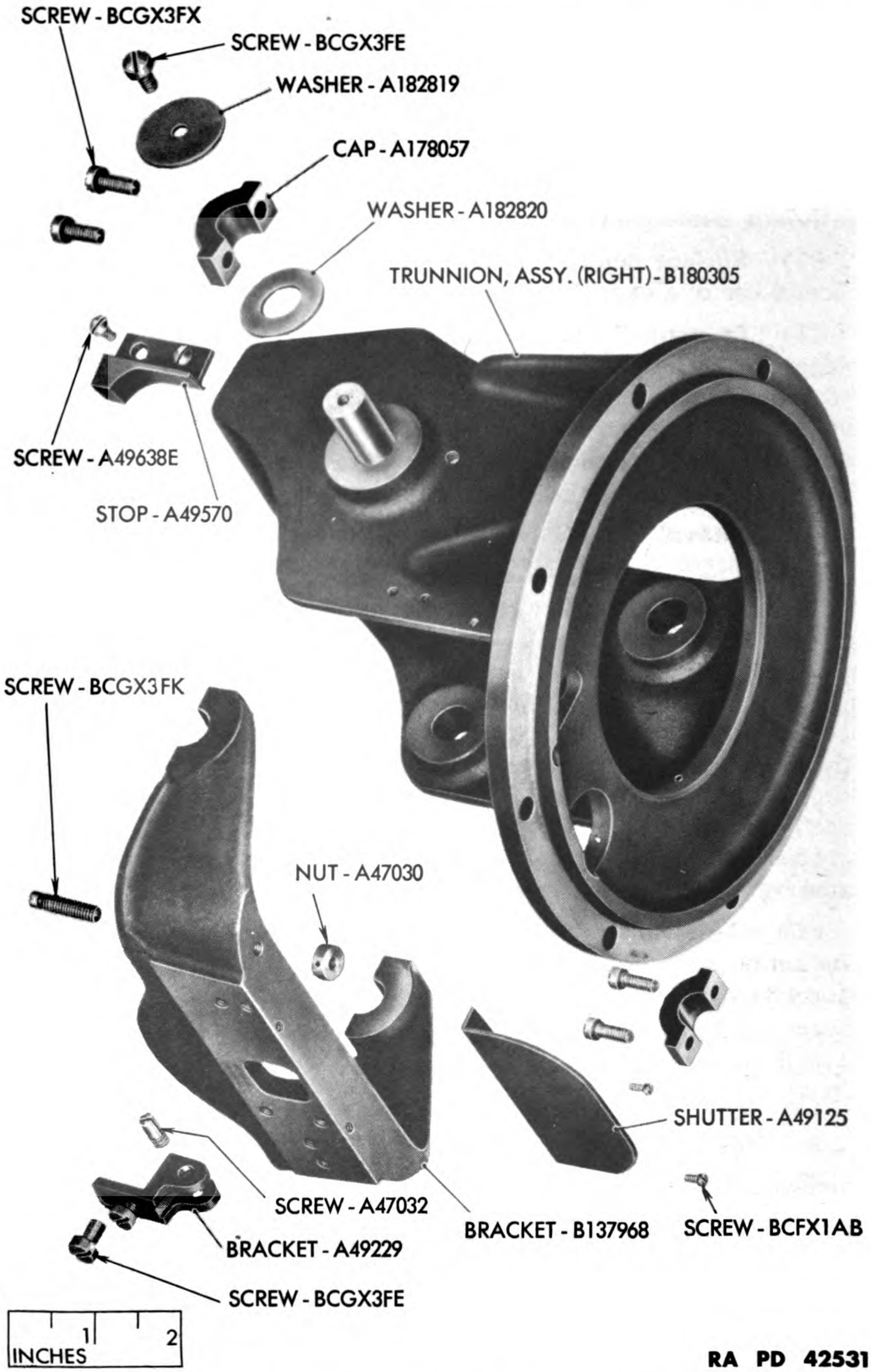

Figure 69 — End Reflector Support Assembly — Exploded View

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 ¼ 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.

(2) The eyepiece lenses and rhomboid prisms are rotatably mounted about the fixed centers of the ocular prisms, permitting the separation of the eyepieces 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.

(3) The eyepiece filters are arranged and mounted so that the turning of a single knob brings a filter of the color indicated by the index into the field of each eyepiece. The knob should rotate 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.

(4) The position of the eyepiece unit in relation to the axis of the 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 the specified tolerances (figs. 48 and 49). Errors greater than these tolerances result in eye strain and impair the observer's accuracy.

(5) 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 the observer to see the greatest amount of light and the largest field. The headrest is adjustable for different heights, and should swing freely into place.

b. Requirements.

(1) Checking and adjustment of the diopter setting, the interpupillary distance, and the dipvergence (up-and-down divergence) can be done without removing the eyepiece assembly from the instrument. Adjustment or replacement of the filters or of the rhomboid prisms requires removal of the assembly. While this does not involve breaking the main hermetic seal of the instrument, the eyepiece unit itself is sealed and its removal should be done in a dust-free room. Removal of the eyepiece housing, for access to the change-of-magnifi-

Figure 70 — Eyepiece Assembly — Face View

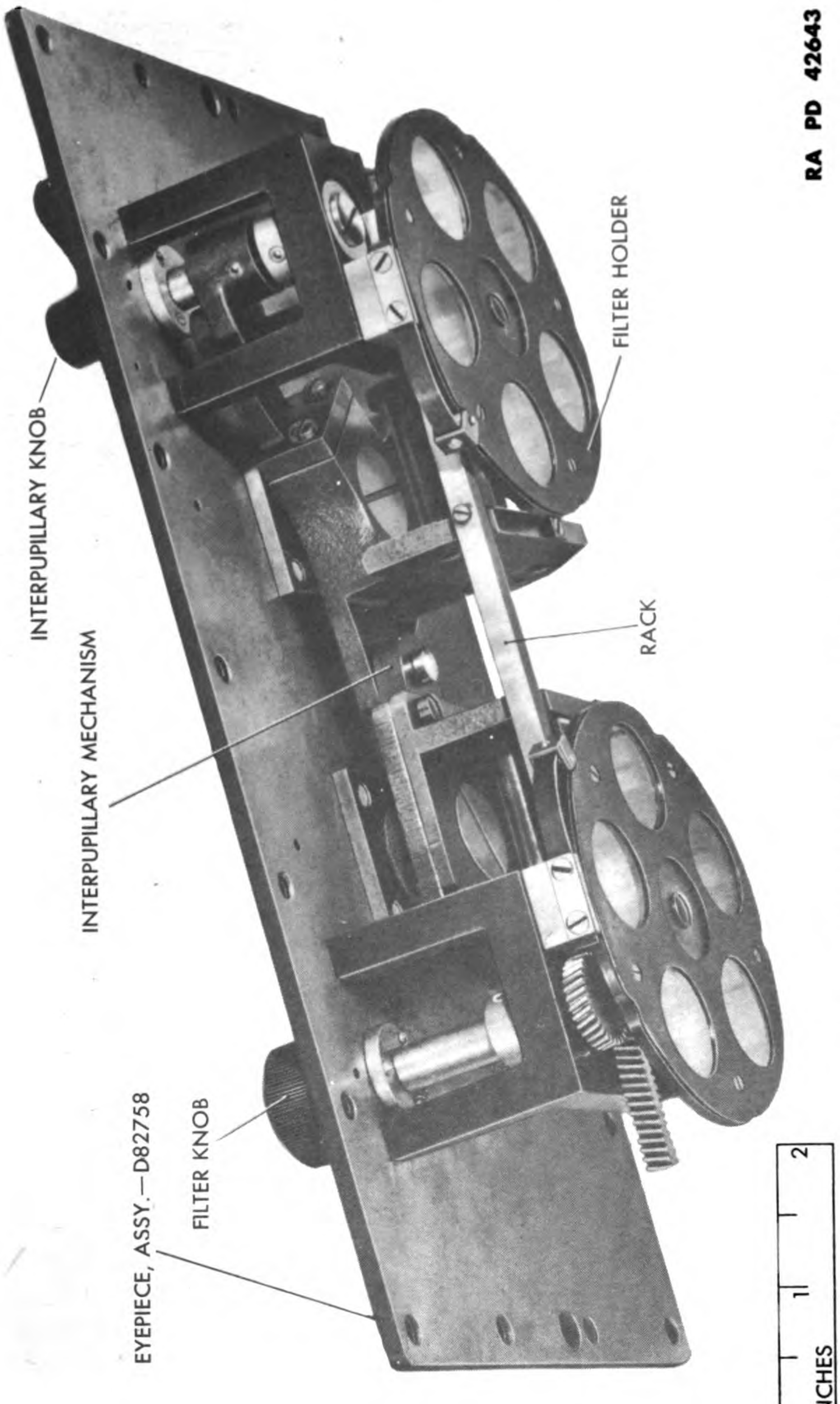

Figure 71 — Eyepiece Assembly — Back View, Top

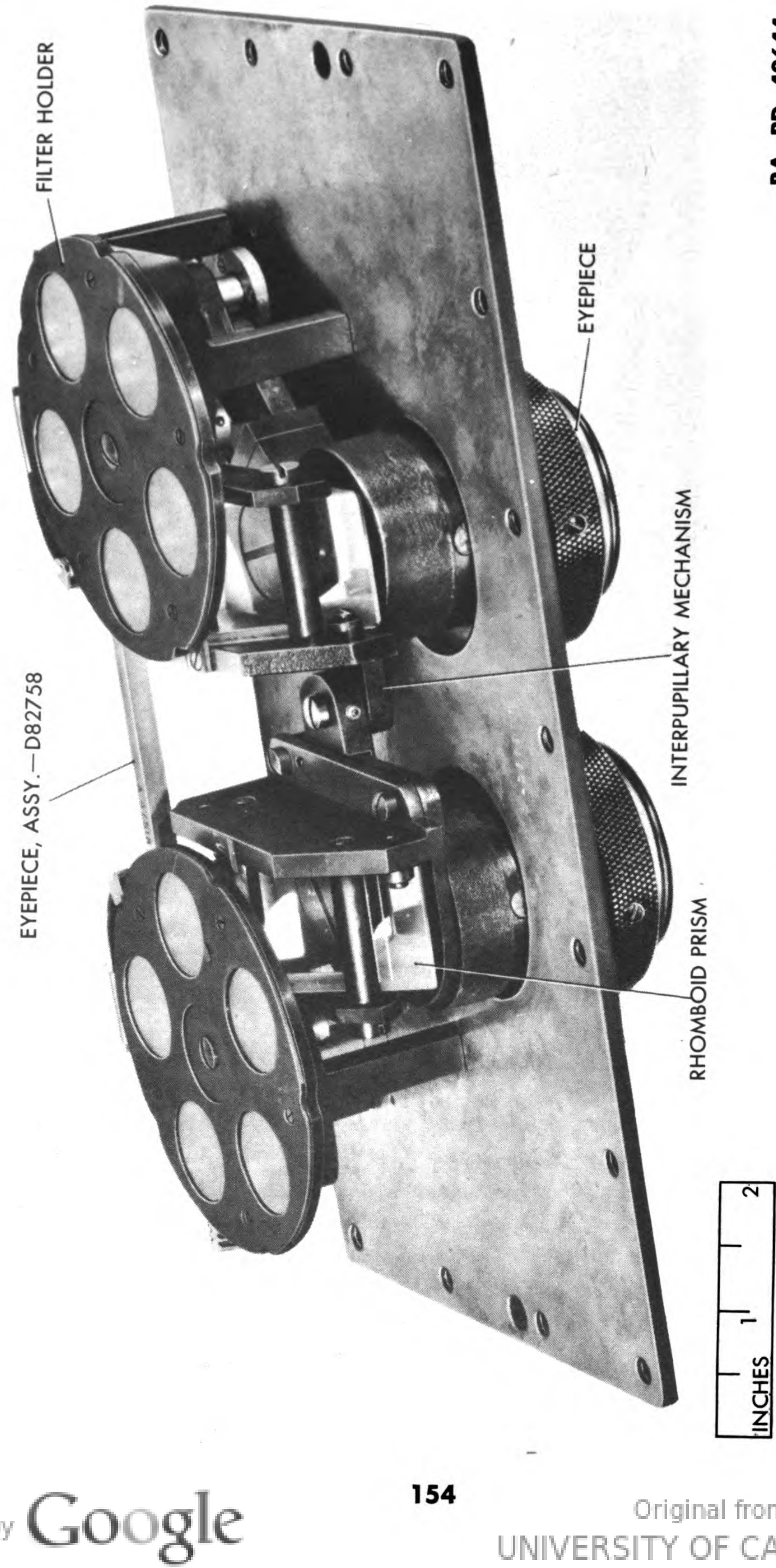

Figure 72 — Eyepiece Assembly — Back View, Bottom

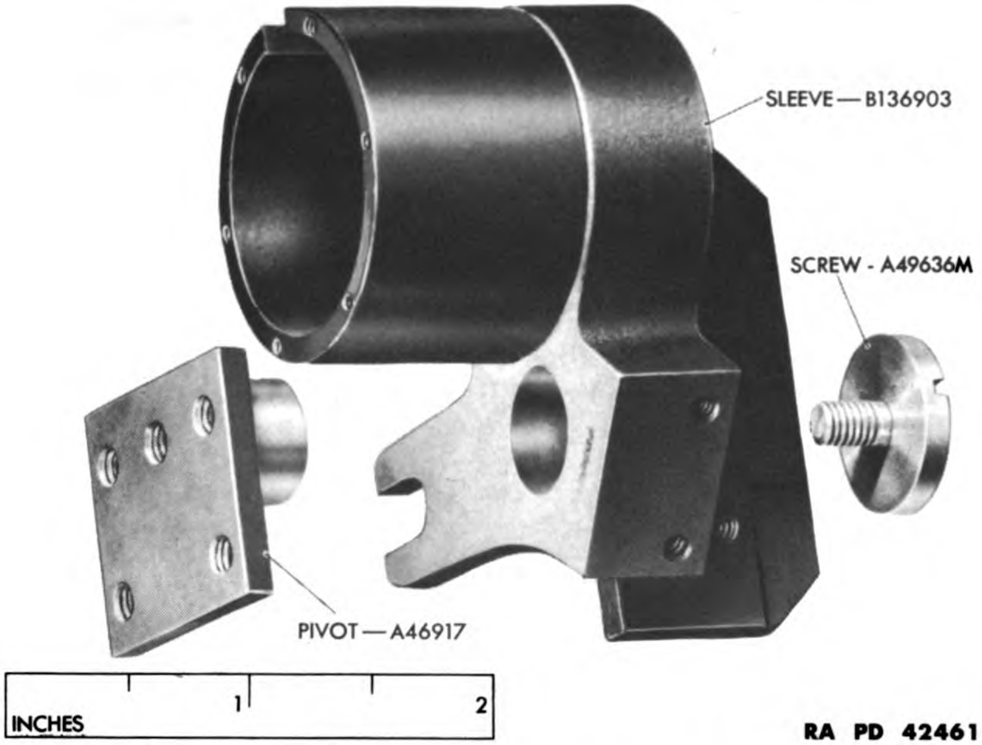

Figure 73 — Removal of Eyepiece Sleeve from Pivot

cation assembly or other purposes, involves breaking the seal of the instrument.

(2) A dioptometer is needed for making a complete check of the diopter setting and adjustment of the diopter scale, though a check for zero diopter setting can be made with a collimating telescope or a divergence tester. 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.

c. Diopter Setting.

(1) The diopter scale should be set to read the correct focus of the eyepiece. If the diopter reading is not within the specified tolerance at all settings of the diopter scale, it will be necessary to make adjustments. Before making such adjustments, check the change in diopter reading in the shift from high to low power as outlined in paragraph 21. If not within tolerance, it is necessary first to adjust the erector lenses as described in paragraph 54 **c** or **d**.

(2) Adjust the diopter setting as follows:

(a) Remove the set screw on the diopter scale. Direct the height finder toward the sky or shine lights in the end windows.

(b) Set the dioptometer for zero diopter reading and the filter knob index at "clear."

(c) Place the dioptometer or the collimating telescope over one of the eyepieces and obtain the sharpest focus of the height finder reticle with the collimator reticle by means of the eyepiece focusing movement.

(d) Move the head back and forth to detect any parallax between collimator and height finder reticles. Make five settings and record the readings.

(e) Set the eyepiece to the mean value of the readings and adjust the diopter scale to zero. Do this by moving the scale on the base of the eyepiece focusing nut with a screwdriver inserted in the elongated hole on the scale, holding the focusing ring to prevent its turning.

(3) Recheck the diopter setting at this point. If a dioptometer is used, check also at the two ends of the eyepiece focus scale (+2 diopters and –4 diopters). If necessary, reset the diopter scale so that the reading will be within ¼ diopter of the true value at all points.

(4) When the proper setting of the diopter scale is obtained, scribe the base of the eyepiece focusing nut through the elongated hole on the diopter scale (fig. 75). Replace the set screw; if necessary, drill and tap a new hole for the #2, 3⁄32-inch round-head screw. Recheck the diopter settings.

(5) Repeat this procedure for the other eyepiece.

d. Interpupillary Distance.

(1) The interpupillary distance adjustment lever, index, and scale are set at the factory for an interpupillary distance movement from 58 mm to 72 mm, and the index should read the actual distance. This distance can be measured with an interpupillary distance template (par. 16), or with a ground glass (par. 21). Adjustments should not be required, but if the measured interpupillary distance does not correspond to the scale setting, proceed as outlined below:

(a) Remove the screw at the top of the interpupillary lever assembly.

(b) Lift the lever from its shaft and remove the pin between the lever and shaft.

(c) Replace the new lever or the old lever to be adjusted over the shaft.

(d) With the hands, move the right and left eyepieces together or apart until the interpupillary distance measures 65 mm (or fits the IPD template).

(e) Hold the eyepieces at this separation and turn the interpupillary lever until the index reads correctly on the scale.

(f) Recheck the actual interpupillary distance and scribe the inside of the interpupillary lever and shaft.

(g) Drill for the straight pin (1/16 by 3/16 in.).

(h) Place the pin in the new hole and replace the screw on the top of the lever.

(2) If for some reason it is not practical to repin the interpupillary shaft and lever, the setting can be adjusted by repositioning the interpupillary scale.

(a) Remove the three screws holding the scale.

(b) With the hands, set the eyepieces as described above.

(c) Hold the eyepieces at this separation and move the scale until the index reads correctly.

(d) Recheck the distance between exit pupils, and scribe the interpupillary scale and the eyepiece plate B136905.

(e) Drill and tap for screws.

(f) Place the screws in the newly drilled and tapped holes.

NOTE: If the interpupillary distance changes when the face is pressed against the eye shields, it indicates looseness or backlash in the eyepiece sleeve pivots (fig. 73) or the interpupillary mechanism. It will be necessary to remove the eyepiece assembly (par. 44) and inspect for the source of the trouble.

e. Up-and-down Divergence ("Dipvergence").

(1) Dipvergence is dependent upon the positioning of the eyepiece unit in relation to the optical tube. A slight shift of the eyepiece plate in relation to the eyepiece housing will change the amount of up-and-down divergence present. Therefore, every time the eyepiece unit has been removed, it will be necessary to recheck the dipvergence and to make the necessary adjustments as outlined below:

(a) Loosen the screws (par. 44 a) holding the eyepiece assembly except for two screws at diagonal corners; loosen these slightly.

(b) Set the change-of-magnification crank for low power (12x) and the interpupillary distance at 65 mm.

(c) By tapping the eyepiece plate lightly at the corners, tilt the eyepiece assembly to bring the low-power moons to the same height in both eyepieces.

(d) Turn the change-of-magnification crank to high power (24x).

(e) Mount the divergence tester above the eyepieces so that the central lines of the left grid coincide with the central reticle mark of the left eyepiece.

(f) Note the relative position of the center height finder reticle lines in the left and right eyepieces (fig. 49).

(g) If necessary, shift the eyepiece plate in the direction shown in figure 49, by lightly tapping the left corner of the eyepiece plate with a drift punch.

(h) Recheck the dipvergence until it is within tolerance.

(i) Tighten all of the eyepiece plate screws and replace the interpupillary scale, filter plate, and name plate.

(j) Recheck the up-and-down divergence.

(2) If it is impossible to bring the dipvergence within tolerance by this method, do one of the following:

(a) Cut down the eyepiece plate screwheads to allow greater movement of the eyepiece unit.

(b) Shift the eyepiece housing assembly slightly by removing the eyepiece assembly (par. 44 **a**) and loosening the 18 housing screws one-half turn and tapping the proper corner. Do not loosen the screws more than one-half turn to avoid losing the pressure in the tube.

(c) If substeps *(a)* and *(b)* above will not correct dipvergence, check for a dipvergence change between high and low power. If a great deal of change is noticed, the reticle is decentered. Correct as outlined in paragraph 53 **f**. If this is not the case, try another eyepiece assembly. If this gives the same result, the *ocular* prisms are probably out of adjustment.

f. Lateral Divergence (Divergence and Convergence).

(1) Adjustments are required if the lateral divergence is outside tolerance. The amount of divergence present is dependent upon the position of the rhomboid prisms in the eyepiece unit as well as upon the reflection angles of the prisms. Adjustments should be required only if a rhomboid prism is being replaced. For divergence outside the allowable tolerance, it is necessary to shift and repin the right rhomboid prism bracket.

(2) Remove the eyepiece unit by removing the 18 screws and breaking the seal between the eyepiece plate and eyepiece housing, as described in paragraph 44 **a**.

(3) Remove the filter assembly over the right eyepiece, as described in paragraph 44 **d**.

(4) Adjust the right prism bracket (S, fig. 76) as follows:

(a) Loosen the three screws at the base of the rhomboid prism bracket A49242 and remove the bracket and pins.

(b) Replace the bracket and start the three screws. Tighten the single screw on the prism side of the bracket and draw up the other two screws snug but not tight.

(c) Replace the eyepiece unit on the height finder and position with six screws.

(d) Check the divergence with the divergence tester with the interpupillary distance set at 65 mm to determine the direction to shift the prism bracket.

(e) Remove the eyepiece unit and shift the prism bracket to rotate the prism in the direction shown in figure 48. (Enlarge the prism bracket screw holes if necessary.)

(f) Recheck the divergence and readjust the prism bracket until the lateral divergence is within tolerance. Preferably try to set at about 14 to 18 minutes divergence. The final check must be made with all of the eyepiece plate screws in place and screwed down tight.

(5) Remove the eyepiece unit, and drill ($1/16$ inch) and pin the prism bracket in place using two straight pins 0.062 inch in diameter. The pins should fit tightly.

(6) Reassemble and mount the eyepiece unit.

(a) Replace the filter holder assembly over the right eyepiece.

(b) Seal and replace the eyepiece unit.

(c) Adjust the instrument for dipvergence as described in subparagraph e, above.

44. EYEPIECE UNIT — REMOVAL AND DISASSEMBLY.

a. Removal and Replacement.

(1) The eyepiece unit must be removed for adjustment or repairs to the filter assemblies or the rhomboid prisms. It must also be removed, together with the eyepiece housing, for operations which require access to the interior of the instrument at the center. The eyepiece plate B136905 and housing B136906, after being perfectly set with a double collimator, should be doweled at diagonal corners to the eyepiece housing adapter C69904 with long heavy straight dowel pins. The dowel holes should not go entirely through the adapter. This improvement will serve as a future aid to maintenance units in the field in replacing the eyepiece assembly.

(2) Remove the eyepiece unit as follows (fig. 74):

(a) Remove the screws holding the interpupillary scale and the filter plate, and turn the plates to expose the eyepiece mounting screws beneath.

(b) Remove the two screws holding the name plate to expose another eyepiece mounting screw.

(c) Remove the 18 screws around the edge of the eyepiece assembly.

(d) Break the seal and lift off the eyepiece assembly.

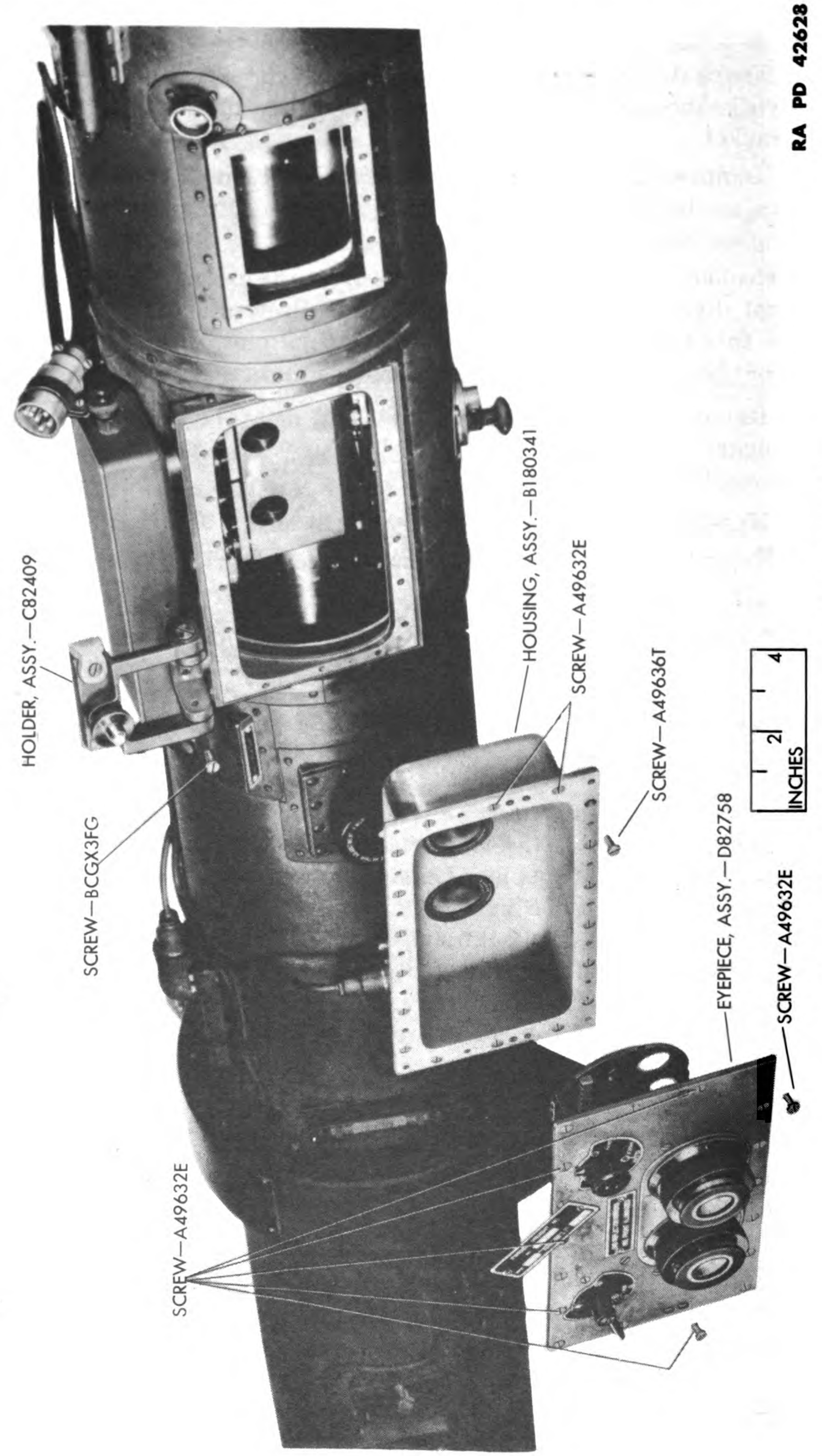

Figure 74 — Removal of Eyepiece Assembly

HEIGHT FINDER TELESCOPE—ADJUSTMENT AND REPAIR

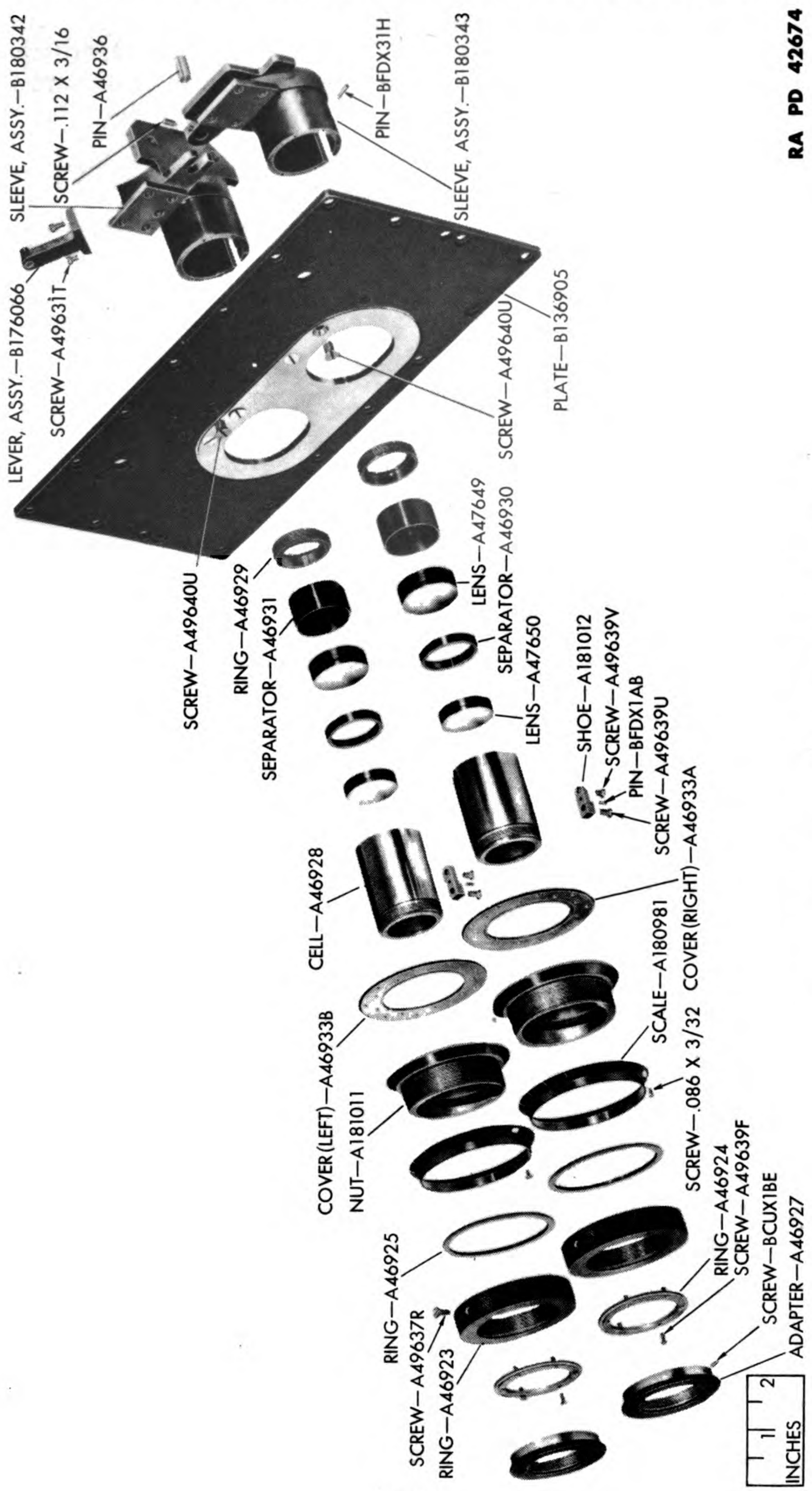

Figure 75 — Disassembly of Eyepiece Cells

(3) The eyepiece housing 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 out the housing.

(4) When replacing the eyepiece housing or eyepiece unit, clean the seating surfaces, apply COMPOUND, sealing, for height finders (par. 32), put the unit in place, and replace the mounting screws. Before finally tightening the screws, center the low-power moons, and check and adjust for dipvergence as described in paragraph 43 **e**. After all the screws are tight, recheck the divergence and dipvergence.

b. Disassembly of Eyepiece Lenses.

(1) If an eyelens or a field lens is damaged or in need of cleaning, remove and disassemble the eyepiece cell as follows (fig. 75):

(a) Remove set screw and eyeshield adapter A46927.

(b) Remove the five screws and retaining ring A46924.

(c) Turn the focusing ring clockwise to lift the eyepiece cell until the shoe clears the focusing nut, and lift out the cell.

(d) Remove retaining ring A46929, then remove separator A46931, field lens A47649, separator A46930, and eyelens A47650. Mark the edges of the lenses, separators, and cell so that they can be reassembled in the same positions.

(2) On reassembly, observe the following precautions:

(a) Seal the eyelens with COMPOUND, sealing, Navy black.

(b) Make sure that the lenses and separators are properly oriented.

(c) The retaining ring should be screwed in tight enough to hold the lenses snugly, but not enough to cause strain. If possible, check the lens assembly with polarized light, which should show minimum strain.

(d) After the cell has been replaced, check lateral divergence (par. 43 **f**). If outside of tolerance, loosen the retaining ring and turn the field lens. Recheck divergence. If divergence cannot be brought within tolerance by turning the eyepiece lenses, the eyepiece unit will have to be removed and the right rhomboid prism bracket rotated and repinned, as described in paragraph 43 **f**.

(e) Check the diopter setting and, if necessary, adjust the scale, as in paragraph 43 **c**.

c. Disassembly of Focusing Mechanism.

(1) Remove the eyepiece cell as in subparagraph **b**, above.

(2) Disassemble the focusing nut as follows:

(a) Remove set screw and focusing ring A46923.

(b) Remove retaining ring A46925.

(c) Remove set screw and diopter scale.

(3) On assembly, reverse the order of disassembly. Lubricate the focusing movement with grease, using only as much as necessary, since an excess might run and smear the optical surfaces. After all the screws are tight, recheck the divergence and dipvergence.

d. Replacement of Filters.

(1) 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 name on the filter plate. Replacement of the filters requires removal of the eyepiece unit from the height finder and should be done only in a room free from dirt and dust and where a divergence tester is available for adjusting the eyepiece unit after it is replaced. The procedure is as follows:

(2) Remove the eyepiece unit as in subparagraph **a**, above.

(3) Disassemble the filter assembly as follows:

(a) Remove the filter assembly by removing the holding screw (A, fig. 76) and pin.

(b) Remove the five screws holding the clamping plate to the filter holder.

(c) Remove the plate and replace or rearrange the filter glasses to obtain the proper arrangement. Filters should be positioned so that any wedge effect will be base up when rotated into position in the eyepiece assembly.

NOTE: Left and right filter mounts rotate in opposite directions.

(4) After reassembly, if the filter assembly does not remain in position, tighten or replace the detent assembly (G, fig. 76).

(5) Reassemble and reseal the eyepiece plate to the eyepiece housing, and adjust the dipvergence as instructed in paragraph 43 **e**. After all the screws are tight, recheck the divergence and dipvergence.

e. Rhomboid Prism Replacement.

(1) A rhomboid prism which has been damaged or does not adjust satisfactorily for lateral or up-and-down divergence can be replaced.

(2) Remove old prism as follows:

(a) Remove the eyepiece unit as described in subparagraph **a**, above.

(b) Remove the filter assembly over the rhomboid prism to be replaced, as described in subparagraph **d**, above.

(c) Remove the rhomboid prism clamp assembly (M or QQ, fig. 76) and lift out the prism.

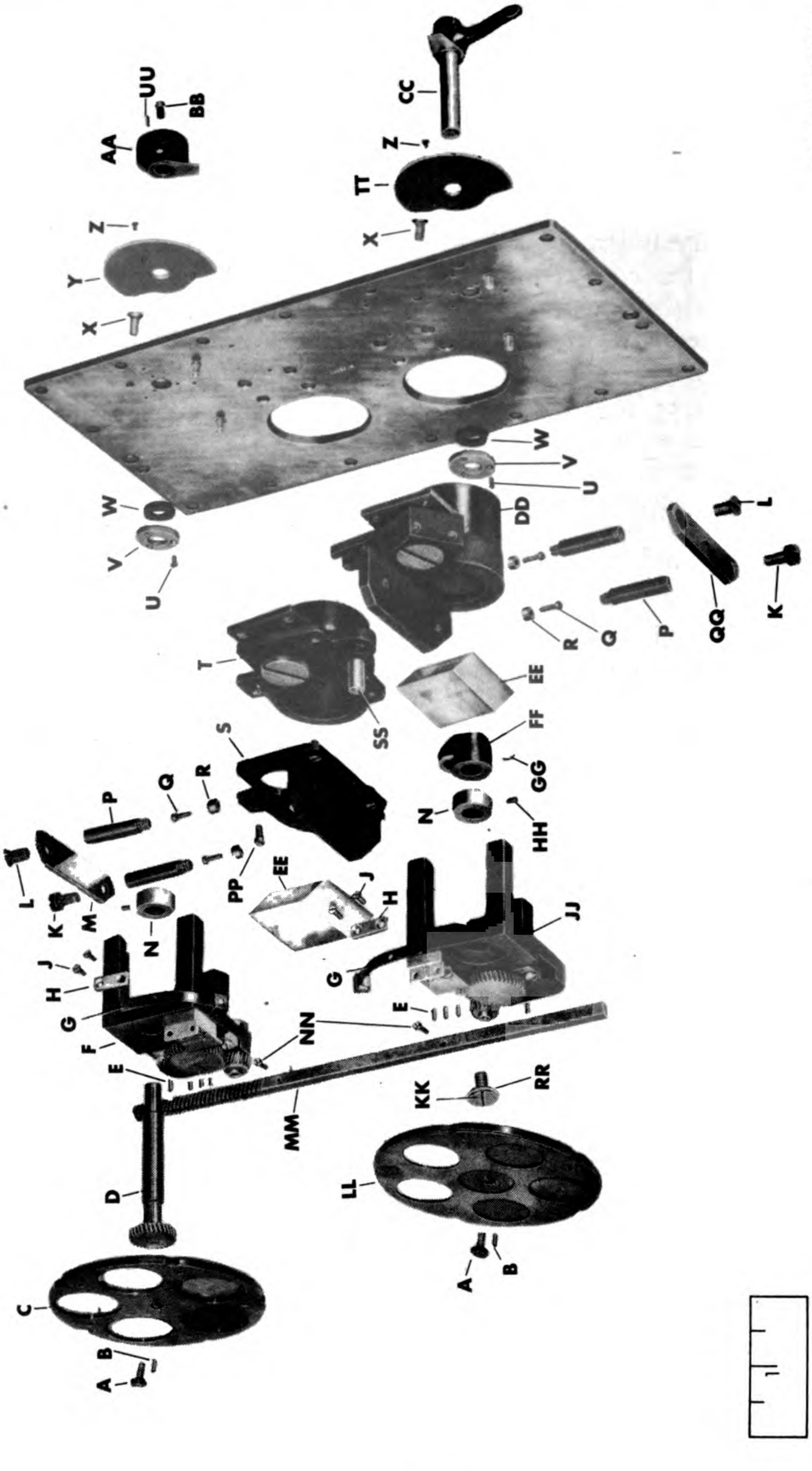

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Figure 76 — Disassembly of Filter Mechanism and Interpupillary Mechanism

A— SCREW—A49630AD
B— PIN—040 X 3/16
C— FILTER, ASSY. (RIGHT)—C82411
D—SHAFT, ASSY.—B180293
E— PIN—STGHT .040 X 11/32
F— BRACKET, ASSY. (RIGHT)—C82388
G— DETENT., ASSY.—B176062
H— PLATE—A47538
J— SCREW—A49639AN
K—SCREW—BCGX4FF
L— SCREW—A49640X
M—CLAMP, ASSY. (RIGHT)—B180294
N— COLLAR—A47536
P— POST—A46937
Q—SCREW—BCFX3AD
R— WASHER—A46935
S— BRACKET—A49242
T— SLEEVE, ASSY. (RIGHT)— B180343
U— SCREW—BCGX4BC
V— RETAINER—A47532
W—PACKING—1/16 SQ. X 1 1/4"
X— SCREW—BCLX4BC
Y— PLATE—A47528
Z—SCREW—A49639H
AA— KNOB, ASSY.—B176052
BB— SCREW—A49630AG
CC—SHAFT, ASSY.—B180344
DD—SLEEVE, ASSY. (LEFT)—B180342
UU—PIN—BFDX1AB
EE— PRISM (RHOMBOID)—A47648
FF— FORK—A47529
GG—SCREW—.112 X 3/16
HH—SCREW—BRISTO #4—.112 X 1/8
JJ— BRACKET, ASSY. (LEFT)—C82408
KK—SCREW—A46954
LL— FILTER, ASSY. (LEFT)—C82410
MM—RACK—A47518
NN—SCREW—A49630G
PP— SCREW—.138 X 3/8
QQ—CLAMP, ASSY. (LEFT)—B180295
RR— WASHER—A46943
SS — PIN—A46936
TT — SCALE—A47525

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Figure 76a — Disassembly of Filter Mechanism and Interpupillary Mechanism

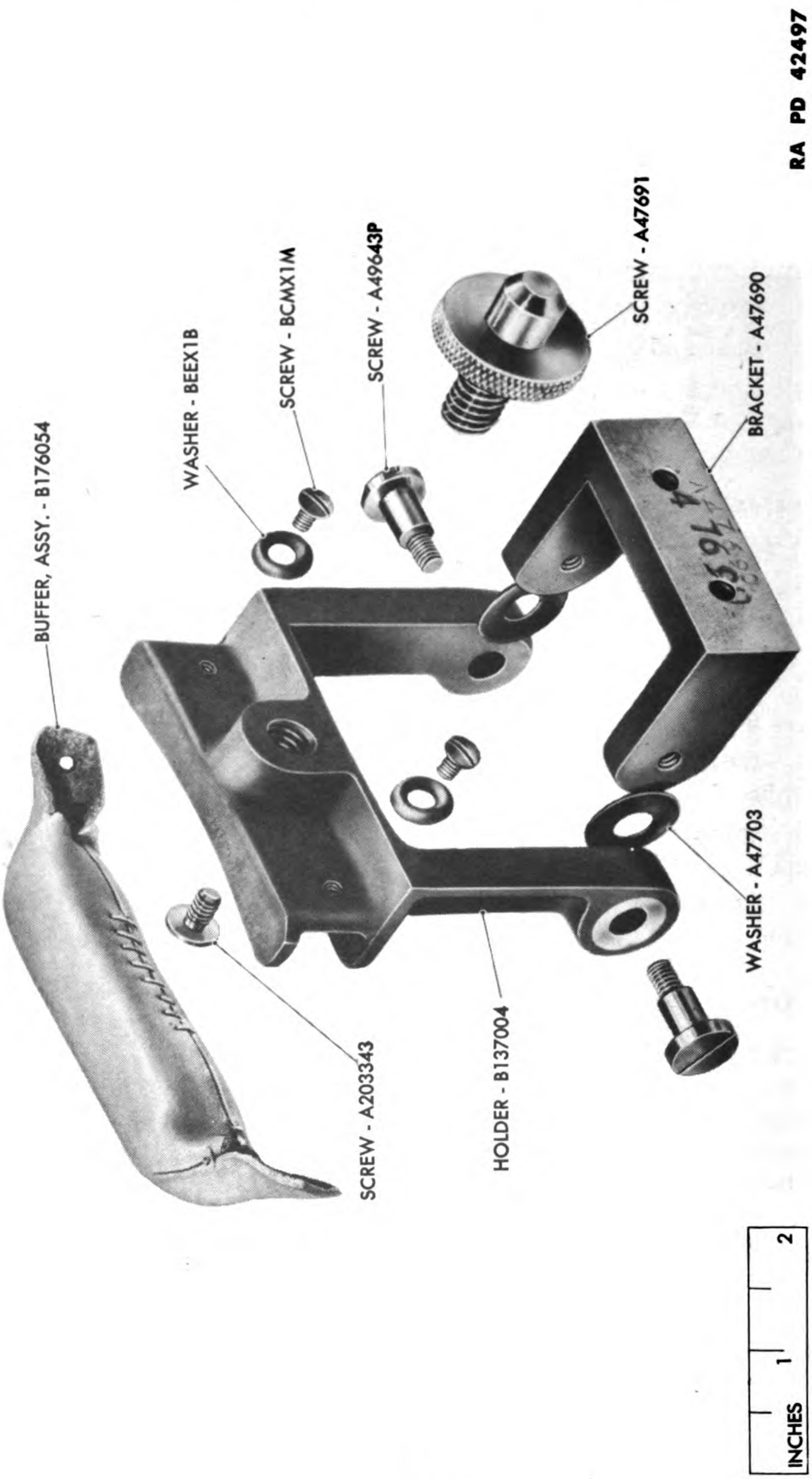

Figure 77 — Disassembly of Headrest Assembly

(3) Insert the new rhomboid prism and replace the clamp assembly.

(a) The mounting surfaces of the bracket and prism must be clean and free from burs or foreign particles which would alter the optical axis of the prism. Check for prism strains with polarized light. If strains are indicated, file down the cork pad or the prism stop to relieve.

(b) Check for lateral divergence, as in paragraph 43 **f**.

(c) Replace the filter assembly.

(d) Seal and replace the eyepiece unit.

(e) Check and adjust for up-and-down divergence, as described in paragraph 43 **e**. After all the screws are tight, recheck the divergence and dipvergence.

f. Headrest Assembly.

(1) If the headrest assembly gives mechanical trouble, adjustments can be made as follows:

(a) Remove the two holding screws (fig. 74) and remove the headrest assembly.

(b) Remove the two pivot screws, the washers, and separate the bracket from the holder (fig. 77).

(c) Remove the two screws and washers to release the buffer assembly.

(d) Remove the stop screw A203343 and the adjusting screw A47691.

(e) Make the necessary adjustment or replacements, and reassemble.

45. OBJECTIVES.

a. General. The objectives are mounted in cells which are clamped in the ends of the optical tube, in order to minimize any possible movement with respect to the reticles. The objectives should be mounted so that their optical centers are alined as closely as possible with the mechanical axis of the optical tube, and so that the individual components are held securely without tilt or strain. 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 sharp focus with the collimator reticle. Another critical check on focus is obtained by noting whether there is any relative movement, due to parallax, between the target image and reticle marks when the eye is moved from side to side above the eyepiece. Presence of a slight amount of parallax is not serious provided it is equal, or matched, for both objectives. Since the refractive index of helium differs slightly from that of air, a correction must be made when the instrument is to be charged with helium. 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 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 and parallax match are used to obtain the best focus of the objectives, and cross field tests are used to determine the match of the optics on the two sides of the instrument.

b. **Requirements.** Any operations on the objectives will require breaking the hermetic seal of the instrument. The compensator unit must be removed to obtain access to the right objective, and the internal adjuster correction wedge must be removed to obtain access to the left objective. These units must be replaced, but do not need to be in adjustment, before making any observations for focus or parallax. An external target at a distance greater than 5,000 yards, is needed for checking the adjustments.

c. **Focusing Objectives to Eliminate Parallax.**

(1) 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.

(2) Sight on an external target at a distance greater than 5,000 yards.

(a) Set the height-range lever in range position and the measuring drum for stereo contact.

(b) Set the interpupillary distance to suit the eyes and check the eyepiece diopter setting for best focus on the reticles.

(3) Focus the right objective as follows:

(a) Remove the compensator assembly as instructed in paragraph 49 c.

(b) Using a spanner wrench, loosen the cell clamping ring A49177 (fig. 78). If necessary, place the end of a brass bar against the edge of one of the openings in the clamping ring and tap the bar with a

wooden mallet to loosen the ring. Take care not to strike and damage the objective assembly or the adjusting nuts. Unscrew the ring by hand.

(c) Using a spanner wrench, loosen the adjusting nuts A49178 on the objective assembly.

(d) If the parallax movement was "with" the eye (the target image moved to the right relative to the reticle as the eye moved to the right or the diopter setting for the target is negative with respect to the setting for the reticle), turn the adjusting nuts out and push the mount assembly into the optical tube to bring the objective closer to the reticle (fig. 50). If the parallax movement was "against" the eye, turn the nuts in to bring the objective out.

(e) Replace the clamping ring and tighten by hand just enough to hold the objective assembly firmly.

(f) Replace the compensator assembly in the instrument and look through the eyepiece to check for parallax.

(g) Repeat adjustment of the adjusting nuts until the parallactic movement of the target image for the fullest possible movement of the eye is less than one-half the width of the center reticle line.

(h) Tighten the adjusting nuts and recheck for parallax.

(4) Rough-focus the left objective. Remove the internal adjuster correction wedge assembly, as instructed in paragraph 46, and focus the left objective as described above. Replace the correction wedge whenever checking the focus and parallax.

(5) Focus left objective for parallax match.

(a) By use of either the measuring knob or the adjuster scale, bring the target image into stereo contact with the reticle marks.

(b) Move the head back and forth above the eyepieces and note whether there is any apparent fore and aft motion of the target image from the plane of the center reticle marks.

(c) If, when the head is moved from left to right above the eyepieces, the image appears to move forward in the field, refocus the left objective, moving it in toward the reticle. If the image moves backward in the field, move the left objective out, away from the reticle (fig. 51).

(d) Refocus the left objective until the parallax effect does not produce any noticeable movement of the target image out of the plane of the center reticle lines.

(6) Recheck the parallax for each objective individually. A slight amount of parallax is permitted in an individual objective as long as parallax match is within tolerance.

(7) Make cross field readings as described in paragraph 20

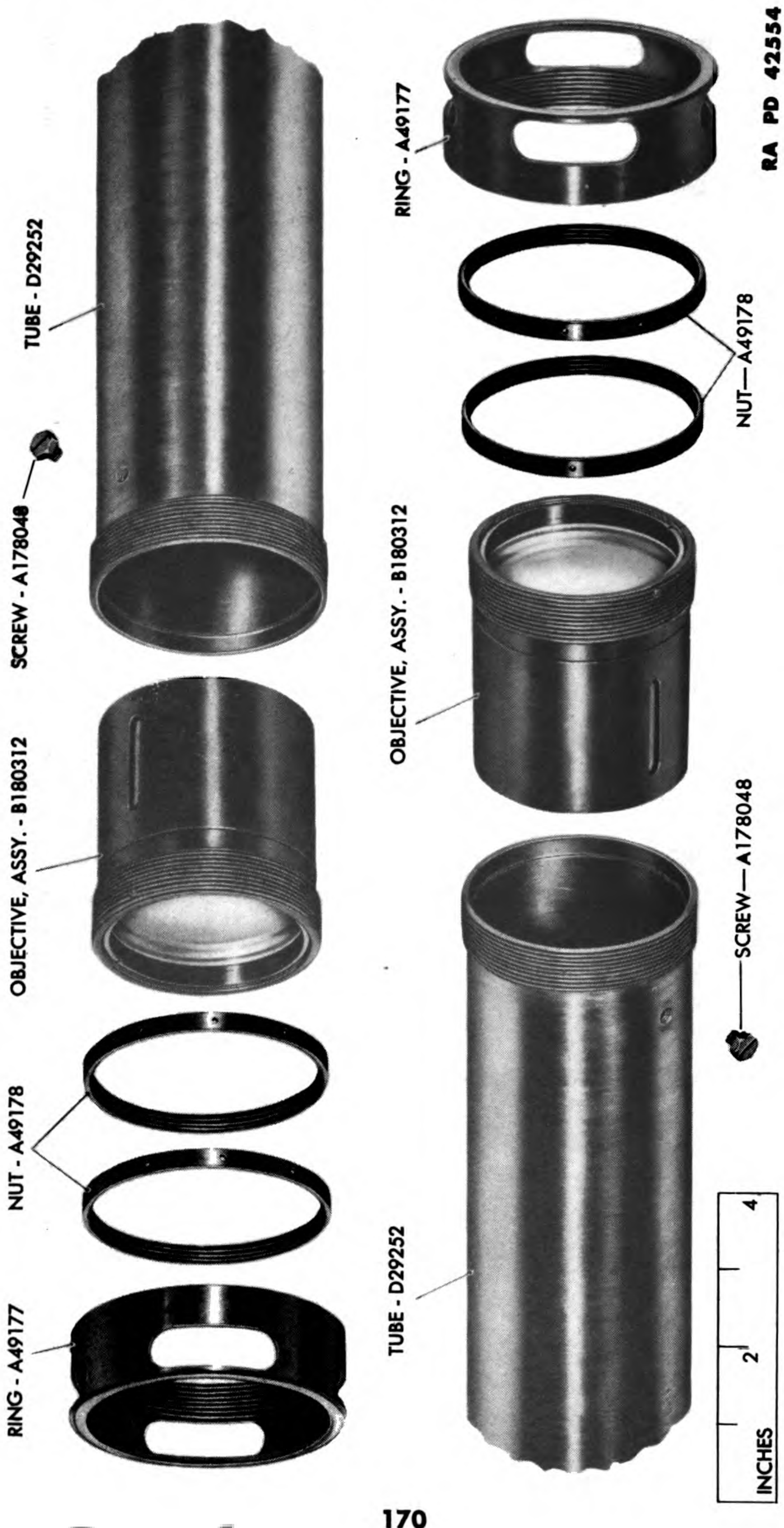

Figure 78 — Removal of Objective Assemblies

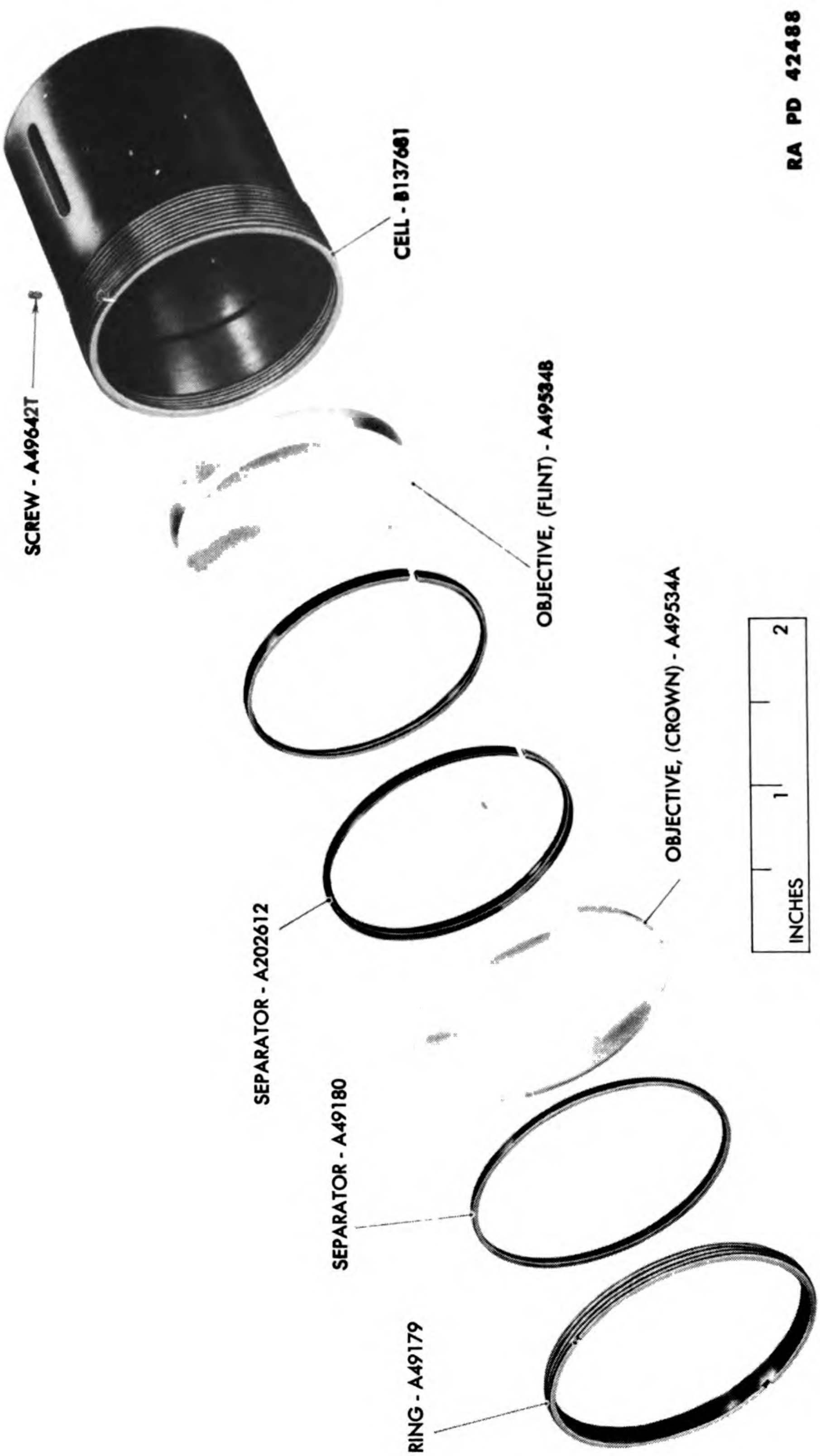

Figure 79 — Disassembly of Objective Assemblies

(fig. 52). The cross field readings should be within tolerance if the objectives have been properly focused and no new optics have been installed, and the end reflectors and the reticles have not been disturbed.

(8) If the cross field readings are within tolerance, tighten the outer adjusting nut against the inner one and tighten the clamping ring on each objective. Recheck the cross field readings after each objective has been clamped in place.

NOTE: If the instrument is to be charged with helium, adjust the objectives for this condition by moving them in toward the reticles after they have been focused as above for air. This adjustment is made by unscrewing the adjusting nuts A49178 an amount equal as nearly as possible to 2.4 holes, or slightly more than one-fifth turn, before tightening them and the clamping rings. Parallax will then be quite noticeable in each side but will disappear when the height finder is charged with helium. Mark the instrument, on the eyepiece, "Helium Parallax Corrected."

d. Changing Focal Length.

(1) If the effective focal length of one objective, plus the effect of any power in the other optics on its side, is greater than the focal length of the other objective plus the effect of the optics on its side, the cross field readings will be high at one side of the field and low on the other side, with a regular change across the field, such as 46-50-53 or 54-50-45, etc. Cross field readings should always be checked by a second observer. The high reading will be on the side of the field toward the objective of longer focal length. The cross field readings can be brought into tolerance most readily by replacing the end windows by others of different power or by replacing one or both objectives. If replacement parts are not available, it may be possible to effect some improvement by interchanging the end windows on the two sides or by interchanging the objectives. If none of these measures brings the readings within tolerance, this can be done by decreasing the focal length of one objective. *This should be attempted only in an optical shop fully equipped with testing instruments such as lens bench and polariscope, and with personnel skilled in their use.* To increase the focal length of an objective, proceed as follows:

(a) Remove the objective assembly.

1. Remove the compensator assembly or internal adjuster correction wedge, and loosen and remove the clamping ring as described in subparagraph c (3), above.

2. Remove screw A178048 (fig. 78) to allow the assembly to be slipped out of the optical tube.

3. Remove the objective assembly from the instrument. (In instruments serial numbers 1 to 128, the left objective cannot be removed through the opening for the correction wedge unit. The smaller components can be removed from the cell, but removal of the cell will require a major disassembly.)

(b) Disassemble the objective assembly.

1. Loosen the set screw and remove ring A49179 (fig. 79).

2. Remove the separators and objectives by inserting a paper cylinder in the cell back of the flint lens and pushing the units out of the cell. Mark the cell with a pencil, and the edges of separators and lenses, so that they can be replaced with exactly the same orientation on reassembly.

(c) Turn the desired amount of stock from the face of the separator A202612, being careful to remove exactly the same thickness of stock from all points around the face of the ring. (Removal of 0.001 inch of stock from the ring will increase the focal length of the objective approximately 0.1 mm and change the difference between adjuster scale readings at center and side of field by one scale division.) Carefully remove all burs from the face of the separator.

(d) Reassemble the objective mount assembly.

1. Replace the lenses and separators in the cell, being careful to keep them in the proper order, right side to, and in the proper relative positions as shown by the pencil marks on the edges.

2. Replace the retaining ring, drawing it tight enough to hold the lenses snugly and prevent shifting, but not enough to cause strains visible by polarized light. (It may be necessary to rechase the threads on this ring at the point where the set screw engaged them.)

3. Replace the set screw.

(e) Replace the objective assembly in the optical tube, replace the set screw A178048, and refocus the objective as described above.

(f) Check the cross field readings and, if necessary, repeat the above procedure to bring the readings within tolerance.

e. Adjusting Decentered Lenses.

(1) If the cross field readings become irregular after the focal length of an objective has been adjusted or the objective mount has been disassembled for any reason, it indicates that the lens has become decentered. The image definition will probably suffer also. If this should occur, attempt to find the best position for the lens as follows:

(a) Remove the set screw A178048 from the optical tube (fig. 78) and the clamping ring A49177 (subpar. **d**, above).

(b) Turn the objective assembly in the optical tube until the best definition of the image is obtained; then mark the top of the cell in line with the set screw hole in the optical tube.

(c) Remove the objective assembly from the instrument, remove the retaining ring and the separators and lenses, marking the separators and lenses in line with the mark on the cell as they are removed.

(d) Turn and replace the units in the cell so that the marks come in line with the set screw hole and slot.

(e) Replace the mount assembly in the proper position in the optical tube and replace the set screw A178048.

(f) Check the focus and, if necessary, refocus the objective and make cross field readings.

46. CORRECTION WEDGE — ADJUSTMENT AND REPLACEMENT.

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 up" position when the adjuster scale is set at 50. Its deviating power should be such that the scale graduations are within 12 percent of the arbitrary unit of error for the instrument at high magnification. Both the orientation of the wedge and its deviating power are checked by determining the value of the adjuster scale graduations as described in paragraph 21.

NOTE: The illustrations show the correction wedge assemblies used in height finders with serial numbers 129 and up.

b. Requirements. Adjustment or replacement of the correction wedge will require breaking the hermetic seal of the height finder.

c. Adjustment of Correction Wedge.

(1) Remove the access plug A181004 from the correction wedge bracket (fig. 38), unscrew the 14 holding screws, slip the wedge assembly to the left to disengage the coupling; then remove the wedge assembly, turning it as necessary to pass through the tube openings.

(2) By means of the measuring knob, bring the internal target line, or the image of a distant fixed target, into stereo contact with the height finder reticle.

(3) Loosen the three screws A49608 (fig. 80) which hold the wedge cell, and replace the wedge assembly in the instrument.

(a) Set the adjuster scale to read "50."

(b) Set the large gear B171933 at the midpoint of its travel.

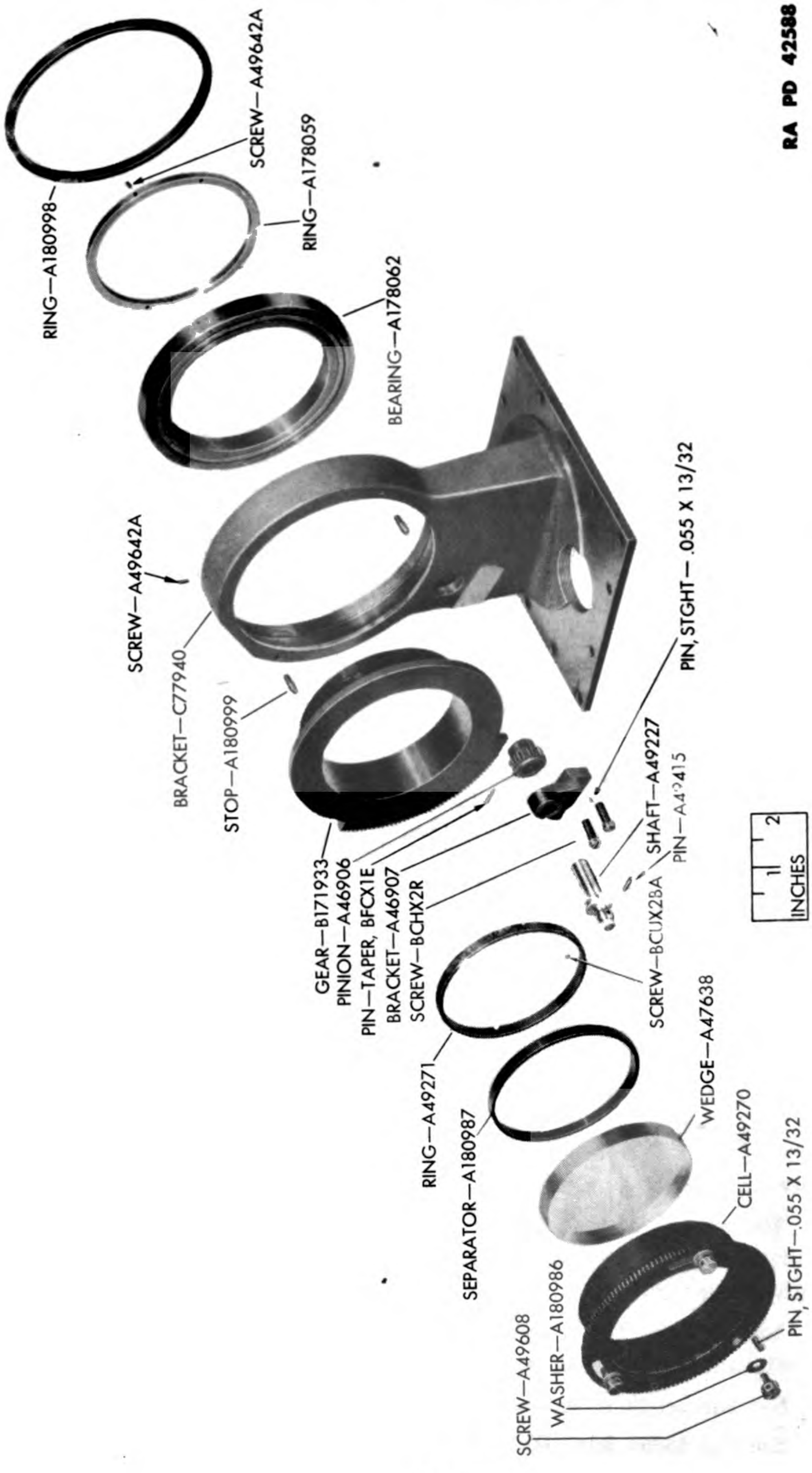

Figure 80 — Disassembly of Correction Wedge Assembly

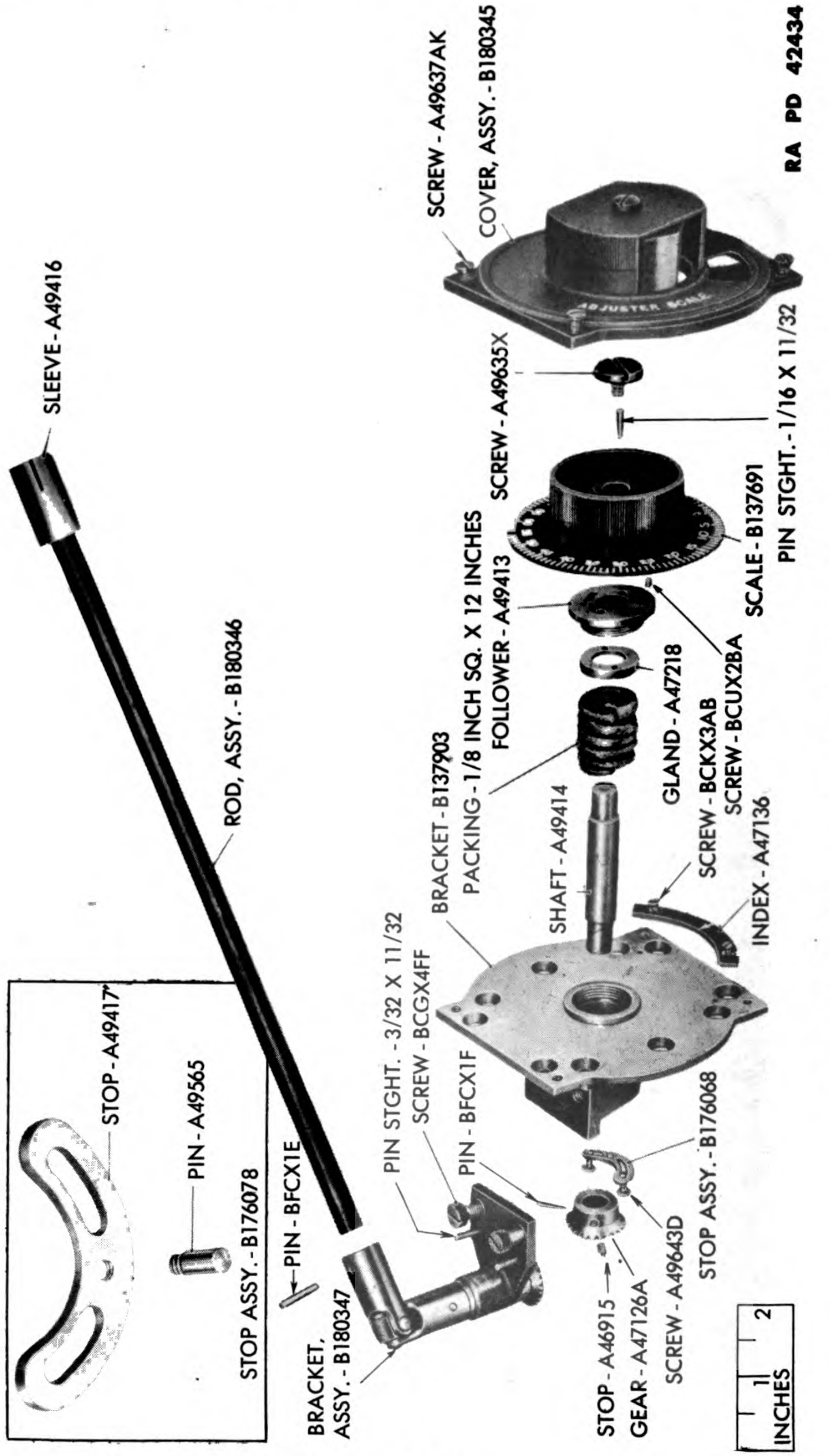

Figure 81 — Adjuster Scale Drive Assembly — Exploded View

(c) Catch the connecting rod with a hooked wire just back of the coupling sleeve.

(d) Insert the wedge assembly, passing the end of the hooked wire out through the access hole in the bracket and turning the assembly as necessary to pass through the tube openings.

(e) Hold the sleeve in position with the wire, observe through the access hole to see that the pin in shaft A49227 is properly alined with the slots of the sleeve, and slide the wedge assembly to the right to engage the shaft in the sleeve.

(f) Replace two diagonally opposite screws to hold the wedge assembly in position.

(g) Turn the adjuster scale to make sure that it has free travel from 0 to 100; then reset at 50.

(4) Insert a forefinger through the plug opening and place it on the toothed surface of the wedge cell (not the gear B171933). While observing through the eyepieces, turn the wedge cell to bring the target image back into stereo contact with the height finder reticle. Check to see that the adjuster scale has not moved off the "50" setting.

(5) Remove the wedge assembly, tighten the screws holding the wedge cell, and replace the assembly in the height finder.

(6) Check the position of the wedge. The adjuster scale should read 50 ± 1 when the target image occupies the same position as it does with the correction wedge removed.

d. Cleaning the Correction Wedge. To clean the correction wedge, remove the wedge assembly as in subparagraph **c** (1), above. Since the glass surfaces may have been coated to reduce reflections, special care is required in cleaning, as described in paragraph 36.

e. Mounting New Correction Wedge.

(1) If the correction wedge has been damaged so as to require replacement, the new wedge must be properly oriented in the assembly.

(2) Remove the wedge assembly as described in subparagraph **c** (1), above.

(3) Replace the wedge.

(a) Remove the three screws A49608, and slip the wedge cell out of gear B171933 (fig. 80).

(b) If the new wedge is not mounted in a cell, loosen the set screw, remove the retaining ring A49271 and separator, and remove the old wedge from the cell. Insert the new wedge, replace the separator, and screw in the retaining ring snugly but not tight enough to strain the glass. Tighten the set screw into the retaining ring.

(c) Insert the cell containing the new wedge into gear B171933.

(4) Aline the wedge as in subparagraph c, above.

(5) Remove the assembly from the height finder and replace the three clamping screws A49608 and washers A180986,

(6) Replace the assembly and check the position of the wedge.

(7) Check parallax and parallax match (par. 45).

f. **Backlash** (par. 22 d (2)). If out of tolerance, locate and repair loose joint, or replace necessary parts.

47. ADJUSTER SCALE.

a. **General.** The adjuster scale operates the correction wedge through bevel gears and a coupling rod. The adjuster scale assembly should not need attention except in case of actual physical damage. In case of a major disassembly, however, it must be removed to permit removal of the inner tube. The cover assembly can be removed and replaced without breaking the seal of the instrument. Removal of the scale and coupling assembly breaks the seal, and the correction wedge assembly should first be removed from the instrument.

b. **Removal and Replacement.**

(1) Remove the two screws and lift the lamp socket and bracket assembly out of the way.

(2) Remove the four screws from its corners and lift off the cover assembly. Take out the two screws from its ends and remove the index. Remove screw A49635X (fig. 81) and work the adjuster scale loose from its shaft.

(3) Remove the 10 screws and lift out the bracket and drive assembly.

(4) Disassembly is illustrated in figure 81.

(5) In reassembling the drive assembly, make sure that the scale and the gear A47126A are so mounted on shaft A49414 and the stop assembly B176068 is so adjusted that the zero mark stops at equal distances from the index mark at the limits of travel of the scale. The two bevel gears should be so meshed that the sleeve A49416 will couple with the correction wedge assembly when the adjuster scale is set at 50 and the gear B171933 (fig. 80) is set at the center of its travel.

(6) Illumination of the scale is covered in paragraph 83.

48. COMPENSATOR ASSEMBLY — ADJUSTMENT IN THE HEIGHT FINDER.

a. **General.** When the height-range lever is set for "range" and the measuring drum reads infinity, the compensator assembly should be in a position for minimum deviation, with the bases of wedges 1 and 3 opposed to the bases of wedges 2 and 4. When the height-range lever is set for "height" and the instrument is level, each pair should be set for minimum deviation, with wedge 1 opposed to 3, and 2 opposed to 4, for any position of the measuring drum. 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 different settings do not agree within the specified tolerance (par. 20), the compensator is out of adjustment and must be corrected. The range adjustment is made by setting the compensator for minimum deviation when the measuring drum is set to read infinity. The height adjustment is made by turning the height conversion bevel gear with respect to its shaft to bring the wedge pairs to minimum deviation at zero elevation. If the compensator is completely out of adjustment (readings cannot be made on the adjuster scale), the compensator should be removed from the instrument, the backlash springs removed, and the gears turned so that the scribed marks on the wedge cell mounting gears line up with the marks on the housing. This places the wedge pins of wedges number 1 and 3 down, and 2 and 4 up with respect to zero mils angular height, or range-infinity position. The backlash springs should then be replaced and the unit installed in the instrument. (See paragraph 49 for these operations. Whenever the compensator is removed, the pinion should be locked as shown in figure 83.) It should then be possible to make readings and adjust the wedges.

b. Requirements. The compensator assembly must have passed the backlash test (pars. 20 and 25). 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 (one whose spread is 2 UOE or less for 10 readings). Range adjustment (range-infinity, height-infinity) will require breaking the hermetic seal. After any adjustment of wedges for range, the setting of the height conversion mechanism (range-infinity, height-900) must be checked (par. 20). All wedge check and adjustment readings must be recorded within $\frac{1}{10}$ UOE.

c. Range Adjustment (Range-infinity, Height-infinity).

(1) If the internal target readings made at height-infinity and at range-infinity differ by more than the tolerance (par. 25), adjust the range shaft coupling as follows:

(2) Remove the cover B137916 (fig. 84) over the bevel pinion. Unscrew the lower large access plug and the small access plug just above the bevel gear, using a spanner wrench. If the plugs are very tight, they can usually be started by placing a punch in each hole

and tapping to loosen. Two men should do this, tapping in unison. Damaged plugs should be replaced.

(3) Set the instrument for readings at zero elevations as described in paragraph 21 i (3):

(a) Carefully level the cradle and height finder telescope.

(b) Set height-range lever at "height" (par. 49 **a** (2)).

(c) Set measuring drum at infinity (*) (par. 49 **a** (2)).

(d) Set interpupillary distance and eyepiece diopter settings to suit observer's eyes.

(4) Adjust the measuring wedge shaft coupling as follows:

(a) Take five internal target readings and set the adjuster scale to the median value obtained.

(b) Shift the height-range lever to the "range" position.

(c) Insert a standard 3/16-inch square socket wrench through the small access opening and engage it with the set screw (C, fig. 89) on the adjustment collar of the coupling. Loosen the screw slightly and leave the wrench engaged. (If the wrench is disengaged, the collar will rotate of its own weight and it is almost impossible to bring it back to position and reengage the wrench without removing the entire compensator assembly. Also, care should be taken not to let the collar slide to the right, as it might hit the gear on the compensator assembly or slide off the coupling entirely.)

(d) While observing the stereo image of the internal target line through the eyepieces, insert the thumb through the large access hole and turn the gear directly under the hole. This will cause the target image to move either toward or away from the observer. Bring the target line into stereoscopic contact with the center reticle line. If the range-infinity reading is lower than the height-infinity reading, turn the gear clockwise; if higher, turn the gear counterclockwise, as when viewed from the center of the instrument. Hold the measuring knob while turning the gear. Be sure that the measuring drum has not turned off the infinity mark.

(e) Slip the tip of a small, thin-bladed screwdriver between the coupling and the end of the drive shaft assembly to make about 1/32-inch clearance and tighten the adjustment collar with the socket wrench.

(5) Check the accuracy of the adjustment by taking five internal target readings in the range-infinity position and five readings in the height-infinity position. The medians should check within the tolerance.

(6) When the range adjustment has been brought within tolerance, check and, if necessary, adjust the height conversion mechanism as in subparagraph **d**, below.

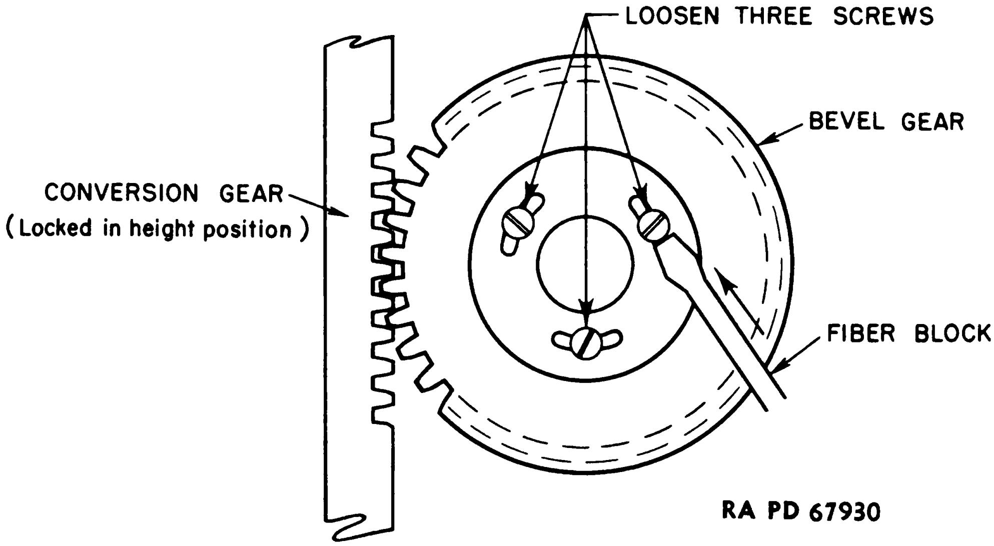

Figure 82 — Adjustment of Tight Bevel Pinion for Range-infinity, Height-900 Readings

(7) Clean the access plugs, apply COMPOUND, sealing, for height finders, and replace in their holes.

(8) Check cleanliness of the bevel pinion and height conversion ring, and replace the bevel pinion cover. Repack the space between the compensator plate and the height conversion ring housings with felt.

d. Height Conversion Adjustment (Range-infinity, Height-900).

(1) If the internal adjuster scale readings made at the two ends of the measuring drum scale (range-infinity and height-900), with the instrument at zero elevation (par. 21) do not agree within the tolerance, adjust the height conversion bevel pinion. It is important that the instrument be on its own cradle and that *both instrument* and *cradle be level* during the adjustment and that the travel of the height conversion ring be accurately 90 degrees. The height finder is subject to possible disturbance of the compensator assembly if the caution instructions on the instrument are not followed.

(2) Set the measuring drum at 900 and the adjuster scale at the median of the five readings made at range-infinity, and the height-range lever in the height position.

(3) Remove the bevel pinion cover and slightly loosen the three lock screws on the face of the pinion (fig. 82).

(4) Adjust the bevel gear shaft. This is very sensitive. If the height-900 reading is lower than the range-infinity reading, turn the shaft in a clockwise direction, using a pin wrench or adjusting pin in

the holes of flange A49286 (fig. 187). If the pinion fits very tightly on the flange, it may be necessary to set a fiber block or brass bar against a screwhead and tap with a hammer (fig. 82).

(5) Tighten the screws and recheck the adjustment by taking five readings at range-infinity and five readings at height-900. Repeat the above procedure if the median values do not fall within tolerance.

(6) In some cases, the bevel pinion will be so far out of adjustment that the adjusting slots will not be of sufficient length to bring the unit within tolerance. In such cases, it will be necessary to slip the bevel pinion and height conversion ring gear one or two teeth. This can be done as follows:

(a) Return screws to the center position of the slots on the bevel pinion.

(b) Disengage the height-range lever from the height bracket and move it to a position where stereo contact is obtained between the internal target line and the center reticle line. Scribe corresponding lines on the pinion and on the conversion ring housing cover. Return the height-range lever to the height bracket.

(c) Remove all but one of the screws holding the compensator assembly to the instrument. Loosen the screw in the upper left corner, but do not remove it.

(d) Slide the compensator assembly away from the conversion ring so that the bevel pinion is disengaged. Turn the bevel pinion far enough to bring the scribed line into position with the mark on the conversion ring housing cover, and reengage the pinion with the conversion ring at this point. Be sure the gears are properly meshed.

(e) Replace the compensator assembly holding screws. Check for backlash and excessive tightness between bevel pinion and conversion ring at three positions: height, range, and midway between. If necessary, tighten ring C69912 and cover C69945 (first remove set screws, if present), and then adjust both by moving them equal amounts in the same direction longitudinally to move race C69947 toward or away from the pinion by a slight amount.

(f) Repeat the fine adjustment of the bevel pinion as in step (4) to bring the readings within tolerance.

(7) Check the following:

(a) Adjuster scale settings at range-infinity, height-infinity, and range-infinity, height-900, preferably by two observers, making sure the instrument and cradle are leveled.

(b) For adjustment of end windows, see paragraph 60.

(c) Main bearing outer race cover C69945 and retaining ring C69912 to see that they have not unscrewed from the bearing housing causing end play in race C69947.

(8) Clean the access plugs, apply COMPOUND, sealing, for height finders and replace them in their holes.

(9) Replace the bevel pinion cover after checking cleanliness of the bevel pinion and conversion ring. Repack the space between the compensator plate and the conversion ring housings with felt.

(10) Check the alinement in elevation of the tracking telescopes (par. 21).

49. COMPENSATOR ASSEMBLY — REMOVAL AND DISASSEMBLY.

a. Explanation.

(1) 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, beyond replacement or adjustment of the backlash springs, 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 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 (par. 48).

(2) There should not be any backlash or looseness between the four *measuring wedges* and either the *measuring* drum or the *height-range conversion race;* 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, backlash springs are used to urge the wedge mounts always in one direction against the drive gears so that any looseness is taken up and its effect reduced to within tolerance. These backlash springs may occasionally become stuck or broken, and need replacement or repair. When the backlash springs are in place, caution should be observed to avoid turning the shafts or gears of the compensator unit beyond the limits of the springs, which may be easily broken. Instruments which have been permitted to lose their pressure tend to "breathe" dampness which, in turn, may cause binding in a compensator by blistering the plating on shafts. This occurs particularly in humid and salt-aired climates.

b. Requirements. 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 individual 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 individual wedges will require the use of a surface plate, and a mounting fixture as described in subparagraph e, below.

c. Removal.

(1) Removal of the compensator unit is necessary during adjustment of several other of the optical units, for removal of the inner tube, and for adjustment of the backlash springs. It will also permit the wedges to be cleaned on exterior surfaces. *Do not remove the wedges from their cells or mounting gears unless absolutely necessary.*

(2) Remove the bevel pinion cover B137916 (fig. 84).

(3) To avoid disturbing the alinement of the wedges, with consequent difficulties in replacing and adjusting the unit, lock the bevel pinion as follows:

(a) Set the measuring drum to infinity and the height-range lever to the "range" position.

(b) Clamp the bevel pinion, using an angle clip held by one of the screws of the bevel gear bracket and engaged with the teeth of the pinion (fig. 83).

(c) Remove the lower access plug A181004 and the small plug A178061. Insert a 3/16-inch square socket wrench through the small plug opening, engage it with the set screw on the collar, and loosen. Remove the 16 holding screws, noting the holes from which the various lengths and types are taken.

(4) Insert a screwdriver through the small plug hole and press the collar to the left while the compensator assembly is moved to the right. When the shaft is disengaged from the compensator, lift the compensator from the instrument, being very careful to prevent any of the gears or other parts of the unit from hitting against any part of the instrument. If the objectives are to be focused, the measuring wedge shaft can be pulled out of the measuring drum engagement gear.

d. Installation.

(1) 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. Installation follows, in

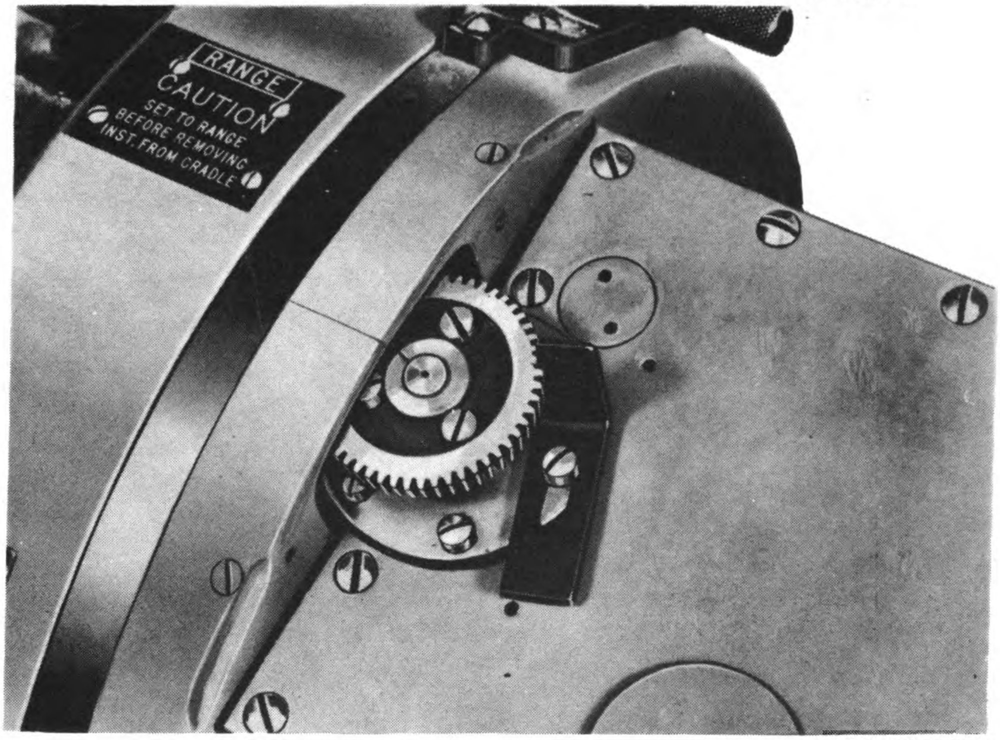

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Figure 83 — Lock for Height Conversion Pinion

general, the reverse order of removal, with the following additional steps:

(2) Fit and adjust coupling A46980 (A, fig. 89).

(a) Check the fit of the coupling on the pins of the coupling on the end of the measuring wedge shaft. The pins should fit snugly, with no backlash.

(b) Slip the adjusting collar (B, fig. 89) over the shank of the coupling, leaving the square-head set screw loose.

(c) Slip the collar and coupling together onto the compensator drive shaft (D, fig. 89).

(d) If the coupling is a tight fit on the shaft, ream out the hole until it will slide on without undue pressure.

(e) Tighten the square-head set screw so that the collar will not slip around on the coupling when the wrench hits the screw, but not so much that the coupling will not slide on and off the shaft freely. This adjustment must be made carefully, or installation of the compensator assembly will be difficult, if not impossible.

(3) Set the measuring drum at infinity (*) and the height-range lever at "range" position.

(4) Install the measuring wedge shaft.

(a) Place a small light or flashlight inside the inner tube to illumi-

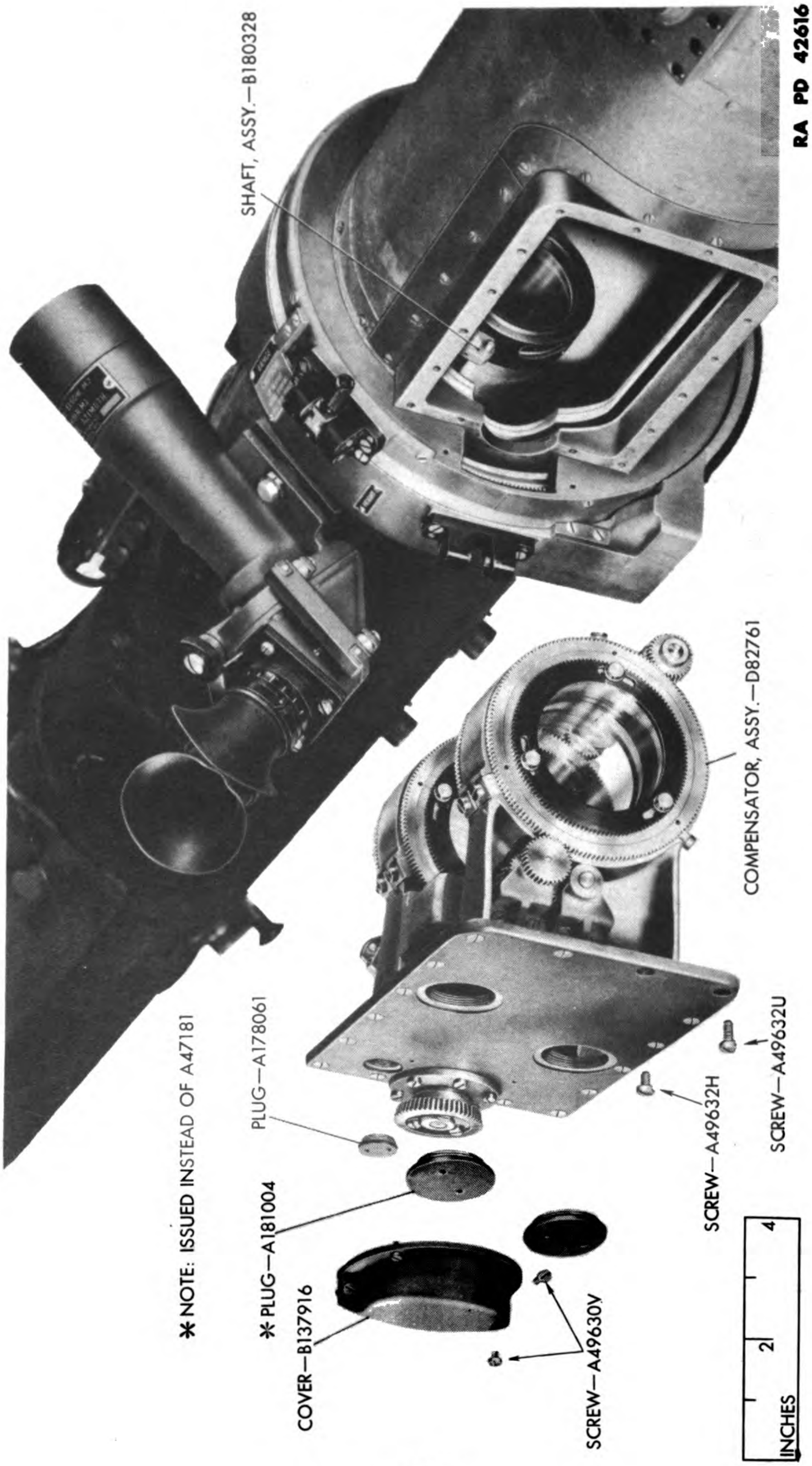

Figure 84 — Removal of Compensator Assembly

nate the measuring drum engagement gear of the measuring knob assembly.

(b) Hold a small mirror inside the inner tube to make the gear visible, and fit the pins of the coupling into the holes of the gear. The pins should fit snugly, with no backlash.

(c) Pull the coupling and collar off the compensator drive shaft and slip onto the pins of the measuring wedge shaft.

(5) Apply COMPOUND, sealing, for height finders, to the compensator adapter.

(6) Insert the compensator assembly carefully into the instrument.

(a) Keep it to the right end of the opening and do not hit the gears against anything.

(b) Move the compensator to the left and slide its shaft into the coupling. A screwdriver or hooked wire inserted through the small access hole can be used to guide the coupling into position.

(c) Do not set the wedge unit down solidly on its adapter, or the sealing compound will cause it to stick before the shaft and coupling are engaged.

(7) Adjust for range (range-infinity, height-infinity) and for height conversion (range-infinity, height-900) as instructed in paragraph 48.

e. Replacement and Adjustment of Individual Wedges.

(1) Adjustment of the individual wedges, with the unit removed from the instrument, is required only if the wedge cells or mounting gears have been disturbed or any disassembly of the unit has been made. The adjustment should be performed only at a base shop or arsenal where qualified ordnance personnel and equipment are available.

(2) A fixture, such as an adjustable angle plate and parallels, is needed to support the measuring wedge unit in the position it occupies in a leveled and horizontal height finder, with the flat mounting surface at 42 degrees from the horizontal (par. 34). This angle must be very accurately set and maintained.

(3) Set the wedge mounts to the neutral position and aline as follows:

(a) Remove the backlash spring assemblies (fig. 85). Mark the backlash springs "Right" and "Left," if they are not marked.

(b) Mark each wedge cell to indicate its position in the unit, so that they can be replaced in the proper order. Remove all four wedges by taking out the three capstan screws which clamp each wedge cell and sliding the cell out of its mounting gear. Lay the cells on the table with the inside surfaces down. Check the inside surface for cleanliness before reassembly.

(c) Turn the height conversion bevel pinion to bring the wedge mounting gears 1 and 3 into alinement with each other, as indicated by the lines painted or scribed across the sides of the gears. Mounting gears 2 and 4 should then also be alined with each other. Clamp the bevel pinion as shown in figure 83.

(d) Turn the range shaft to bring all of the mounting gears into alinement with each other and with the lines marked on the housing.

(e) Wind and mount the backlash spring assemblies as described in subparagraph f, below.

(4) There are four wedges to the unit, and they are referred to by numbers 1 to 4, counting from the center of the instrument or the wedge nearest the conversion bevel gear. At the base of each wedge, a small groove is ground on the edge to fit over a locating pin in the cell. The wedges, in their cells, are alined in the mounting gears as follows:

(a) Insert wedge number 1 into its mounting gear with its base (locating pin) down. Fasten the wedge cell loosely with the three screws and washers.

(b) Arrange a surface plate, 8- by 10-inch or larger, carefully leveled in front of the right end window of the height finder.

(c) Train the height finder on any convenient sharp vertical target, and aline with the center mark of the right reticle.

(d) Clamp the compensator on its 42-degree bracket and place on the surface plate in line with the end window.

(e) Rotate the wedge until the target appears to be as high in the field as it will go. If necessary, realine the height finder on the target.

(f) Turn the compensator bracket end for end, so that the light passes through in a reverse direction. If this shifts the target image from the center reticle mark, rotate the wedge slightly to bring the image halfway back. Shift the height finder in azimuth to complete the correction.

(g) Again turn the compensator bracket end for end. If the target image shifts sideways at all, again correct, rotating the wedge for the first half of the adjustment and shifting the height finder to complete the adjustment.

(h) Continue this procedure until not the slightest lateral shift is detectable when the unit is reversed.

(i) Secure the wedge cell by tightening the three lock screws. Check the alinement by again turning the compensator end for end.

(j) Insert the second wedge cell, with wedge approximately base up. Rotate the wedge to bring the target image to its lowest point, and repeat substeps *(f)*, *(g)*, *(h)*, and *(i)*, above.

(k) Repeat the process for wedge 3 (base down) and wedge 4

(base up). In each case, remove all lateral shift before the next wedge is inserted.

(5) If the shellac around the heads of the mounting screws A49608 is broken on one cell, indicating that one and only one of the wedges has moved, this wedge can be set exactly as the fourth wedge in the steps above. This eliminates the necessity for removing and remounting the entire wedge set-up.

(6) Check the adjustment of the four wedges by turning the range shaft clockwise and counterclockwise about 10 turns each way. The image of the target should travel back and forth horizontally with no change in height. If the travel of the image is not horizontal, the wedges are not correctly adjusted.

(7) Installation of the compensator assembly in the instrument is described in subparagraph d, above.

f. Backlash.

(1) If the readings for up-scale and down-scale settings of the measuring drum do not agree within 1 UOE, it indicates that there is backlash somewhere between the drum and the compensator wedge cells. Backlash or looseness can occur between the drum engagement gear A49508 and the measuring drum, in the range shaft couplings, or in the gearing of the compensator assembly. If the backlash springs are broken or sticking, or are not wound to the proper tension, even the necessary clearances in the gears will cause trouble, and any excessive play will be aggravated. Backlash between the drum engagement gear and the measuring drum can be eliminated by adjustment of the measuring drum bearings (par. 52). To find and correct backlash in the range shaft or compensator unit, proceed as follows:

(2) Remove the compensator assembly as described in subparagraph e, above. Take all precautions noted.

(3) Feel the shaft assembly B180328 (fig. 84) to detect any looseness in the coupling to the drum engagement gear. Withdraw the shaft from the instrument and check the fit of the coupling to the compensator unit. Examine for looseness of the coupling pins or of the couplings on the shaft.

(4) Remove the backlash mechanism assemblies (fig. 85). Let the backlash springs unwind slowly, or they will break.

(5) Check the following points in the compensator assembly (figs. 87 and 89):

(a) Bevel gear shafts A49169 and A49168 must have no end play. End play can be eliminated by changing the thickness of spacer (G, fig. 89).

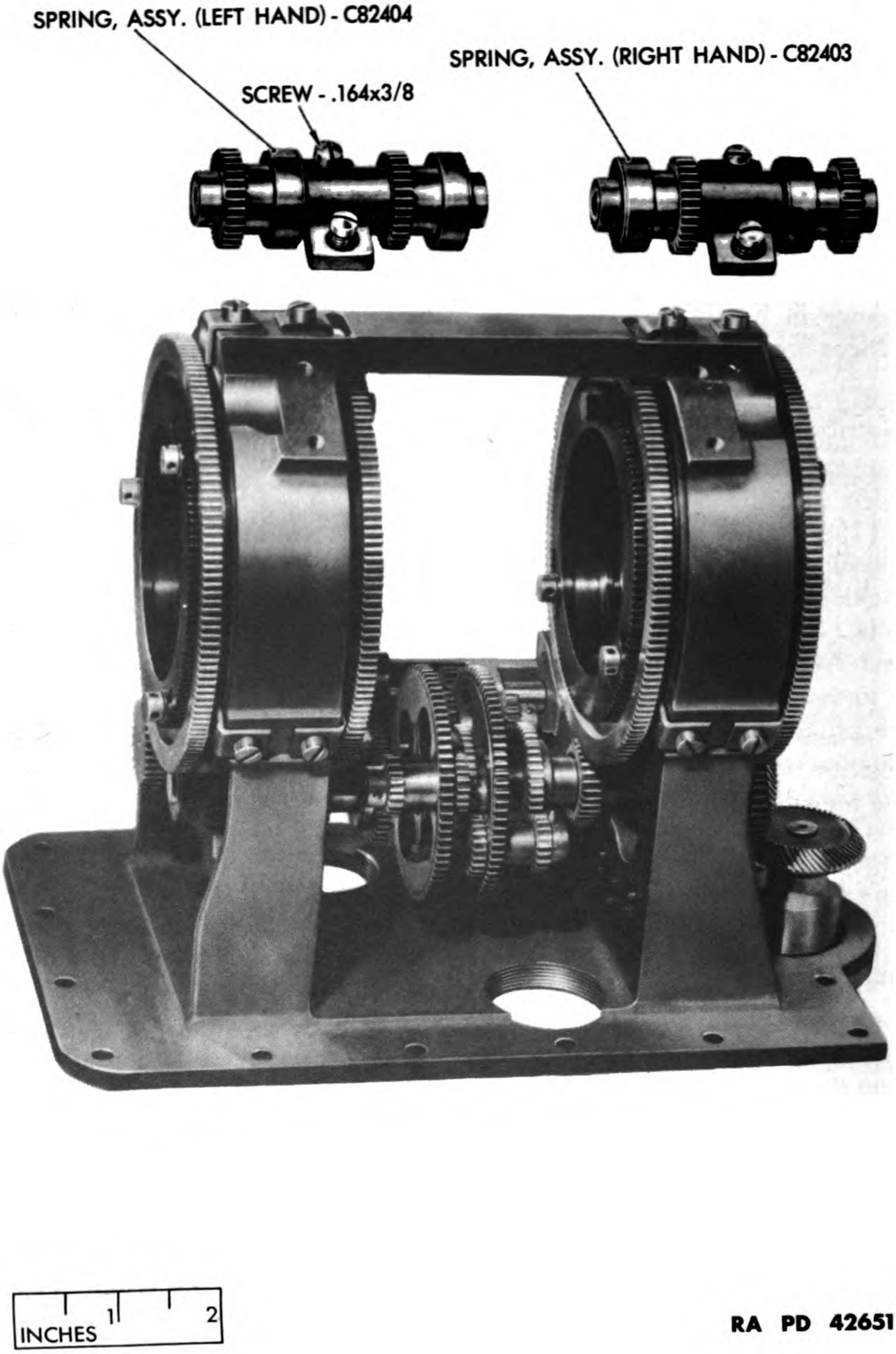

Figure 85 — Removal of Compensator Backlash Mechanisms

(b) There must be a minimum of backlash between the bevel gears B137965 and B137966.

(c) There must be a minimum of backlash (not more than 0.002 inch) between either of the range drive pinions A49266 and A49165 and the large gears A49262. Excessive backlash can be eliminated by moving the bracket A49166 closer to the planetary gears and repinning it to the housing.

(d) There must be a minimum of backlash (not more than 0.002 inch) between the four planetary pinions A49264 and either of the triple gears A49164A or between the four pinions A49263 and the central gear A49162. Excessive backlash is best eliminated by replacement of the gears and pinions.

(e) End play between the gears listed in substep *(c)* and *(d)*, above, will not affect the accuracy of the instrument and may be beneficial, since it tends to eliminate binding which would be very undesirable. No wobble is permissible, however.

(f) The ball bearings which support the wedge mounting gears should have some end play to insure against binding. About 0.005 inch is optimum; more may cause trouble.

(g) The wedges must be securely mounted in their cells, so that no rotation is possible.

(6) After the above sources of backlash have been checked and, if necessary, adjusted, aline all four wedge mounts in the neutral position, with the lines painted or scribed on the mounting gears and the housing all in line.

(a) Turn the height conversion bevel pinion to line up wedge mount 1 with 3, and 2 with 4, and clamp the bevel pinion as shown in figure 83.

(b) Turn the range shaft to bring all of the mounting gears into alinement with each other and with the lines on the housing.

(7) Inspect the backlash springs (fig. 86) and, if they are not broken, wind and remount them as follows:

(a) Turn the pinions on the left-hand backlash mechanism four turns in the direction of the arrow on each spring.

(b) With the pinions under tension, replace the spring assembly on the wedge housing, meshing the pinions with the mounting gears for wedges 1 and 2, and replace the mounting screws. (The wedges are numbered 1 to 4, starting with the one next to the height conversion bevel gear.)

(c) Turn the pinions on the right-hand backlash mechanism three turns in the direction of the arrows, and mount the assembly with the pinions meshed with the mounting gears for wedges 3 and 4.

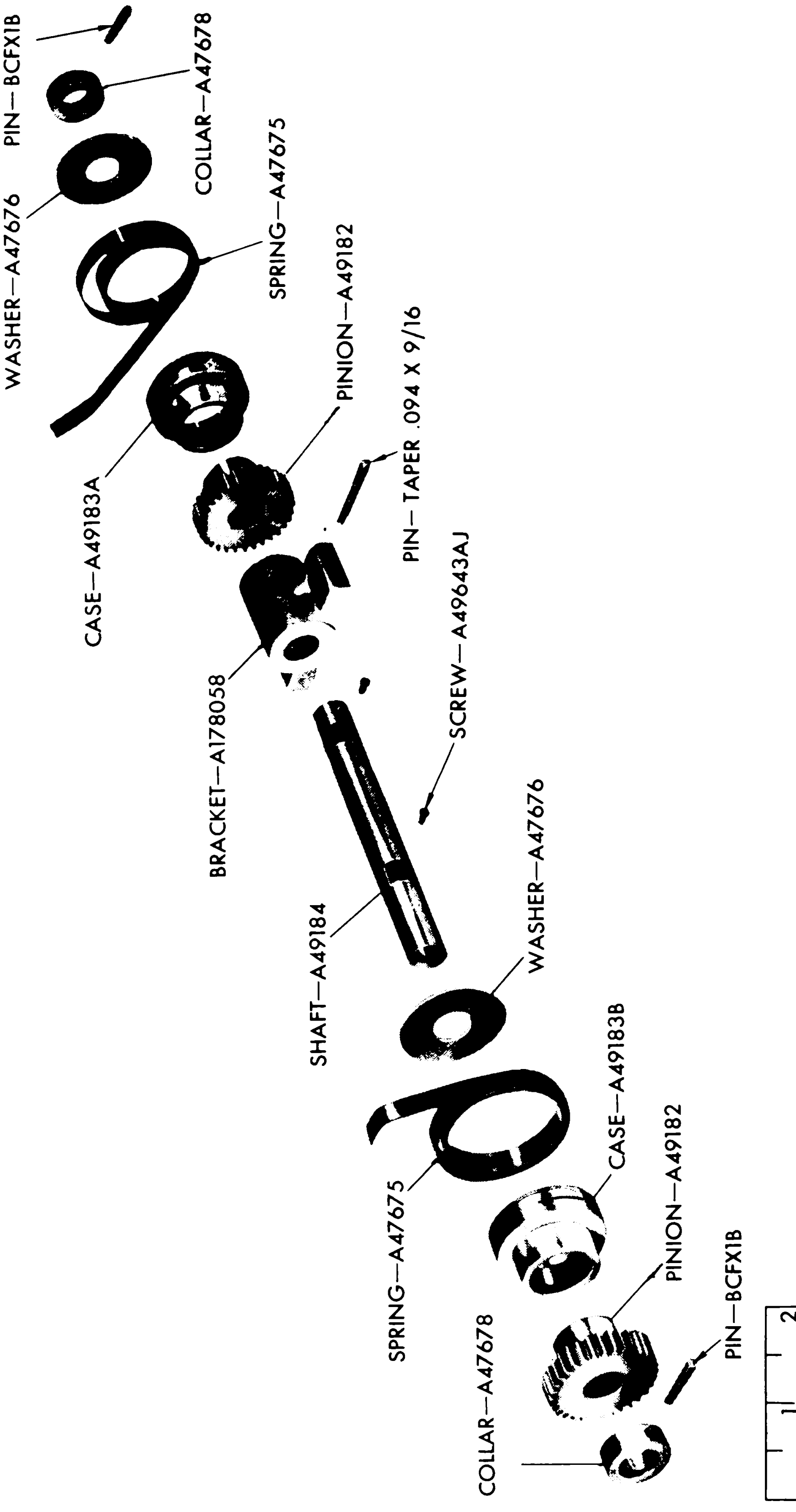

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Figure 86 — Compensator Backlash Mechanism, Right — (The Left Mechanism Is Identical Except That the Two Spring Cases, A49183A and A49183B, Are Interchanged and the Springs Are Turned to Correspond)

HEIGHT FINDER TELESCOPE—ADJUSTMENT AND REPAIR

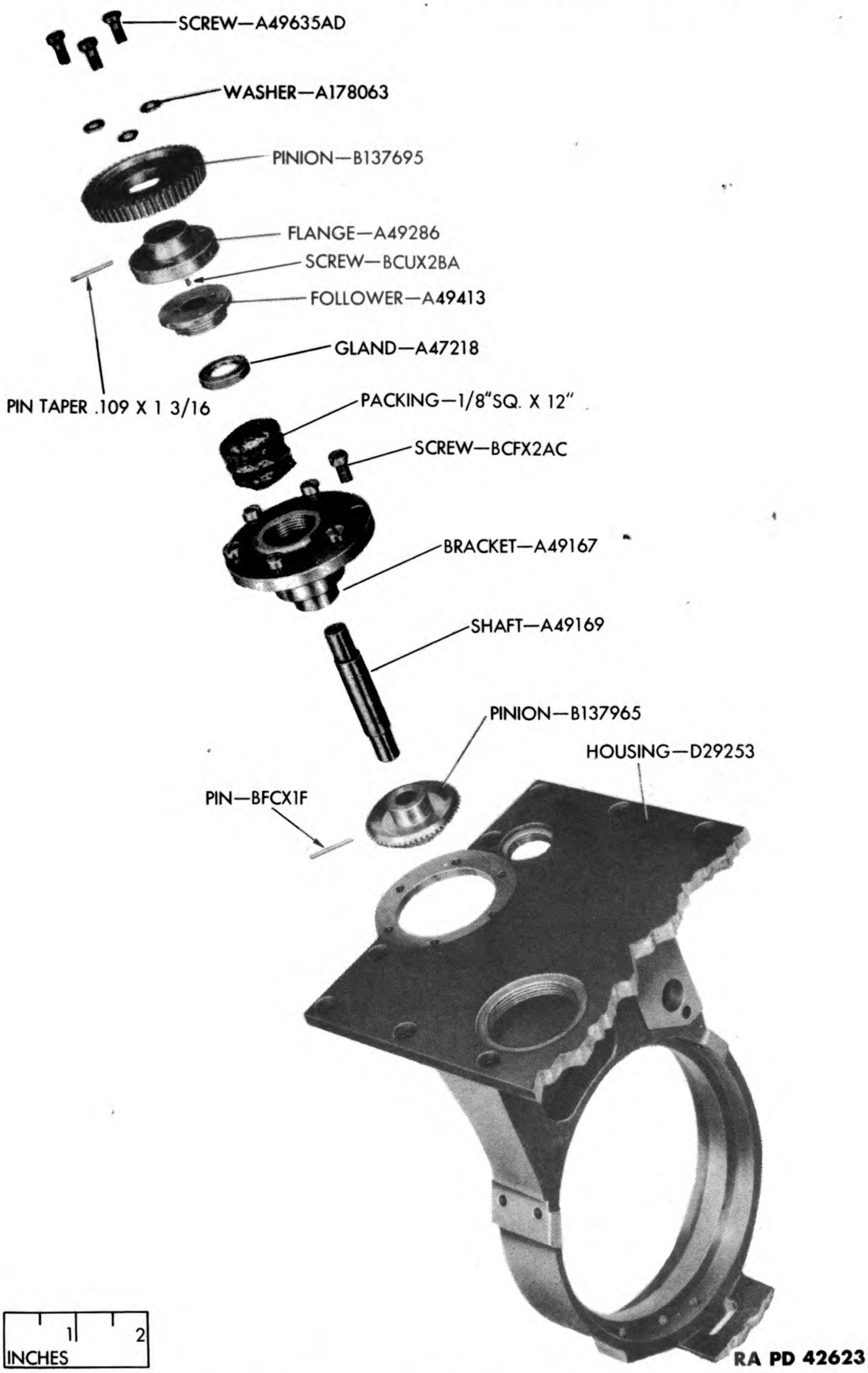

Figure 87 — Height Conversion Bevel Pinion Shaft Assembly — Exploded View

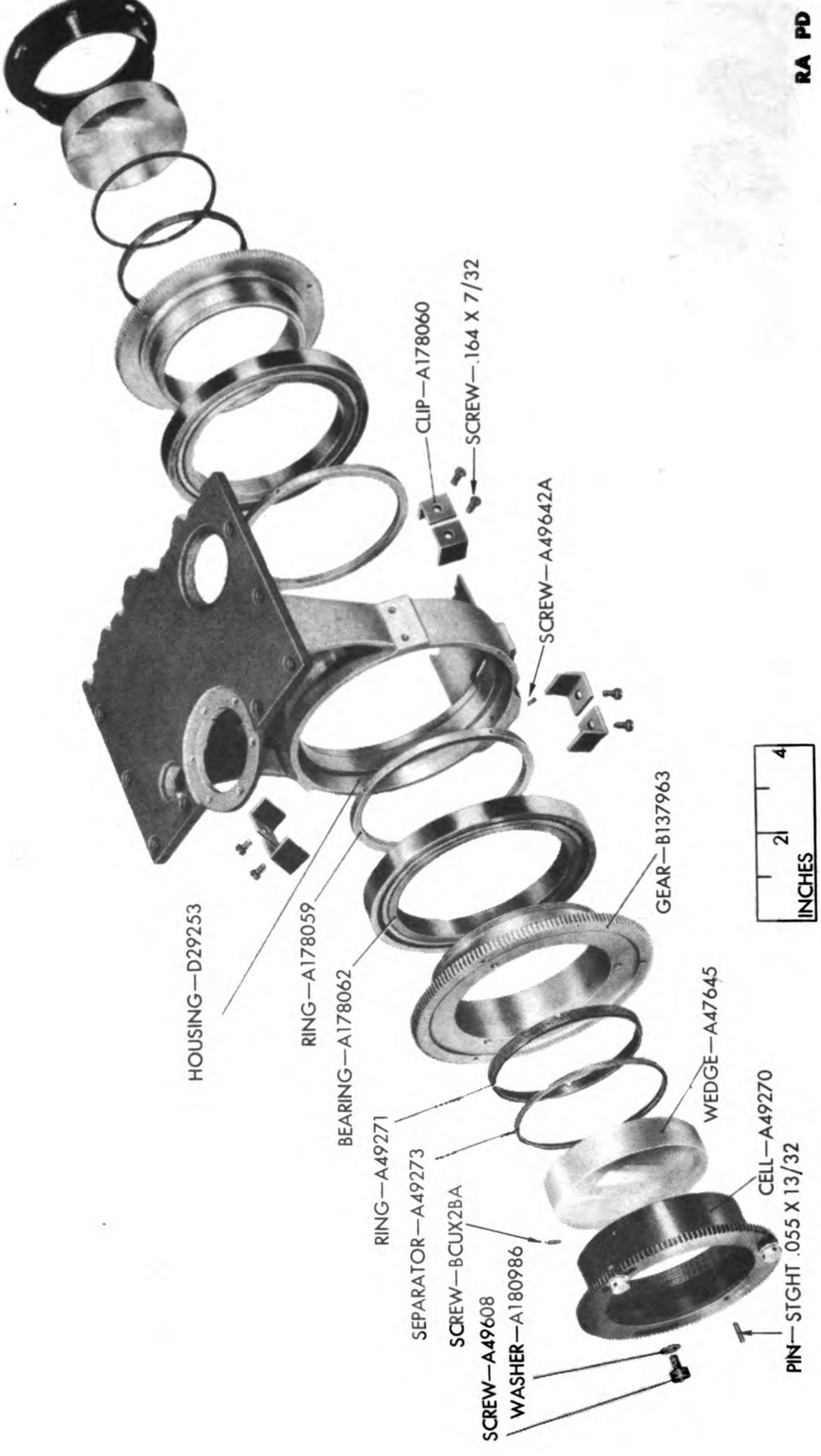

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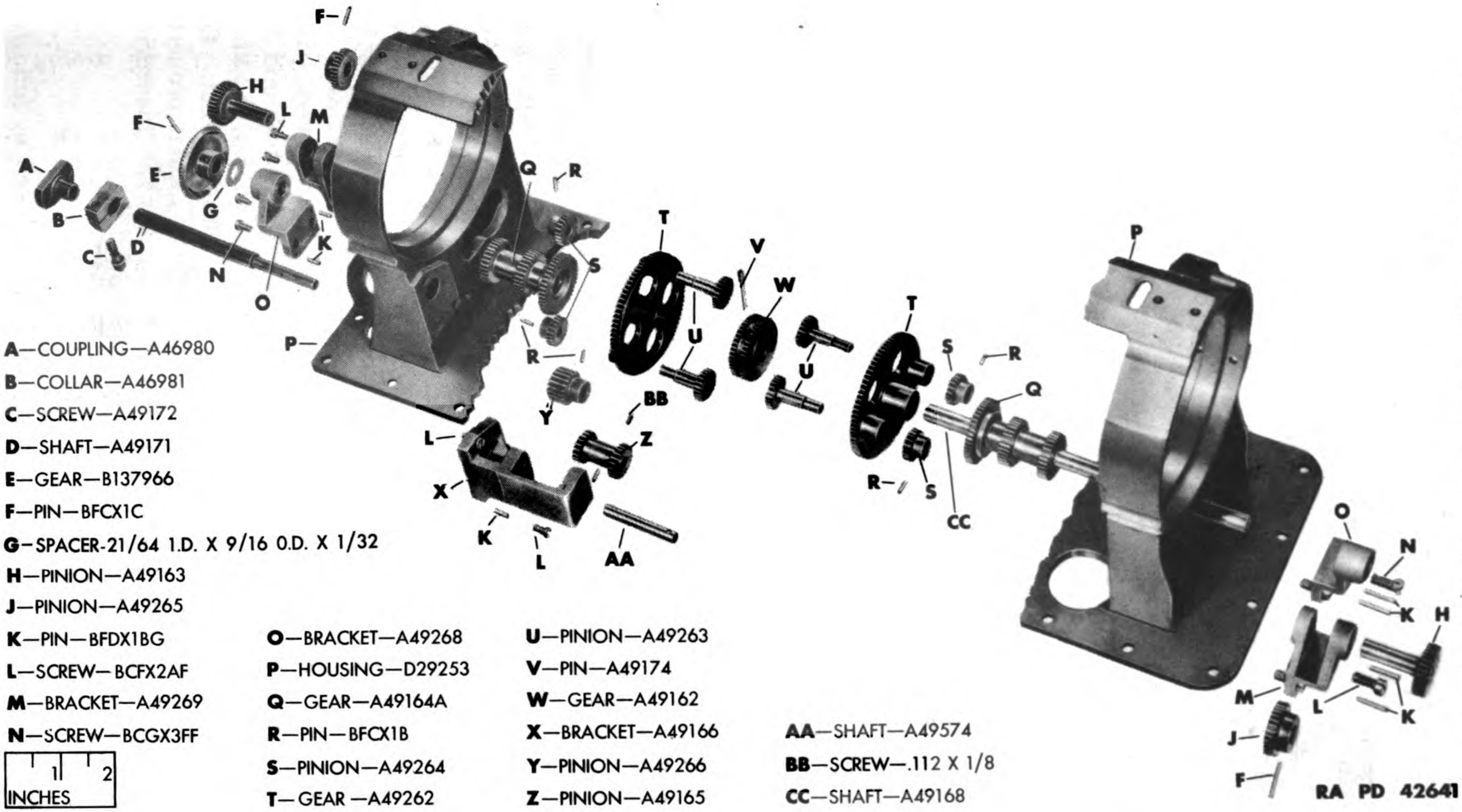
Figure 88 — Cells, Mounting Gears, and Bearings for Compensation Wedges 1 and 2 — Exploded View (The Assemblies for Wedges 3 and 4 Are Identical with These)



- A—COUPLING—A46980
- B—COLLAR—A46981
- C—SCREW—A49172
- D—SHAFT—A49171
- E—GEAR—B137966
- F—PIN—BFCX1C
- G—SPACER-21/64 I.D. X 9/16 O.D. X 1/32
- H—PINION—A49163
- J—PINION—A49265
- K—PIN—BFDX1BG
- L—SCREW—BCFX2AF
- M—BRACKET—A49269
- N—SCREW—BCGX3FF
- O—BRACKET—A49268
- P—HOUSING—D29253
- Q—GEAR—A49164A
- R—PIN—BFCX1B
- S—PINION—A49264
- T—GEAR—A49262
- U—PINION—A49263
- V—PIN—A49174
- W—GEAR—A49162
- X—BRACKET—A49166
- Y—PINION—A49266
- Z—PINION—A49165
- AA—SHAFT—A49574
- BB—SCREW—.112 X 1/8
- CC—SHAFT—A49168

1 2
INCHES

Figure 89 — Compensator Planetary Gear System — Exploded View

g. Disassembly. The compensator unit must not be disassembled unless absolutely necessary, and only at a base shop or arsenal by competent personnel. The general outline of disassembly procedure is as follows:

(1) Remove backlash mechanism assemblies (fig. 85).

(2) Remove the height conversion pinion assembly (fig. 87) by removing the six screws BCFX2AC.

(3) Remove wedge mounting gear assemblies and ball bearings (fig. 88) after taking off the three clips retaining each bearing.

(4) Unscrew the threaded pin A49174 (V, fig. 89) from the central gear A49162 to release the main shaft A49168 which can then be drawn out of its bearings. Identify all the gears so that they can be replaced in the same positions.

(5) Remove range drive shaft bracket A49162 and idler gear brackets A49269.

(6) For assembly, reverse the order of disassembly. Rotate each mounting gear to its neutral position, with the mark alined with the mark on the housing, before meshing with its drive gear. Aline the wedges as described in subparagraph e, above.

50. MEASURING KNOB ASSEMBLY.

a. General. The measuring knob adapter assembly is geared directly to the measuring drum, and operates the compensator assembly through a coupling shaft. Apparent tightness of the knob may be due to tight bearings on the measuring drum. This condition is most likely to occur in the earlier instruments which do not have a spring in the bearing assembly to take up expansion of the drum, such as might be caused by exposure to the sun. This condition can also be caused by dirt under the packing or by loose screws rubbing against the drum. Another frequent cause of binding is the result of a set screw in the flange of follower A49413 coming loose and allowing the follower to unscrew against the measuring knob adapter A47187. Correction of this fault will not necessarily release the helium charge, as only the knob assembly need be removed. The knob adapter assembly is removed for adjustment or repair and for removal of the inner tube from the instrument. Removal of the knob adapter assembly breaks the hermetic seal of the instrument. On replacing the assembly, care must be taken that the gear is properly engaged with the range drum. In order to engage the measuring wedge shaft, the compensator assembly must be removed.

b. Removal and Disassembly.

(1) To remove the knob adapter assembly, proceed as follows:

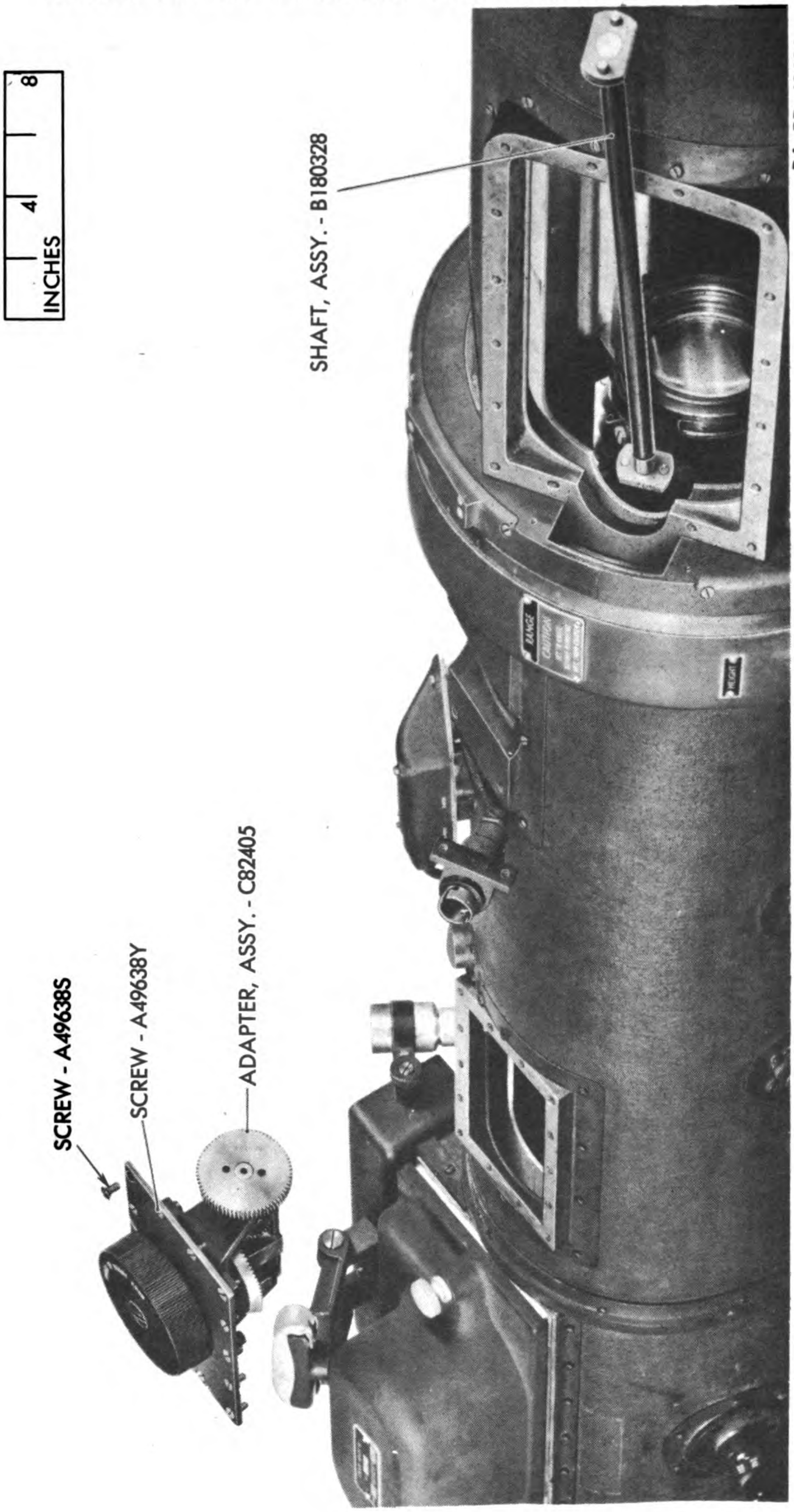


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Figure 90 — Removal of Measuring Knob Adapter Assembly and Measuring Wedge Shaft Assembly

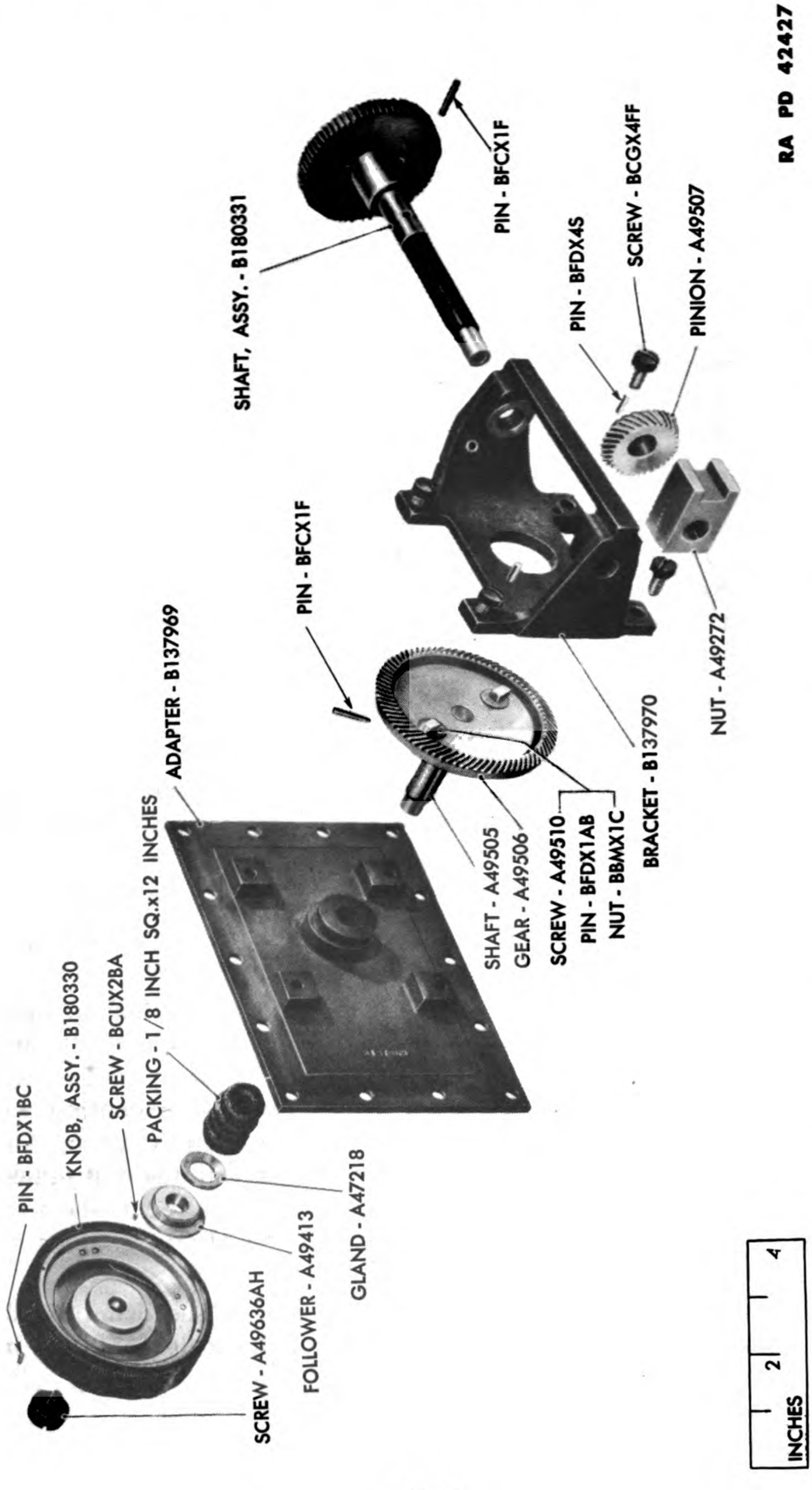

Figure 91 — Measuring Knob Adapter Assembly — Exploded View

(a) Remove the compensator assembly, observing the precautions in paragraph 49.

(b) Draw the measuring wedge shaft assembly (fig. 90) out through the measuring wedge opening.

(c) Remove the 14 holding screws, tilt the knob adapter assembly to the right, and lift it out of the instrument.

(2) To disassemble the unit (fig. 91), release and withdraw the shafts as follows:

(a) Turn the knob to run the stop nut to the left end of its shaft, away from the gears.

(b) Take out pin to release pinion A49507.

(c) Turn the drum engagement gear to screw the stop nut off the shaft, slip off the pinion, and withdraw the shaft from the bracket.

(d) Remove the holding screw and work the knob assembly off its shaft.

(e) Release the set screw and loosen follower A49413.

(f) Remove the four screws and lift bracket B137970 away from adapter B137969, at the same time pulling the knob shaft assembly out of its bearing.

(3) To reassemble the unit, reverse the order of disassembly.

(4) Replace the assembly in the height finder as follows:

(a) Set the measuring drum so that the 550-yard mark just shows clearly on the low side of the sliding index. The drum can be rotated by hand through the knob assembly opening.

(b) Rotate the knob counterclockwise until it hits the end stop.

(c) Insert the knob adapter assembly into its opening and engage the gear with the range drum teeth. Insert holding screws.

(d) Check the action of the knob and drum. If backlash or tightness can be felt, adjust the range drum bearings to correct. It must be borne in mind that, if the radial bearings of the drum are adjusted too loosely in the interest of smooth operation, heat expansion will change the relationship between the knob adapter and the drum. This change will later be manifested in the wedge check to make it appear that the wedges are out of tolerance in range. The effect is the same as that caused by bumping the measuring knob assembly stops excessively hard.

(e) Check for full travel of the range drum. The drum should travel equal amounts beyond the two ends of the scale (550 and infinity).

(f) Replace the measuring wedge shaft and compensator unit as in paragraph 49, and adjust the compensator unit (par. 48).

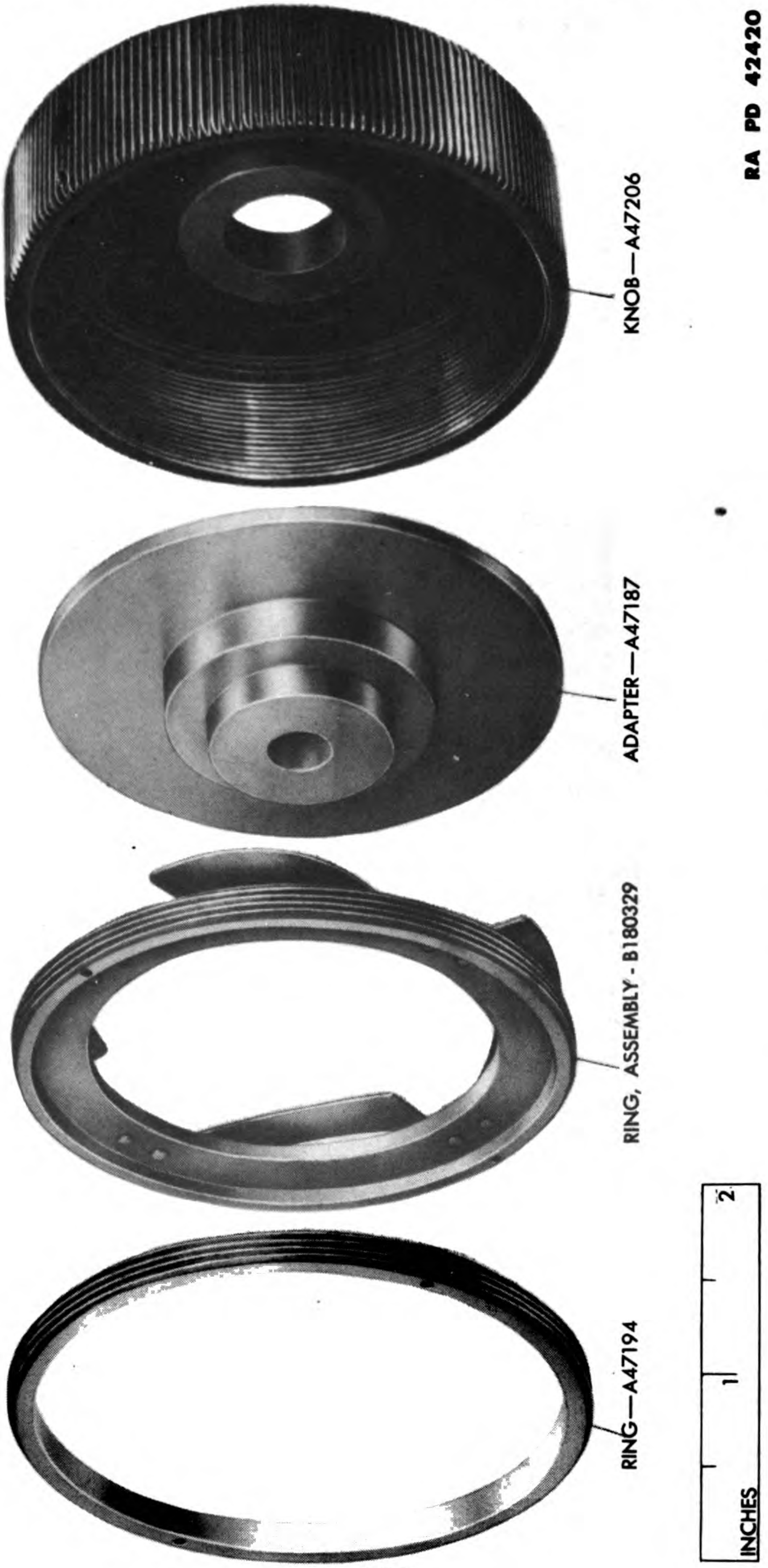

Figure 92 — Disassembly of Measuring Knob

c. Adjustment.

(1) The friction adjustment of the knob should be tight enough to drive the range drum and measuring wedges in a positive manner, but loose enough to allow slipping when the end stops are reached. If nccessary, adjust the friction as follows:

(a) Remove the holding screw, and slip the knob off its shaft (fig. 91).

(b) Using a spanner wrench, unscrew the retaining ring A47194; then screw the spring ring assembly B180329 in or out as necessary to adjust the friction (fig. 92).

(c) Replace and tighten the retaining ring to lock the adjustment.

(d) Replace the knob on its shaft, replace pin BFDXIBC and insert and tighten the holding screw.

(2) The limit stops should allow the knob and its shaft to make nine complete turns, enough to drive the measuring drum the full length of its scale.

(3) Field experience indicates that the amount of slippage is affected by the temperature. The average observer prefers a positive grip.

51. MEASURING DRUM WINDOW AND INDEX.

a. General. The measuring drum index travels in a guide back of the measuring drum window. A roller fixed to the back of the index rides in a groove in the drum and drives the index back and forth as the drum is rotated. The index should not require attention unless it becomes jammed or otherwise damaged, possibly as a result of breakage of the window. Field experience shows that a few indices becomes loose and jump vertically. If this occurs, it will show up as a range backlash error.

b. Removal and Disassembly.

(1) The index assembly and window assembly are removed as one unit as follows:

(a) Remove the two screws and lift the lamp bracket assemoly out of the way (fig. 93).

(b) Turn the measuring knob to bring the index to left end of the window.

(c) Remove the 16 screws around the outside of the window assembly, lift the right end of the window assembly and slide it and the index assembly to the right and out of the instrument.

(2) Slide the index out of the guide on the window assembly. Do not disassemble the window from its frame unless necessary.

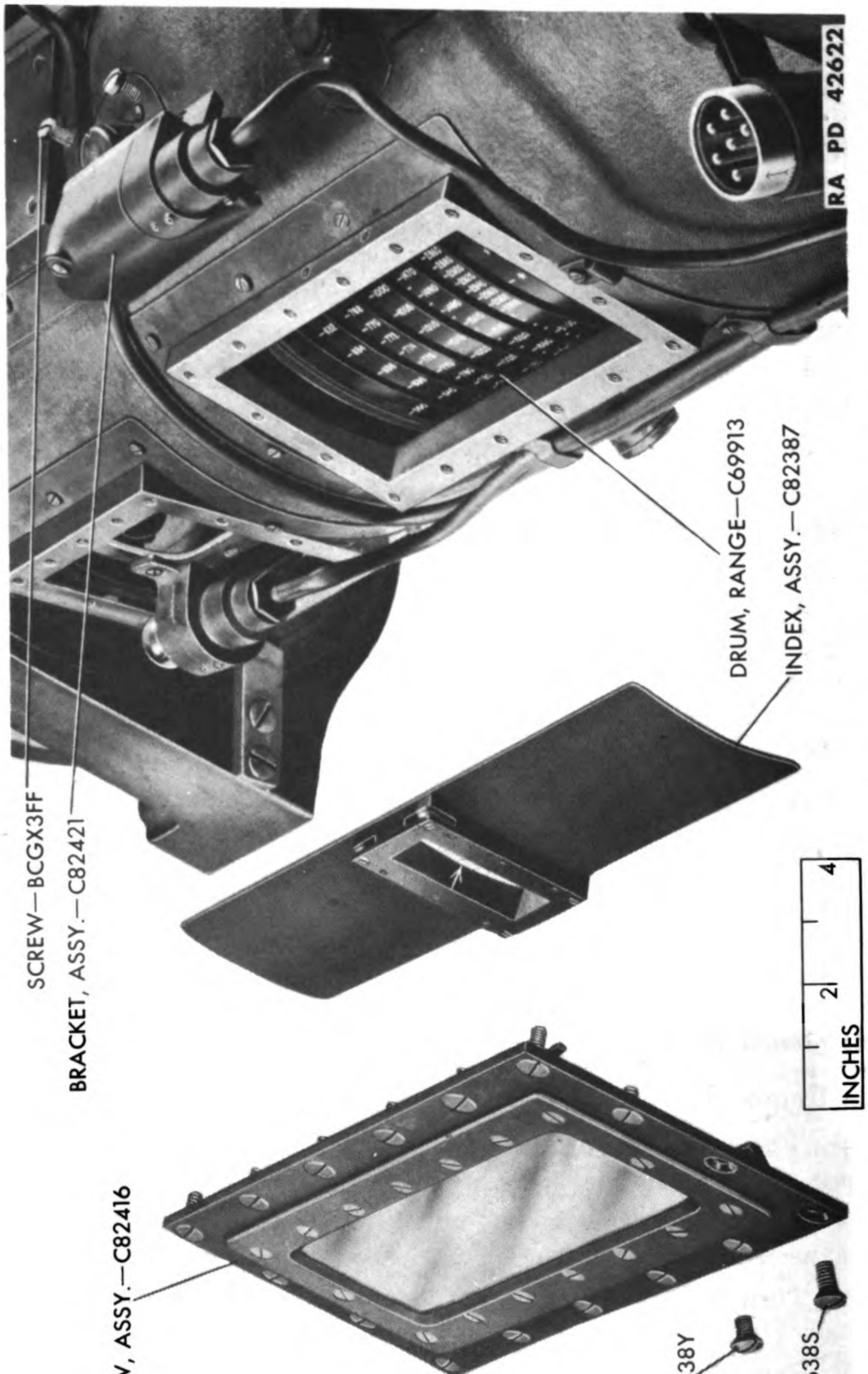

Figure 93 — Removal of Measuring Drum Window and Index

(3) For assembly and replacement, reverse the order of disassembly. On replacing the index and window in the instrument, make sure that the roller at the back of the index drops into the groove of the measuring drum before the window assembly is forced into place; otherwise the engraved surface of the drum may be damaged.

c. Replacing Glass in Range Window.

(1) Remove the 16 inner screws and lift off the window frame.

(2) Remove the old glass and clean out the recess in the cover and guide.

(3) Install the new window, sealing the edges with Navy black sealing compound.

(4) Replace the frame and tighten all its screws uniformly.

52. 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 by three roller bearings and is driven by a gear of the measuring knob unit. The drum can be withdrawn from the outer tube after the inner tube has been removed, but this should seldom be necessary and should be avoided if possible.

b. Removal of Drum.

(1) After the inner tube has been removed from the outer tube, the range drum can be removed as follows:

(a) Remove the caps from the six drum bearing adapters (fig. 94).

(b) Remove the two screws, screw the retaining ring out, and pull out the bearing assembly at each of the six bearings.

(c) Draw the drum out the right end of the outer tube, taking care to avoid scratching the polished surface. (This could be done by placing two thin wooden runners, lightly coated with grease, about 4 inches apart along the bottom of the outer tube and sliding the drum on them.)

c. Replacing and Mounting Drum.

(1) Insert the range drum through the right end of the outer tube, with the end of the drum carrying the gear teeth toward the center of the instrument. Use wooden runners as mentioned above (but not greased) to support the drum as it is slid through the tube, and take pains to protect the drum and prevent damage. Locate the drum so that the bearing grooves at each end are centered below the bearing adapters.

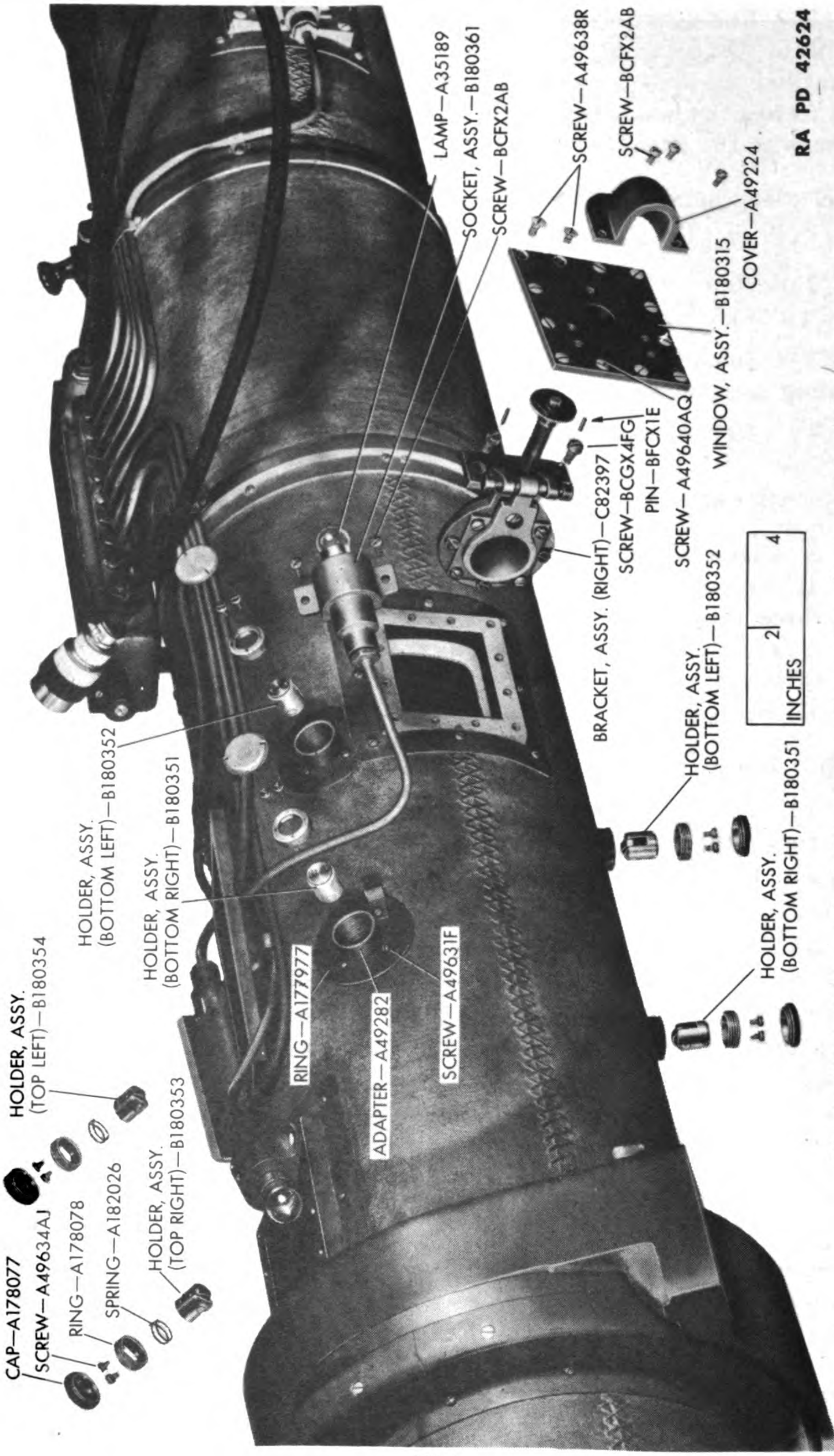

Figure 94 — Removal of Measuring Drum Bearings and Reticle Assembly

(2) Fit the bearings to hold the drum centered as follows:

(a) Insert the bearing holder assemblies B180352 (one washer on roller shaft) in the two bottom bearing adapters toward the center of the instrument (fig. 94) and screw in the retaining rings.

(b) Insert the bearing holder assemblies B180351 (without washers) in the two bottom bearing adapters toward the right end of the instrument, and screw in the retaining rings.

(c) Adjust the retaining rings so that the four lower bearings support the drum centered in the outer tube without tilt. Be sure that the bearing rollers are in the grooves of the drum and are not twisted. (The line between the two holes at the outer end of each holder should be perpendicular to the axis of the instrument.)

(d) Insert the top holder assemblies B180354 (left) and B180353 (right), and insert the springs and retaining rings. Screw down the rings to compress the springs fully, then back them off about one-eighth turn.

(e) Check to see that the drum is still concentric with the outer tube; if not, readjust the lower bearings. Mount the measuring knob (par. 50) and check the motion of the drum, which must turn freely without binding or tight spots. The teeth must be fully meshed with the engagement gear, to avoid the danger of the drum jumping out of mesh.

NOTE: It is essential that the bearing holder assemblies be properly assembled. If the springs and washers are not replaced as they should be to prevent longitudinal movement, or if the bearing shaft lug tips do not give perfect direction, the rollers will tend to climb the sides of the grooves and will wear the edges of the groove off in the form of filings, resulting in rough drum action. The anodized coating of the drum has been known to come off and deposit in spots, likewise causing bumpy turning of the drum.

(3) After the inner tube has been replaced in the height finder and the range knob has been installed, recheck the adjustment of the drum bearings, making sure there is neither backlash nor excessive tightness or binding.

(a) When the bearings are properly adjusted, clamp each retaining ring and holder assembly with the two screws.

(b) Apply COMPOUND, sealing, for height finder, to the seating surfaces and replacing the six bearing caps.

53. RETICLES.

a. Explanation. The two reticles provide the reference marks with which the relative positions of the two images of the target are compared. Therefore, they must be properly alined and located in the optical system, and must match each other closely in size and design (except for the symmetrical differences involved in locating the fore and aft marks). Since the surfaces of the reticles are sharply focused by the eyepieces, any dust, dirt, or scratches will be magnified and sharply visible, thus possibly interfering with stereo observations. Therefore, it is particularly important that the reticle surfaces be kept clean and free from dust. The reticles are mechanically mounted in such a way that they can be adjusted for alinement in the optical system and then fastened, so that they can be removed for cleaning and replaced with a minimum amount of disassembly or effect on the adjustment. The center mark of each reticle should be located on the line which passes through the optical center of its erector lens in both the high and low power positions. If the center mark is one unit off this axis, the image of this mark formed in the eyepiece focal plane will be $\sqrt{2}$ units from this axis in high power and $1/\sqrt{2}$ units from the axis in low power. Because of this difference, it is possible to detect decentering of the reticle by shifting the erectors while observing the reticle image through a divergence tester or dioptometer and noting the movement of the central line of the reticle image in relation to the grid or cross hair in the tester. 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 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.

b. **Requirements.** Adjustment or cleaning of the reticles necessitates breaking the hermetic seal of the instrument. Centering requires the use of a divergence tester or dioptometer, or a collimating telescope with cross hairs. Adjustment for tilt requires an external target with well-defined detail level with the height finder or a collimating telescope with cross hairs, and also that the end reflectors be in proper adjustment. (For method of alining reticles before the end reflectors are adjusted, see paragraph 66.) 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).

c. **Matching.** The corresponding marks on the two reticles must be of exactly the same width; otherwise it is extremely difficult to make stereo contact. Furthermore, the two reticles must be matched for equal spacing of the lines; otherwise range readings will vary at different points across the field. There should be no more than 0.00005-inch cumulative variation over half the field, each half measured from the center marks as a starting point. A variation of more

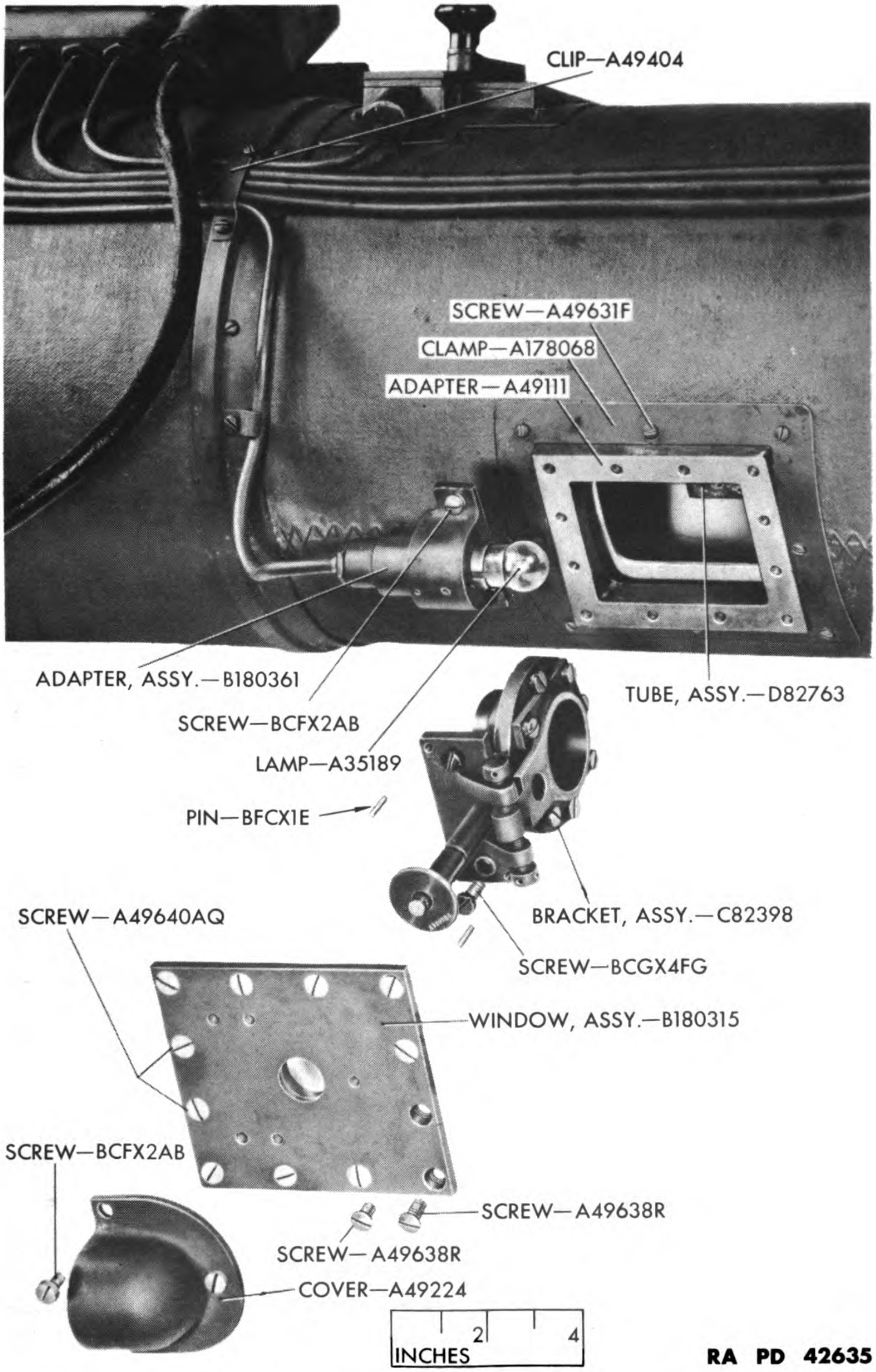

Figure 95 — Removal of Left Reticle Assembly

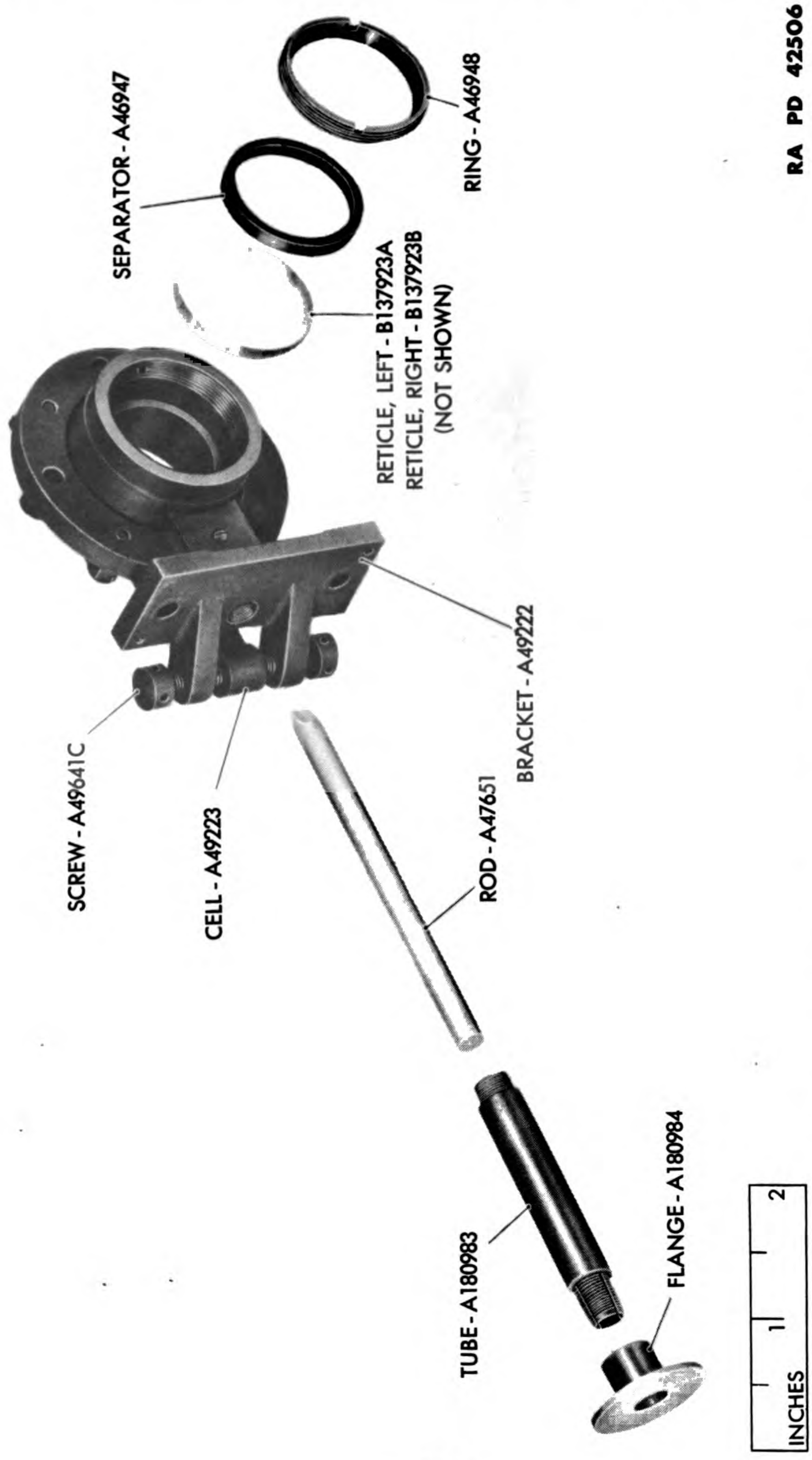

Figure 96 — Reticle Bracket Assembly — Partially Exploded View

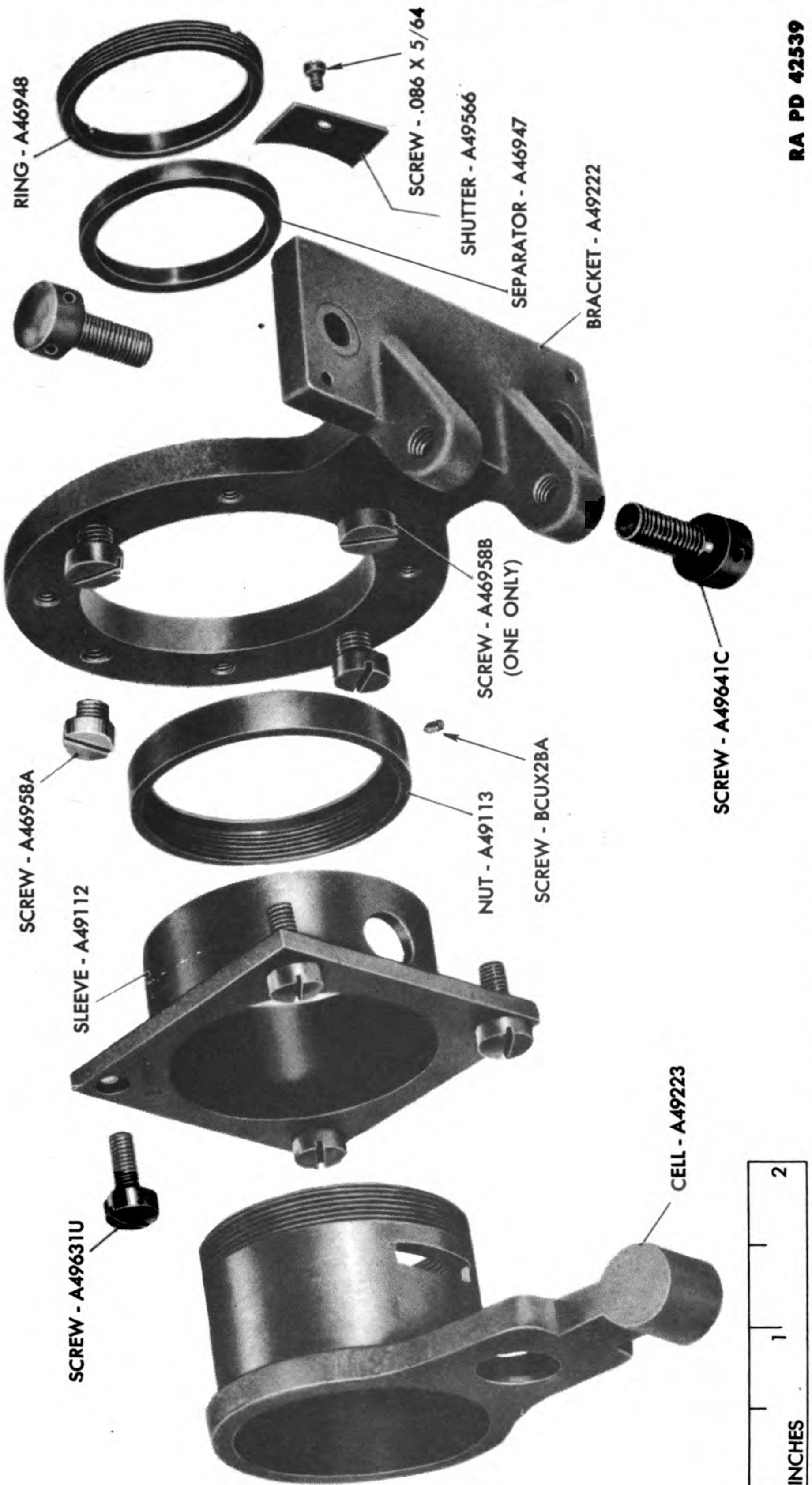

Figure 97 — Reticle Cell, Sleeve, and Bracket Assembly — Exploded View

than 0.00005 inch might result in cross field error beyond the allowed limits. 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 below. The adjustments must be made in the order given.

d. Replacement of Reticles.

(1) A factory-matched pair of reticles can be substituted for a damaged pair in the height finder. The reticles should preferably be mounted in cells and sleeves. Replace only one reticle at a time and complete the rough-adjustment for tilt and the centering adjustment before replacing the second reticle.

(2) Remove one reticle assembly:

(a) Shift instrument to low power.

(b) Remove the lamp cover, the socket assembly, and the window assembly (figs. 94 and 95).

(c) Remove the two mounting screws and, using the illuminating rod holder as a handle, lift the reticle assembly. Since the bracket is pinned to the optical tube, it will be necessary to work it loose gently before it can be withdrawn. Turn the assembly through 90 degrees so that it can pass through the opening.

(3) Install the new reticle:

(a) Unscrew the flange A180984 and pull out the illuminating rod (fig. 96).

(b) Remove the four holding screws from the corners of the sleeve (fig. 97), withdraw the sleeve and cell, carefully insert the new mounted reticle, making sure that the etched surface of the reticle faces the objective lens, and replace the four screws. Do not touch the eccentric adjusting screws A46958A and A46958B at this point.

(c) Replace the illuminating rod and flange. Replace the reticle assembly in the height finder and tighten both screws.

(d) Adjust the illuminating rod for best illumination (par. 82).

(4) Rough-adjust for tilt, as in subparagraph e, below, and center, as in subparagraph f, below.

(5) Replace the other reticle, as in steps (2), (3), and (4), above.

(6) Make fine adjustment for tilt as in subparagraph g, below.

e. Rough-adjustment of Reticle for Tilt.

(1) Carefully level the cradle, and aline the height finder on a target at approximately the same height.

(2) 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 twice the width of a reticle line.

(3) If the amount of tilt is excessive, adjust the reticle as follows:

(a) Loosen one capstan screw on the reticle bracket (fig. 96) and tighten the other to tilt the reticle in its mount. If the reticle marks are high on the right side of the field, loosen the upper screw for the right reticle or the lower screw for the left reticle, and vice versa when the left end is high.

(b) When the reticle tilt is within tolerance (step (2), above), tighten the capstan screw. If it is impossible to fully correct the reticle tilt, remove the reticle assembly from the height finder. Adjust the capstan screws to set the arm of the cell in midposition and loosen the retaining ring A46948 (fig. 96). Lay the assembly on a sheet of cross ruled paper, with the etched surface of the reticle down, and aline the mounting surface of the bracket parallel to one line. Square up the reticle with the ruled lines, tighten the retaining ring and set screw. Keep fingers and tools away from etched (plano) side of the reticle. Use a small rubber suction cup or clean eraser to turn the reticle in its cell from the *curved* side.

f. Centering Reticle.

(1) If a reticle is not centered with respect to the erector lens movement, stereo readings will be difficult and considerable eyestrain may result.

(2) Set up height finder with a divergence tester or dioptometer on the eyepiece. Focus for a sharp image of the height finder reticle.

(3) Turn the change-of-magnification crank from 12x to 24x, and note the movement of the center reticle mark in relation to the divergence tester grid or the dioptometer cross line. (At 24x, the height finder reticle mark is about 4 minutes wide in the divergence tester field.) Hard fast turning of the change of power crank will in time cause a change-of-magnification outside of tolerance at 12x and 24x.

(4) If adjustment is necessary, remove the two mounting screws and lift out the reticle assembly, turning it through 90 degrees so that it will pass through the opening. Since the assembly is pinned to the optical tube, it will be necessary to work it loose gently before it can be lifted out.

(5) Slightly loosen the four holding screws at the corners of the sleeve (fig. 97) and, by turning the eccentric screws A46958A, move the reticle cell and sleeve slightly to produce the necessary correction, so that when the erector lenses are shifted from 12x to 24x the com-

bined 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 or dioptometer placed over the eyepiece (fig. 54).

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.

(6) Tighten the four holding screws on the sleeve and apply a spot of shellac where each screwhead contacts the surface of the sleeve.

(7) Replace the reticle assembly in the optical tube, tighten the mounting screws, and shellac the heads.

g. Final Adjustment for Reticle Tilt.

(1) In order to prevent eyestrain (in extreme cases) and in order to prevent "lean" of the main reticle pattern, it is necessary to have the reticles accurately adjusted for tilt. It is also necessary to have the right reticle accurately adjusted for tilt in respect to the compensator deflection; otherwise a height-of-image error will be introduced in the right side as the wedges are turned from 550 yards to infinity. Therefore, begin with the adjustment of the right reticle.

(2) RIGHT RETICLE. Adjust for tilt until the image of a stationary target does not rise or fall more than the diameter of the ball marks on the reticle as the wedges are turned from 550 to infinity. Then check the reticle for tilt as in subparagraph e, above, except this time, the target image should fall at the same height at both ends of the field within *one-half* the width of a reticle line. If both conditions cannot be satisfied completely, compromise between the two. When adjustment is complete, apply a spot of shellac to the end of each capstan screw where it contacts the arm of the reticle cell.

(3) LEFT RETICLE. Adjust left reticle for tilt as in subparagraph e, above, except this time the target image 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, or, if this is not possible, due to halving error caused by compensator wedge traverse, at least get them both the same amount off parallel.

h. Cleaning 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.

(2) Do the cleaning in a dust-free room; otherwise the condition may be aggravated instead of improved. Prepare for cleaning as follows: Place 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 ethyl alcohol. Small dust specks or lint should be removed by using a vacuum system as follows:

(a) Connect a rubber hose from the vacuum line to a piece of small-diameter metal tubing, formed as shown in figure 98. If the vacuum line is not available, the suction effect can be obtained by applying compressed air to the end of the Venturi valve assembly B138732 marked "To Tank" with the valve turned to "Vacuum." The hose should be connected to the outlet marked "To Instrument."

(b) Wrap a strip of onionskin paper or typewriter second sheet 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 $\frac{1}{16}$ inch is very effective. If the 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.

(c) 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.

(d) 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.

(4) To remove oil or grease, remove the reticle mount as described in subparagraph **d**, above, and clean the reticle as described in paragraph 36.

(5) Seal with COMPOUND, sealing, for height finder, and replace plates and lamps. Use short screws in center holes at each end of plate.

SPECIAL NOTE: If any of the above adjustments, but not all of them, are necessary, it is quite important that the *sequence* of operations in Table III be followed.

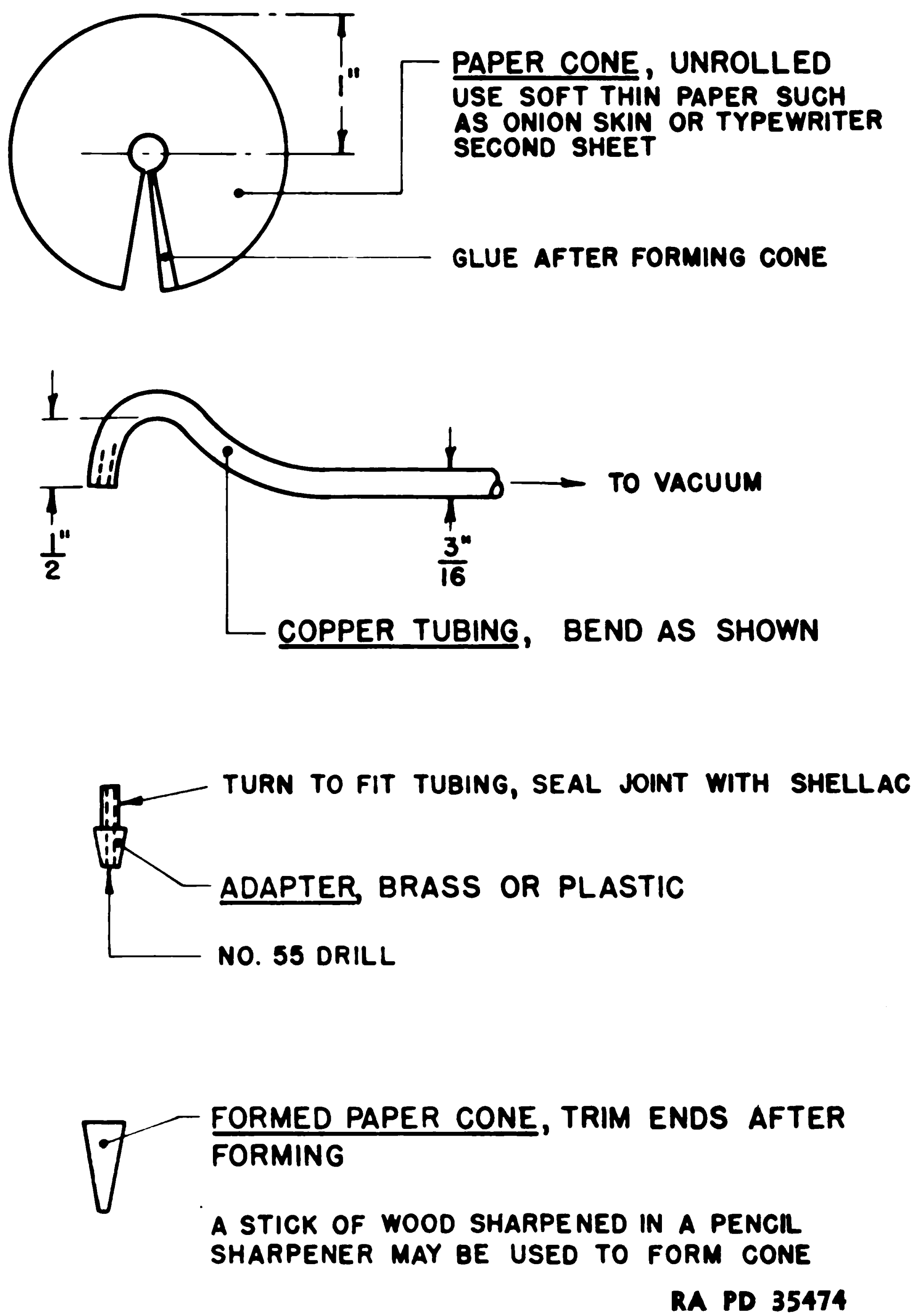

Figure 98 — Suction Nozzle for Removing Reticle Dust Particles

TABLE III

SEQUENCE OF OPERATIONS FOR
REPLACEMENT AND ADJUSTMENT OF RETICLES

1. **For replacement.** Obtain factory-matched pair of mounted reticles.

2. **Replace first reticle.**

   a. Remove reticle assembly from height finder.

   b. Remove reticle cell and sleeve, and insert new reticle. Do not disturb eccentric adjusting screws.

   c. Replace and adjust illuminating rod.

   d. Rough-adjust reticle for tilt. (Image height should vary less than twice the width of a reticle line.)

   e. Center reticle. (Jump not more than 5 minutes horizontally or vertically (fig. 54).)

3. **Replace second reticle.** Repeat all operations in step 2. (After centering, the combined jump of reticles must not be more than 5 minutes horizontally or vertically.)

4. **Fine-adjust right reticle for tilt.**

   a. Check with plane of compensator deflection. (From 550 to infinity, image height should vary no more than width of ball marks.)

   b. Adjust to external field. (Image height should vary no more than one-half width of reticle line when traversed across reticle field.)

5. **Fine-adjust left reticle to match right reticle.**

6. **Clean reticles.** Take special care, work in dust-free room, use vacuum line with paper nozzle.

7. **Seal and replace window and lamp assemblies.**

54. ERECTOR LENSES AND CHANGE-OF-MAGNIFICATION LEVER.

a. **Explanation.** The erector lenses are mounted in the optical tube between the reticles and the ocular prisms. Image rays are converged by the curved surface of the reticle into the erector lens. The erector lens system serves three purposes: it erects the image of the target so that it will appear natural to the observer; it images both the target image and the reticle at the focal plane of the eyepiece; and it allows choice between the two image magnifications of 12 and 24 power. Each erector lens is a symmetrical unit consisting of two cemented achromatic lenses mounted in a sliding tube. A blurred appearance of the reticles after the best eyepiece focus setting has been made can be caused by faulty or dirty erector lenses. If the blurred appearance persists after thorough cleaning and checking of the eyepiece unit, it can be assumed that the trouble is within the instrument, and a major disassembly will be required as described in paragraph 65. The focus of the eyepieces at both high and low power is dependent upon the position of the erector lenses in relation to the reticles and the eyepiece lenses. The change in magnification is accomplished by shifting the erector lenses along the axis of the optical tube by turning the change-of-magnification crank and linkage mechanism. If the distance moved between the high and low power positions of the erector is too great or too small, the diopter setting will change by more than the allowable ¼ diopter in shifting from one power to the other. Poor focus will result from incorrect adjustment in the change-of-magnification mechanism.

b. **Requirements.** Since the erector lenses and linkage mechanism are within the inner tube, any repairs or adjustments will require breaking the hermetic seal of the height finder. Adjustment to eliminate shift of focus can be done most readily, and removal and disassembly of the erectors can be done only after the optical tube has been removed from the instrument. A divergence tester or a dioptometer is needed for checking shift of focus.

c. **Eliminating Shift of Focus (with Optical Tube Removed from Height Finder).** When the optical tube is removed from the inner tube during a major disassembly of the height finder, any shift of focus can readily be eliminated by adjusting the positions of the erector cells in the erector tubes, as described in paragraph 66.

d. **Eliminating Shift of Focus (Height Finder Assembled).**

(1) When the optical tube is assembled in the instrument, the erector cells are not accessible, but the length of travel of the erectors, and thus the shift of focus, can be changed by adjusting the length of the high-power detent spring. This is a major job and should not be attempted unless absolutely necessary. Since it affects both sides of the instrument equally, it should be done only when the magnitude of the shift of focus is approximately the same for both eyepieces.

(2) Remove the left (high-power) detent assembly as follows:

(a) Remove eyepiece unit and eyepiece housing as described in paragraph 44 a.

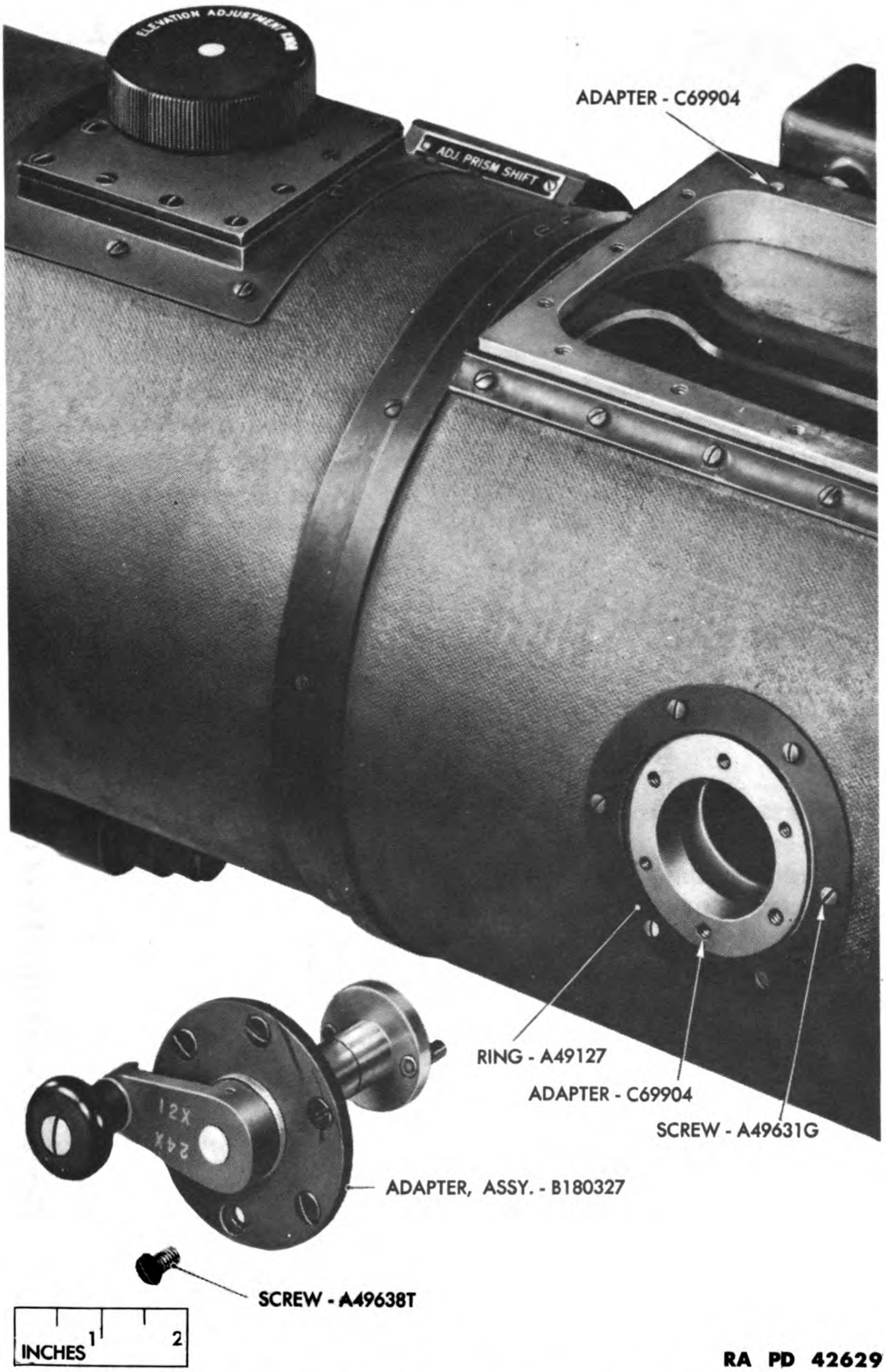

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Figure 99 — Removal of Change-of-magnification Crank Adapter Assembly

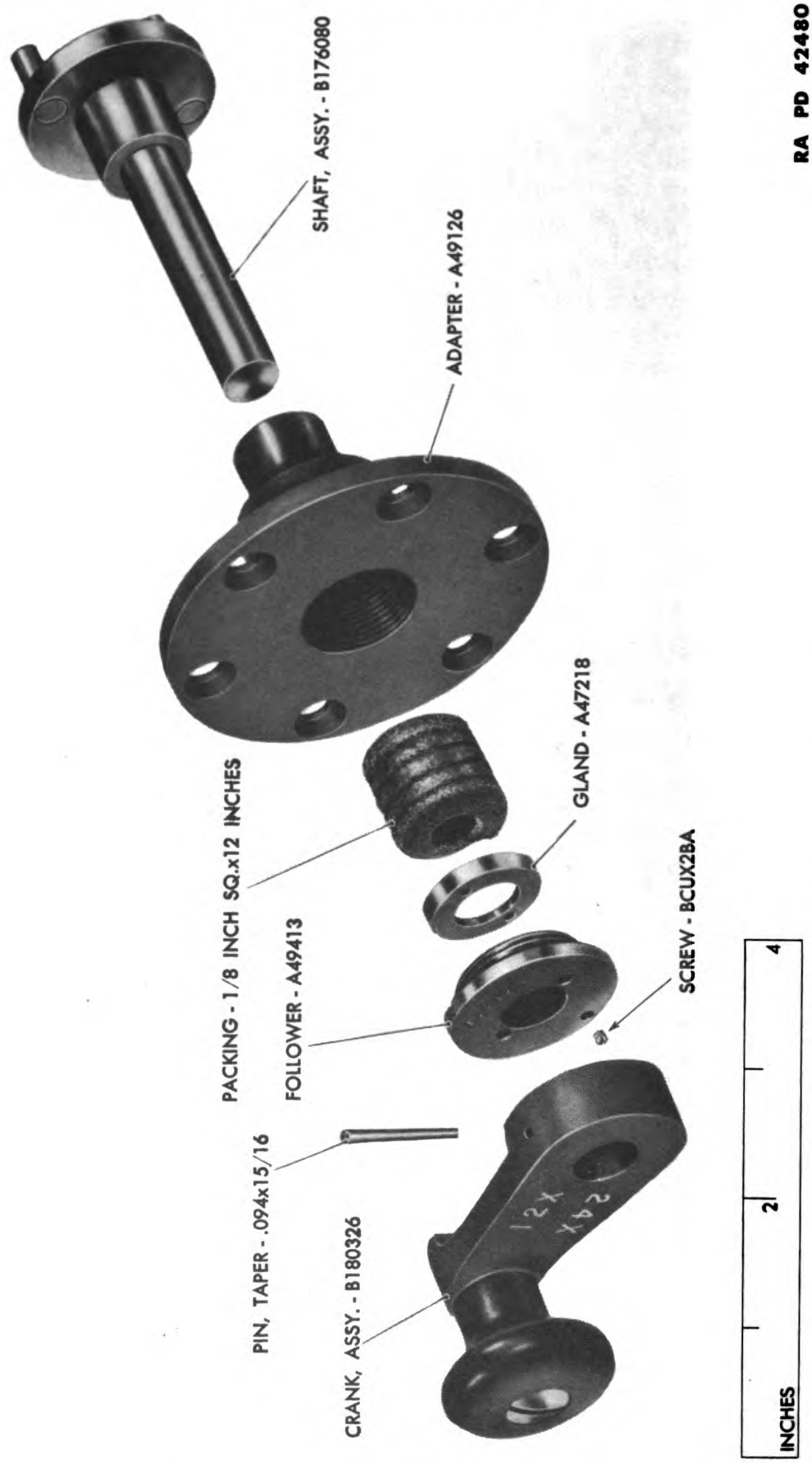

Figure 100 — Disassembly of Change-of-magnification Crank Adapter Assembly

(b) Remove the two screws holding the spring to the left-hand bracket (fig. 31).

(3) If the eyepiece diopter settings for zero parallax with the divergence tester or collimating telescope reticle decrease in shift from low to high power, enlarge the two screw holes in the spring on the sides away from the detent block to increase the effective length of the spring. If necessary to go in the other direction, obtain a shorter detent assembly.

(4) Reassemble the detent assembly and check the adjustment.

(a) Force the filed edges of the holes against the screws while tightening the screws.

(b) Replace the eyepiece housing and eyepiece unit, using four corner screws to hold each in place.

(c) Check the diopter settings for high and low power with a divergence tester or a dioptometer to determine whether the shift of focus has been brought within ¼ diopter.

(5) When the shift of focus is within tolerance, proceed as follows:

(a) Seal with COMPOUND, sealing, for height finders, and replace the eyepiece housing and eyepiece unit and adjust for dipvergence as in paragraph 43 e.

(b) Recheck the shift of focus from high to low power.

e. Change-of-magnification Crank.

(1) The movement of the change-of-magnification crank should be free but positive. A click should be heard at each of the two alternate settings. The pins of the shaft assembly should not bind in the slots of the change-of-magnification disk, even at the extreme settings of the elevation adjustment knob. Also, the ends of the pins should not touch the change-of-magnification disk or its pivot screw at any angle of elevation of the height finder. If the crank is damaged or there is any indication of trouble, disassemble and make needed repairs as follows:

(2) Remove the six screws, break the seal and slide out the crank adapter assembly (fig. 99).

(3) Remove taper pin (fig. 100), lift the crank off the shaft, and slide the shaft out of the adapter.

(4) Loosen the set screw, back out the follower and remove the gland and packing.

(5) If the end of the shaft bears against the change-of-magnification disk when the instrument is elevated, causing changes in internal target settings, turn off part of the shoulder which bears against the inner end of the adapter, so that the shaft will seat deeper into the

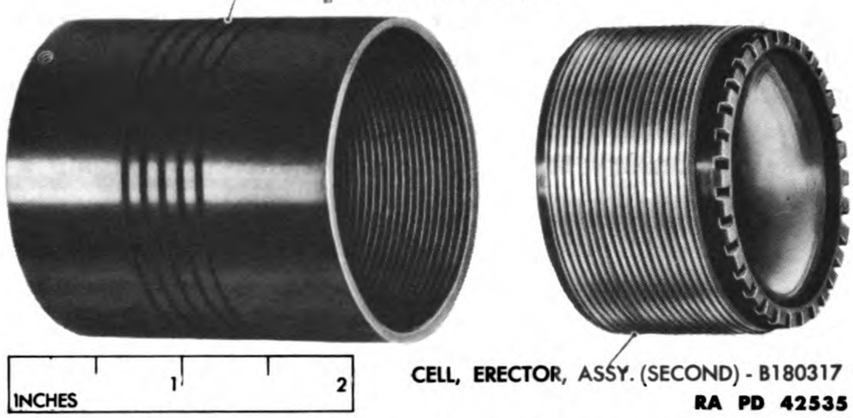

Figure 101 — Separation of First and Second Erector Cell Assembly

adapter and provide more clearance for the change-of-magnification disk. Fit and repin the crank assembly or place a washer under the crank to compensate for the metal turned off the shaft.

f. Erector Lens and Sleeve.

(1) Each erector cell is mounted in a tube which slides in a sleeve fitted in the optical tube, and cannot be removed until the optical tube has been removed from the instrument. The clearance between the erector tube and sleeve should be 0.0002 inch. If the shift from one power to the other is difficult, there may be mechanical trouble in the linkage mechanism or sleeve clearance. A very blurred or indistinct image of the reticle may indicate need for adjustment, cleaning, or replacement of the erector lens. However, the points mentioned in paragraph 65 should be checked before the necessary major disassembly is undertaken. After the optical tube has been removed from the instrument, the erector tubes can be removed as described in paragraph 65 d. If necessary, the erector lenses can be disassembled from their cells as follows:

(2) Mark the first and second cells so that they can be reassembled in exactly the same position; then loosen the set screw and screw out the second cell assembly (fig. 101).

(3) Loosen the inner set screw in the second cell, screw out the retaining ring, and slide out the separator and erector (fig. 103).

(4) Loosen the set screw of the first cell, screw out the retaining ring, and remove the separator and erector (fig. 102).

CAUTION: Since the lens surfaces may have been coated to reduce reflections, use care in handling and cleaning (par. 36).

(5) When remounting the erectors in their cells, make sure that all

HEIGHT FINDER TELESCOPE—ADJUSTMENT AND REPAIR

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Figure 102 — Disassembly of First Erector Cell

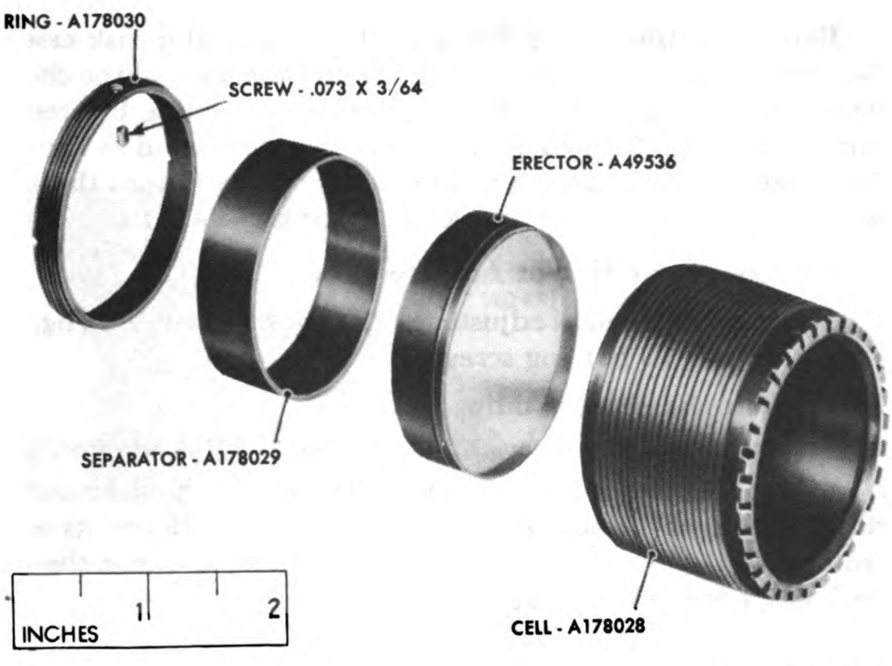

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Figure 103 — Disassembly of Second Erector Cell

parts are replaced in the proper positions and orientations. Check with polarized light for lines of strain, and shellac the heads of the set screws.

(6) Screw the second cell into the first cell to the correct depth as indicated by the marks. Adjustment of the focal length, if necessary, and replacement and adjustment for shift of focus are described in paragraph 66.

55. HEIGHT ADJUSTER DISK (HEIGHT OF IMAGE ADJUSTMENT).

a. **Explanation.** The internal target readings made at the two extreme ends of the travel of the height adjuster disk should agree within 2 UOE. If the readings are not within tolerance, and the internal target line is free from tilt or lean, it is an indication that the axis of rotation of the height adjuster disk is not properly alined parallel to the reference plane of the height finder, and it will be necessary to adjust it by tilting the adjuster assembly.

CAUTION: Every effort should be made to determine whether the variation is due to one of the internal adjuster target lines being rotated very slightly to cause fused stereo-vertical appearance so slight as to be hard to detect. If this be true the same corrective effect can be obtained by slightly rotating one internal adjuster objective bearing the reticle to parallelism with the other (par. 57).

b. **Requirements.** Leveling of the height adjuster disk assembly involves breaking the hermetic seal of the instrument, and the checking of the adjustment requires that the internal target line be free from any tilt or lean (par. 57). The special wrench illustrated in figure 109 will facilitate the work, since it will make it possible to turn the adjusting screw without replacing the knob assembly each time.

c. **Adjustment of Height Adjuster Disk.**

(1) Remove the height adjuster knob adapter assembly (fig. 104), after removing its 10 holding screws.

(2) Adjust the disk mounting as follows:

(a) Loosen the four screws at the corners of the adapter.

(b) Turn the two set screws (fig. 105) in by equal amounts, to tilt the disk assembly while keeping its adapter parallel to its seat on the inner tube. (The set screws may be located in either the upper or the lower edge of the adapter.)

(3) Test the setting:

(a) Tighten the four holding screws.

(b) Using the special height adjuster wrench (fig. 109), turn the adjuster screw as far as it will go in one direction.

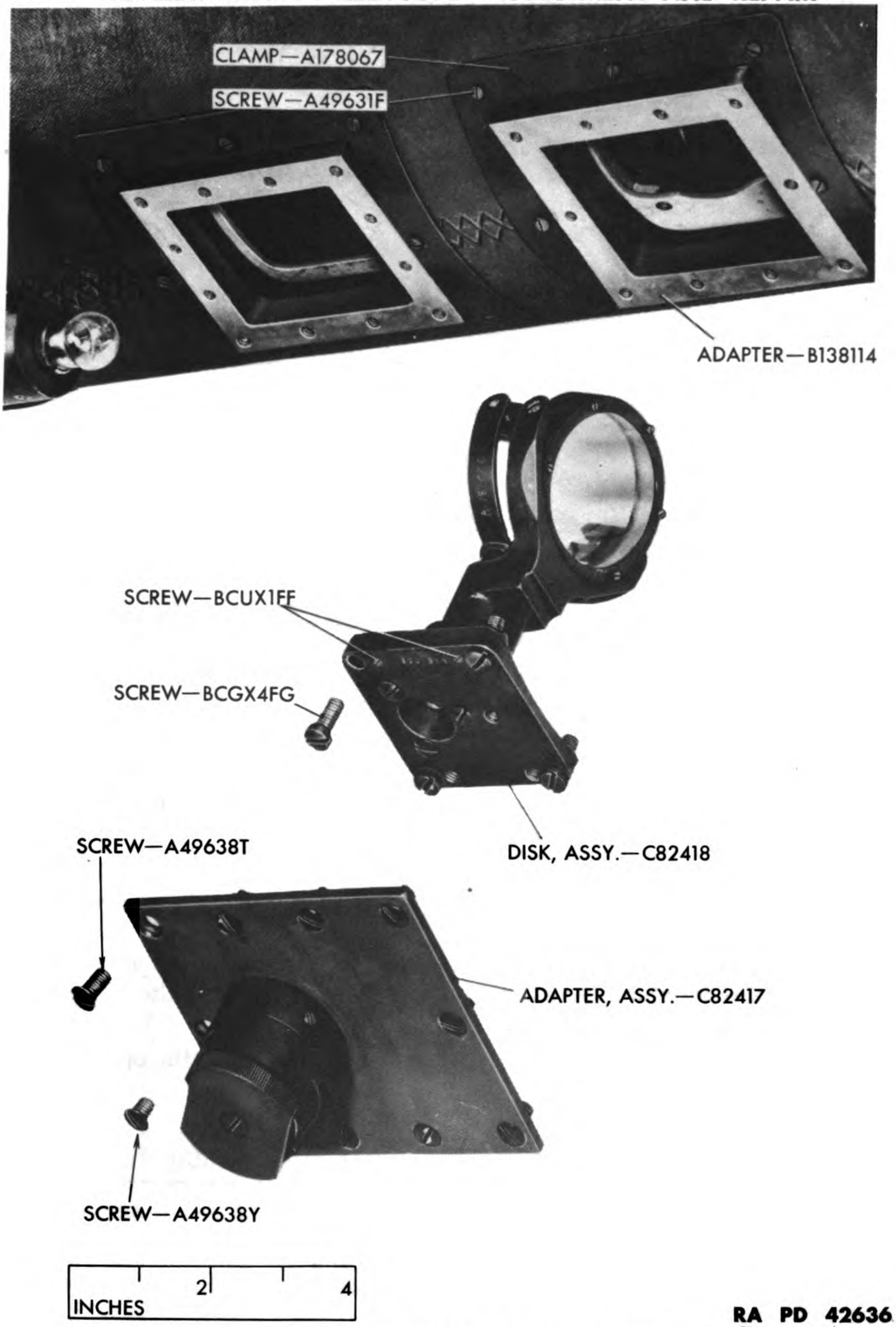


Figure 104 — Removal of Height Adjuster Adapter Assembly and Height Adjuster Disk Assembly

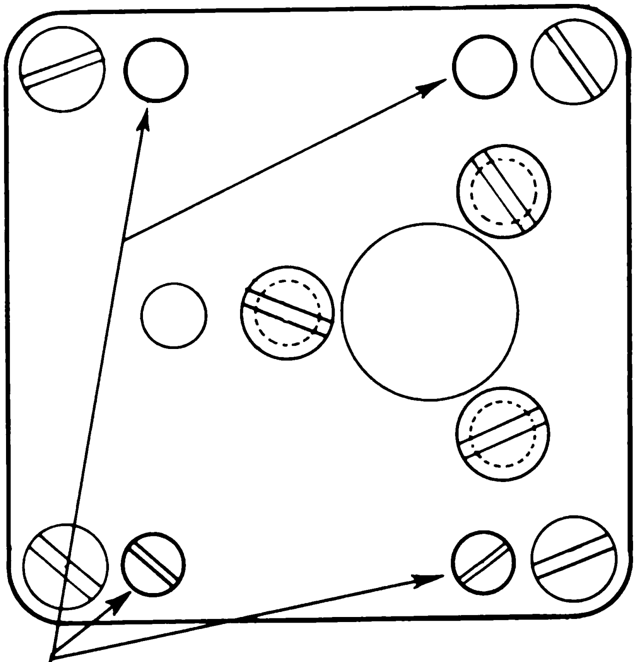


Figure 105 — Positions of Set Screws for Adjusting Height Adjuster Disk Assembly

(c) Make five internal target readings and record the median.

(d) Turn the adjuster screw as far as it will go in the other direction and make five internal target readings.

(4) Repeat steps (2) and (3), above, until the readings are within tolerance. If, after the first trial, the readings are closer together, continue to turn the set screws in. If the readings are farther apart, turn the set screws out. It may be necessary to remove the set screws from the holes in which they are found and place them in the holes on the other side of the adapter.

(5) Make sure height adjuster assembly does not touch the optical tube.

(6) Replace the knob adapter assembly:

(a) See that the joining surfaces between the assembly and its adapter on the tube are clean and properly coated with COMPOUND, sealing, for height finders.

(b) Place the assembly in position, making sure that the joint A178054 (fig. 106) properly engages the head of the adjuster screw A181007 (fig. 108).

(c) Replace and tighten the 10 holding screws, placing the 2 short screws in the middle holes at the ends of the adapter.

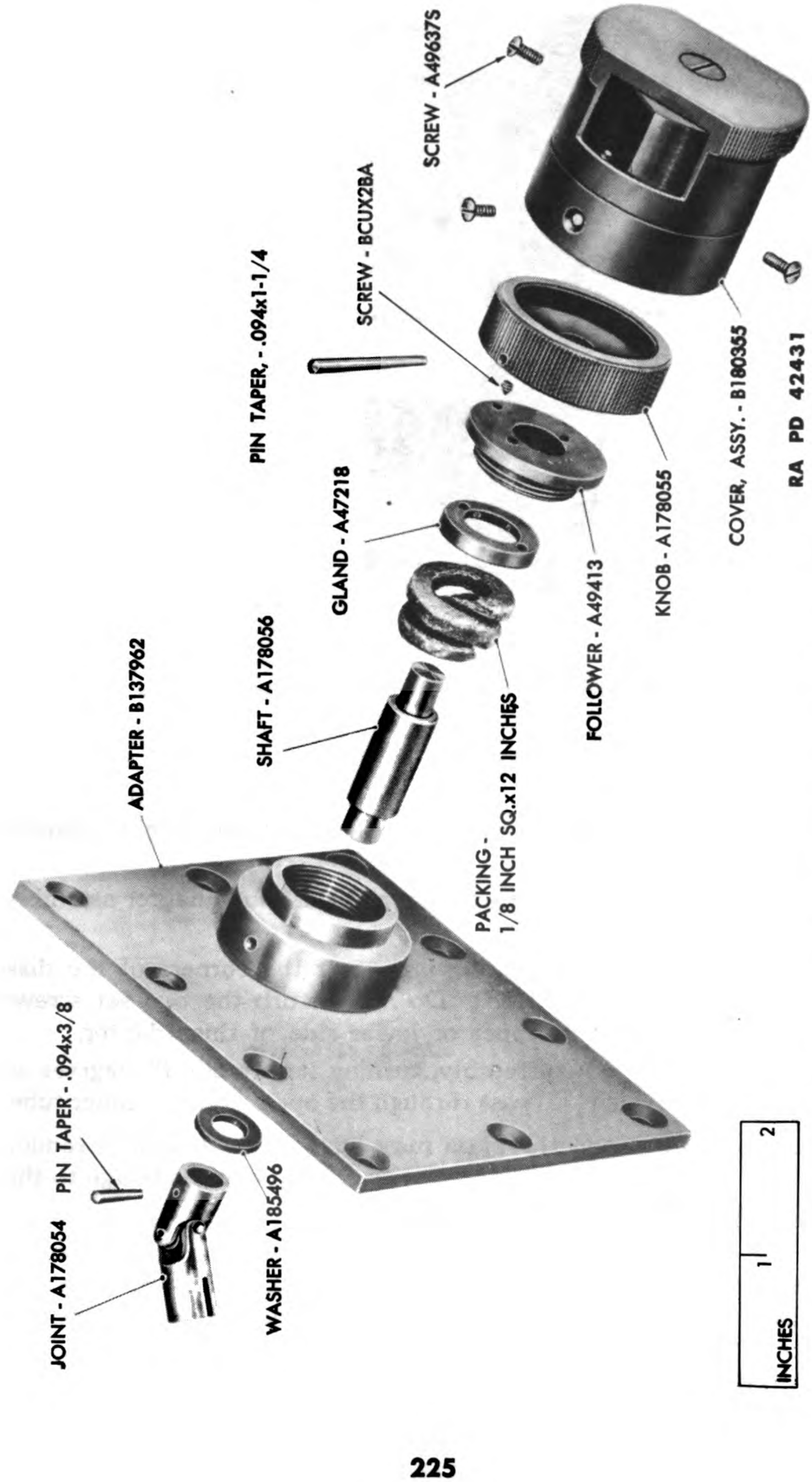


Figure 106 — Disassembly of Height Adjuster Assembly

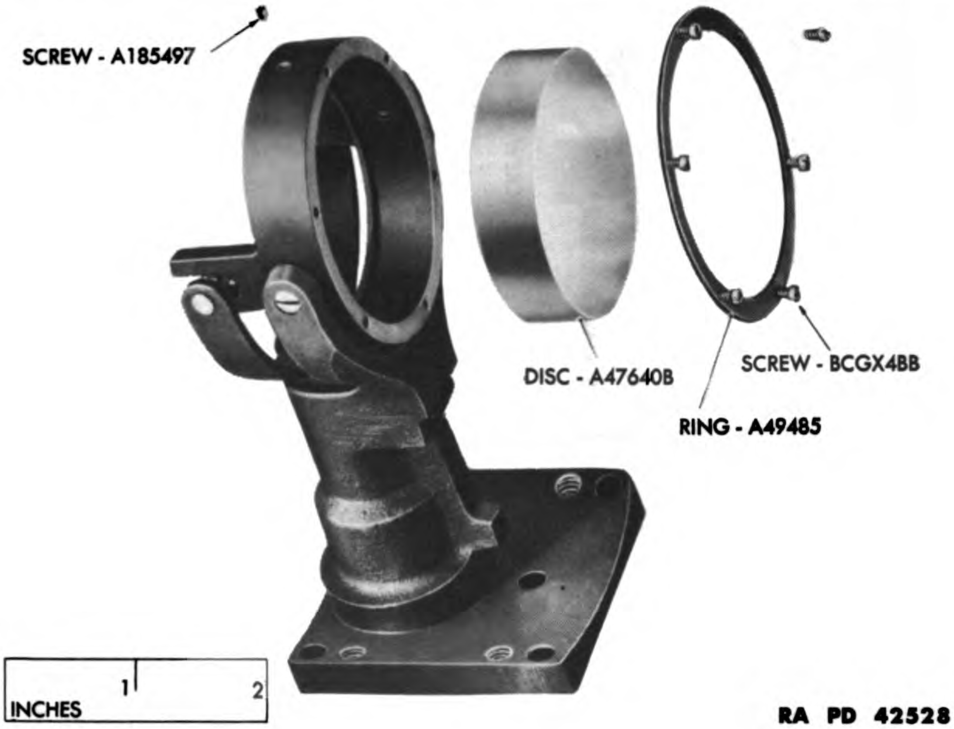


Figure 107 — Removal of Height Adjuster Disk from Its Mount

d. Removal of Height Adjuster Disk.

(1) In order to clean or replace the height adjuster disk, or any parts of its mounting, it is necessary to remove the height adjuster disk assembly as follows:

(a) Remove the 10 holding screws and the knob adapter assembly (fig. 104).

(b) Remove the four holding screws at the corners of the disk adapter assembly. CAUTION: Do not disturb the two set screws in the inner holes on the upper or lower side of this adapter.

(c) Lift out the disk assembly, turning it through 90 degrees so that the hinge and yoke will pass through the opening in the inner tube.

(2) The surfaces of the glass may have been coated to reduce reflections; if so, it must be handled with care to avoid damage to the coating (par. 36).

(3) To install a new disk, remove the six screws (fig. 107) to permit removal of the retaining ring A49485 and the disk A47640B. The ring should clamp a new glass tightly enough to prevent any looseness, but not enough to show strains in polarized light.

(4) After the disk assembly is replaced in the inner tube, and before the knob assembly is sealed on, check the internal target read-

HEIGHT FINDER TELESCOPE—ADJUSTMENT AND REPAIR

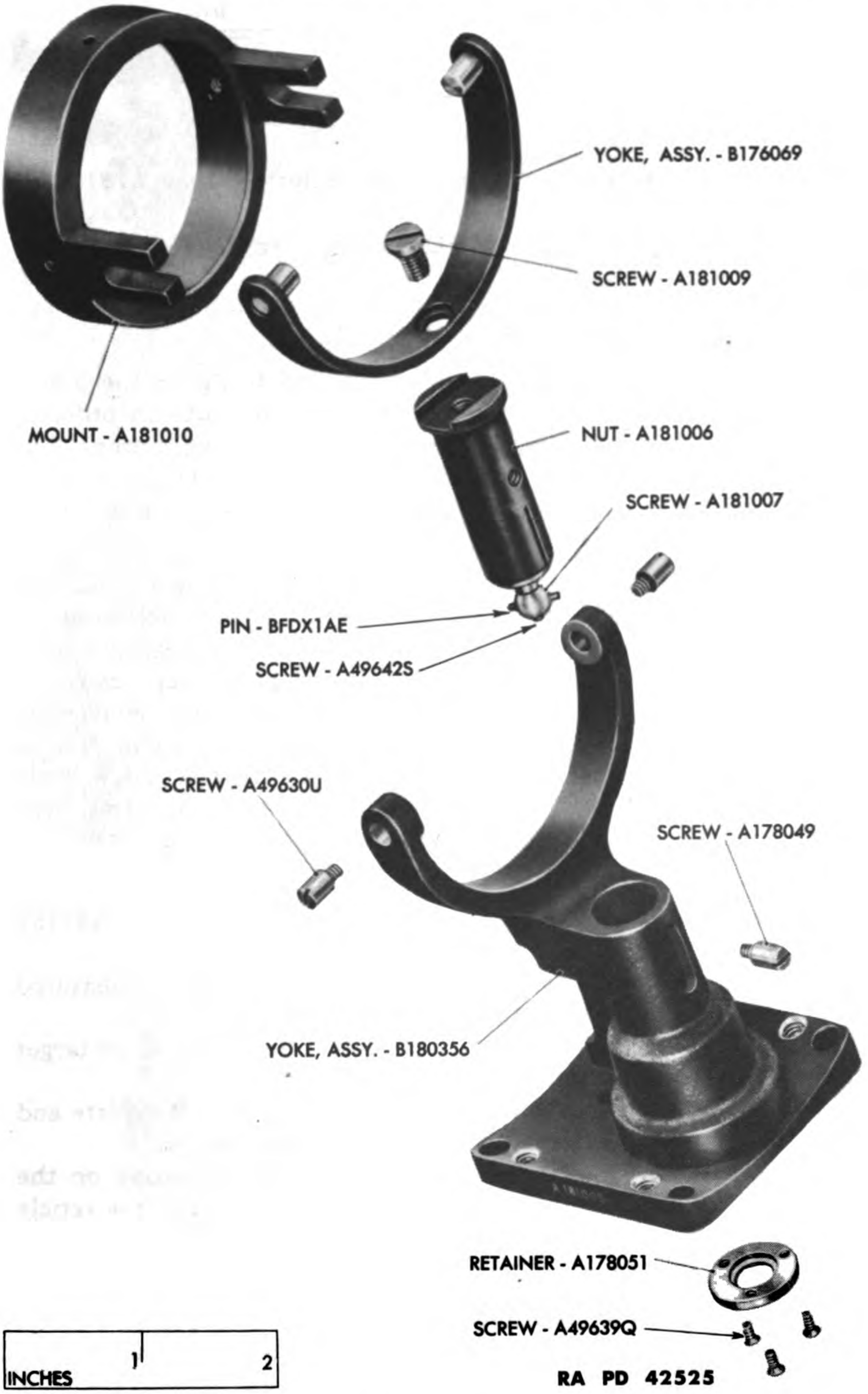


Figure 108 — Disassembly of Height Adjuster Disk Assembly

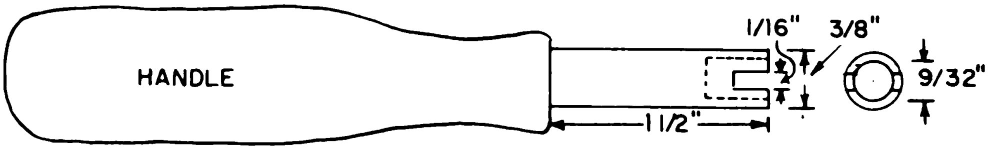


Figure 109 — Special Wrench for Height Adjuster Screw A181007

ings and, if necessary, adjust the disk as described in subparagraph c, above.

56. ELEVATION ADJUSTMENT KNOB.

a. **General.** The 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. The stops should be set to allow rotation of the tube through an angle ½ to 1 degree, and if one of the stops should become loose it will be necessary to readjust the fine elevation unit.

b. **Requirements.** In order to adjust the stops, it is necessary to have an external target with a measured vertical span which subtends an arc of approximately 30 minutes (height of 8¾ yards for each 1,000 yards of range). The elevation tracking telescope must be properly alined with respect to the movement of the height conversion ring (pars. 41 and 71). In an emergency, the adjustment can be made by estimating the positions of the image in the reticle field, which is 3 degrees in diameter at low magnification. The adjustment does not involve breaking the hermetic seal of the instrument.

c. **Adjustment of the Stops.**

(1) Loosen the nut A47158 on the rear stop screw A47159 (fig. 111).

(2) Aline the height finder so that the bottom of the measured target is centered in the elevation tracking telescope.

(3) Turn the elevation adjustment knob until the top of the target is centered in the main reticle field.

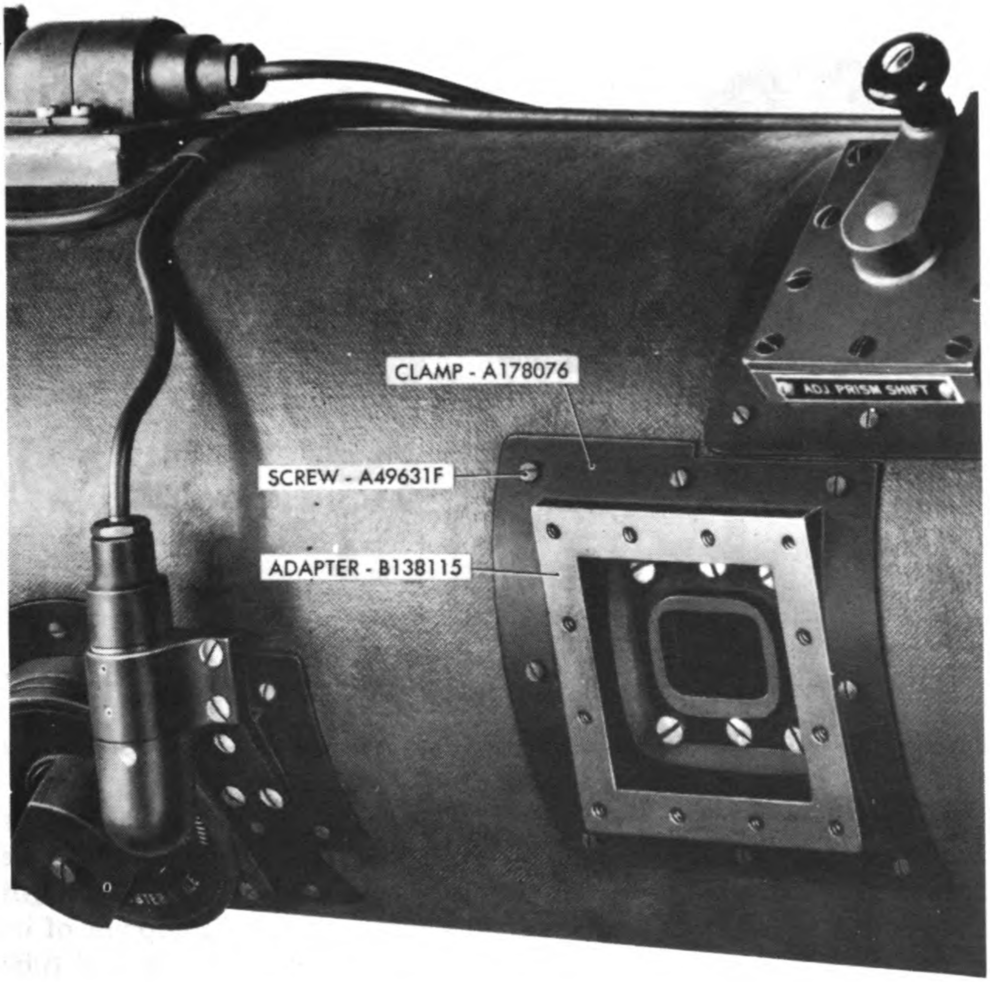
(4) Place the stop screw against the lug on the adapter plate and tighten the nut. Recheck the position of the target image.

(5) Loosen the other stop, aline the tracking telescope on the top mark of the target, center the bottom of the target in the reticle field, and set and tighten the stop.

d. **Removal and Disassembly.**

(1) To remove the elevation adjustment knob adapter assembly, remove the 12 screws and lift the assembly out of the instrument (fig. 110).

(2) To disassemble the unit, remove the taper pin and pull the knob assembly from the shaft (fig. 112).



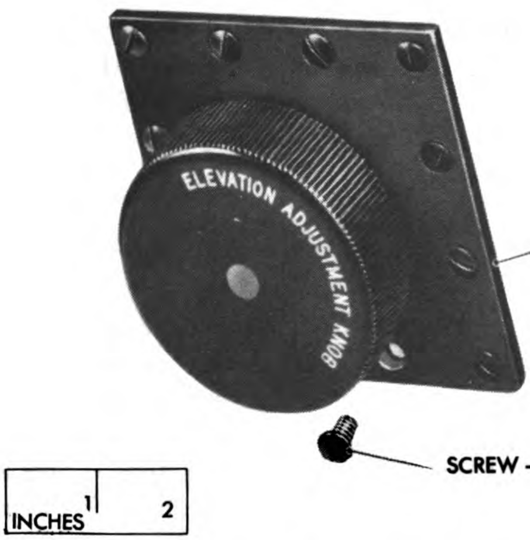


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Figure 110 — Removal of Elevation Adjustment Knob Adapter Assembly

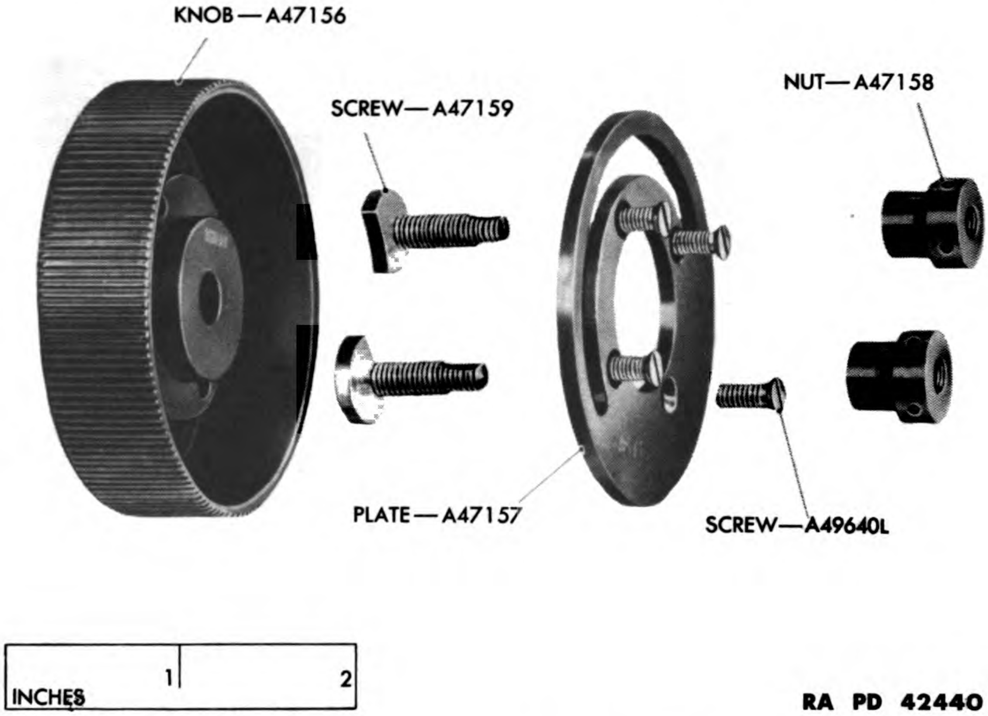


Figure 111 — Elevation Adjustment Knob and Stops — Exploded View

(3) When replacing the unit, clean the seating surfaces of the adapters and apply COMPOUND, sealing, for height finders. Slide the ball bearing race into the bracket on the inner tube from left to right and replace the 12 screws. The knob should be at the midpoint of its travel when the outer tube is leveled and the flat on the optical tube beneath the eyepiece housing is at 10 degrees to the horizontal. The shaft and bearing should fit snugly with no looseness or lost motion. Lost motion usually can be eliminated by squeezing together the upper and lower sides of the adapter on the inner tube and refitting the bearing to it. CAUTION: The knob ball bearing race will tilt off axis of rotation unless great care is used in assembling.

57. INTERNAL TARGET SYSTEM — COMPLETE ADJUSTMENT.

a. **Explanation.** 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. The one exception is the use of the centering disk for shifting the position of the target line to suit the preference of the stereo observers. 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.

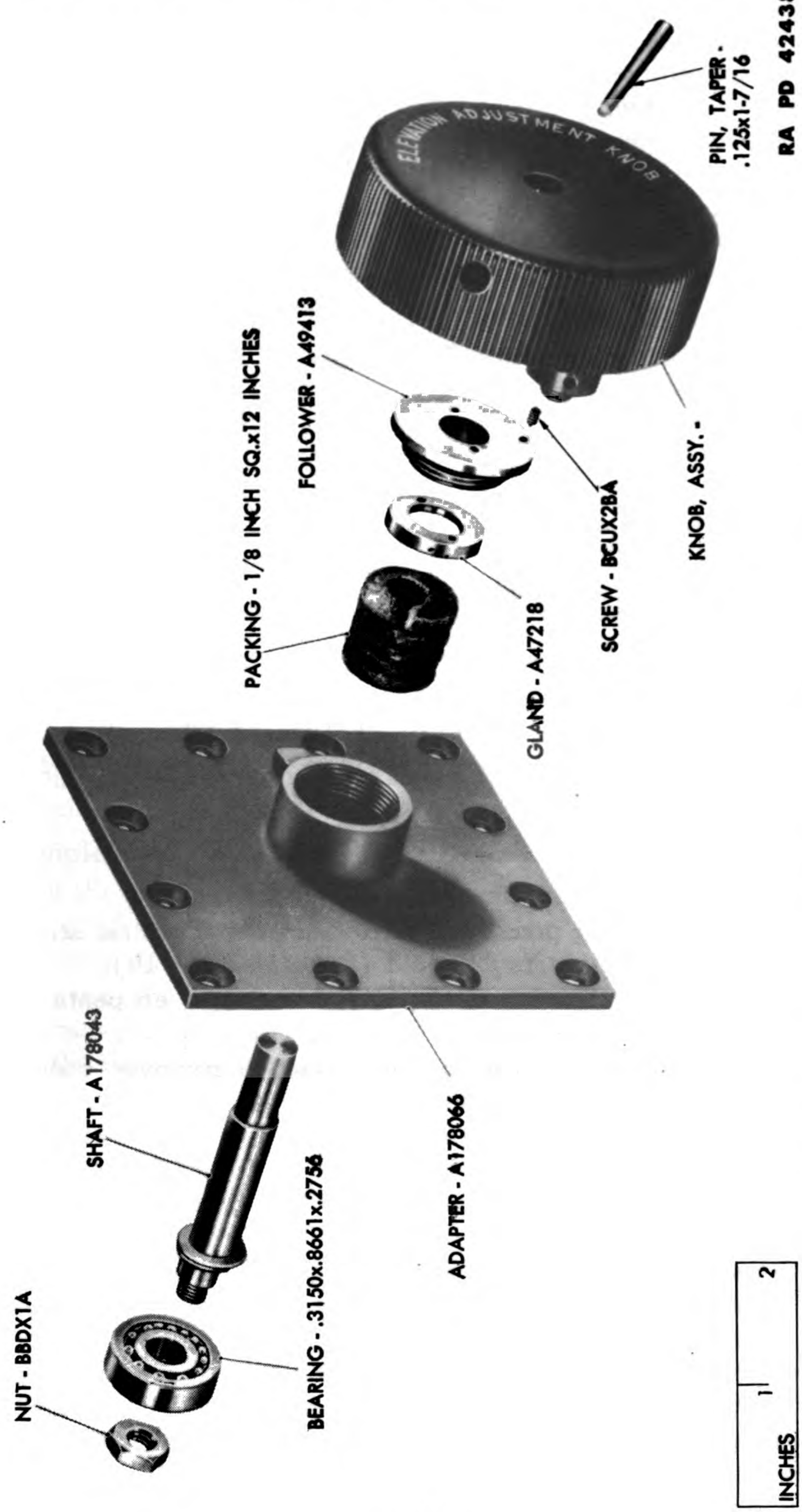


Figure 112 — Disassembly of Elevation Adjustment Knob Adapter Assembly

b. Requirements. 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.

c. Outline of Adjustment of Internal Target System.

(1) PREPARATION (HEIGHT FINDER MAIN OPTICAL SYSTEM MUST BE IN ADJUSTMENT).

(a) Set height-range lever at "height" and measuring drum at "infinity."

1. Adjust height adjuster for halving on an external target.

2. Set adjuster scale at 50.

(b) Set internal target centering disk at midposition (fig. 113). (Adjusting screws project equal amounts from bracket—do not turn screws too tight.)

(c) Remove end windows. (Mark windows and adapters so that they can be replaced in the same positions.)

(d) Turn adjuster prism shift for internal readings.

(e) Remove right and left internal target bracket assemblies (figs. 115 and 116).

(2) ROUGH-ADJUSTMENT.

(a) Penta Prisms.

1. Insert light into left bracket opening (fig. 117).

2. Tilt right penta prism mount, by turning eccentric screw, to center light spot in right reticle field (figs. 118 and 119).

3. Place light in right bracket opening and adjust left penta prism.

(b) Check Mirror Settings.

1. Insert both bracket assemblies, place lamp over condenser opening of left bracket, examine moon in right eyepiece. (Moon should be evenly illuminated, shadows at sides balanced or eliminated, no sharp cut-off.)

2. Repeat for right bracket—check left eyepiece.

(c) Objectives.

1. Flint objective. Set cell so that target line is at right angles to center line of adapter arm and tighten set screw (both bracket assemblies) (fig. 121).

2. Focus. Insert both bracket assemblies, turn crown objective cell of right assembly to focus target line in plane of right reticle.

3. Turn crown objective to bring "image up" and set target line the proper distance to right of center reticle mark (fig. 122).

4. Replace condenser cell.

5. Repeat for left assembly.

(d) *Wedges.*

1. Turn left wedge cell to bring moon "image down" and place target line proper distance to right of center reticle (fig. 122).

2. Tighten set screw.

3. Turn right wedge cell to bring "image down" and target line into stereo contact with main reticle. Tighten set screw.

4. *Check.* Adjuster scale reading should be between 40 and 60.

(e) Shellac set screws and install guides.

(3) FINE-ADJUSTMENT.

(a) Adjust penta prism to recenter moons. (Left moon centered up and down within 1 minute; right moon within 1 minute of left moon.)

(b) Remove "tilt" (fig. 123) and "lean" (subpar. **d** (12) *(d)*, below). Adjust left objective adapter to remove tilt from target line in right eyepiece. Adjust right objective adapter to remove all "lean" in stereo.

(c) Adjust wedge adapters to bring adjuster scale reading to desired value 50.

(d) Adjust centering disk to place target line in desired position in reticle field (par. 55 **a**).

(e) Shellac holding screws and adjusting screw. Seal and replace illuminating window assemblies and lamps.

(f) Replace and adjust end windows (par. 60).

d. Complete Adjustment of the Internal Target System.

(1) Set the height-range lever at "range," set the measuring drum at "infinity (*)," adjust the height adjuster on an external target and set the adjuster scale at 50.

(2) Set the centering disk at middle position of its travel as follows:

(a) Remove the access plug just below the junction box (fig. 113).

(b) If the headless adjusting screws do not project equal amounts from the bracket, loosen one and tighten the other until they do. (Do not tighten the screws excessively, or the mount may be distorted enough to crack the glass.) This should center the centering disk. If the disk or its mount has been damaged, it will be necessary to remove from the outer tube all units which interfere with the complete rotation of the inner tube in order to bring the centering disk bracket under the opening for the eyepiece housing, through which the assembly (fig. 114) can be withdrawn. This should seldom be necessary.

(3) Remove the end windows as instructed in paragraph 60. (Mark the windows so that they can be replaced in the same positions.)

(4) Turn the prism shift crank for internal target readings.

(5) Remove both internal target bracket assemblies as follows:

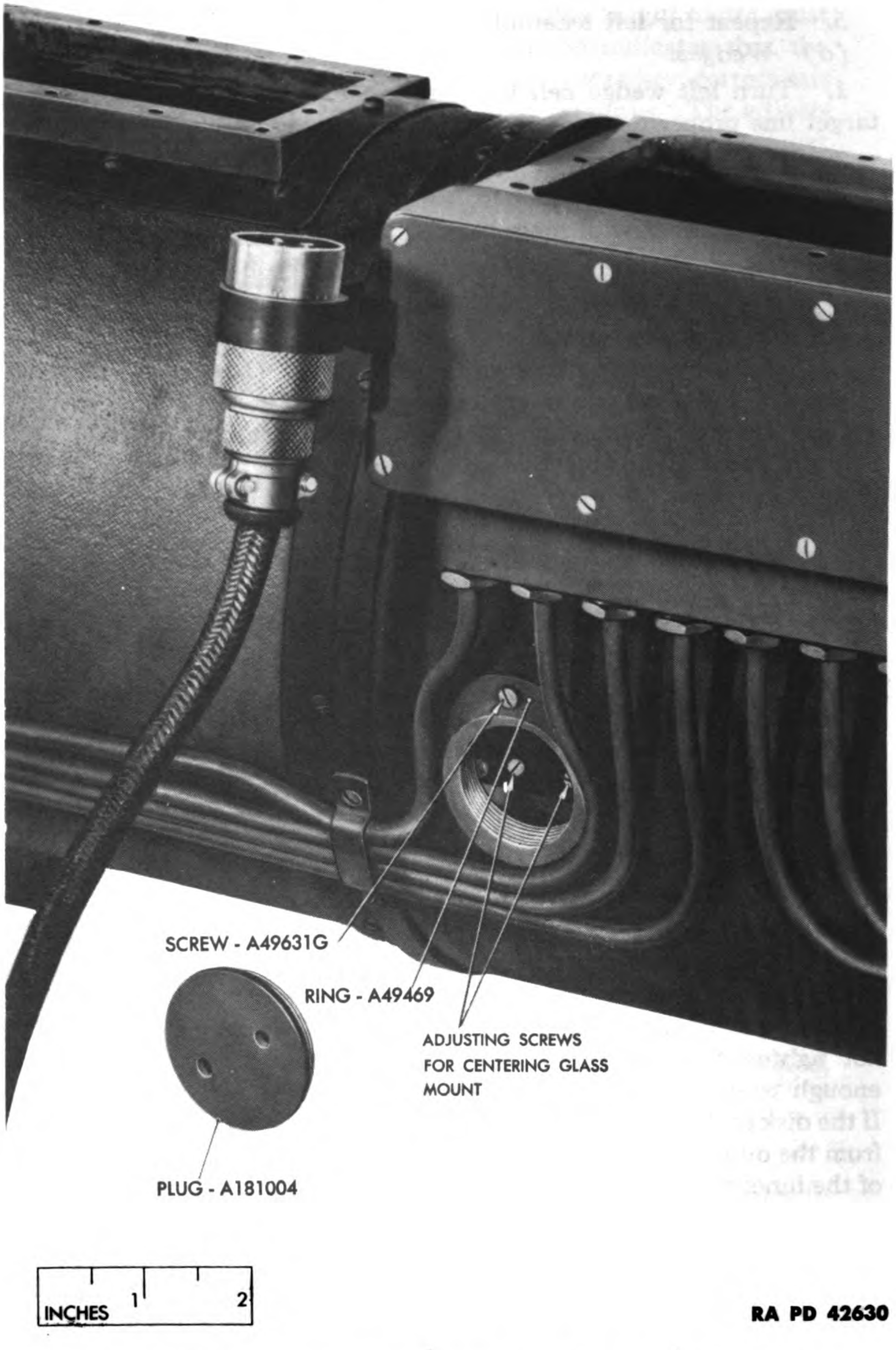


Figure 113 — Removal of Access Plug for Adjustment of Internal Target Centering Disk

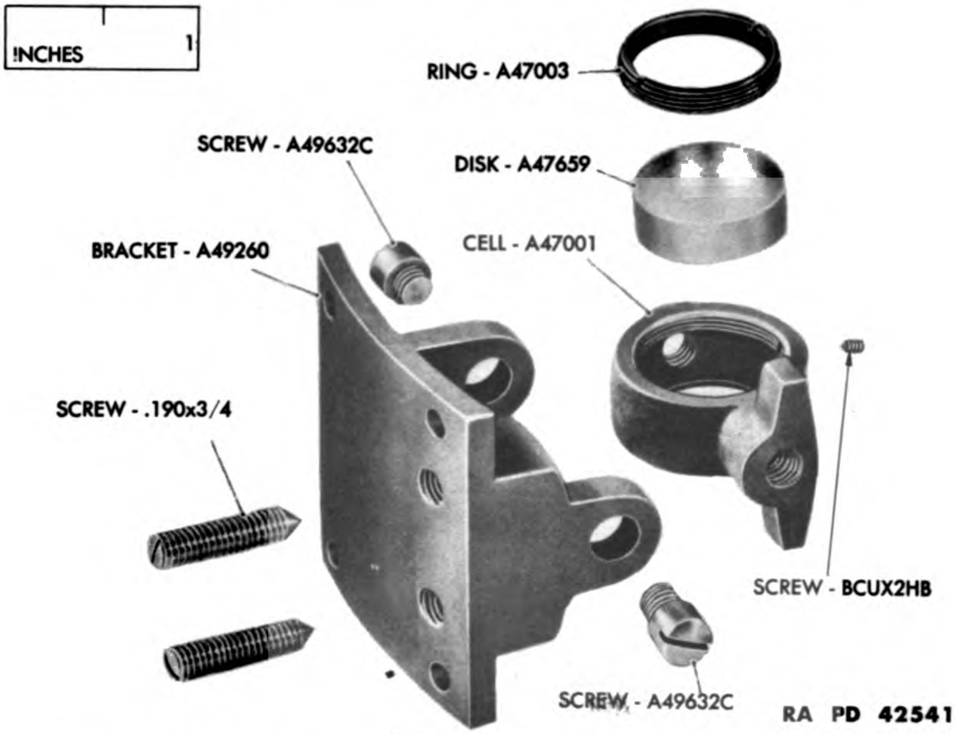


Figure 114 — Internal Target Centering Disk Bracket Assembly — Exploded View

(a) Remove the lamp cover and socket assembly by removing the five screws (figs. 115 and 116). Remove the clamp holding the lamp cable, so that the socket can be pulled back without kinking the tubing.

(b) Remove the window assembly.

(c) Remove the four bracket mounting screws and withdraw the internal target bracket assembly perpendicularly to the inner tube. The assembly is positioned by two pins, so it may be necessary to force it slightly.

(d) Shake the bracket assembly and listen for any rattle which would indicate loose mounting of lenses, wedge, or mirror. Then test all set screws securing lenses, mirror, and wedge, to make sure that there is no strain induced in the glass.

(6) Rough-adjust penta prisms for image height.

(a) Insert a light into the internal target opening (fig. 117), shine it down the small air tube, and look through the eyepieces to check the horizontal and vertical positions of the light images. When the light is in the left opening, look in the right eyepiece, and vice versa. If the image is not approximately centered as in figure 118, adjust the penta prisms as follows:

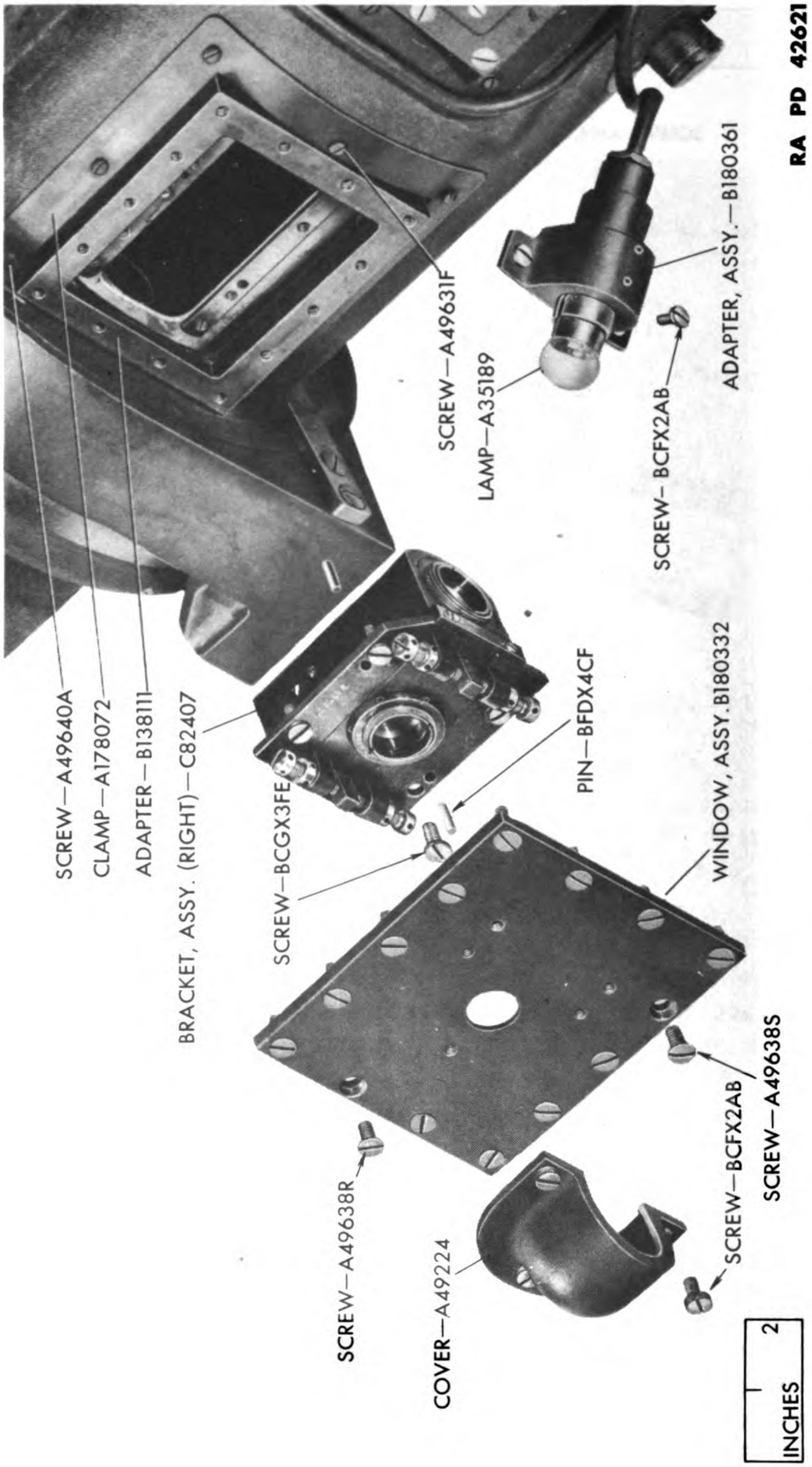


Figure 115 — Removal of Right Internal Target Bracket Assembly

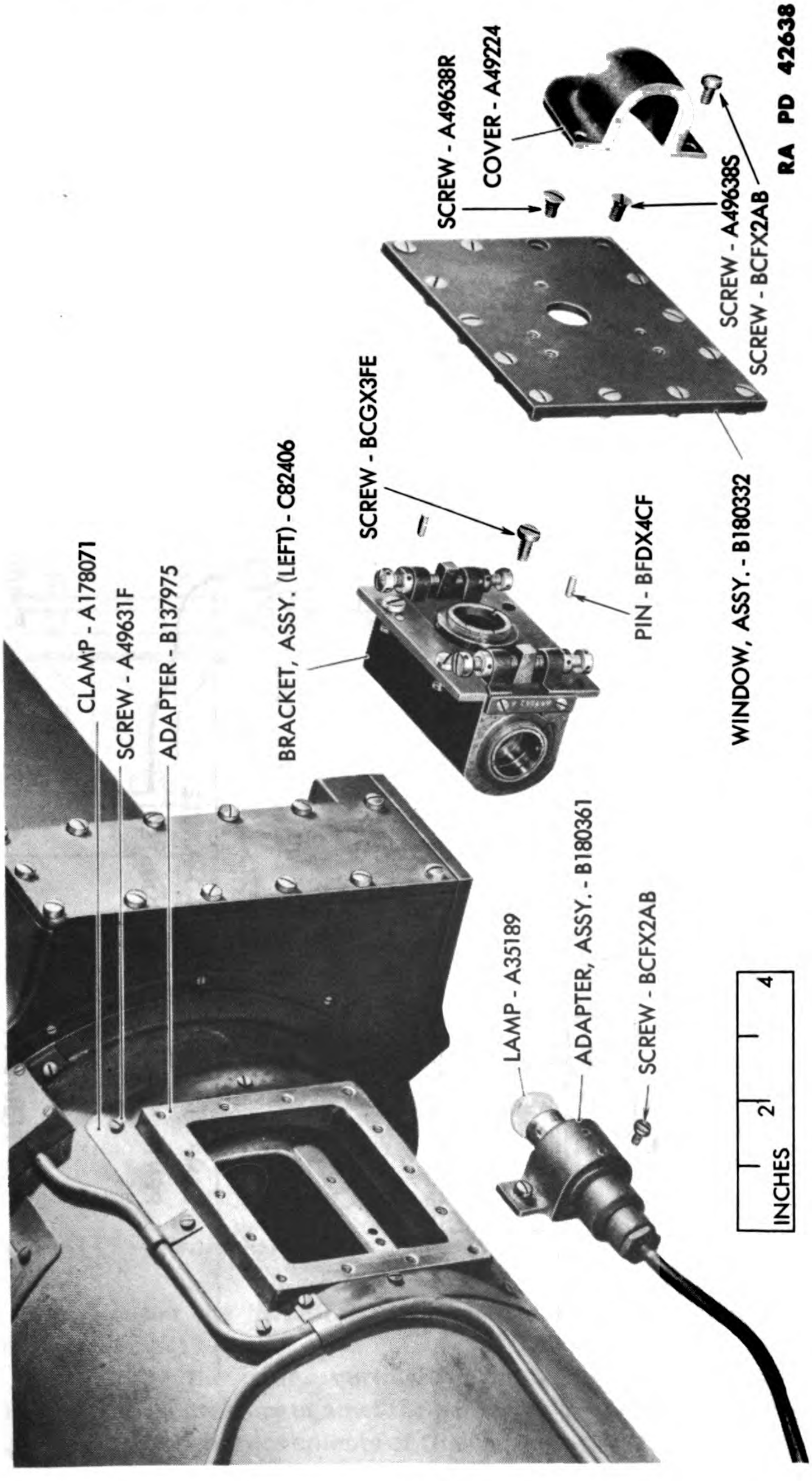


Figure 116 — Removal of Left Internal Target Bracket Assembly

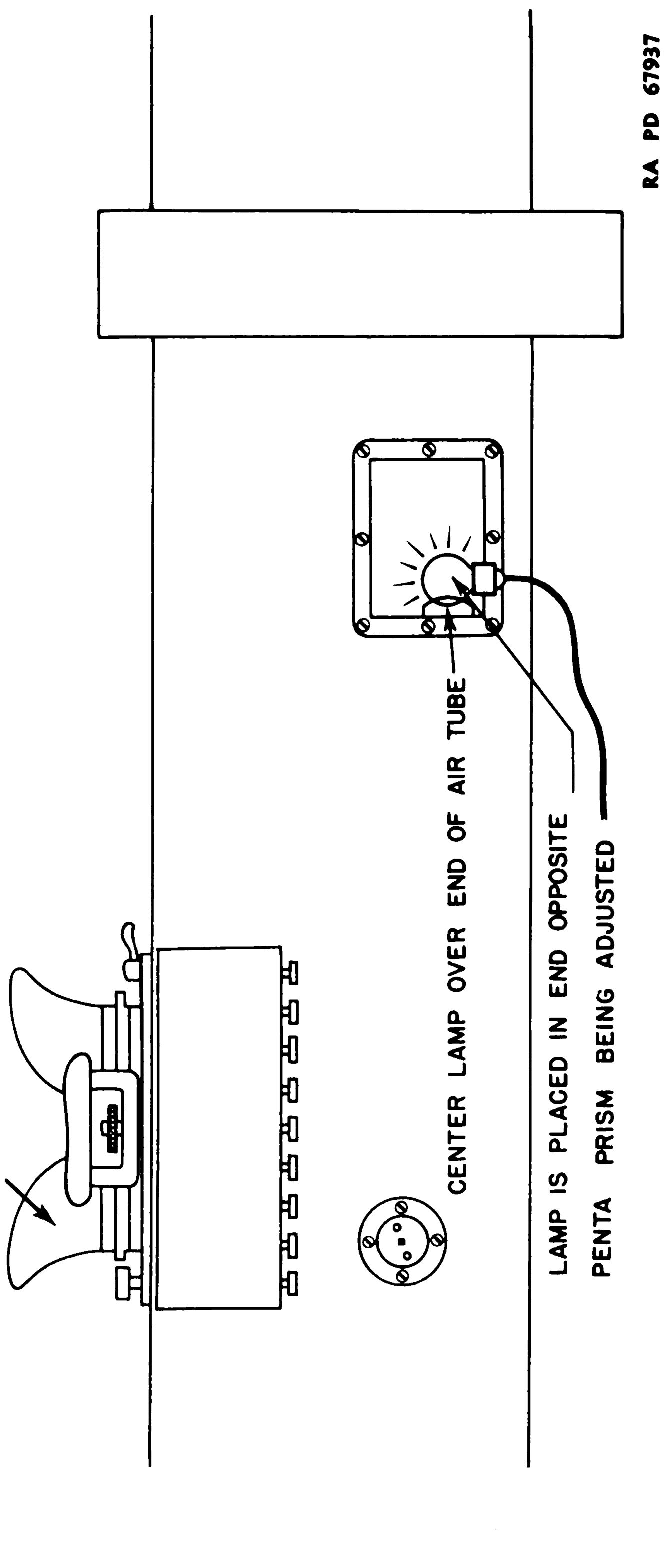


Figure 117 — Arrangement for Checking Penta Prism Adjustment

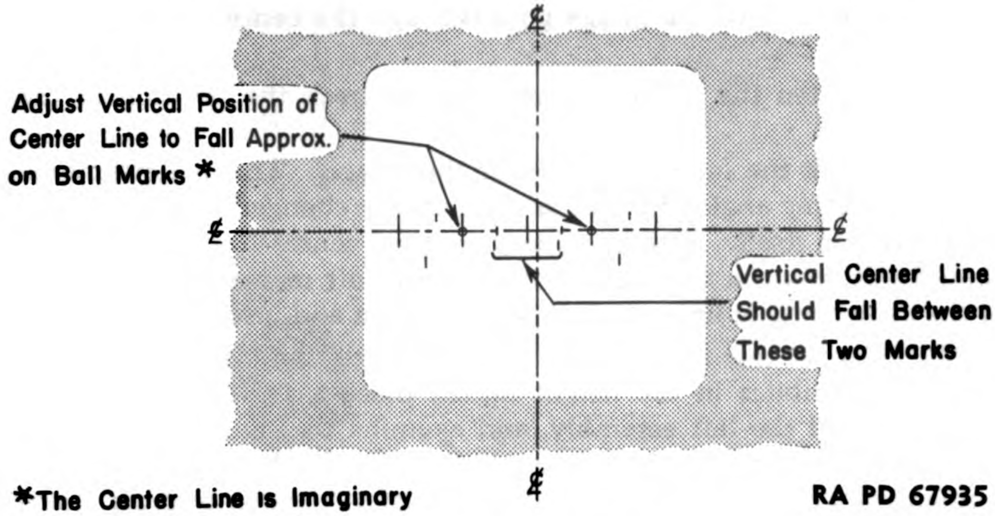


Figure 118 — Appearance of Light Spot in Reticle Field for Rough-adjustment of Penta Prism

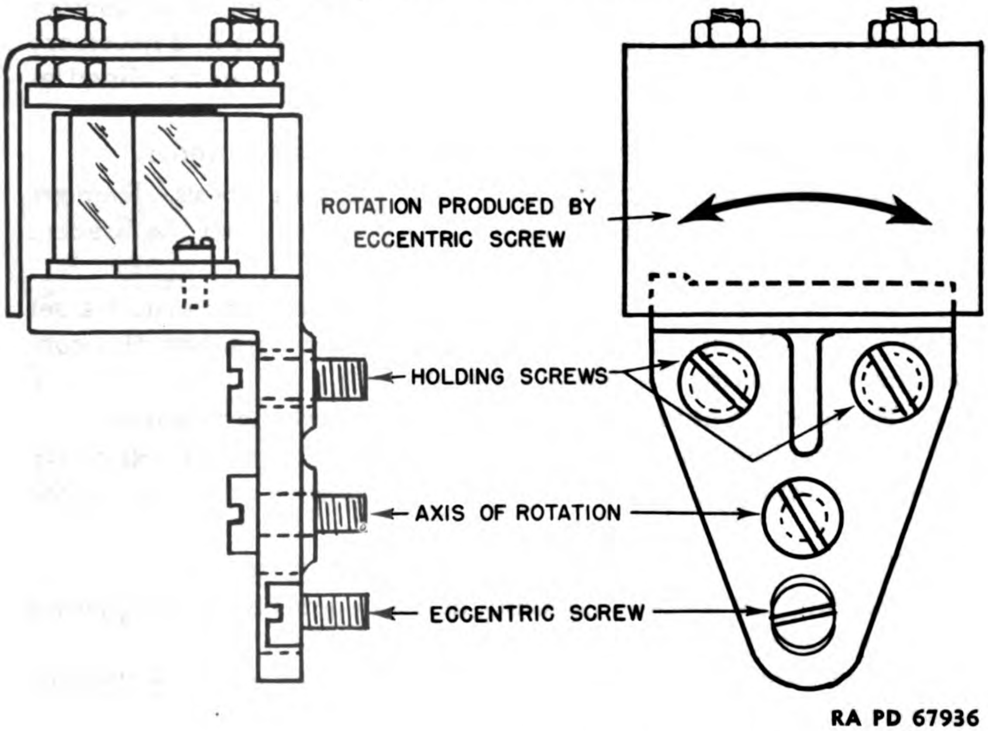


Figure 119 — Penta Prism Mount, Showing Eccentric Adjusting Screw

(b) Loosen the three holding screws on the penta prism mount assembly (fig. 119).

(c) Center the image vertically by turning the eccentric screw enough to bring pressure against the penta prism mount and then releasing it, causing slight movements of the mount, until the imaginary hori-

zontal center line of the image goes through the center of the reticle lines.

(d) Tighten the holding screws and recheck the position of the image.

(e) Check the lateral position of the image. This is determined by the reflecting angle of the prism and can be changed only by changing the prism itself. The imaginary vertical center line of the image should fall between the first set of fore and aft marks on either side of the center reticle line. If it does not, obtain and insert a new prism.

(7) Check the mirror settings. Replace both internal target bracket assemblies in the height finder, place a light over the condenser lens of the left assembly, and examine the light image in the right eyepiece. There should be a full image of the aperture of the condenser, with no shadows at the edge of the moon and no sharp cut-off. (Some earlier models have small condenser apertures, in which case the shadows cannot be eliminated. The crescents should be equal on the sides, with top and bottom evenly spaced.) Repeat with the right assembly. The mirrors have been alined at the factory and should require no further adjustment. However, if it is necessary to install a new mirror and mount, the replacement can be alined as follows:

(a) Remove the bracket assembly from the height finder.

(b) Loosen the lock nuts and back off the capstan screws. Remove the guide A49161B and the wedge adapter A49255 from the bracket B137680 or B137921 (fig. 120).

(c) Remove the set screw on top of the bracket and install a set screw in the small hole on the side of the bracket (opposite the condenser mount), leaving the screw loose.

(d) Remove the old mirror assembly and insert the new one.

(e) Rough-aline the mirror by sighting through the objective aperture and centering the image of the condenser aperture on the mirror.

(f) Replace the wedge adapter, guide, and screws.

(g) Replace the bracket assembly in the height finder and place a light in front of the condenser.

(h) Look through the height finder eyepiece to view the "moon" or image of the condenser aperture and the objective cell aperture. (The light reflected by the mirror in the left bracket assembly is seen through the right eyepiece, and that from the right mirror is seen through the left eyepiece.)

(i) Insert a small screwdriver through the condenser opening and rotate the mirror assembly until it is set to produce a full image of the condenser aperture with no shadows at the edge of the moon (or with crescents equal).

HEIGHT FINDER TELESCOPE—ADJUSTMENT AND REPAIR

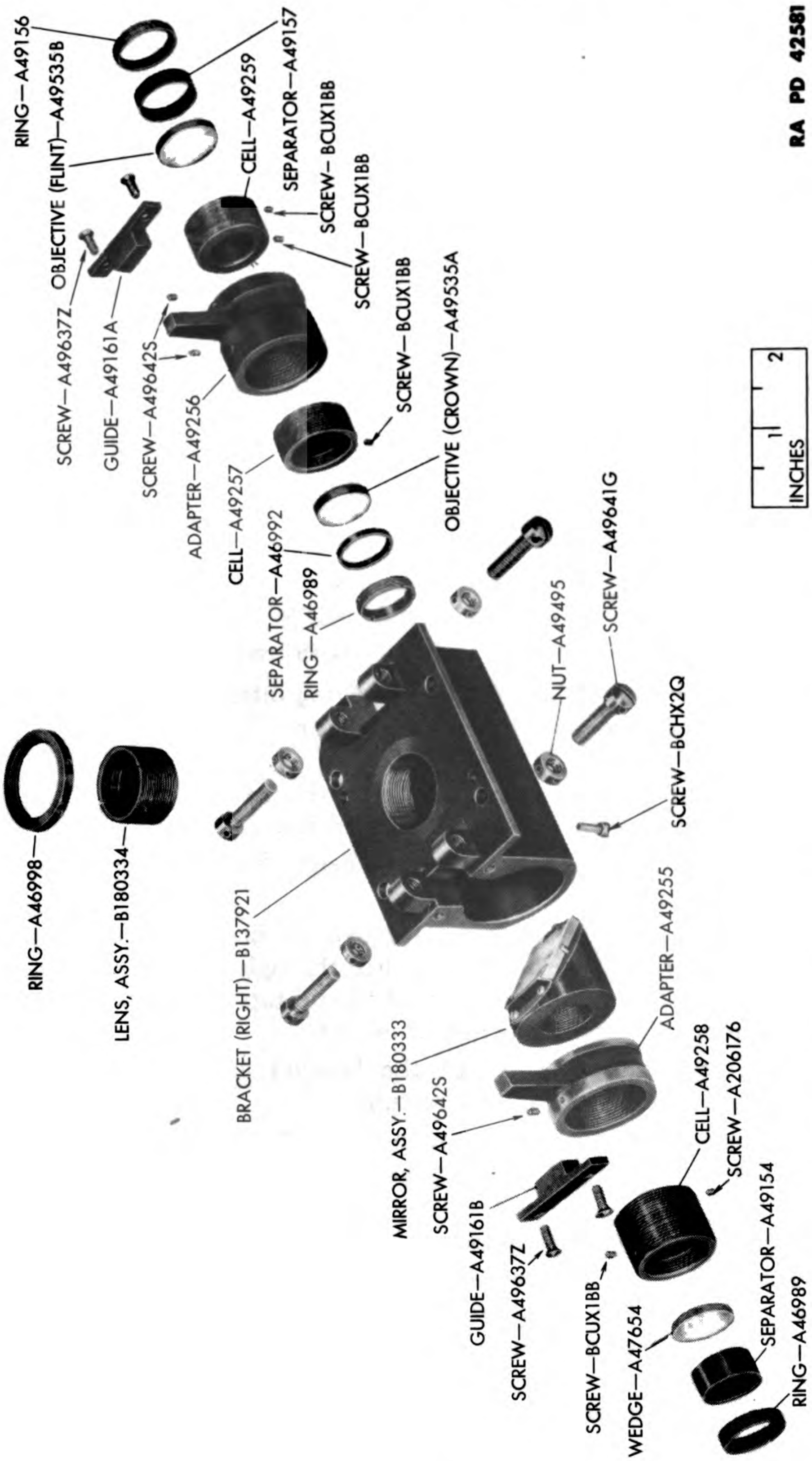


Figure 120 — Right Internal Target Bracket Assembly — Exploded View (Left Assembly Is Identical Except for Bracket B137680 in Place of Bracket B137921)

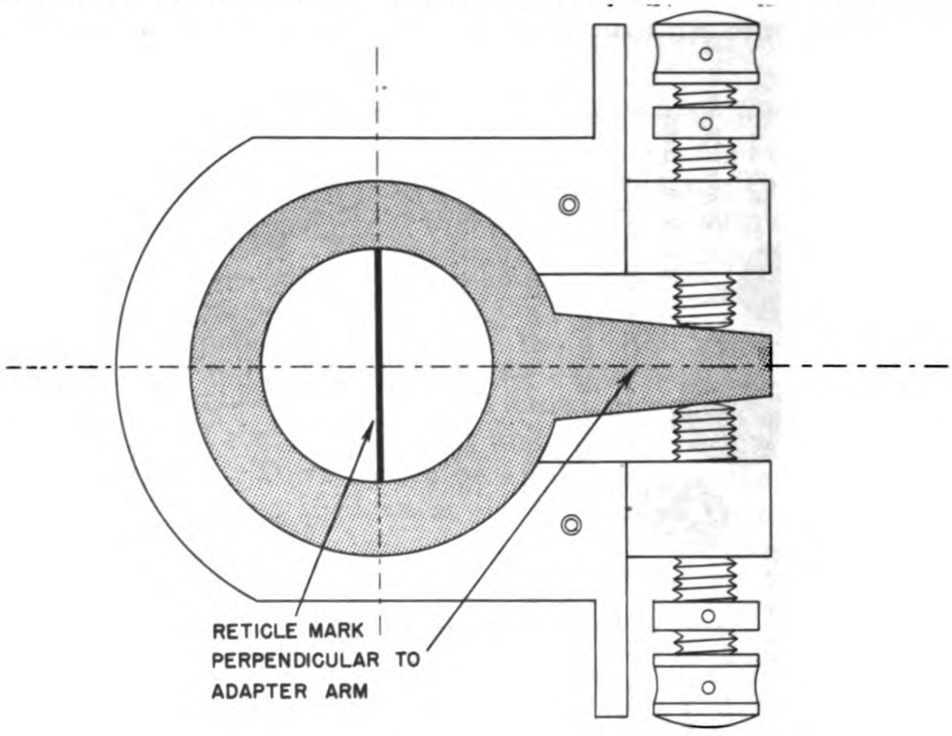


Figure 121 — Alinement of Flint Objective To Bring Internal Target Line Perpendicular to Adapter Arm

(j) Remove the bracket assembly from the height finder and tighten the small set screw on the side of the bracket.

(k) Replace the bracket assembly in the height finder and recheck the setting of the mirror.

(l) If the mirror setting is correct, remove the bracket assembly, spotdrill the mirror mount with a No. 28 drill through the hole on the back of the bracket. Finish with a No. 32 drill and tap with a standard 6-40 tap. Do not drill through the mirror mount.

(m) Install the set screw, insert the bracket assembly in the height finder, and recheck the mirror setting.

(8) Focus the objectives and rough-adjust the reticles (target lines) after the mirrors of both bracket assemblies have been set and checked.

(a) Remove the left bracket assembly from the height finder.

(b) Remove the two guides A49161A and A49161B, the wedge adapter assembly, and the objective adapter assembly.

(c) Loosen the flint objective cell set screw (in the narrow rim of the adapter), and set the cell so that the target line appears perpendicular to the center line of the adapter arm (fig. 121). Tighten the set screw.

(d) Loosen the crown objective cell set screw (in the wide rim of the adapter).

(e) Replace the objective adapter in the bracket and adjust the capstan screws to hold the adapter arm at midposition.

(f) Loosen the lock ring A46998, remove the condenser lens assembly, and replace the bracket assembly in the height finder.

(g) Shine a light through the opposite bracket assembly and focus the crown objective by turning its cell A49257 by means of a scratch awl or a jeweler's screwdriver inserted through the condenser aperture, while another operator views the image of the target line through the left eyepiece. Use care to avoid scratching the glass. The focus is not very delicate, and several turns of the cell may be required to bring the image to proper focus. (It is helpful to have the instrument in low power, but a sharper focus may be had at high power.)

(h) Adjust for the wedging effect of the crown objective. It probably will have been noticed while focusing the crown objective that some wedging effect was present, that is, the moon was moved through a small circular path as the lens cell was rotated. Turn the cell to bring the moon to the top of this circular path (image up), then turn the cell enough to place the target line in its best position, about one and one-half times the width of the main reticle line to the right of the center reticle line (fig. 122). (Check to see that the adjuster scale is still at 50.) If this position cannot be reached, approach it as closely as possible. (This adjustment should not require more than about one-half turn of the cell and will not greatly affect the focus.)

(i) Remove the bracket assembly from the height finder, remove the objective adapter from the bracket, and tighten the crown objective cell set screw.

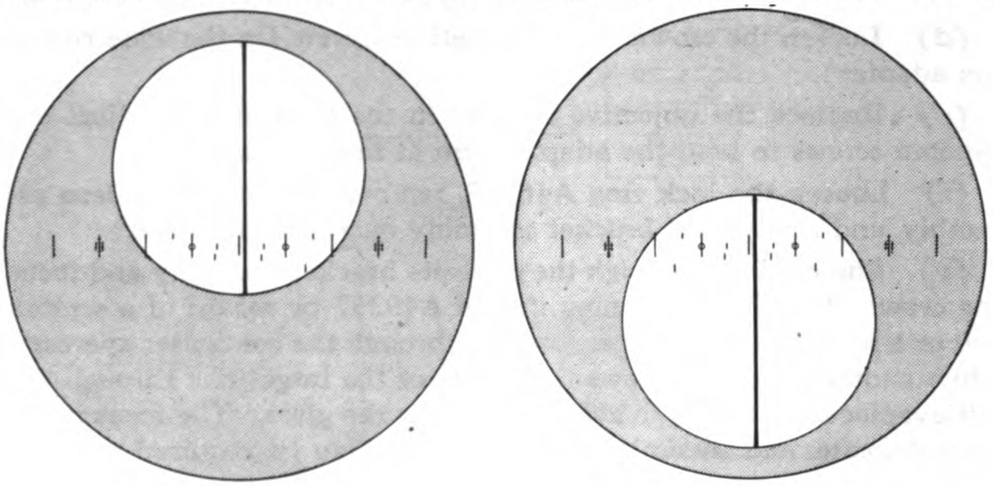
(j) Replace the condenser cell, the wedge adapter, and the objective adapter in the bracket. Set the capstan screws to hold the adapter arms in midposition.

(k) Replace the bracket assembly in the height finder and repeat the focusing and setting for the objectives of the right assembly. (Make sure the range drum is still set at infinity (*).)

(9) After both crown objectives have been focused, rough-adjust the wedges to bring the target lines into proper position for stereo readings.

(a) Loosen the set screws on the wedge adapters of both bracket assemblies.

(b) Using a scratch awl placed against the outer shoulder of the left wedge cell, turn the cell to bring the moon seen through the left eyepiece to its lowest position (image down). Then adjust the cell to bring the target line one and one-half times the width of the reticle line to the right of the center reticle line (fig. 122). Tighten the set screw.



RA PD 67934

Figure 122 — "Image Up" and "Image Down" Positions of Internal Target Moons

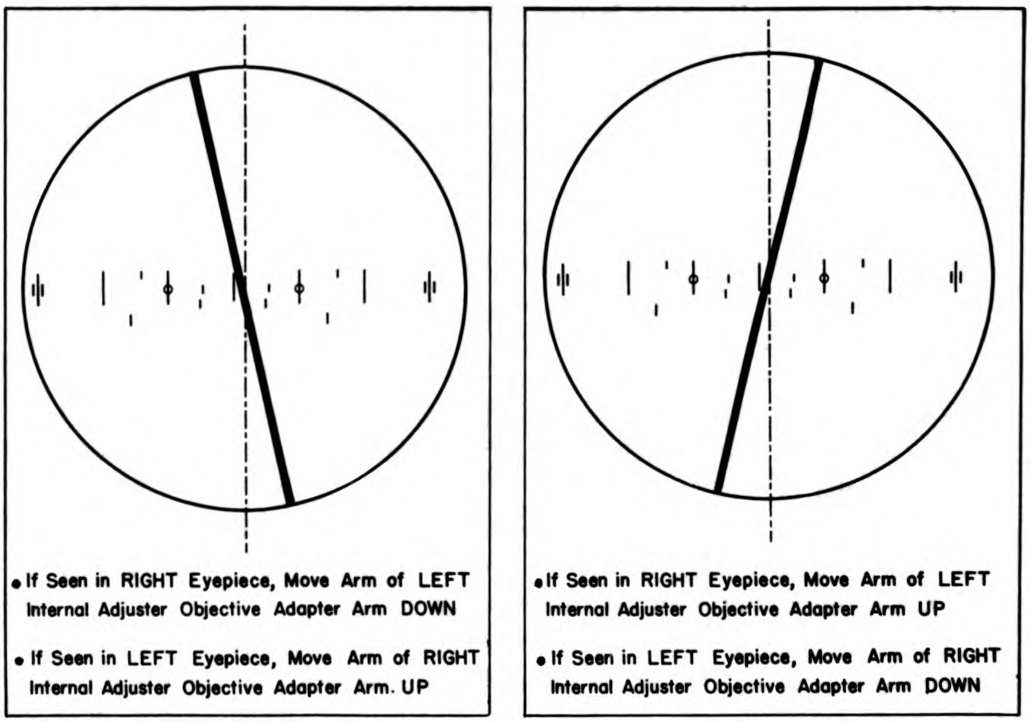


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Figure 123 — Adjustment To Remove Tilt from Internal Target Lines

(c) Proceeding as above, set the right wedge "image down." Continue adjustment of the right wedge to bring the target line into stereo contact with the center reticle line. (If it improves the illumination, set the wedges "image up," and aline.)

(d) Check the setting by taking adjuster scale readings, and adjust the right wedge cell until stereo contact is obtained with adjuster scale readings between 40 and 60.

(e) Tighten the set screw on the wedge cell.

(10) Shellac set screws and install guides.

(a) Remove the left bracket assembly from the height finder.

(b) Apply a small quantity of VARNISH, shellac, to the set screws of the flint objective and the wedge cells.

(c) Replace the guides A49161A and A49161B over the objective and wedge adapter arms.

(d) Apply shellac to the edges of the heads of the screws holding the guides.

(e) Replace the assembly in the height finder and repeat with the right bracket assembly.

(11) Adjust penta prisms to center the moons, which will have become vertically decentered by the adjustment of the wedges and objectives.

(a) Loosen the three holding screws of each penta prism mount (fig. 155).

(b) Adjust the left penta prism to locate the moon centrally about the reticle field. Turn the eccentric screw a small amount, and then back it off while the position of the moon in the field is being observed. Check the position of the moon by noting the tangency of the right or left edge with one of the main reticle marks. The moon should be centered up and down in the reticle field within 1 minute. (The length of the center reticle line corresponds to 3 minutes.)

(c) Tighten the holding screws on the mount and check the adjustment.

(d) Adjust the right penta prism as in the preceding step, but center its moon in relation to the left moon. The two moons should be at the same heights in their respective reticle fields within 1 minute (approximately one-third the length of the center reticle line). Check the relative position of the moons by increasing the interpupillary distance until the two images no longer appear superimposed (fig. 47).

(e) Tighten the holding screws on the penta prism mount and check the adjustment.

(12) Adjust the objectives to remove all "tilt" and "lean" of the target lines.

(a) Note the position of the target line and check for parallelism with the height finder reticles. If the target line is not parallel with the reticle lines, "tilt" is present.

(b) Loosen one capstan screw and tighten the other of the pair toward the center of the height finder to raise or lower the objective adapter arm of the left bracket assembly to remove all "tilt" from the target line seen through the right eyepiece (fig. 123). Then tighten the screws and their lock nuts.

(c) Repeat the above adjustment on the right bracket assembly to remove all "tilt" from the target line seen through the left eyepiece.

(d) Examine the target line in stereo and check for "lean." "Lean" appears toward or away from the observer and is caused by a slight difference in the tilt of the target lines seen through the two eyepieces. No "lean" will be noticeable if the two target lines are parallel. Remove any "lean" by further adjustment on the right bracket assembly. This stereo-vertical effect of "lean" may be detected on the IAC scale by reading on the internal target, using the IACS knob with the height adjuster disk at first one and then the other of its extremes.

(13) Make final adjustment of the wedges to bring the target line into stereo contact at the desired adjuster scale reading. If the adjustment is for less than 10 scale units, make the adjustment on the right wedge. If the correction is for more than 10 units, make adjustments equally on both wedges.

(a) Set the adjuster scale at 50 (or other desired reading).

(b) Raise or lower the arm of the wedge adapter, by adjusting the capstan screws (the pair toward the end of the height finder), to bring the target line into stereo contact with the plane of the center reticle mark.

(c) Check the adjustment by making adjuster scale readings, and readjust the screws until the readings come between 48 and 52.

(d) Tighten the capstan screws and their lock nuts, and recheck the adjuster scale readings.

(14) If necessary, adjust the position of the internal target line in the reticle field for most convenient readings by the stereo observer. It is suggested that the target line be so placed that, when viewed through the left eyepiece with the adjuster scale set at 50, the target is one and one-half minutes to the right of the center reticle line (fig. 124).

(a) Remove the centering disk access plug (fig. 113).

(b) Set the adjuster scale at 50, and note the position of the target line as seen through the left eyepiece.

(c) Loosen one of the headless adjusting screws and tighten the other until the target line is in the desired position. (Loosening the screw toward the right end of the height finder and tightening the one toward the left end will move the target line to the right in the reticle field, and vice versa.)

(d) See that both screws are snug against the arms of the centering disk cell. Do not draw the screws too tight or they may bend the mount and crack the glass.

(e) Apply a drop of VARNISH, shellac, as a seal, to the sides of the screws where they enter the bracket.

(f) Clean the access plug, apply COMPOUND, sealing, for height finder, and replace plug in its adapter.

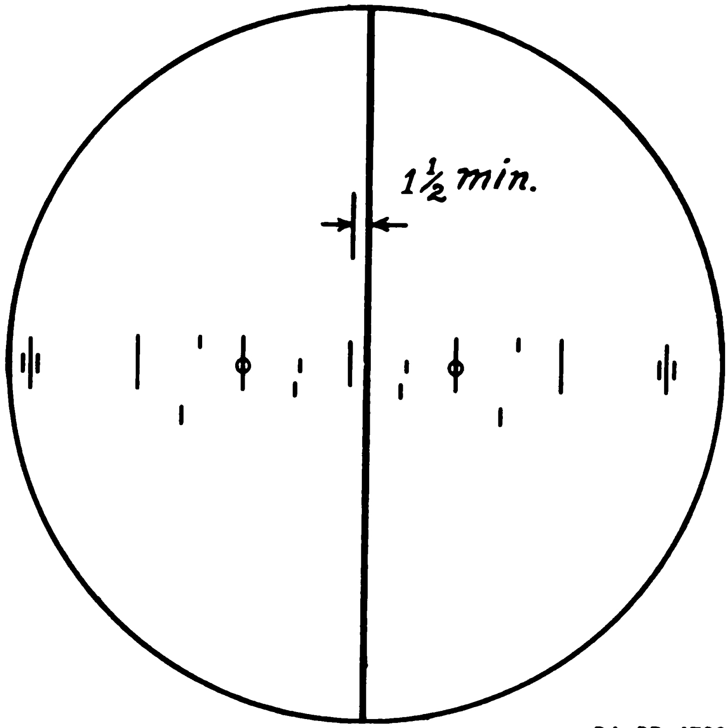

Figure 124 — Suggested Lateral Position for Internal Target Line

(15) Replace illuminating window assemblies and lamps.

(a) Tighten the screws which hold the internal target bracket assemblies to the inner tube, and apply shellac around the heads of the screws.

(b) Check the tightness of the capstan set screws and lock nuts and apply a spot of VARNISH, shellac, to the joining surfaces of the lock nuts and brackets.

(c) Apply COMPOUND, sealing, for height finders, and replace the internal target illuminating window assemblies.

(d) Replace the lamp socket assemblies and covers and adjust the illumination as described in paragraph 82 **a**.

(16) Replace and adjust end windows to give correct reading on an external target of known range. Follow instructions in paragraph 60 **c**.

58. INTERNAL TARGET SYSTEM—CLEANING AND ADJUSTMENT OF INDIVIDUAL UNITS.

a. Individual Adjustment of the Internal Target Units.

(1) CENTERING DISK. The position of the target line in the reticle field can be adjusted for the convenience of the stereo observer. Follow instructions in paragraph 57 **d** (14).

(2) COLLIMATING WEDGE. Adjustment of the internal target collimating wedges will be necessary if adjustments have been made to optics in the main optical system, or if temperature conditions are such as to take the adjuster scale readings off the scale. Adjust the wedges according to instructions starting in paragraph 57 **d** (13).

(3) ADJUSTMENT OF A LOOSE WEDGE OR CROWN OBJECTIVE. A loose wedge cell or crown objective cell will cause erratic changes in the adjuster scale readings, and must be tightened and readjusted. Try to determine in which assembly the loose cell is located. Note the positions of the target lines and moons in the reticle fields with the adjuster scale set at 50 and the range drum at infinity. As a further check, tap the internal target bracket assembly and note any jump of the target line. The wedge and crown lens of the right bracket assembly affect the target line seen through the right eyepiece. To tighten and readjust the cell, follow the instructions paragraph 57 **d** (omit steps (6) and (7) and, in removing the objective adapter from the bracket, (8)), loosen only one capstan screw, and do not loosen the flint objective cell, in order to reduce likelihood of needing to adjust for "tilt" or "lean."

(4) PENTA PRISM. If the moons are not properly centered and matched vertically, the penta prisms will need adjustment, as described in paragraph 57 **d** (11).

(5) ADJUSTMENT OF OBJECTIVE FOR REMOVING "TILT" OR "LEAN" OF TARGET LINES. The target lines should not show any visible "tilt" or "lean." "Tilt" appears as a diagonal placing of the target line in the reticle field. "Lean" appears as a forward or backward leaning of the target line when observed stereoscopically. It is caused by tilt of different degrees in the target lines as seen through the two eyepieces. "Tilt" and "lean" can be removed by adjusting the objective adapters as described, starting in paragraph 57 **d** (12).

b. Removal of Internal Target Optics for Cleaning or Replacement.

(1) Removal of the various units of the internal target system is described in paragraph 57 **d**. The care and cleaning of optical surfaces is discussed in paragraph 36.

NOTE: In some instruments, the wedges and the objectives are locked in their respective cells by set screws which project into recesses in the edges of the glass. These set screws must be loosened before the glass parts are removed from their cells.

(2) After any of the units have been removed and replaced in the instrument, they must be checked and adjusted as described in paragraph 57 **d**. The illuminating windows and the condensers can probably be replaced without adjustment. The windows must be properly sealed in their adapters with the sealing compound described in paragraph 32.

(3) The end window adjustment must be checked on an outside target of known range (par. 60) after any adjustments are made to a wedge or objective, or if a penta prism or a mirror is replaced. (Slight variations in the setting of a wedge or objective or in the plano-parallelism of the surfaces of a mirror or the reflecting angle of a prism will cause variations in the internal target setting and thus affect the range readings.)

59. ADJUSTER PRISM SHIFT ASSEMBLY.

a. Explanation. The adjuster prism shift operates, through the prism shift rods, to bring the internal target penta prisms into position before the end mirrors for internal target readings, and to move them out of the way for external observations. At the same time, the shift lever actuates a switch to turn on the internal target lamps when the penta prisms are in position for internal readings. The switch can be opened for repairs (par. 83 c) without breaking the seal of the instrument. Removal of the shift assembly will break the hermetic seal. However, since the shift does not require any sensitive adjustment, it should not need removal except to repair mechanical damage or when the inner tube is to be removed.

b. Removal and Disassembly.

(1) In order to remove the prism shift assembly, the prism shift rods must first be disconnected from the assembly, which can then be unscrewed and lifted from the instrument. Proceed as follows:

(2) Disconnect prism shift rods.

(a) Remove both end boxes (par. 61).

(b) Remove the link screws to disconnect the prism shift links from the penta prism brackets. Do not disturb the penta prism stop or stop screw.

(c) Remove the end reflector supports as described in paragraph 42 g.

(d) Measure or mark the distance from the center of the holes at the end of each prism shift link to the end of the inner tube, when the prism shift crank is at the "on" position (completely counterclockwise when facing crank). This determines the correct position for replacing the link assemblies.

(e) Take out the three screws and remove the plate assembly B180308 (fig. 125).

(f) Turn the crank slowly clockwise until the racks are disengaged. Mark the position of the crank at the point of disengagement. (This will be helpful in reassembly, as the correct position of the two racks with respect to the pinion gear, crank, and stop can be found only by trial.)

(g) Draw out the link assemblies.

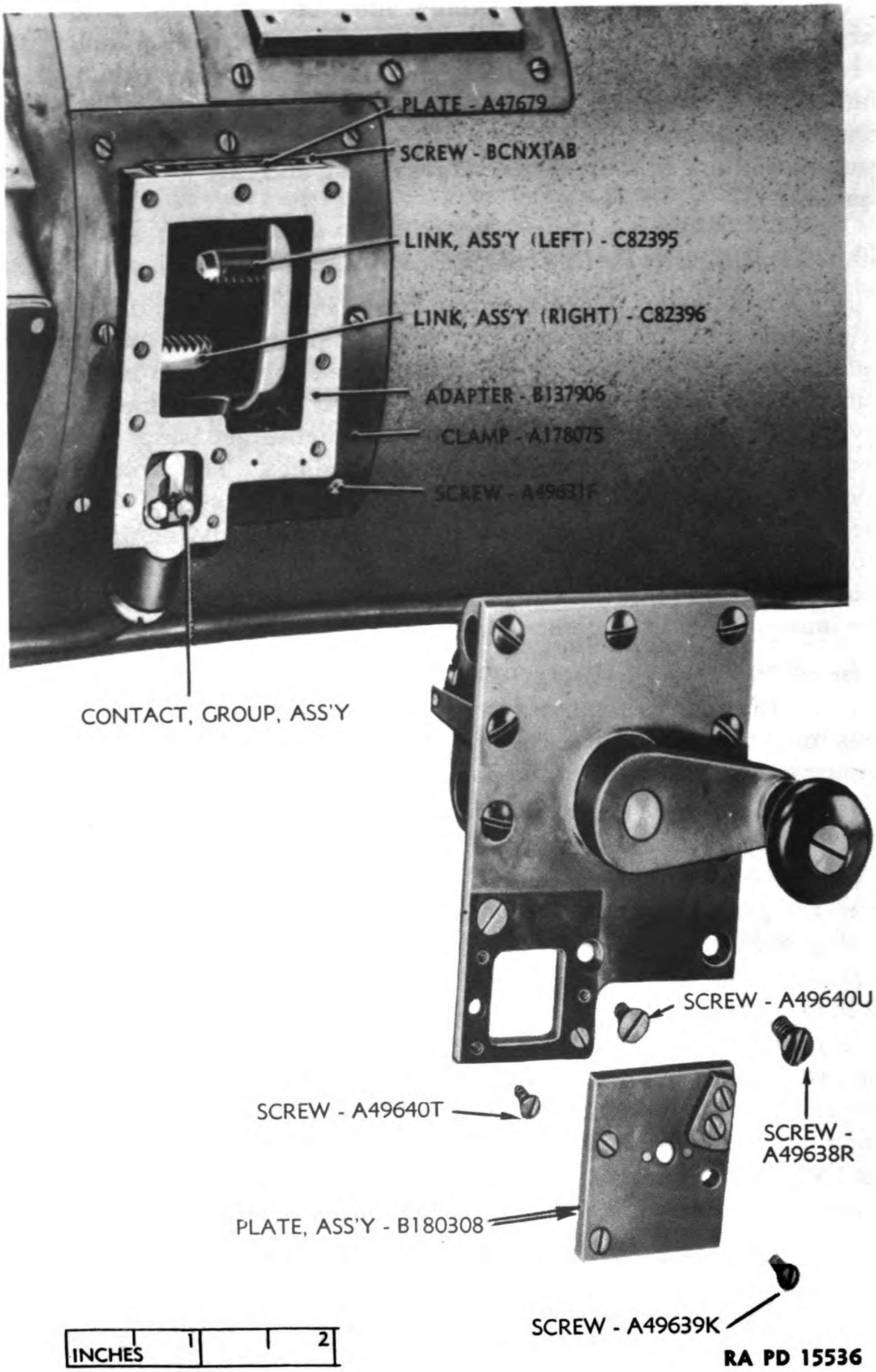

Figure 125 — Removal of Adjuster Prism Shift Assembly

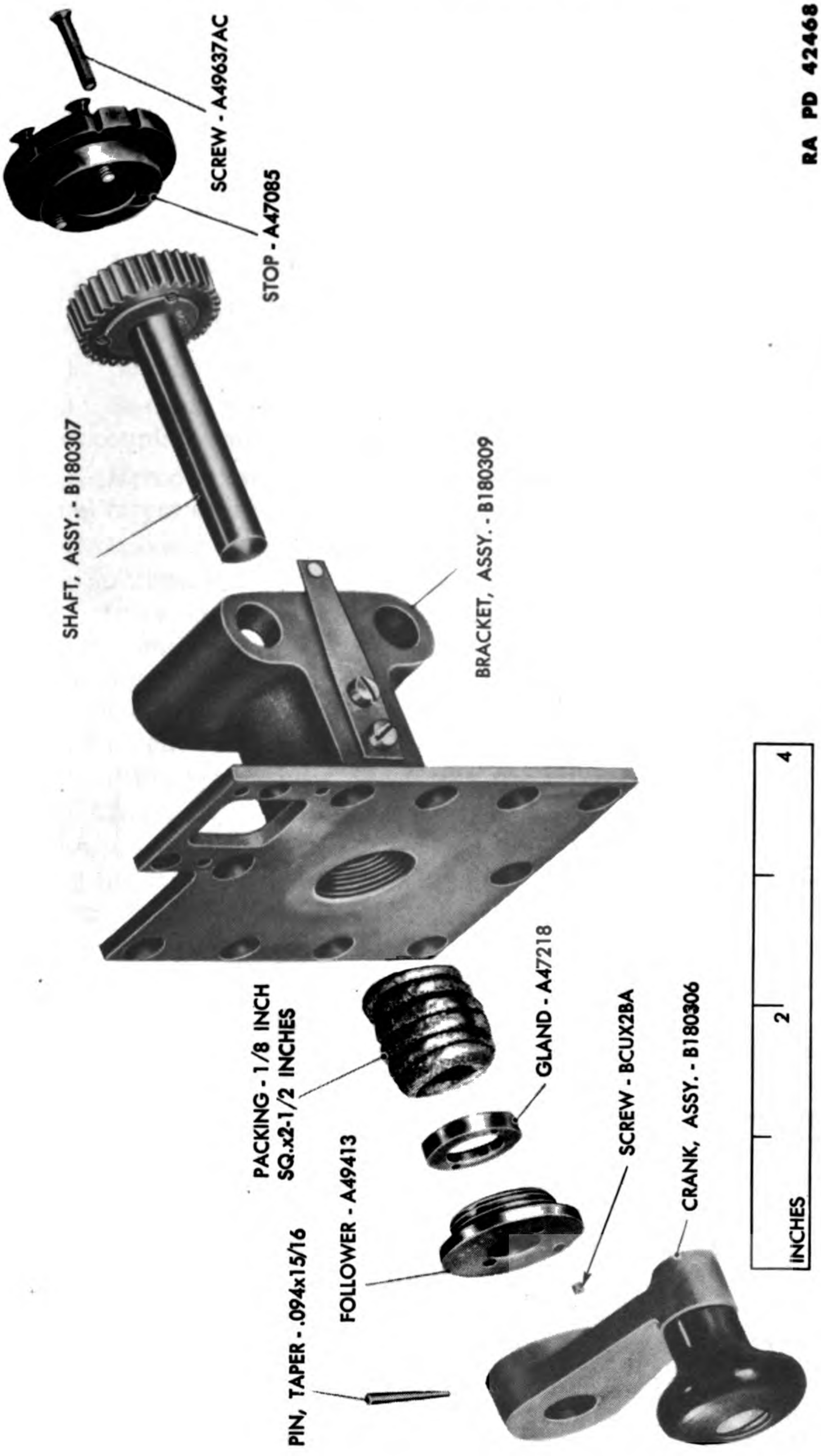

Figure 126 — Adjuster Prism Shift Assembly — Exploded View

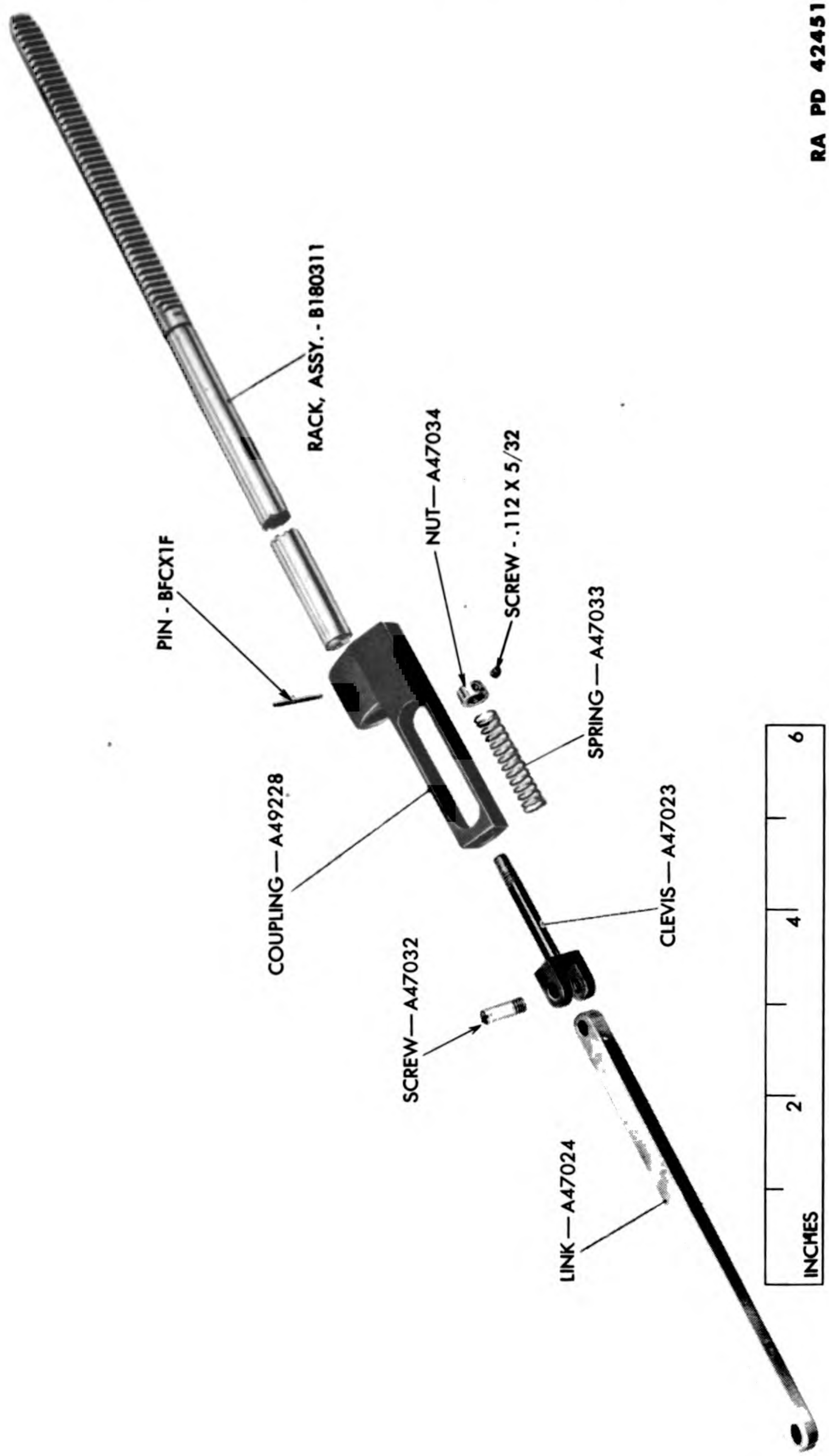

Figure 127 — Left Prism Shift Link Assembly

(3) Remove the eight oval-head screws and the four flat-head screws, and lift out the shift assembly.

(4) Disassembly of the shift assembly is illustrated in figure 126.

(5) Repair or removal of the contact assembly is discussed in paragraph 83 c.

c. Assembly and Replacement.

(1) In assembly, reverse the order of disassembly.

(2) Make sure that the stop A47085, shaft assembly, and crank assembly are properly alined so that the detent point rests in the proper notch of the stop when the crank is against its stop.

(3) See that the insulating tip is not lost from the contact button.

(4) See that the link assemblies are properly assembled with the correct couplings and racks at the correct angles (figs. 127 and 128).

(5) Remove the eyepiece unit and housing (par. 44) and the left internal target bracket assembly (par. 57 c).

(6) Insert the right rack through the lower of the two small holes of the air tube spacers (the holes just above the internal target air tube). Insert the left rack in the left end of the instrument through the upper small holes of the air tube spacers. The racks should then come in the relative positions shown in figure 125, with the left rack above the right and the toothed sides facing each other. Pull the link assemblies out just enough so that the ends of the racks are about even with the sides of the opening in the inner tube.

(7) Replace the shift assembly and put in its holding screws. If necessary, use fresh COMPOUND, sealing, for height finders, on the seating surfaces. Make sure that the flat-head screws are in the proper positions as shown.

(8) Engage the racks with the shift assembly as follows:

(a) Turn the crank to the position at which the racks were disengaged.

(b) Push the outer ends of the link assemblies so that the racks enter their bearings in the shift bracket with their ends against the pinion. Guide the racks by reaching through the eyepiece opening and left internal target opening.

(c) While assistants push in on the links, turn the crank counterclockwise to engage the racks.

(d) Turn the crank counterclockwise until the holes in the ends of the connecting links are at the distance from the ends of the inner tube as measured before disassembly. The crank should then be in such a position that it would come against its stop if the latter were in place.

(e) If the two links and the crank do not all come to the proper positions simultaneously, disengage the racks and reengage them with the crank in different positions until they do.

(f) Turn the crank clockwise about one-half turn and replace the plate assembly.

(g) Replace the eyepiece housing and assembly (par. 44) and the left internal target bracket assembly (par 57 c).

60. ADJUSTMENT OF THE END WINDOWS.

a. **Explanation.** The end windows consist of wedges of very acute angle or low refracting power, and they provide a final adjustment to obtain correct range readings on external targets after the height finder optical system has been alined on the artificial infinity target provided by the internal target system. This adjustment is equivalent to a personal calibration correction or IACS offset for an observer and differs as much as 2 to 10 UOE between good observers. If more than one observer uses the same instrument, the end windows should be so set that the majority will be able to use, as their personal corrections, values as nearly as possible equal to zero; that is, they will read *true range* with the IACS determined by use of the internal target. 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 adjuster 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 UOE. 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 adjuster 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. **Requirements.** 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 3° F 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.

c. **Adjustment on Outside Target.**

(1) Set the height-range lever in a range position, the measuring drum at infinity, and the prism shift for internal target readings.

(2) Make five readings and record the median value.

(3) Turn the prism shift 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 adjuster scale. Record

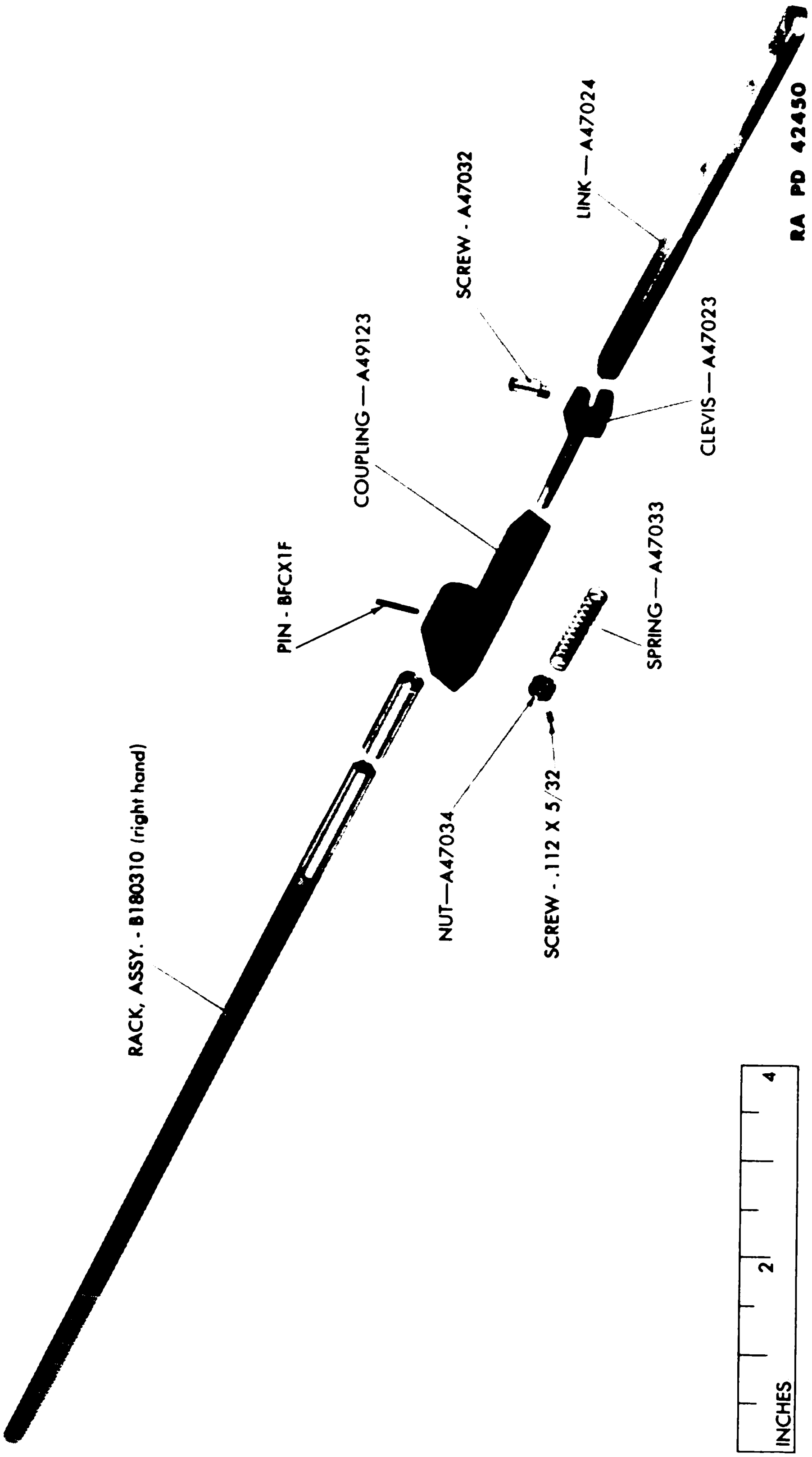

Figure 128 — Right Prism Shift Link Assembly

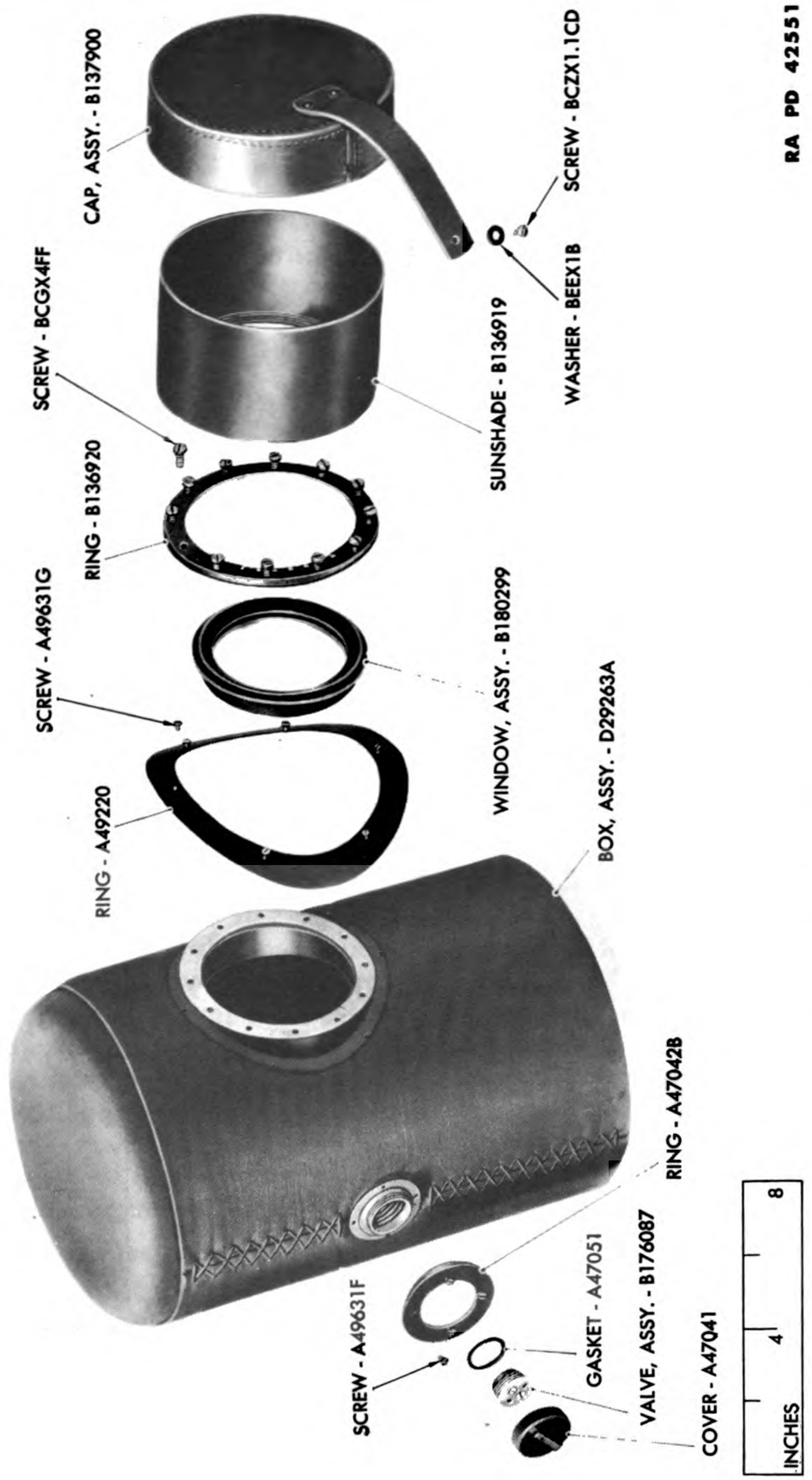

Figure 129 — End Box — Exploded View

the median of the readings. As an alternative method, since the measuring wedges give more than 30 times the stereo movement that the IAC scale does, it will be more accurate to set the median value obtained in step (2), above, on the IAC scale, bring the external target into stereo contact using the measuring knob and record the deviations of five readings in yards. Convert the median deviation to UOE with a De Yoe slide rule.

(4) If the necessary correction (difference between the median values for steps (2) and (3),) above is greater than 1½ UOE but less than 10 UOE, make the correction on the *left* end windows as follows:

(a) Set the adjuster scale at the median value for the internal target reading, from step (2), above.

(b) Remove the sunshade by unscrewing it from the end window ring (fig. 129).

(c) Slightly loosen the 12 screws around the end window (one-half turn only, in order to avoid breaking the hermetic seal and loosing the gas pressure in the instrument).

(d) 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 will damage the end window.)

(e) Turn the end window slightly (about 5 deg.) with the end window wrench.

(f) Check the window position by making 10 range readings on the outside target and comparing the median with the true range.

(g) Repeat substeps *(e)* and *(f)*, above, until the median 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.

(h) Tighten the 12 clamping screws and replace the sunshade.

(5) 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 realinement of the M7 Tracking Telescopes.)

(a) Set the adjuster scale midway between the values found in steps (2) and (3), above.

(b) Adjust the right end window, as described in step (4), above, for true range readings.

(c) Set the adjuster scale at the median value of the internal target readings (for step (2), above).

(d) Adjust the left end window as in step (4), above.

(e) Realine the M7 Tracking Telescopes as instructed in paragraph 71.

d. Replacement of the End Windows.

(1) When an end window is replaced, it will be necessary to rough-adjust the new window before making the final adjustments described in the foregoing paragraphs.

(2) If only one new window is being installed, proceed as follows:

(a) Unscrew the sunshade, remove the 12 screws BCGX4FF and the clamping ring. The end window assembly can then be removed from its seat.

(b) If possible, use a new window of the same power (scribed on back of mount) as the window being replaced. (If the new window A47636 is to be placed in the old frame, use Navy black sealing compound (par. 32) to provide a gas tight mounting.)

(c) Coat the seating surfaces of the window frame and the ring B136920 with COMPOUND, sealing, for height finders, and replace the window assembly in the height finder.

(d) Replace the clamping ring and its 12 screws. Leave the screws just loose enough to allow the window assembly to be turned.

(e) Swing the height finder to center the target in the reticle field on the side opposite the window that is being replaced.

(f) Using an end window wrench, turn the window while an operator views the target image through the eyepiece. First turn the window to bring the image to the lowest point of its circular path (image down), then make the slight further adjustment to center the target with respect to the reticle.

(g) Use the height adjuster, if necessary, to bring the two images to the same height.

(h) Make the final adjustment of the end window as described in subparagraph c, above, before tightening the window in place.

(i) Check parallax on each side and stereo parallax.

(3) If both end windows are to be replaced, follow the procedure outlined above, but remove both end windows and aline the height finder on the target so that the target images seen through the two eyepieces will be equidistant in opposite directions from the center reticle lines (fig. 130). Replace the end windows and adjust them, image down, to bring the target images into coincidence with the center reticle line.

e. Removal of End Window for Cleaning.

(1) If an end window is to be removed for cleaning only, place a scribe mark on the window frame opposite the 30-degree mark of the scale on the clamping ring. This will make it possible to replace the window without readjustment.

(2) 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 36.

HEIGHT FINDER TELESCOPE—ADJUSTMENT AND REPAIR

HEIGHT FINDER ALIGNED, END WINDOWS REMOVED

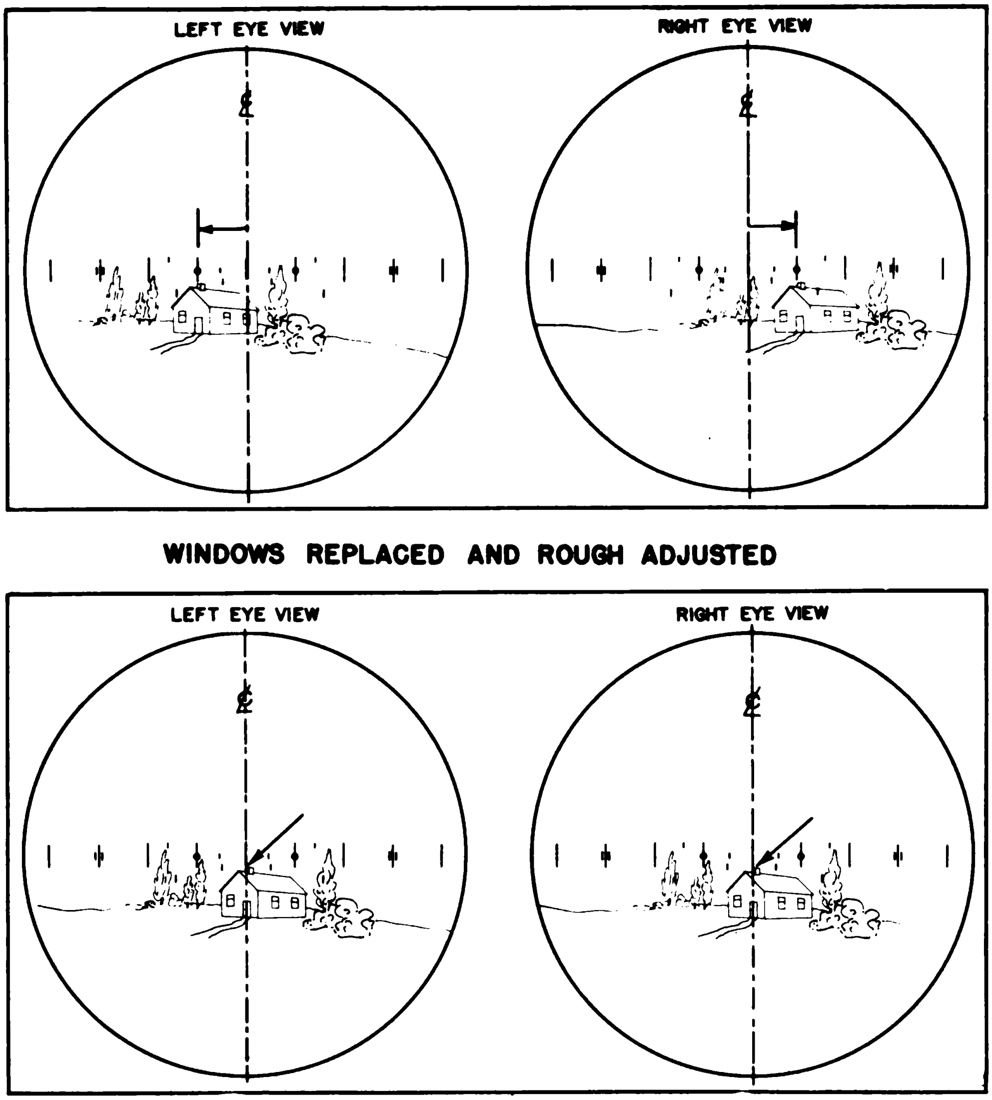

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Figure 130 — Alinement of End Windows

61. END BOXES.

a. General. The end boxes carry the end windows and the charging valves, and house the end reflectors which are extended beyond the outer and inner tubes of the instrument. The end boxes must be removed for cleaning, adjustment, or replacement of the end reflectors and for various other operations on the height finder. Removal of the end boxes breaks the hermetic seal of the instrument.

b. Removal and Replacement.

(1) Turn the adjuster prism shift for external readings.

(2) Take out the 10 screws (fig. 66), and remove end box ring A49110.

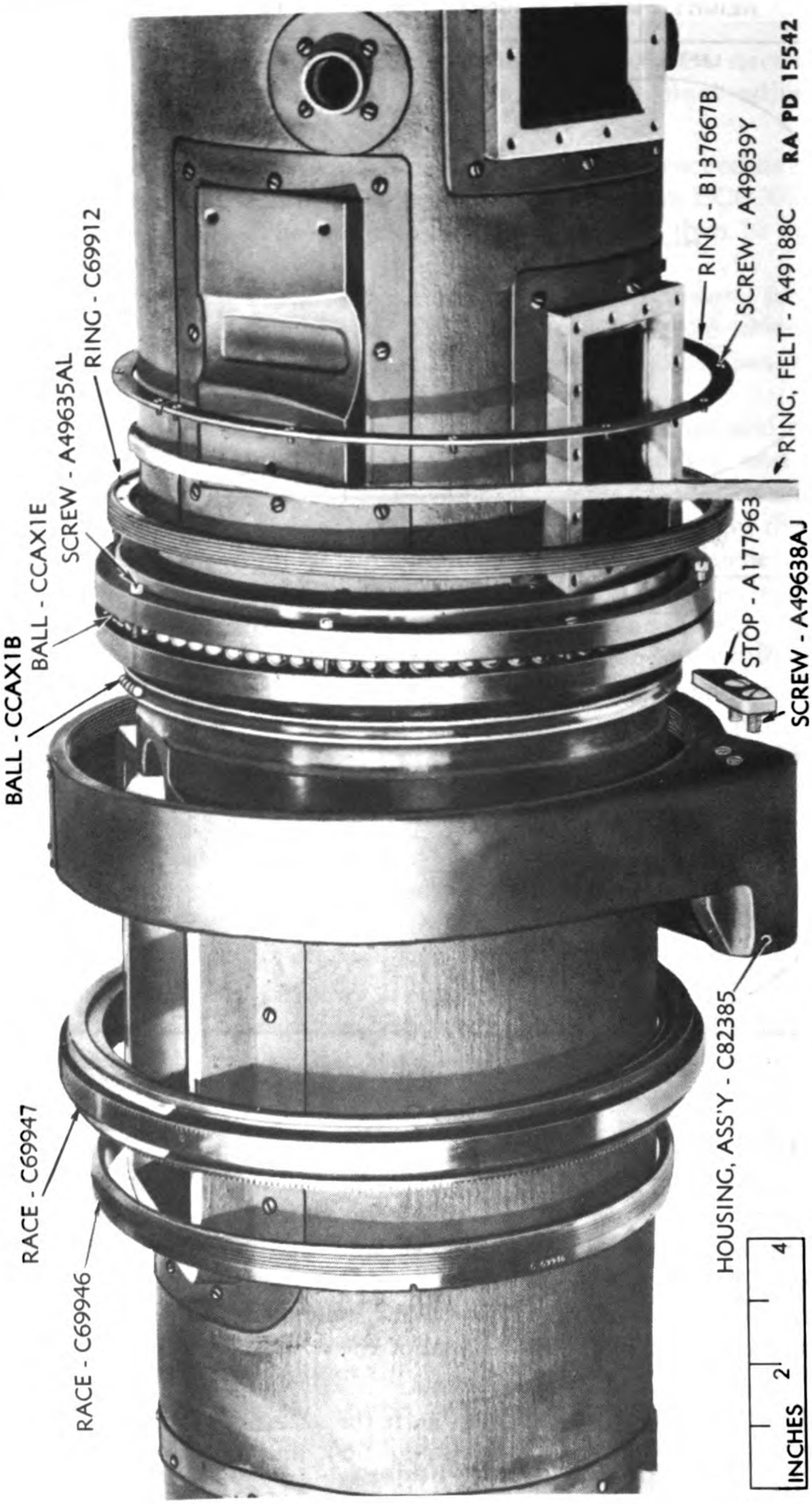

Figure 131 — Right Main Bearing — Exploded View

(3) Remove the eight hexagonal-head screws BCBX1AA which hold the end box.

(4) Slip 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.

(5) 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.

62. RIGHT MAIN BEARING AND HEIGHT CONVERSION RING.

a. General. The right bearing housing contains the right-hand support for the tube and the ring gear which operates the height conversion mechanism. There should be no need to disassemble the housing except in case of damage to the bearing or ring. Disassembly requires breaking the hermetic seal.

b. Disassembly.

(1) Support the height finder tube on padded V-blocks.

(2) Remove the compensator assembly as described in paragraph 49. Observe all precautions.

(3) Remove the eight cover screws and lift off the two parts of the height conversion ring cover.

(4) Remove the height conversion ring.

(a) Release the holding set screw and unscrew the inner part of the conversion ring race C69946 (fig. 131). Take care to prevent the ball bearings from falling through the compensator opening into the instrument.

(b) Remove the ball bearings and slide the outer conversion ring C69947, including the two felt packing rings, out of the bearing housing.

(5) Remove the main bearing.

(a) Remove the 14 screws, the split retaining ring, and the felt packing ring at the inner side of the housing (fig. 131).

(b) Unscrew the retaining ring C69912 from the housing and push the bearing housing toward the end of the tube to expose the main bearing.

(c) Take out the eight screws, open the split outer race, and remove the ball bearings.

(6) To slip the circular parts of the bearing off the right end of the tube, strip the tube as follows:

CAUTION: Extensive damage may result if these directions are not followed.

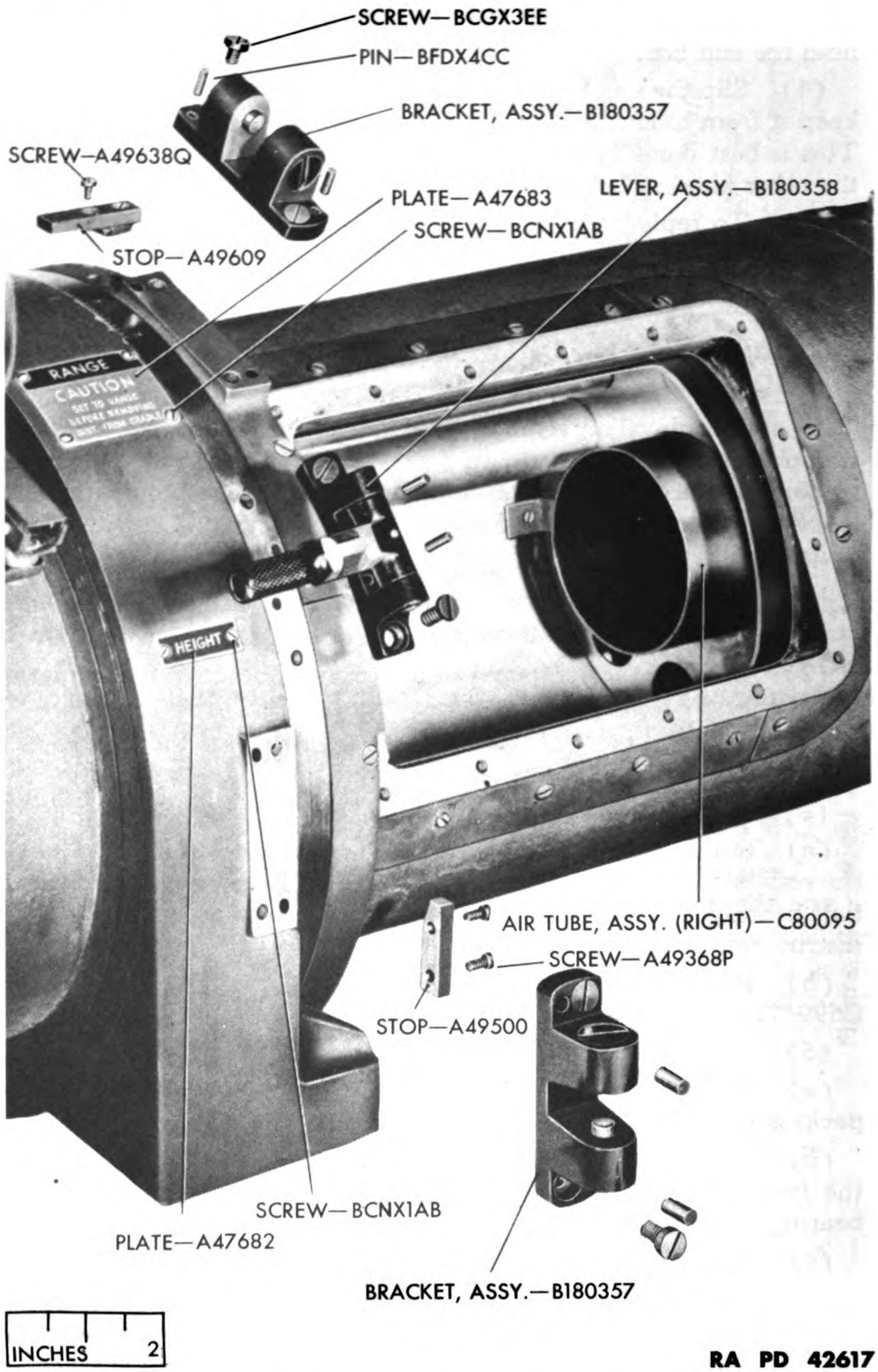

Figure 132 — Removal of Height-range Lever and Range and Height Stops

(a) Remove the right carrier handles (par. 64).

(b) Remove the right end box (par. 61).

(c) Insert stout metal or wood blocks *firmly* between the inner and outer tubes so as to prevent the inner tube from sagging or shifting.

(d) Identify and scribe each of the 3 right roller bearing assemblies, remove the 12 screws holding each bearing, and take off the bearings (par. 65).

(7) For reassembly, reverse the order of removal, with the following precautions:

(a) Lubricate the ball bearings and the felt packing rings with GREASE, lubricating, special.

(b) The balls for the height conversion ring assembly can be most easily handled by sticking them to the inner corner of the ring by means of the prescribed grease. The inner race, when screwed home, forces the balls into position.

(c) Replace and adjust the compensator as directed in paragraphs 48 and 49.

c. Height-range Lever and Stops. The height-range lever controls the operation of the height conversion ring. It should seldom need attention except in case of damage to the lever or the parts with which it is associated (fig. 132). When the cradle and tube are accurately leveled, the height conversion ring should travel through an angle of exactly 90 degrees. This can be checked as described in paragraph 41 d.

63. LEFT MAIN BEARING HOUSING.

a. General. The left bearing housing contains the left main bearing and the elevating worm and gear mechanism. It can be disassembled without breaking the hermetic seal of the instrument, but taking the circular outer race or the retaining ring completely off the height finder tube requires removal of certain units from the tube which will break the hermetic seal.

b. Disassembly.

(1) Support the outer tube on padded V-blocks.

(2) Remove the elevating mechanism as follows:

(a) Remove the six screws and remove the coupling plate A49147, coupling A49131, and spring A49132 (fig. 133).

(b) Remove the 13 screws and remove the worm housing assembly (fig. 134).

(3) Remove the elevation index as follows:

(a) Scribe the elevation index A49419 (fig. 63) and the canvas clamp on which it is mounted to show the exact position of the index.

(b) Scribe across the bearing retaining ring and the bearing housing with respect to the index mark.

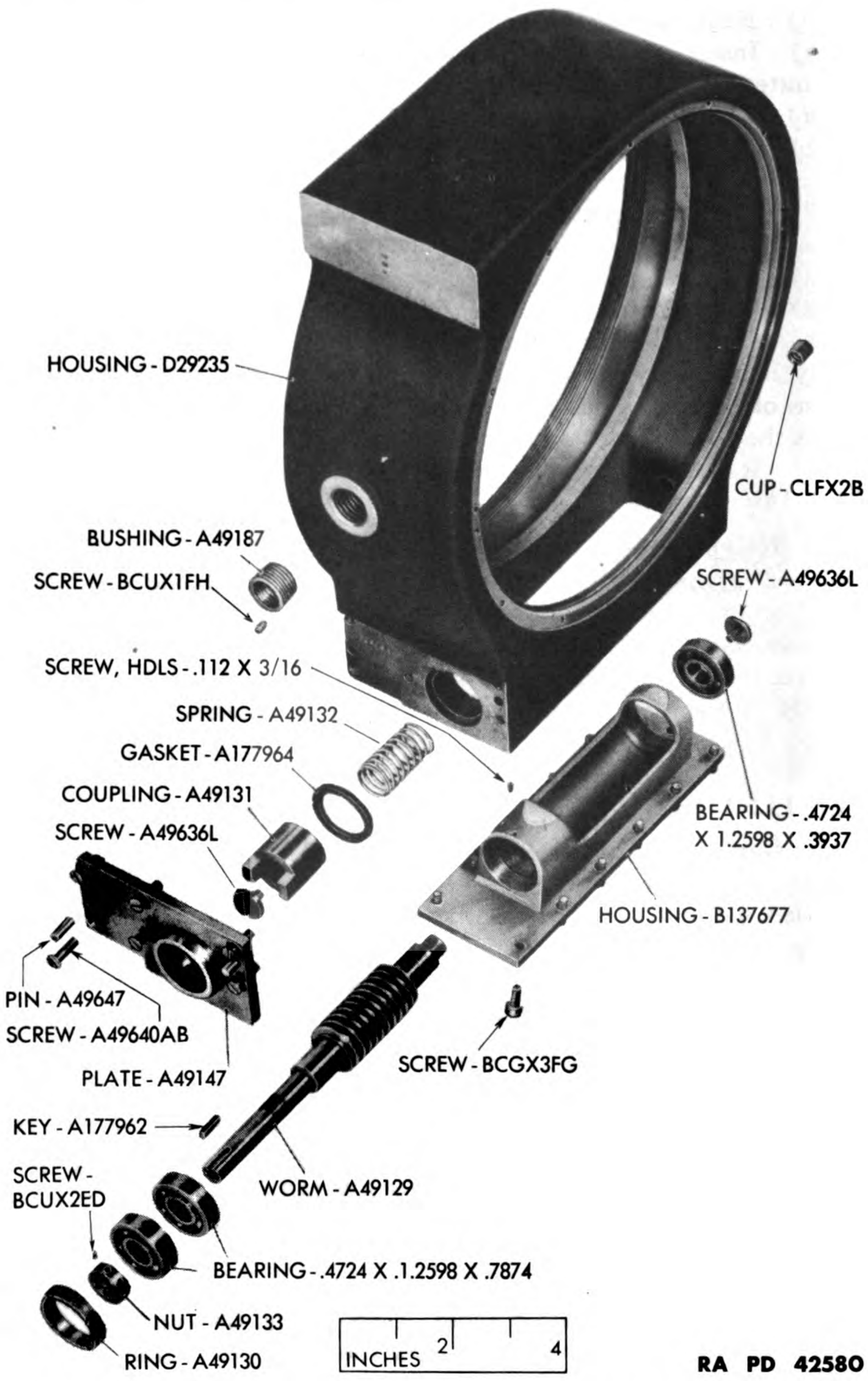

Figure 133 — Left Main Bearing Housing Assembly — Exploded View

(c) Take out the two mounting screws and remove the index.

(4) Disassemble the main bearing.

(a) Remove the 14 screws and take off the clamp rings and the felt packing rings on each side of the housing (fig. 134).

(b) Remove the bearing retaining ring C69912.

(c) Remove the eight screws, pull out one side of the split race C69911, remove the balls, and withdraw the other half of the race.

(d) Remove the six screws A49638T from the elevation gear segment, slide the segment and bearing housing toward the center of the instrument, away from the bearing, and remove the gear segment.

(5) In order to slip the circular parts over the left end of the tube, it is necessary to strip the tube as follows:

CAUTION: Extensive damage may result if these directions are not followed.

(a) Remove the elevation tracking telescope (par. 75 **b**).

(b) Remove the left carrier handle assembly (par. 64).

(c) Remove the left end box (par. 61).

(d) In order to allow removal of the inner tube bearings, insert stout metal or wood blocks firmly between the inner and outer tubes so as to prevent the inner tube from sagging or shifting.

(e) Make certain that the instrument is approximately level. Identify and scribe each of the three inner tube bearing assemblies. Take out the mounting screws and remove the assemblies (par. 65).

(f) For reassembly, reverse the order of removal. Pay particular attention to replacing the scribed parts in their proper places. Lubricate the ball bearings and felt packing freely with GREASE, lubricating, special. The elevation index should coincide with its line when the height finder is exactly level and mounted on the cradle and tripod.

64. CARRIER HANDLES.

a. General. The carrier handles support the full weight of the height finder telescope during storage and shipment. Therefore it is important that the carrier handle assemblies be mounted accurately parallel. The carrier handles should not need to be removed unless they are damaged or if it is necessary to disassemble the main bearing housings. 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 adequately firm supports.

b. Removal and Replacement.

(1) Remove the four screws (fig. 135). Drop down the bar assembly and lift off the two caps.

(2) Disassembly of the bar assembly is illustrated in figure 136.

(3) When replacing the bar assemblies, make sure they are mounted parallel to each other.

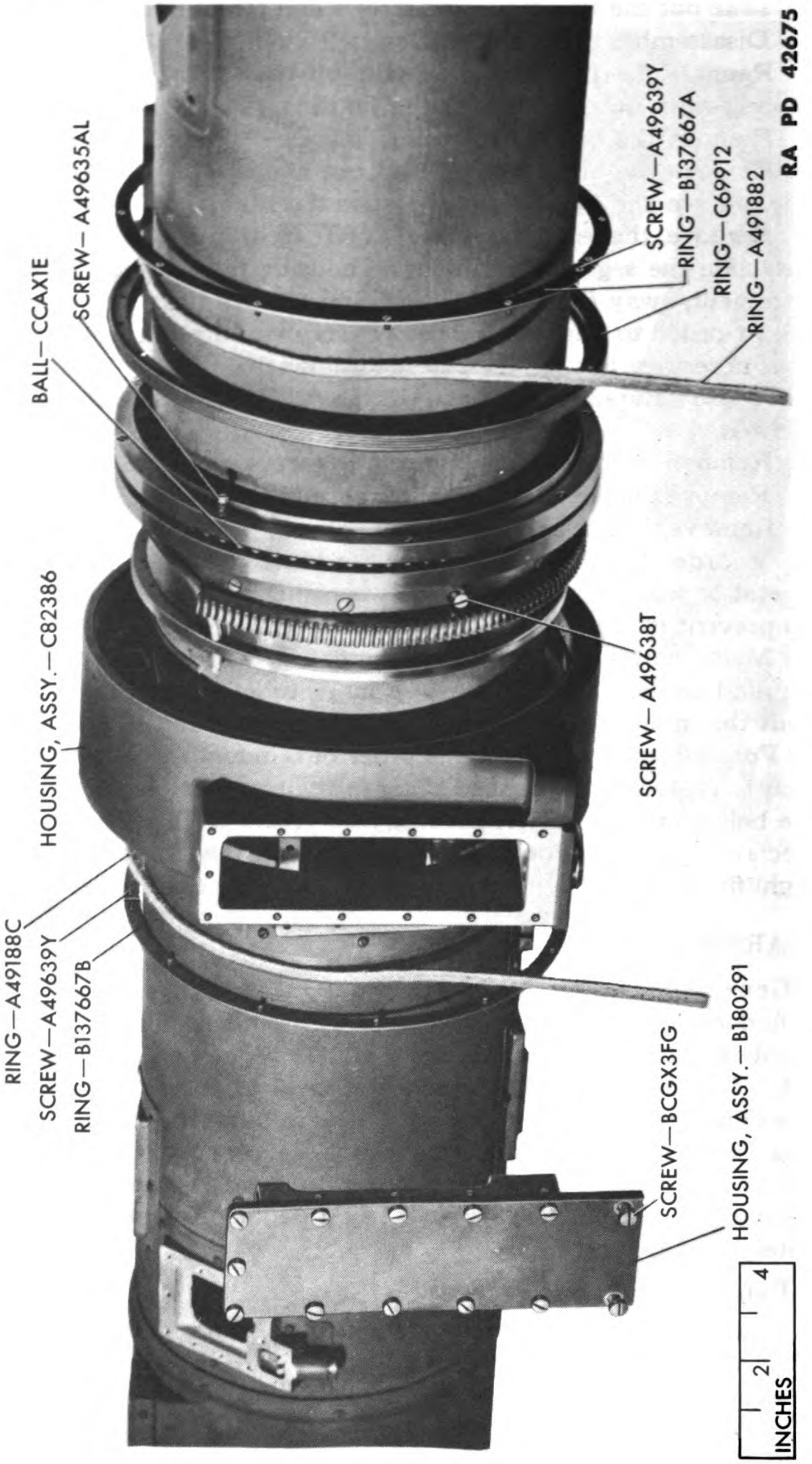

Figure 134 — Disassembly of Left Main Bearing

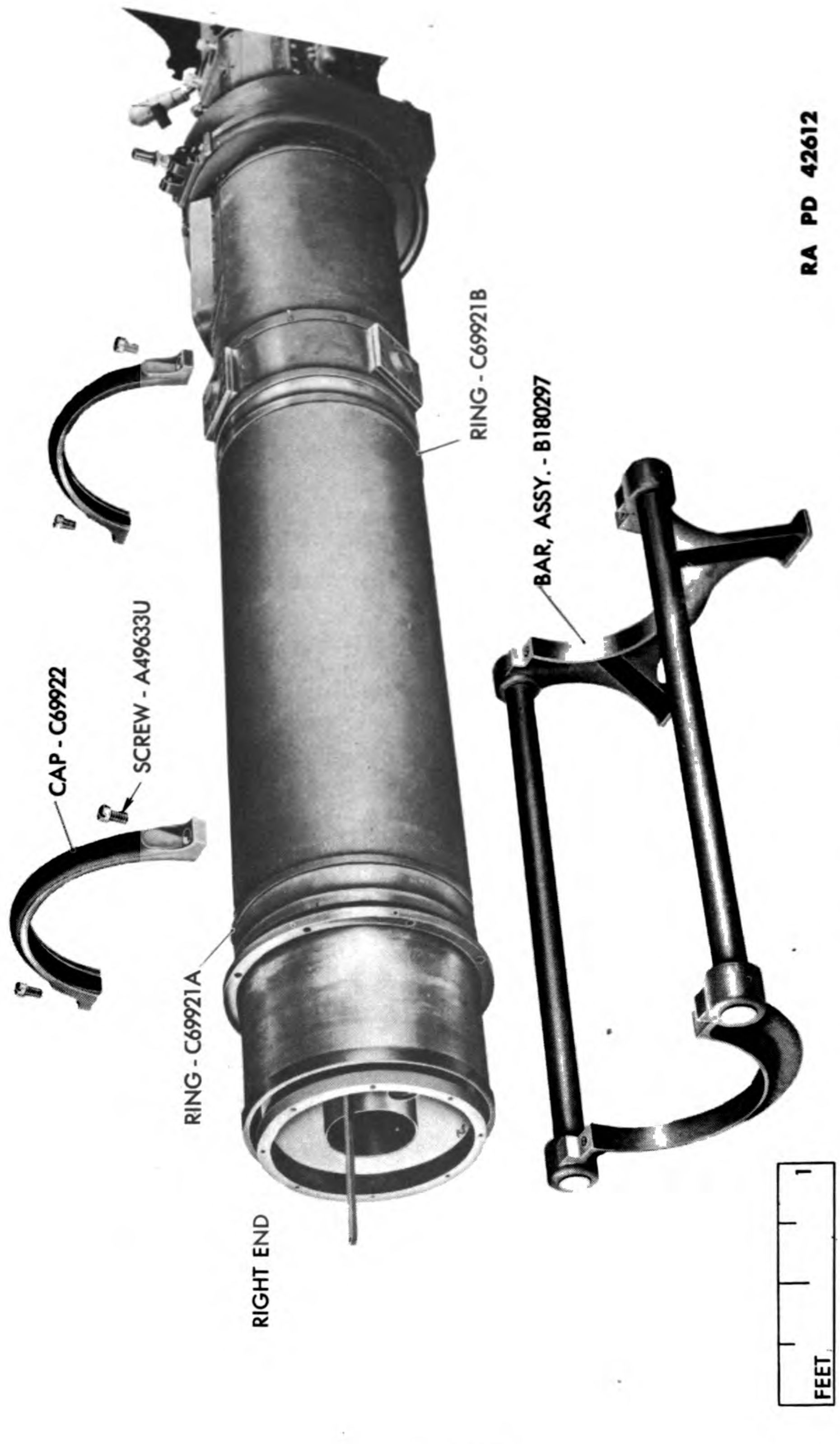

Figure 135 — Removal of Carrier Handles

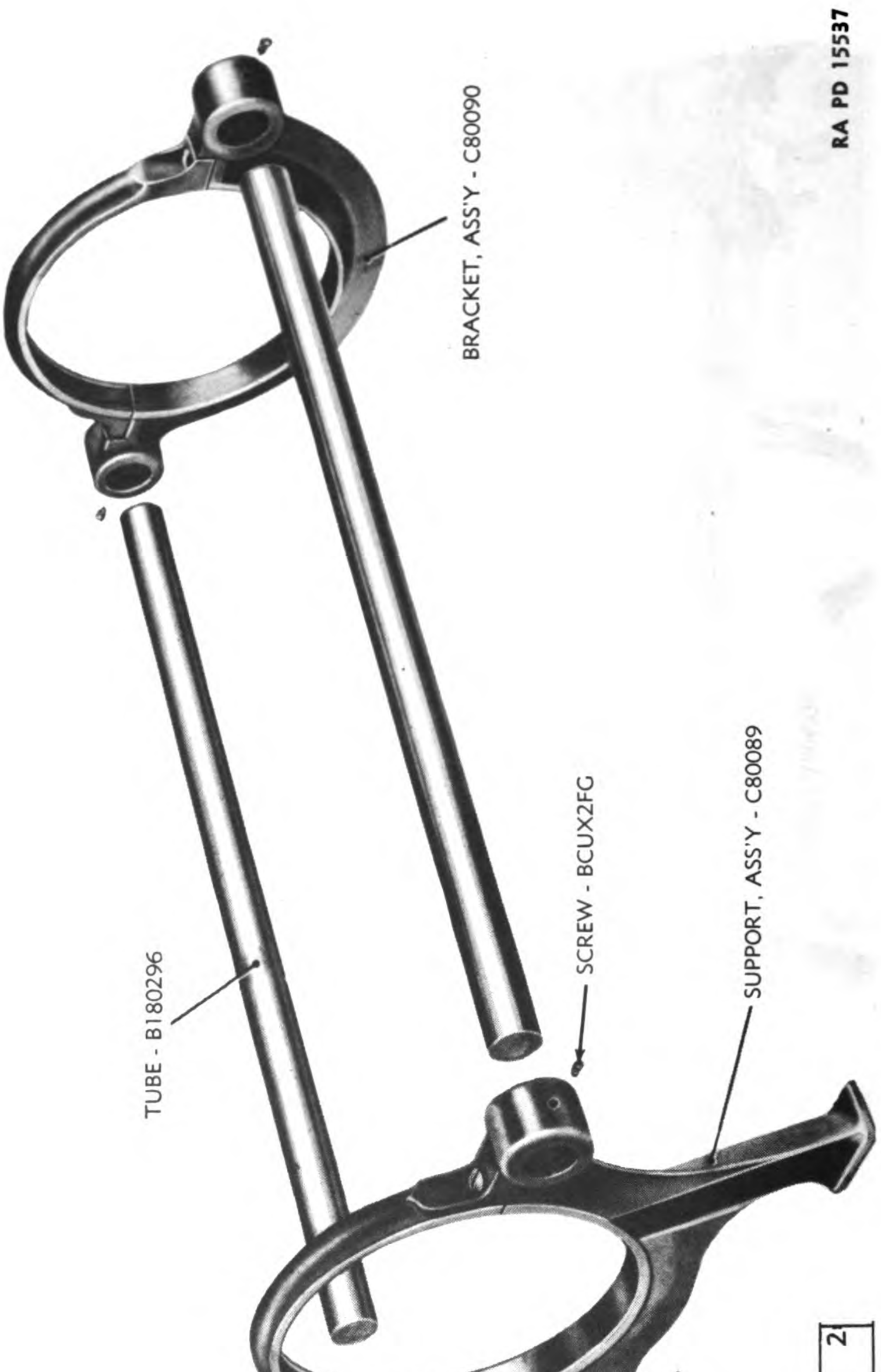

Figure 136 — Disassembly of Carrier Handle Bar Assembly

(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 XI

HEIGHT FINDER TELESCOPE—DISASSEMBLY AND ASSEMBLY

	Paragraph
Disassembly of height finder telescope	65
Assembly of the optical tube	66
Assembly and adjustment of units to the height finder	67

65. DISASSEMBLY OF HEIGHT FINDER TELESCOPE.

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** (par. 33).

(1) Removal of the inner tube and the optical tube will be required for cleaning, adjusting, or replacing the erectors or the ocular prisms. Faulty or dirty erectors, and dirty ocular prisms or prisms on which the silvering has deteriorated, will cause a blurred appearance of the reticle marks even after the best eyepiece focus setting has been made. Such a blurred appearance can also be caused by moisture on one of the surfaces between the reticle and the eye, or by dirty optics in the eyepiece unit. Therefore, before starting a major disassembly, test the instrument as follows:

(a) Remove the eyepiece unit as described in paragraph 44, inspect the optical surfaces and clean if necessary. Clean the windows at the bottom of the eyepiece housing.

(b) If the blurred appearance persists after replacing the eyepiece unit, desiccate the instrument (par. 35).

(c) 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.

c. Removal of the Inner Tube.

(1) This disassembly may normally be performed only at a base shop where complete equipment and qualified personnel are available. It may be emergency third or fourth echelon maintenance under the conditions outlined in paragraph 33.

(2) 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 lens tissue paper and mount in a closed box to prevent damage and exclude dust.

(a) Eyepiece (par. 44).
(b) Eyepiece housing (par. 44).
(c) Compensator assembly (par. 49) (clamp bevel gear).
(d) Measuring knob assembly (par. 50).
(e) Right and left reticle assemblies (par. 53).
(f) Right and left internal target bracket assemblies (par. 57).
(g) Height adjuster knob assembly and mount assembly (par. 55).
(h) Correction wedge unit (par. 46).
(i) Adjuster scale assembly (par. 47).
(j) Elevation adjustment knob assembly (par. 56).
(k) Change-of-magnification crank assembly (par. 54).
(l) Right and left end boxes (par. 61).
(m) Right and left end reflector supports (par. 42).
(n) Adjuster prism shift assembly and link assemblies (par. 59).

(3) Removal of the units listed in step (2), above, can be done safely with the instrument on its own cradle and tripod. However, for removal of the inner tube, place the instrument at the right end of a bench twice its length. Support the outer tube on a pair of suitable felt-lined wood V-blocks which are high enough to allow space between the instrument and bench to see and reach the openings for the reticle mounts.

(4) Mark the exact position of the right end adapter C69928 (fig. 137) with respect to the inner tube by scribing a line across both. Remove set screw BCGX3FG. Insert a piece of metal, large enough to keep the tube from turning, through any of the various openings of the inner and outer tube, and remove the end adapter with a spanner wrench. The adapter at the left end of the inner tube is not removable.

(5) Provide four auxiliary supports made of flat aluminum stock 7/16 inch thick, 4 inches long, and 1½ inches wide, bent to a 3⅝-inch radius, to keep the inner tube centered within the outer tube while it is being removed. Place a support under the inner tube at each end of the instrument and at each reticle opening.

(6) Identify and scribe the three roller assemblies near each end (figs. 137 and 138) so that they can readily be replaced in the same positions. Remove the three right roller assemblies.

HEIGHT FINDER TELESCOPE—DISASSEMBLY AND ASSEMBLY

Figure 137 — Removal of End Adapter and Inner Tube Bearing Roller Assemblies

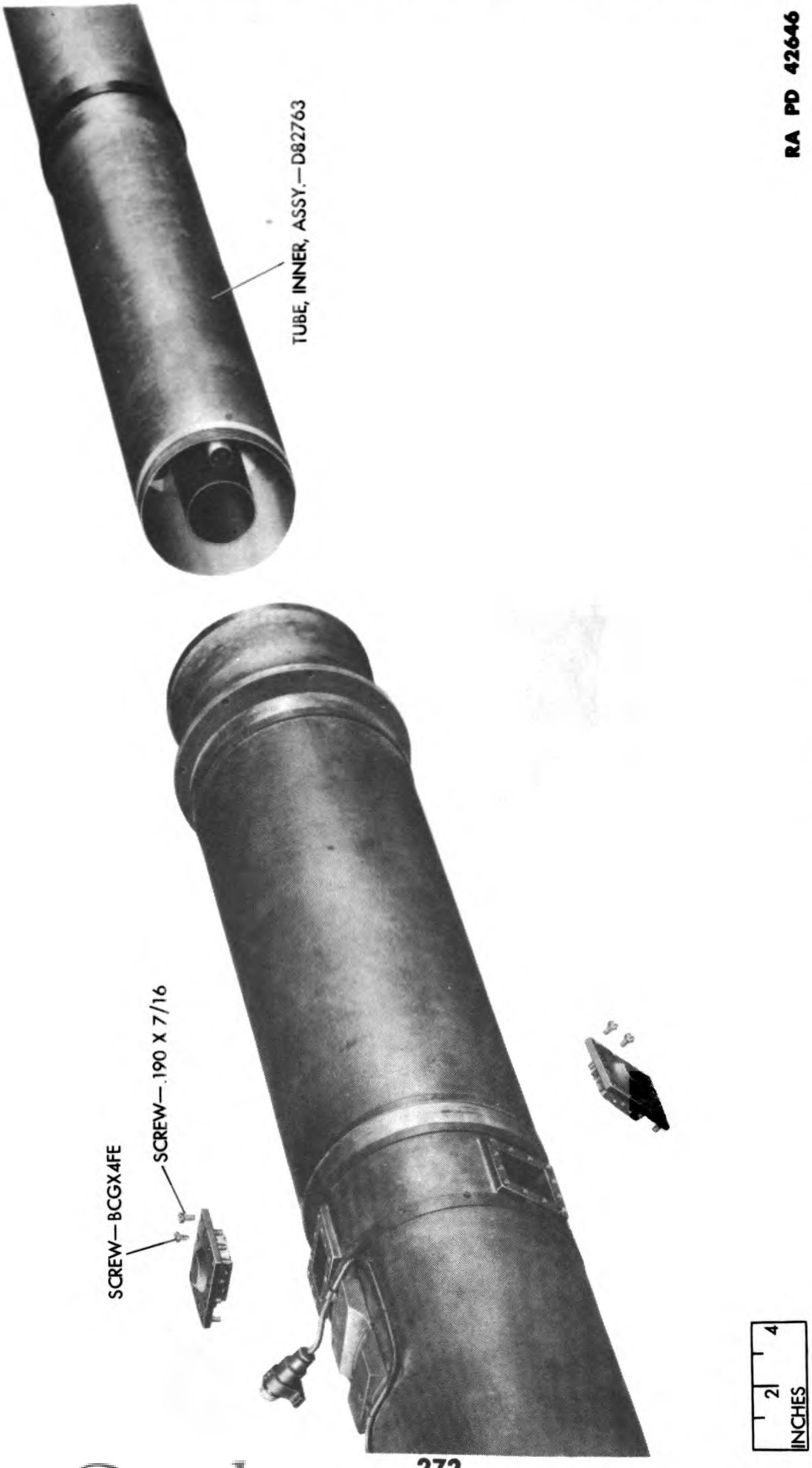

Figure 138 — Removal of Inner Tube

(7) Rotate the inner tube one-sixth of a turn and remove, through the bearing adapter openings, the three countersunk screws which secure the right bearing ring to the inner tube. Using brass or aluminum rods, push the bearing ring off the right end of the tube, so that the tube can pass through the measuring drum.

(8) Remove the three left roller assemblies (fig. 138).

(9) Carefully slide the inner tube out the left end of the outer tube, being careful not to allow the inner tube to drop off its auxiliary supports or to touch the measuring drum. Continually support the inner tube as it is being drawn from the outer tube, and allow the right end auxiliary support to follow the inner tube until it is near the measuring drum. The other supports should remain stationary.

CAUTION: Withdraw the inner tube from the *left* end of the instrument only.

(10) Remove the inner tube completely and set it up on V-blocks to allow the optical tube to be removed.

d. Removal and Disassembly of the Optical Tube.

(1) To remove the optical tube from the inner tube, proceed as follows:

(a) Remove the internal target centering disk bracket assembly C82415 located in front of the eyepiece opening (fig. 139).

(b) Remove the three screws holding each of the two spacers and the two screws holding the bracket of the right air tube assembly, and slide the assembly out of the tube.

(c) Remove the plug and the screw which holds the optical tube. These are located below and to the right of the measuring knob opening.

(d) Slide the optical tube out the right end of the inner tube, supporting it carefully and turning it on the way out as necessary to prevent the change-of-magnification disk assembly or the ocular prism mounts from striking the right support blocks. The optical tube is heavy and at least two men are needed to handle it safely.

(e) Place the optical tube on V-blocks spaced to fit the bearing rings.

(2) Remove the right and left clamp rings A49177 and locating screws A178048, and slide out the right and left objective assemblies (fig. 78). Mark the cells to identify them. Do not disturb the two lock nuts A49178 on each mount since they determine the correct positions for the objectives and will permit reassembly of the mounts to the optical tube without requiring adjustment for parallax.

(3) Remove erectors as follows:

(a) Remove screws A49643M to disconnect the change-of-magnification links, and remove the link supports A47064 (fig. 31).

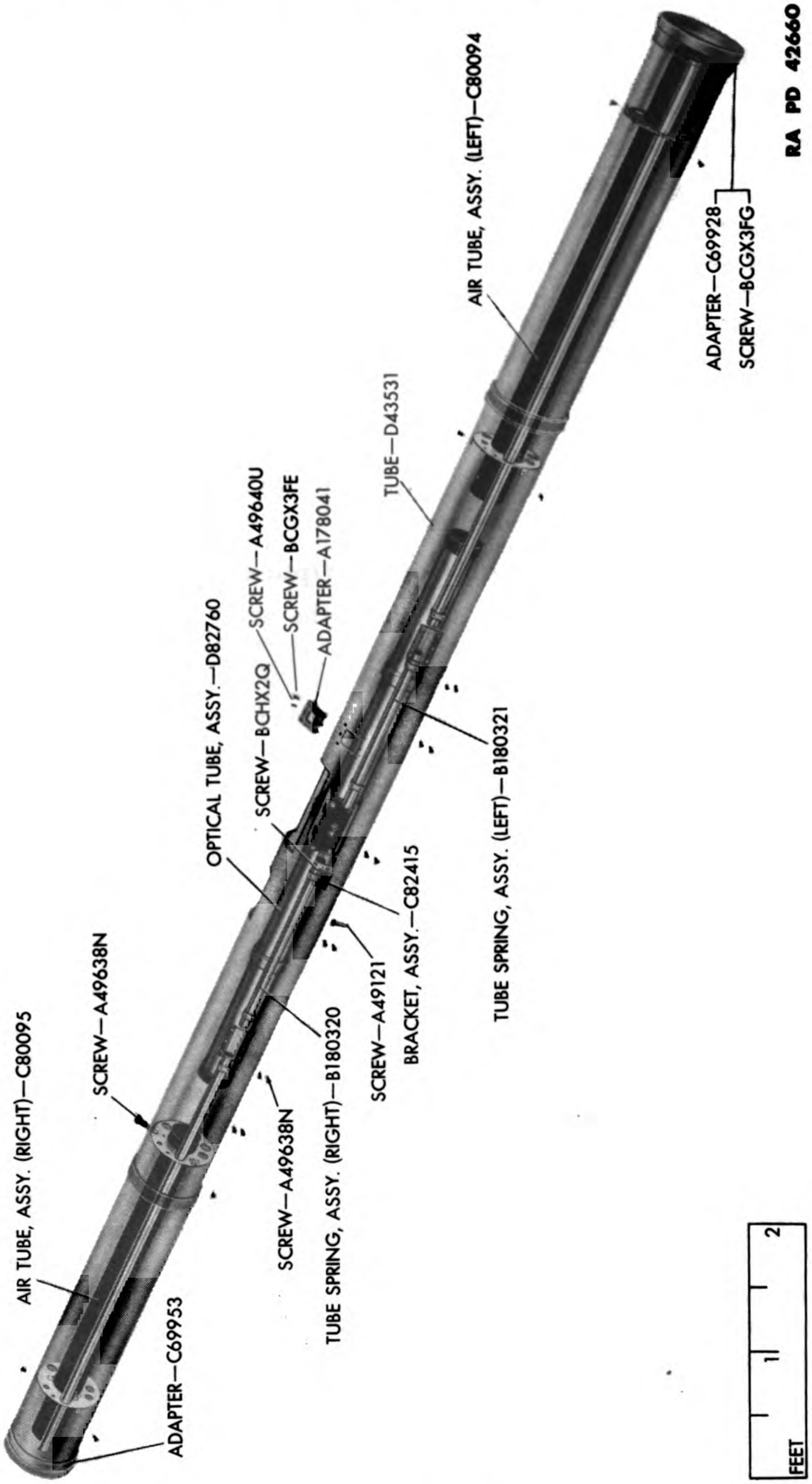

Figure 139 — Inner Tube Assembly — Phantom View

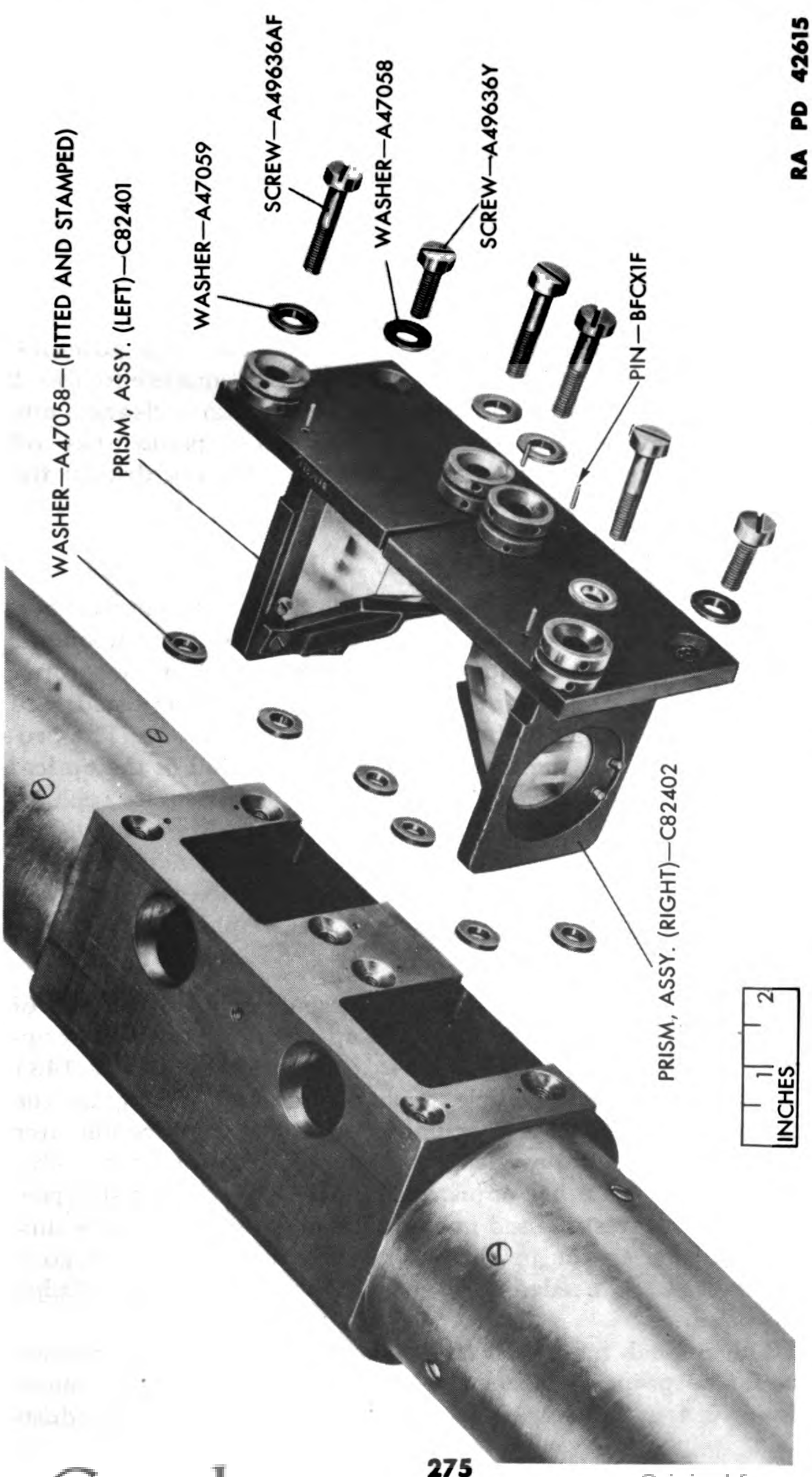

Figure 140 — Removal of Ocular Prism Assemblies

(*b*) Engage the threaded portion of the special tool illustrated in figure 142 with the threads near the outer end of the erector tube, then withdraw the tube from its sleeve and remove from the optical tube. Use care to avoid scratching, denting, or otherwise marring the surface of the tube. Repeat for the other erector tube.

(*c*) Removal and disassembly of the erector cells is described in paragraph 54.

(4) Remove the ocular prism assemblies by removing the three screws holding each assembly (fig. 140) and lift the assemblies from the tube. Do not disturb the adjusting bushings and lock nuts. Identify and mark each of the washers A47058 between the brackets and the optical tube so that they can be replaced in the same positions, since the washers vary in thickness. If these instructions are followed, the prisms can be removed from their respective mounts, cleaned, and remounted without readjustment. To dismount a prism, take off support A49105 (fig. 141) and spring A49128. Do not disturb the two locating plates A47056 and strip A47055.

66. ASSEMBLY OF THE OPTICAL TUBE.

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, rough-adjusted, and fine-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, and if proper precautions were taken during disassembly to avoid disturbing their adjustment, the assembly of the optical tube will be much simplified, being merely the reverse of the disassembly.

b. Requirements.

(1) Certain of the mechanical adjustments require the use of special jigs or fixtures which can be made up according to the descriptions and drawings given in paragraph 34. An autocollimator (fig. 143) is needed for alining new reticle mounts and for squaring up the entrance and exit faces of the ocular prisms. If an autocollimator cannot be obtained or improvised, these steps can be omitted. This will make some of the other adjustments more difficult but still possible. A divergence tester, used in conjunction with the eyepiece unit which will be used on the height finder and which must be in good working condition, is needed for centering the reticles and alining the ocular prisms.

(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-

HEIGHT FINDER TELESCOPE—DISASSEMBLY AND ASSEMBLY

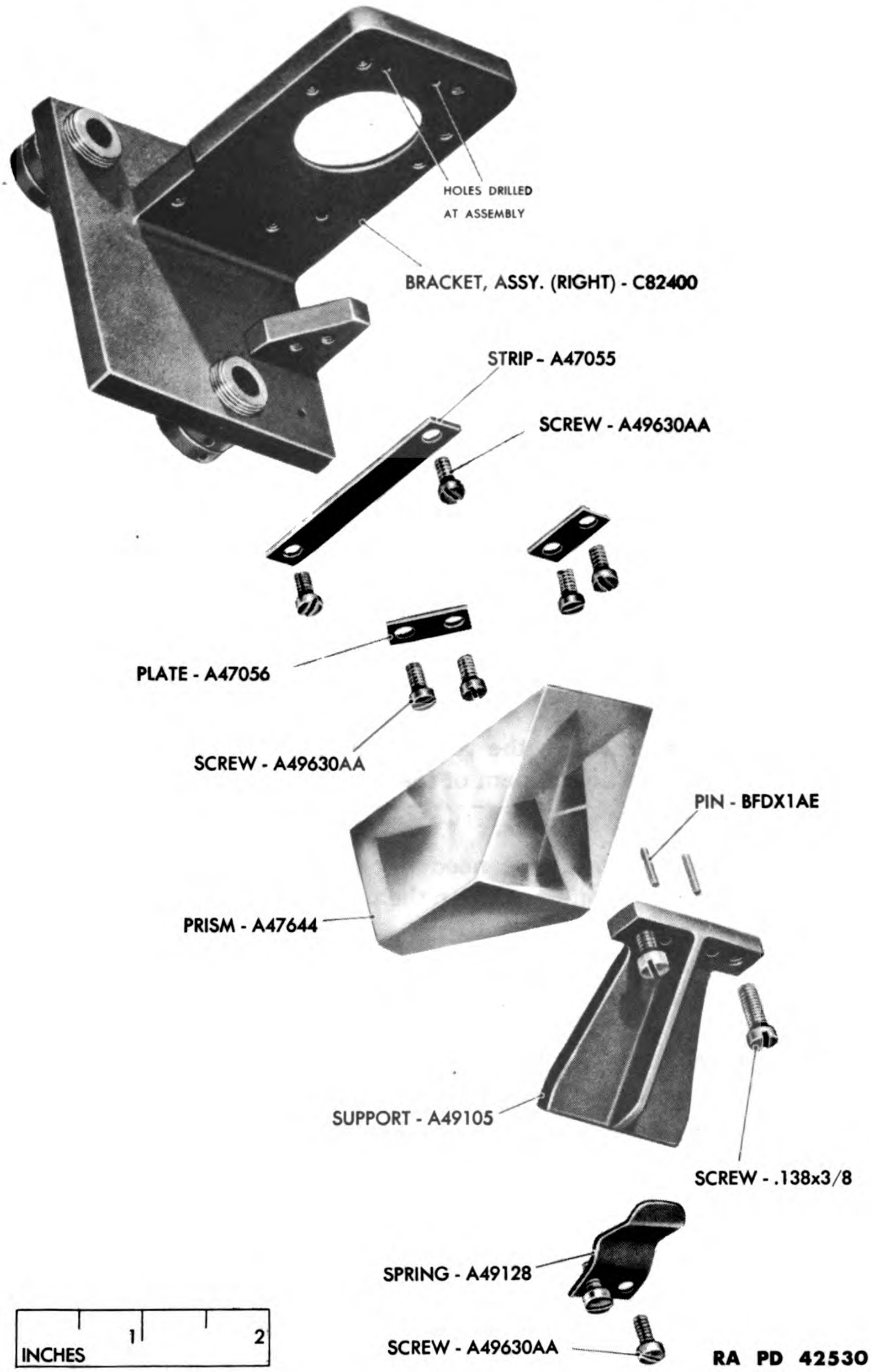

Figure 141 — Ocular Prism Assembly — Exploded View

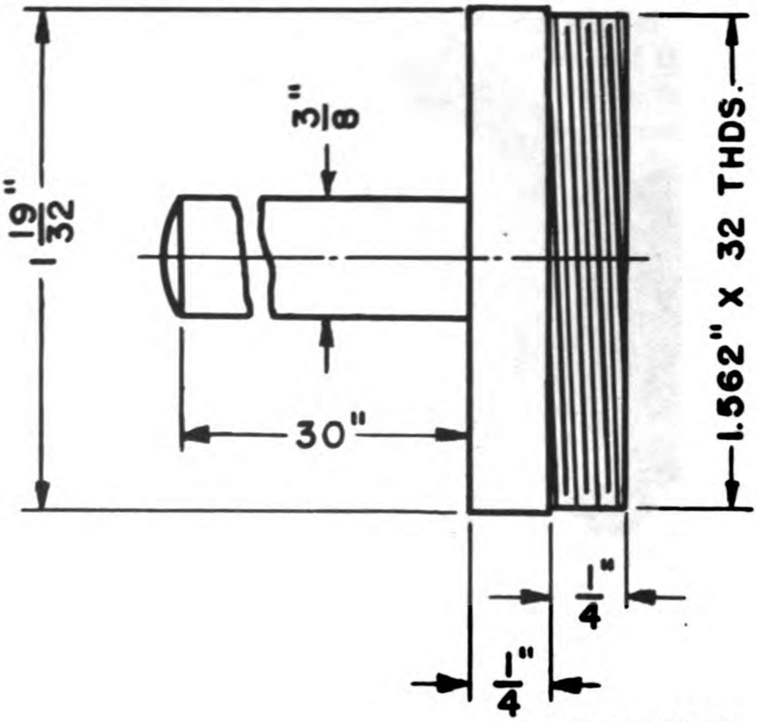

Figure 142 — Tool for Removing Erector Slide Tube

free room. Even then, the reticle will probably need cleaning after the assembly and adjustment of the height finder have been completed.

c. **Fit Reticle Mounts.**

(1) This operation is needed only when installing new reticle mounts. It can be omitted when the previously fitted mounts are being replaced.

(2) Turn the optical tube so that the reticle openings are on top, and mount the autocollimator in the left end of the tube. Check the alinement of the autocollimator by placing a mirror flat against the opposite end of the tube and noting whether the collimator cross hairs coincide with the reflected image.

(3) Insert the left reticle bracket assembly in the tube and check the vertical positions of the collimator cross hairs and the image reflected from the reticle. If they do not autocollimate within 30 minutes, it indicates that the reticle bracket is tilted excessively, and the mounting seats (fig. 144) should be scraped to correct.

(a) Scrape the seats to bring the vertical tilt within 30 minutes.

(b) Check the quality of the bearing surfaces with PRUSSIAN BLUE, on a flat plate. The seats should show at least 50 percent contact symmetrically distributed between the two seats and between the two ends of each seat.

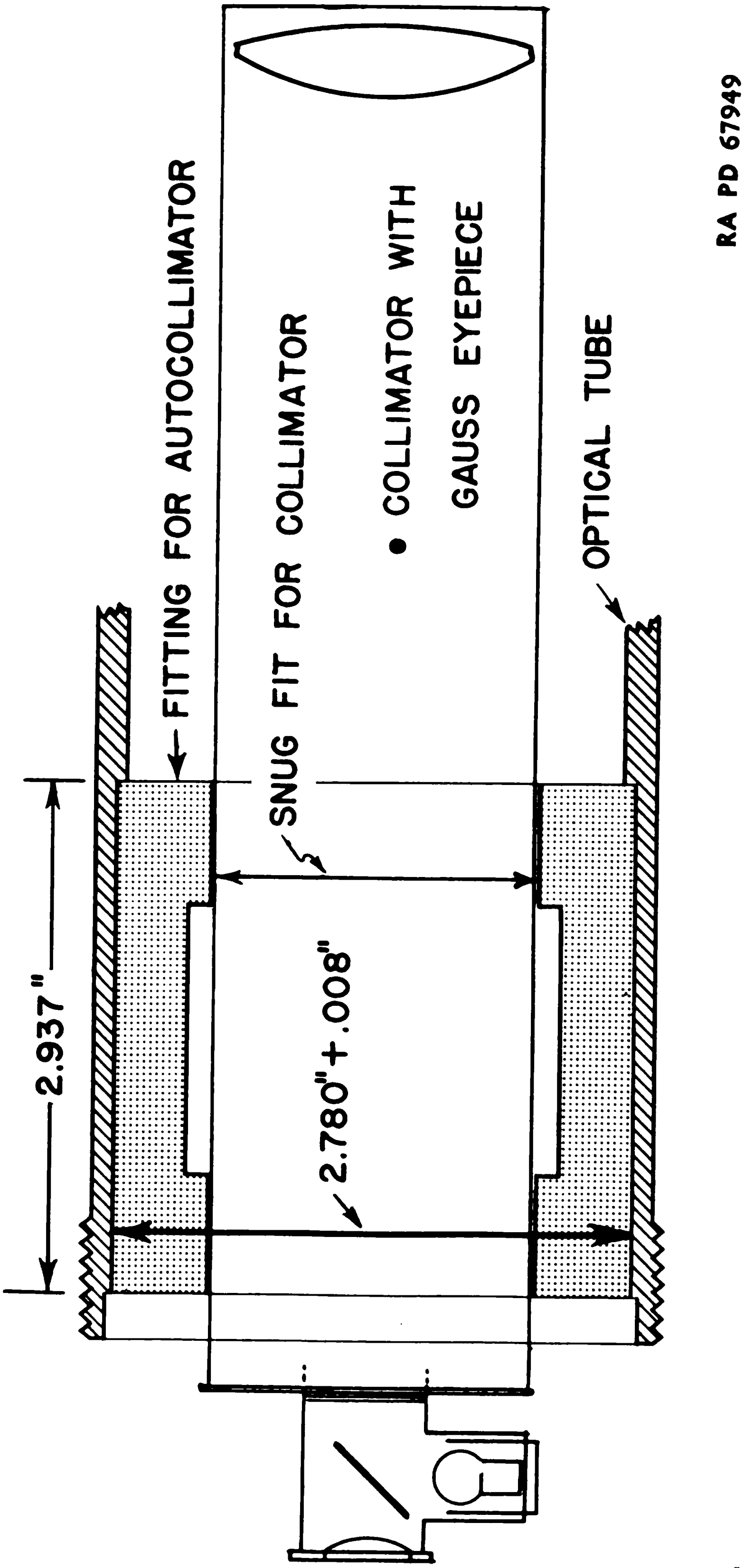

Figure 143 — Autocollimator in Bushing to Fit Optical Tube

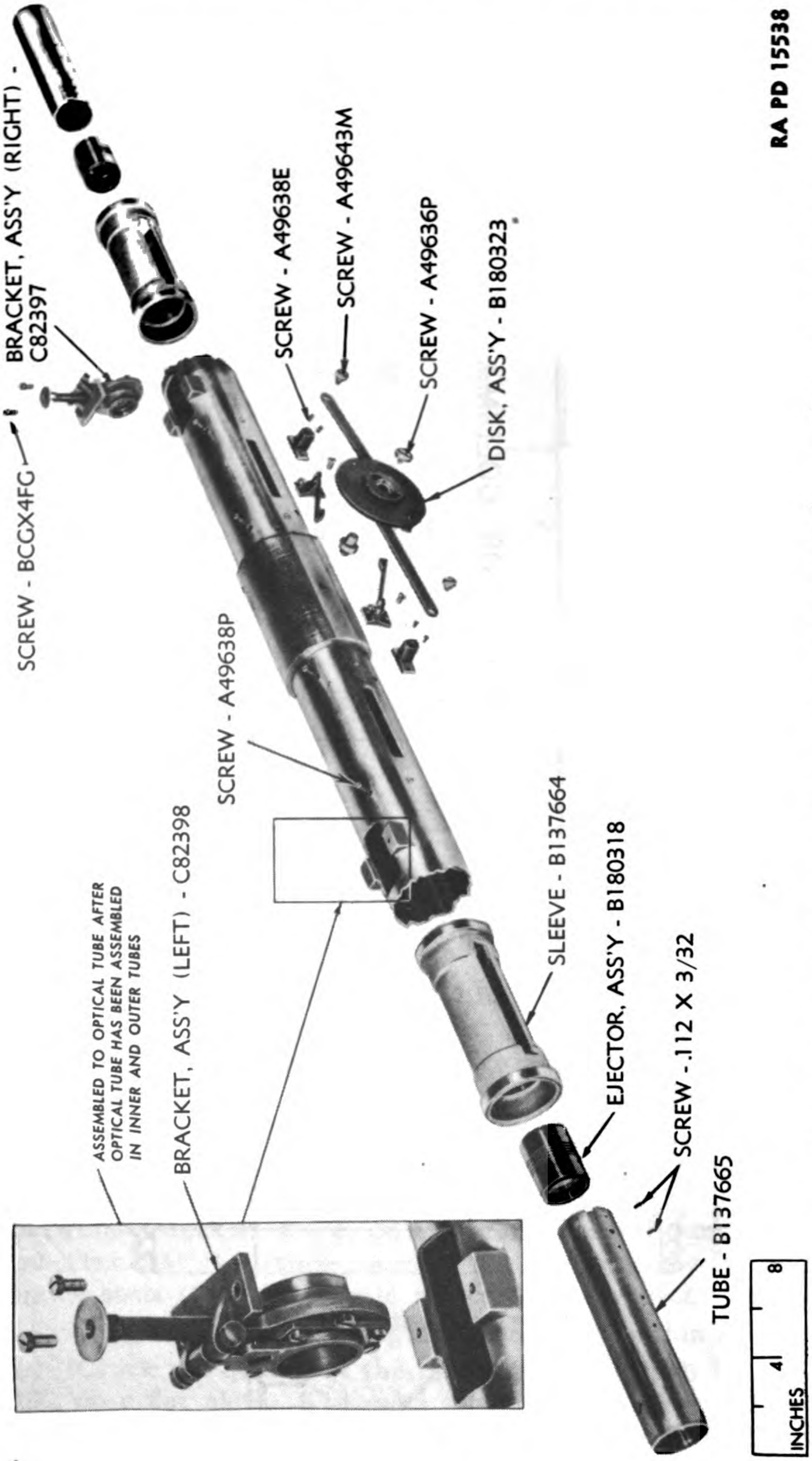

Figure 144 — Optical Tube, Showing Retical Bracket Seats and Erector Tubes and Sleeves — Partial Exploded View

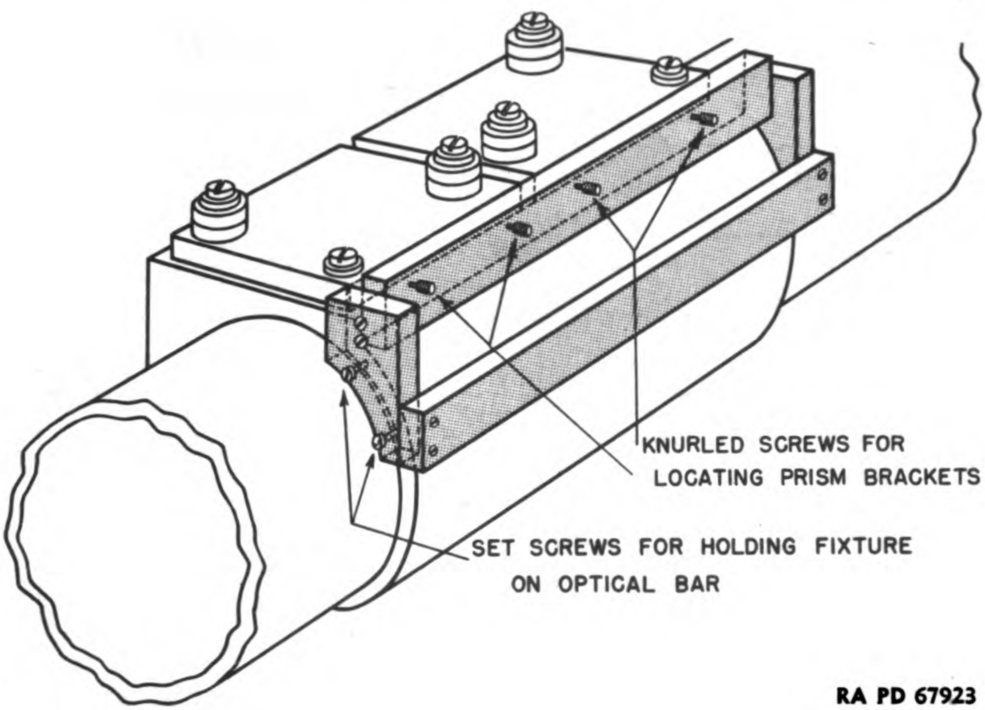

Figure 145 — Fixture for Alining Ocular Prism Brackets

(4) Check the lateral positions of the collimator cross hair and image, and twist the bracket assembly so that the two autocollimate within 10 minutes. Tighten the mounting screws and recheck.

(5) Drill, ream, and fit the taper pins BFCX1E (fig. 95, par. 53).

(6) Remove reticle assembly.

(7) Repeat for the right reticle.

d. Center Ocular Prism Brackets.

(1) The ocular prism brackets must be mechanically centered so as to utilize the full aperture of the prisms and avoid cut-off of the light beams. This operation is necessary only when installing new brackets or if the adjusting bushings of the old brackets have been disturbed.

(2) Fasten the prism alining fixture to the optical tube (fig. 145).

(3) Remove the erector cells from the erector tubes, insert the tubes in their sleeves, attach the change-of-magnification link supports, and connect the links.

(4) Attach the centering plug (fig. 146) to the left prism bracket, put the bracket in place in the optical tube, with the proper washers in place under the mounting screws.

(5) Turn the change-of-magnification disk to draw the erector tube in over the centering plug, tighten the mounting screw, and adjust

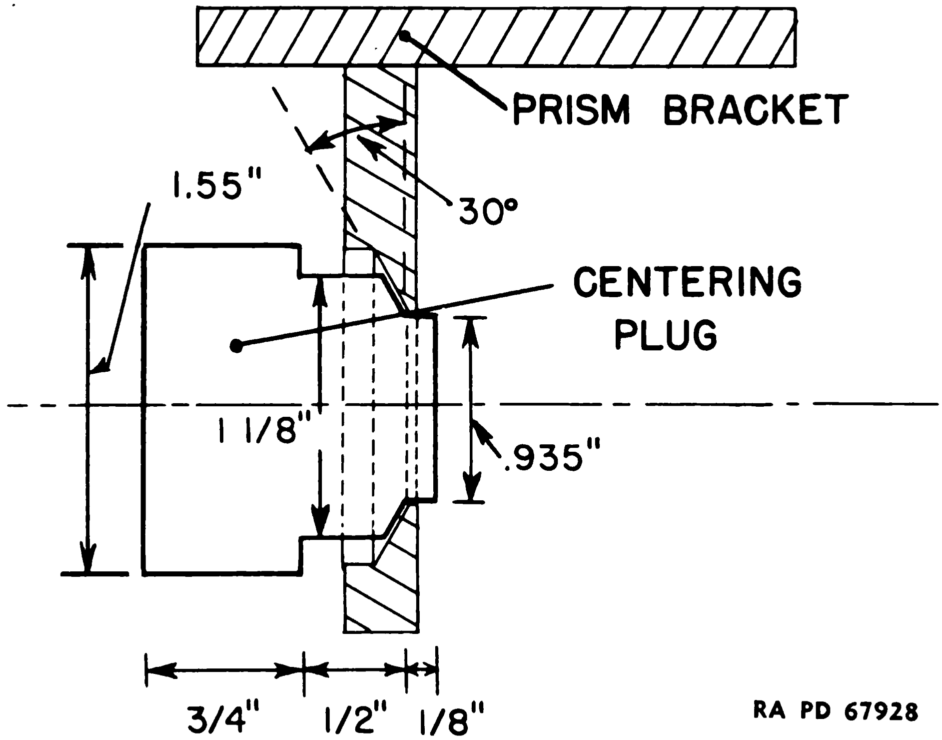

Figure 146 — Plug for Centering Ocular Prism Bracket

the front bushing so that the bracket is seated solidly. Lock the bushing with the lock nut A47057.

(6) Slide the erector tube back and remove the prism bracket and the mounting plug.

(7) Repeat for the other prism bracket.

e. Square Entrance and Exit Surfaces of Prisms.

(1) This adjustment is not needed when replacing the original prism assemblies, provided the proper precautions were taken to avoid disturbing the adjusting bushings or prism locating strips, as described in paragraph 65.

(2) Mount the autocollimator in the left end of the optical tube and check the alinement.

(3) Mount the left ocular prism in its bracket, holding it with only the spring clip and the long strip A47055 (fig. 141), and replace the bracket in the tube.

(4) Adjust the bushing to autocollimate the cross hairs vertically and the adjusting screw of the alining fixture to autocollimate the cross hairs laterally (fig. 145). Tighten the lock nut on the bushing and the locking screw on the alining fixture.

NOTE: From this point on, do not disturb the bushings or the screws on the alining fixture.

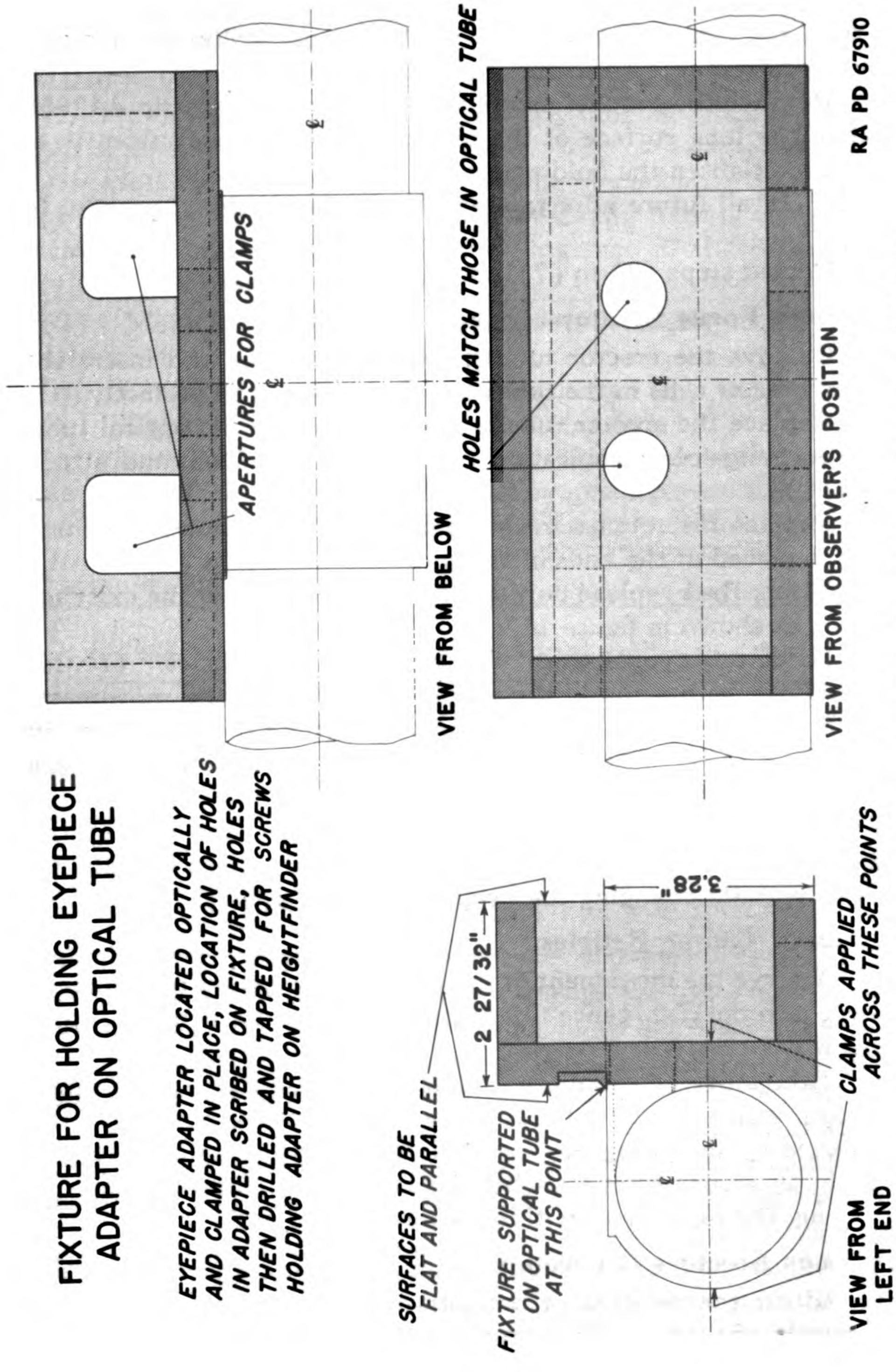

Figure 147 — Fixture for Mounting Eyepiece Assembly on Optical Tube

(5) Place a mirror over the exit aperture of the tube.

(6) Rotate the prism (not the bracket) about the axis of the bar by inserting a pencil through the other exit aperture and turning the prism with the eraser. When the cross hairs autocollimate, the adjustment is correct.

(7) Remove the bracket assembly, line up the long strip A47055 parallel to the long surface of the prism and as far away from it as possible, then tighten the holding screws.

NOTE: In all future adjustments of the prism, keep it parallel to this strip.

(8) Repeat steps (2) to (7), above, for the right prism.

f. Rough Focus Erectors.

(1) Remove the erector tubes from their sleeves and insert the assembled erector cells in the tubes, which they must fit perfectly.

(2) Replace the erector tubes in their sleeves in the optical tube, mount the change-of-magnification link supports A47065, and attach the links.

(3) Replace the reticles in the optical tube and illuminate them with lamps placed at the ends of the tube.

(4) Mount the eyepiece unit and divergence tester at the exit face of the tube as shown in figure 147.

(5) Focus the eyepieces on the height finder reticles. (If this cannot be done within the limits of the eyepiece focusing movement, adjust the focal length of the erector lens by turning the second cell in or out in the first cell (fig. 101) to change the separation of the lens components.)

(6) Rough-focus the erector lenses, by sliding the cell in the erector tube, until the image of the reticle is equally sharp at high and low power without changing the eyepiece diopter setting.

g. Rough Center Reticles.

(1) Observe the movement of the image of the center reticle mark with respect to the divergence tester grid as the erector is moved from high to low power.

(2) If the movement is more than 10 minutes, either up and down or sideways, remove the reticle assembly and adjust the position of the reticle sleeve by loosening the four holding screws in its corners and turning the eccentric screws slightly to nudge it in the direction desired. Bring the movement within 10 minutes for each reticle.

h. Focus Erectors Accurately.

(1) Adjust the position of the left erector assembly in its tube until the eyepiece focus settings for zero parallax between the height finder reticle marks and divergence tester grid are the same within 1/8 diopter for both high and low power settings of the erector lens. Tighten the set screw to hold the erector cell.

(2) Repeat for the right erector.

i. Adjust Ocular Prisms.

(1) The prisms are adjusted by movement in one or more of the three directions as follows:

Along axis of bar—by sliding the entire bracket.

Toward or away from the eyepiece—by moving prism only.

Up or down—by moving prism only.

There must be no rotational movement; the edge of the bracket is kept in contact with the screws of the alining fixture, the mounting bushings are not disturbed, and the long face of the prism is kept parallel to the longstrip A47055.

(2) Make use of the three movements, according to the table below, to meet the following conditions:

(a) Divergence between 0 and 30 minutes (fig. 48).

(b) Dipvergence within 15 minutes (fig. 49).

(c) 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 4 diopters down and 2 diopters up from this point.

Prism Movement		Image Movement in Divergence Tester	Focal Plane Movement
Left Prism	Up	To Right and Down	None
	To Right	To Left	Away from Eyepiece
	Toward Eyepiece	Up	Toward Eyepiece
Right Prism	Up	To Left and Down	None
	To Right	To Left	Toward Eyepiece
	Toward Eyepiece	Up	Toward Eyepiece

j. Center Reticles Accurately. Repeat the adjustment in subparagraph g, above, until the combined jump of both reticles as the erectors are shifted from high to low power is not more than 5 minutes up and down or sideways (fig. 54).

k. Set Prisms Accurately.

(1) Repeat the prism adjustment as in subparagraph i, above, to come within the following tolerances:

(a) Divergence 15 minutes (±5 minutes).

(b) Dipvergence within 10 minutes.

(c) Eyepiece cells at equal height (within 1 mm). Full focusing movement –4 to +2 diopters.

(2) Remove the prism assemblies from the bar. Loosen the screws and slide strip A47055 into contact with the long face of the prism,

and tighten screws securely. Mount the two plates A47056 and the support A49105 in contact with the respective faces of the prism. Examine in polarized light for strain and, if necessary, file strips and support to relieve points of pressure. Tighten locating plates and pin the supports.

(3) Replace prism bracket assemblies in the tube in correct position.

l. Pin Erector Cells.

(1) Remove the left erector lens tube and cell, taking care not to disturb the position of the cell in the tube.

(2) Mark the position of the cell in the tube, then remove the cell and tighten the set screw (fig. 101) to lock the second cell. Replace the cell in the tube and position as marked.

(3) Replace the tube in its sleeve in the optical tube, attach the change-of-magnification link support and link. Check the shift of focus, if necessary adjust the position of the cell in the tube, then tighten the set screw which holds the cell.

(4) Remove the erector tube and drill and tap into the cell for the permanent set screw to hold the cell. Insert set screw and replace the tube in its sleeve.

(5) Repeat steps (1) through (4), above, for the other erector.

(6) Check centering of reticles. The combined jump on shift of focus should not be greater than 5 minutes (fig. 54).

(7) Check the erector focus. The focus of either eyepiece should not change more than ⅛ diopter on shift from high to low power.

m. Pin Prism Brackets to Optical Tube.

(1) Check the prism alinement, which should still be within the tolerances:

(a) Divergence 15 minutes (±5 minutes).

(b) Dipvergence 10 minutes or less.

(c) Eyepiece cells project equal distance from eyepiece plate (within 1 mm).

(2) Drill and ream the prism brackets and optical tube for locating pins BFCX1F (fig. 140). After inserting the pins, recheck the adjustment. If the brackets have moved slightly, readjust and repin.

(3) Apply VARNISH, shellac, to the adjusting bushings, lock nuts, holding screws, etc.

n. Reticles and Objectives.

(1) Remove both reticle bracket assemblies. They will be replaced and adjusted for tilt after the optical tube has been reassembled in the inner tube and the inner tube in the outer tube. Tape over both ends of each reticle cell to exclude dust, and tape the openings of the optical tube to exclude dust and protect the seating surfaces from scratching or other damage.

(2) The objectives will be replaced and focused after the height finder has been reassembled.

o. Outline of Operations in Assembly of Optical Tube.

(1) Fit reticle brackets. Scrape seats to bring vertical tilt within 30 minutes. Bring horizontal alinement within 10 minutes and fit taper pins.

(2) Center ocular prism brackets. Use alining fixture and centering plug to center entrance aperture with respect to erector lens tubes.

(3) Square entrance and exit surfaces of prisms.

(a) Adjust prism bracket to autocollimate reflection from entrance surface of prism.

(b) Rotate prism to autocollimate reflection from mirror on exit surface of optical tube.

(4) Rough focus erectors.

(5) Rough center reticles. Bring jump within 10 minutes vertically and horizontally for each reticle.

(6) Focus erectors accurately. Eyepiece focus changes not more than ⅛ diopter between high and low power.

(7) Adjust ocular prisms.

(a) Slide prism or bracket, no rotational movement, to bring:

1. Divergence between 0 and 30 minutes.

2. Dipvergence within 15 minutes.

3. Focal planes within 1 mm.

(8) Center reticles accurately. Combined jump of both reticles within 5 minutes vertically and horizontally.

(9) Set prisms accurately.

(a) Repeat step (7), above, to bring:

1. Divergence 15 minutes (±5).

2. Dipvergence within 10 minutes.

3. Focal planes within 1 mm—full focusing movement of eyepiece cells.

4. Mount locating strips and pin supports.

(10) Pin erector cells.

(a) Tighten cell set screws, check shift of focus, if necessary adjust, install set screw.

(b) Check reticle jump and shift of focus.

(11) Pin prism brackets.

(a) Check prism alinement—tolerances in step (9), above. Install locating pins, recheck adjustment, apply VARNISH, shellac, to bushings, nuts, screws.

67. ASSEMBLY AND ADJUSTMENT OF UNITS TO THE HEIGHT FINDER.

a. General. After the optical tube has been assembled and adjusted, it is assembled in 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.

b. Assembly of Units to the Inner Tube.

(1) Prepare inner tube.

(a) Inspect for cleanliness. Blow out any dust, lint, or metal chips.

(b) Apply a light coat of grease and wipe off all excess.

(c) Scribe the positions of the right end adapter and right bearing ring, and remove them from the inner tube. (This will have been done during disassembly.)

(2) Insert and pin the optical tube.

(a) Insert the optical tube into the right end of the inner tube, supporting it carefully and turning it as necessary to avoid striking the supports or the walls of the inner tube.

(b) Fit the bearing surfaces of the optical tube onto the bearing blocks in the inner tube, with the springs (fig. 148) coming under the upper bearing blocks.

(c) Check the fit of the tube. There should be no side play, but it should be possible to turn the tube by hand.

(d) Adjust the position of the optical tube so that the hole in the right bearing ring lines up with the hole in the lower rear bearing block.

(e) Grease the locking screw, insert it into the hole, and turn it in snug. The taper end of the screw should extend into the optical tube ⅛ inch with a good fit, but should not bottom in its hole or jam the optical tube against the opposite supports. The optical tube must not rotate at all when the pin is in place.

(f) Screw in the plug on top of the locking screw and apply VARNISH, shellac, to the head of the plug.

(3) Insert air tube assemblies (figs. 139 and 149).

(a) Inspect the air tube assemblies for broken or missing springs.

(b) Blow out large and small tubes with air hose to remove any dirt or dust.

(c) Insert the air tube assemblies in the inner tube, and replace and tighten the screws which hold the spacers and mounting brackets.

(4) Mount the internal target centering disk bracket assembly C82415 to its adapter near the middle of the inner tube (fig. 139). Turn the adjusting screws to set the plane of the disk perpendicular to the axis of the tube.

HEIGHT FINDER TELESCOPE—DISASSEMBLY AND ASSEMBLY

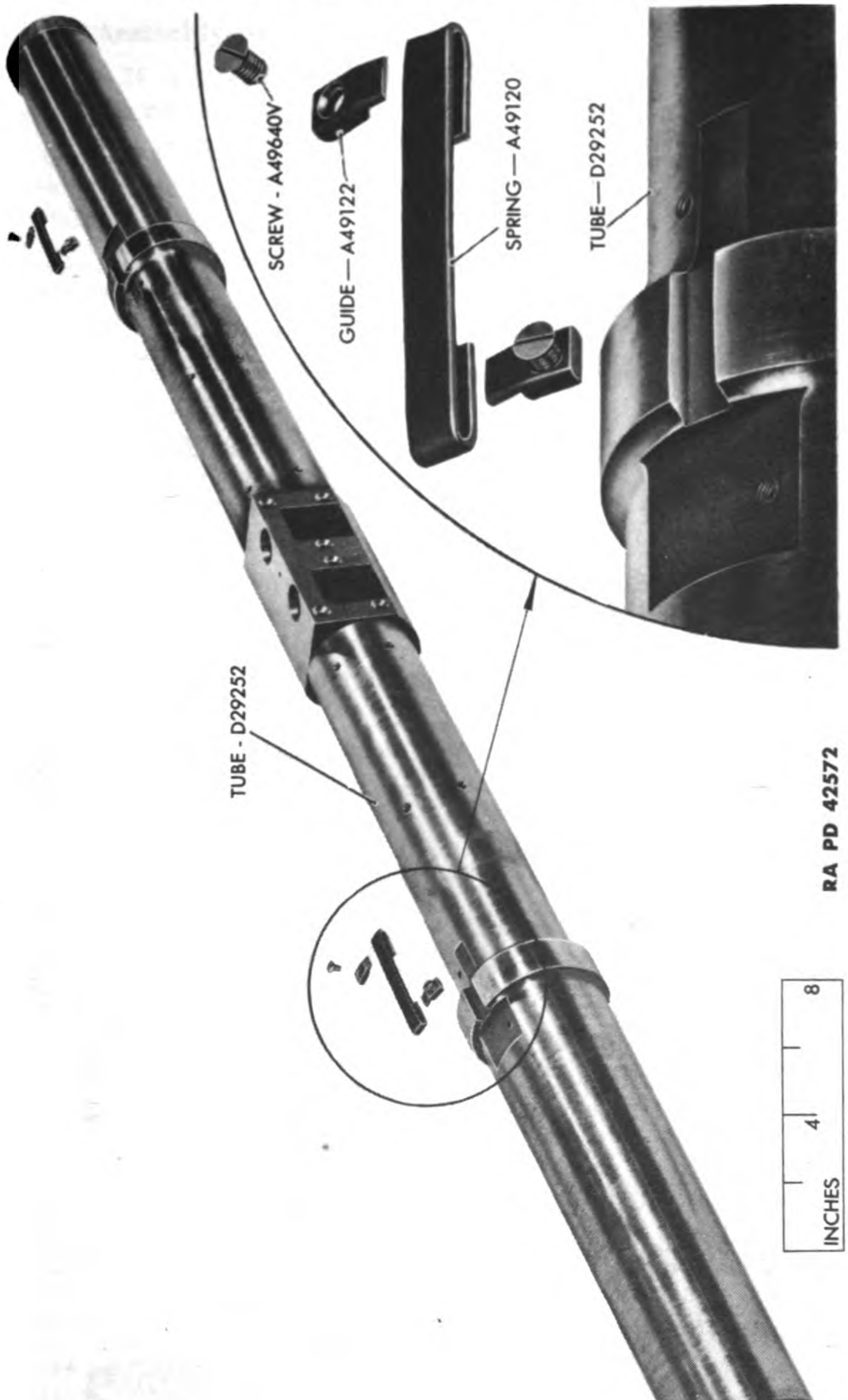

Figure 148 — Bearing Surfaces and Friction Springs of Optical Tube

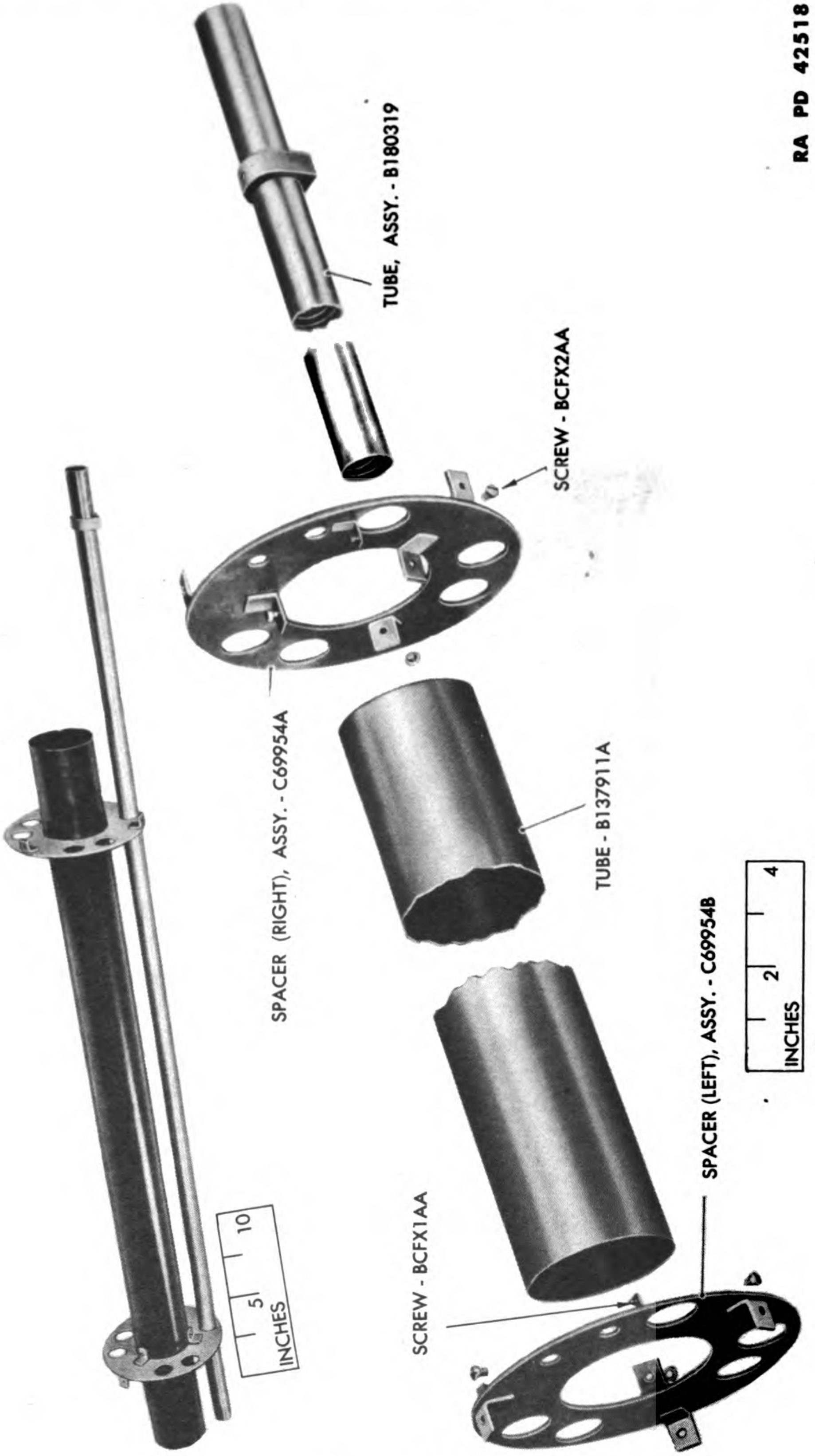

Figure 149 — Left Air Tube Assembly

c. Assembly of Inner Tube in Height Finder.

(1) If the measuring drum has been removed from the outer tube, replace it and its bearings as described in paragraph 52.

(2) If the main bearings have been removed, reassemble them as described in paragraphs 62 and 63. Replace the carrier handles as in paragraph 64.

(3) If the roller bearings have been replaced on the outer tube, remove them.

(4) Insert the inner tube.

(a) Rotate the inner tube so that the back edge of the eyepiece opening is at the top.

(b) Place the curved temporary supports described in paragraph 65 in the outer tube to support the inner tube. Insert the inner tube into the left end of the outer tube and slide it in until it nearly reaches the measuring drum.

(c) Inspect to see that the inner tube will not hit the measuring drum. If necessary, adjust the drum bearings to position the drum so it will not touch the inner tube. Leave the top bearings loose so that, if the inner tube is raised and strikes the drum, damage will be slight.

(d) Slide the inner tube through the measuring drum and into position in the outer tube. Rotate the drum with the fingers as the inner tube is being slid through. *The inner tube must not touch the drum during this assembly. Do not rotate the inner tube.*

(e) Slip the right bearing ring onto the inner tube, and tap it into place with a long brass rod and a mallet. Line up the scribed marks on the ring and inner tube and replace the three holding screws.

(5) Assemble inner tube bearings.

(a) Grease the inner tube bearing rings on the sections over which the roller bearings travel.

(b) Clean and grease the rollers of the bearing assemblies.

(c) Apply COMPOUND, sealing, for height finders, to the bearing plates and assemble the four lower bearing assemblies to the outer tube. Make sure that the bearings are replaced on the same adapters and in the same positions as before.

(d) Remove the temporary inner tube supports and assemble the two top bearings to the outer tube.

(e) Check the action by rotating the inner tube. It should roll easily, but there should be no looseness and no end play.

(6) Replace the end adapter on the inner tube. Draw it up tight so that the screwholes in the adapter and inner tube line up, and install the locking screw.

d. Installation of Mechanical Units on Height Finder.

(1) Install the various mechanical units in the order given below. In each case, check the fit of the unit to its adapter on the outer tube; then, after any other necessary adjustments have been made, apply a thin film of COMPOUND, sealing, for height finders, to the adapter, clean excess compound from the screw holes, fit the unit in place, and insert and tighten the proper holding screws. Be sure the screws used are not too long, or they may bottom in the holes and force the adapter loose from the outer tube. Refer to the paragraphs indicated for pictures and further details.

(2) Elevation adjustment knob, paragraph 56 d.

(a) Apply a thin film of grease to the roller bearing and check for snug fit of bearing in its adapter on the inner tube. Seal and mount.

(b) Place a level on a 10-degree metal wedge on the eyepiece adapter and level the outer tube. Eyepiece level should check with main height finder level. Place the level and 10-degree wedge on the face of the optical tube, and turn elevation adjustment knob to bring the face parallel to eyepiece adapter within 5 minutes. Adjust the stop screws (par. 56 c) to hold the adjustment knob in this position during subsequent operations.

(3) Adjuster prism shift assembly (par. 59 c).

(a) Apply a thin film of grease to the racks of the prism link assemblies, insert racks through the proper holes in the air tube spacers (right rack in lower holes, left rack in upper holes).

(b) Check fit of adjuster shift assembly on adapter, apply sealing compound, and mount. Turn crank to position at which racks were disengaged.

(c) Push ends of racks into bearings in shift assembly with their ends against the pinion.

(d) Turn crank counterclockwise to engage racks and draw racks in. Turn crank to normal stop position. Each link should extend 1⅜ inches from the end of the inner tube to the end of the link.

(e) Replace stop assembly.

(4) End reflector supports (par. 42 g).

(a) Mount end reflector supports on ends of inner tube, with prism links extending through proper slots. Scribe marks on the rims of the supports and make corresponding marks on the inner tube at the limits of adjustment of the supports. Set the supports at the mid point of their movement and tighten bolts.

(b) Grease ends of prism links and attach to penta prism yokes with pivot screws.

(c) Check penta prism stops. Both yokes should close simultaneously, with flat front surfaces parallel to axis of height finder.

(5) Change-of-magnification crank (par. 54).

(a) Should seat smoothly on its adapter.

(b) Crank should swing through lower half of arc. Action should be smooth, no binding, no pressure on change-of-magnification disk.

(6) Measuring drum window and index (par. 51 **b**).

(a) Check for cleanliness of window and index, slide index into guide back of window, fit assembly into place with roller in slot of measuring drum.

(b) Turn drum through its entire travel; index and covers must move freely and not touch drum surface.

(7) Measuring knob (par. 50 **b**).

(a) Grease teeth of measuring drum and drum engagement gear sparingly.

(b) Turn drum to bring 550 mark at lower edge of index opening, turn measuring knob counterclockwise to stop, insert knob unit, and engage gear with drum.

(c) Check for full travel of drum. End marks should stop same distance (about 5/8 in.) beyond index line at both ends.

(8) Adjust measuring drum bearings (par. 52 **c**).

(a) Drum must roll freely, with no backlash between drum and measuring knob. Drum must not touch index or inner or outer tube.

(b) Clamp each ring and bearing with two screws, recheck bearing adjustment, replace bearing caps.

(9) Eyepiece housing (par. 44).

(a) Clean faces of ocular prisms carefully with vacuum line (par. 53 **h**) and cotton swab. Check cleanliness of inside surfaces of windows of eyepiece housing.

(b) Seal housing in place, turn in holding screws below outer surface of housing, but do not tighten.

(10) Set up height finder on its tripod and cradle (par. 13).

e. Installation and Adjustment of the Main Optical System.

(1) The ocular prisms and erectors should be adjusted, and the reticles partly adjusted, before the optical tube is installed in the inner tube. Installation of the other optical parts, and the further adjustments, must be made in the order given below. If this order is not followed, certain adjustments will be disturbed by later operations. Pictures and further details about the units will be found in the paragraphs listed.

(2) Mount end reflector blocks and set base length. The adjustment for base length is usually necessary only when new end reflector blocks are being mounted. Previously set end reflector blocks which are being replaced can be located by centering the marks scribed on the bottoms over the holes of the mounting bosses.

(a) Mount objectives in ends of optical tube (par. 45).

(b) Mount the end reflector assemblies on their supports, holding each loosely with the three mounting screws.

(c) With the instrument in low power, install eyepiece unit temporarily and center the moons in the eyepieces by moving the eyepiece unit and housing from side to side. Eliminate dipvergence by rotating eyepiece and housing. Tighten screws holding eyepiece housing.

(d) Rotate each end reflector block into proper position, using the 45-degree template (fig. 150), with the leg against the shoulder of the outer tube and the sloping edge against the front surface of the reflector block.

(e) Examine low-power field in each eyepiece for "cut-off." If one side of field is dimmer than the other, move reflector toward front or rear of instrument to correct.

(f) Cover objectives with stops having central apertures 3/16 inch in diameter, and set up base length fixture (fig. 151) in front of height finder.

(g) Slide base length fixture back and forth lengthwise until spots of light appear in reticle fields.

(h) Move end reflector blocks in or out until spots of light appear in the same relative position in left and right fields (fig. 152). (Disregard any differences in height.)

(i) Recheck for "cut-off" (substep *(e)*, above); then tighten set screws in tops of reflector supports to hold reflector blocks in place.

(j) Remove the three mounting screws from each block and scribe bottoms of blocks around inside of holes in the end reflector supports.

(k) Replace the three screws in each block and remove aperture stops from objectives.

(3) Rough-focus objectives (par. 45) for a distant target (not necessary to insert correction wedge or compensator at this time).

(4) Fine-adjust reticles for tilt.

(a) Place a horizontal reference line in the focal plane of each eyepiece in the following manner: Remove the eyepiece cells (par. 44 b) and stretch a hair or silk fiber across the bottom of each cell, centered, and as nearly as possible at right angles to the radius through the focusing shoe. Fix the hairs in place with a drop of shellac at each end. Trim the excess length of hair and replace the cells in the eyepiece assembly.

(b) To calibrate the cross hairs, remove the eyepiece unit from the height finder and set up with the plate vertical, place a level on the upper edge of the plate, and level the unit. Using an auxiliary lens, such as one of the height finder objectives, form an image of a horizontal reference line, such as a chalk line or the edge of a large level,

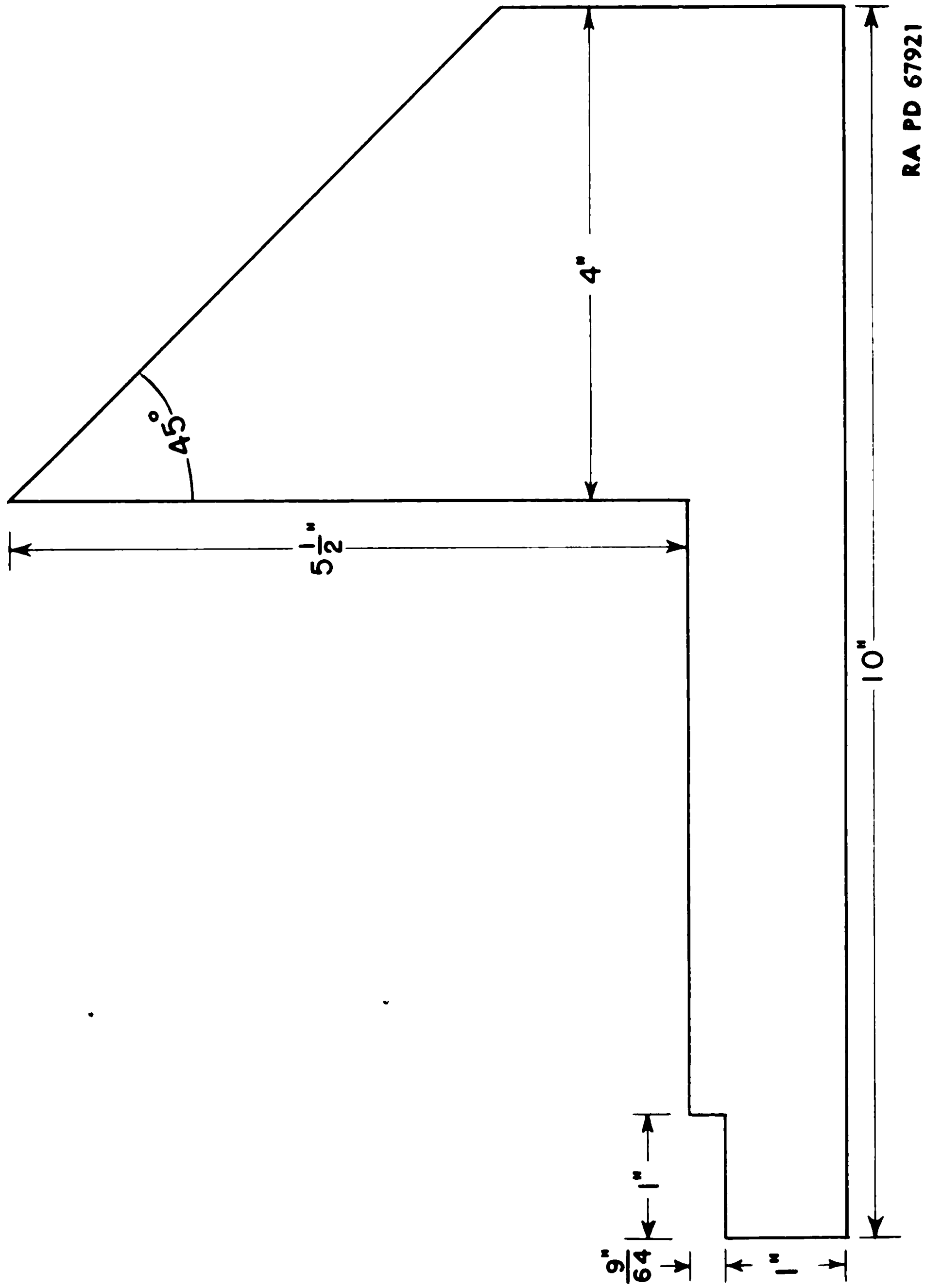

Figure 150 — 45°-angle Template Dimensions

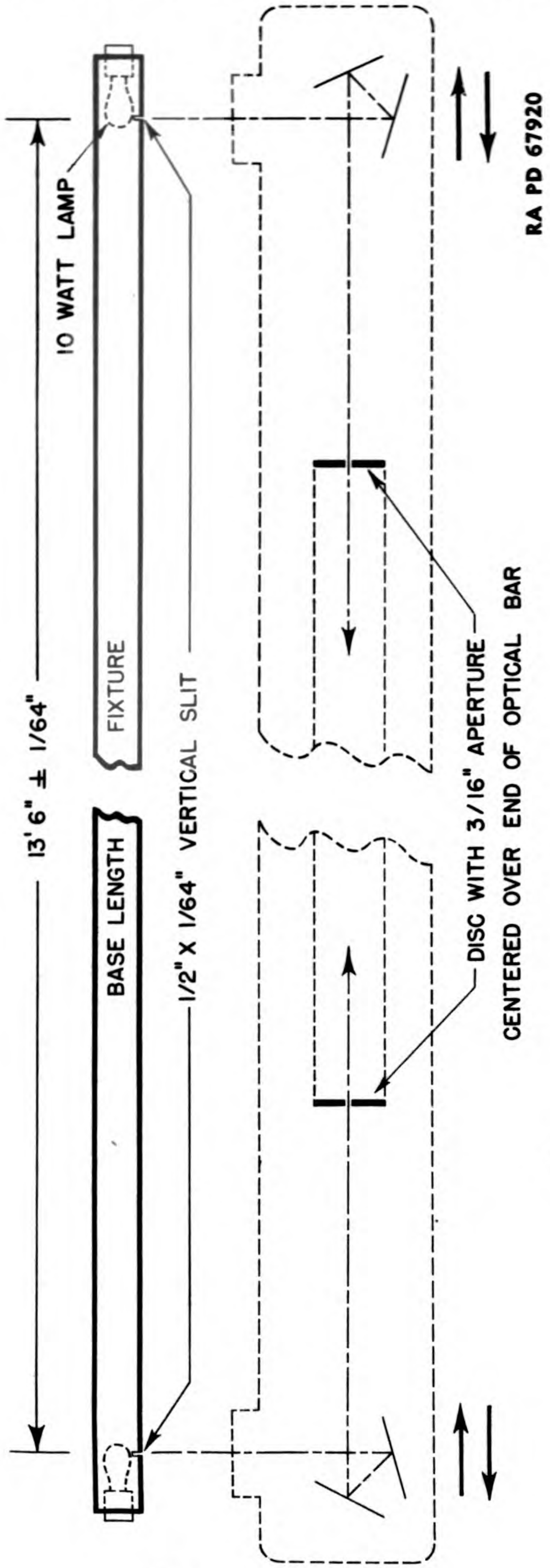

Figure 151 — Base Length Fixture

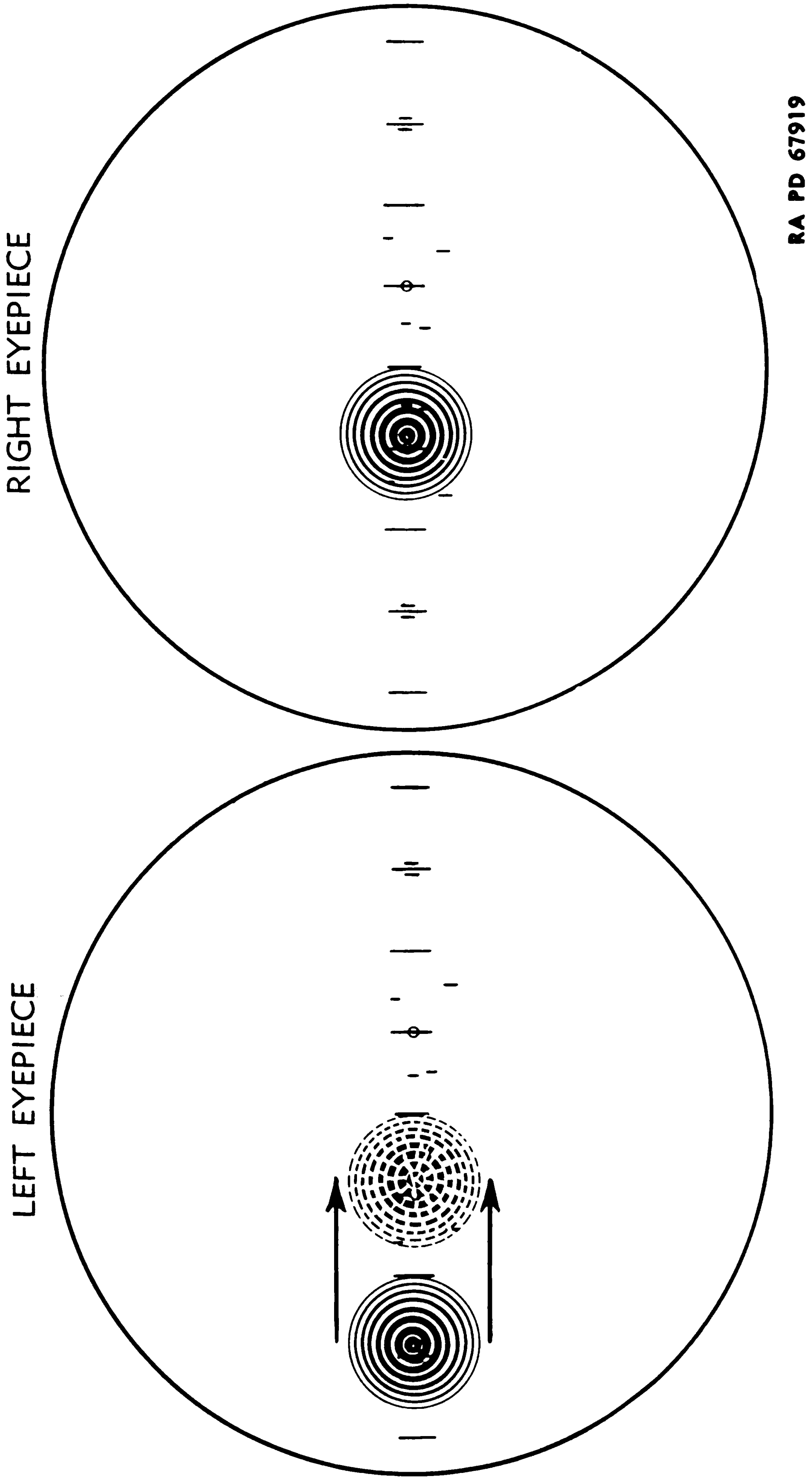

Figure 152 — Appearance of Light Spots in Reticle Field During Adjustment of Base Length

in the focal plane of the left eyepiece and practically coinciding with the cross hair. Turn the interpupillary distance lever to bring the cross hair parallel to the horizontal reference line and record the setting. Repeat for the right eyepiece and record its setting.

(c) Mount the eyepiece unit temporarily on the height finder with screws in the corners, elevate the height finder to 1420 mils (80 degrees) in order to bring the eyepiece plate vertical, place a level on the upper edge of the plate, and level the eyepiece unit.

(d) Mount the right reticle in the height finder and set the interpupillary distance at the value recorded for the right eyepiece.

(e) Adjust the capstan screws to bring the plane of the reticle marks parallel to the eyepiece cross hair.

(f) Train the height finder on a distant target and install the properly adjusted measuring wedge unit (par. 49). Backlash mechanisms should be removed to avoid damage. Turn the wedges to traverse the target image across the reticle field. The target image should not rise or fall more than the width of the reticle ball marks as the wedges are turned from infinity to 550-setting. If necessary, adjust the reticle to meet this condition, then tilt the eyepiece unit enough to aline the cross hair with the reticle while keeping the interpupillary distance at the value recorded for the right eyepiece.

(g) Repeat substeps *(d)* and *(e)*, above, for the left reticle. The purpose of this adjustment is to make the images of the reticles in the focal planes of the two eyepieces as nearly parallel as possible in order to reduce eyestrain and increase accuracy for the stereo observer. The right reticle is alined with the deviation plane of the measuring wedges in order to avoid introducing a halving error as the wedges are turned for different distances.

(h) Tighten the capstan screws and apply a spot of VARNISH, shellac, at the contact point between the end of each screw and the arm of the reticle cell.

(i) Remove the temporary cross hairs from the eyepiece cells.

(5) Adjust eyepiece unit (pars. 43 and 44).

(a) Apply COMPOUND, sealing, for height finders, around housing rim and replace eyepiece unit.

(b) With the instrument in low power, center the moons in the eyepieces by moving the eyepiece unit from side to side.

(c) Mount the divergence tester, and correct dipvergence (up-and-down divergence) by tilting the eyepiece unit as necessary (should be within 10 minutes, fig. 49) in both high and low power.

(d) Tighten eyepiece holding screws and remove divergence tester.

(6) Install height adjuster in midposition (par. 55).

(a) Check for cleanliness, and mount unit on its adapter on inner tube.

(b) Using the special height adjuster wrench (fig. 109), turn the adjusting screw of the height adjuster to one end of its travel; then turn to the other end, counting the turns.

(c) Set the adjusting screw at its midposition.

(7) Install correction wedge (par. 46).

(a) Aline height finder on target with image centered in left reticle field.

(b) Mount adjuster scale on height finder (par. 47); set at reading of 50.

(c) Set correction wedge at midpoint, insert in height finder, engage drive shaft in coupling sleeve, mount unit on its adapter.

(d) Check that wedge is set "image up." When adjuster scale is turned to increase scale reading, target image in left reticle field should move to the right without appreciable change in height.

(e) Turn adjuster scale to recenter left image, close cover, tape in place, and leave undisturbed until end reflector supports have been scraped in.

(8) Scrape end reflector supports. This should be necessary only when new end reflectors or new supports have been installed. Scraping is a difficult operation and should be avoided whenever possible.

(a) Level outer tube and aline on distant target at same height as instrument. Fasten elevation handwheel so it cannot be turned while end reflector assemblies are unbolted.

(b) Check mirrors of right end reflector to see whether there is any contact or possibility of contact with bosses on reflector support.

(c) Unbolt right mirror block and loosen set screw on top.

(d) Where necessary, file edges of bosses to eliminate contact with mirrors.

(e) Check tightness of bolts and position of right end reflector support. Scribe mark on casting should be midway between limit marks on inner tube.

(f) Place right mirror block on bosses with scribed marks centered over holes.

(g) Note height of target image at center of right reticle field. Traverse height finder to move image across field and note any change in height of image (tilt). Check that elevation adjustment knob has not become loose (moons centered vertically in eyepieces).

(h) File bosses according to diagrams in figure 153 to correct for tilt and vertical placement of image in reticle field. Keep surfaces of the bosses level, using PRUSSIAN BLUE, on a flat plate to check contact.

(i) Scrape bosses to obtain at least 80 percent bearing surface, uniformly distributed around the circle (fig. 154), when flat plate is in contact with all three bosses.

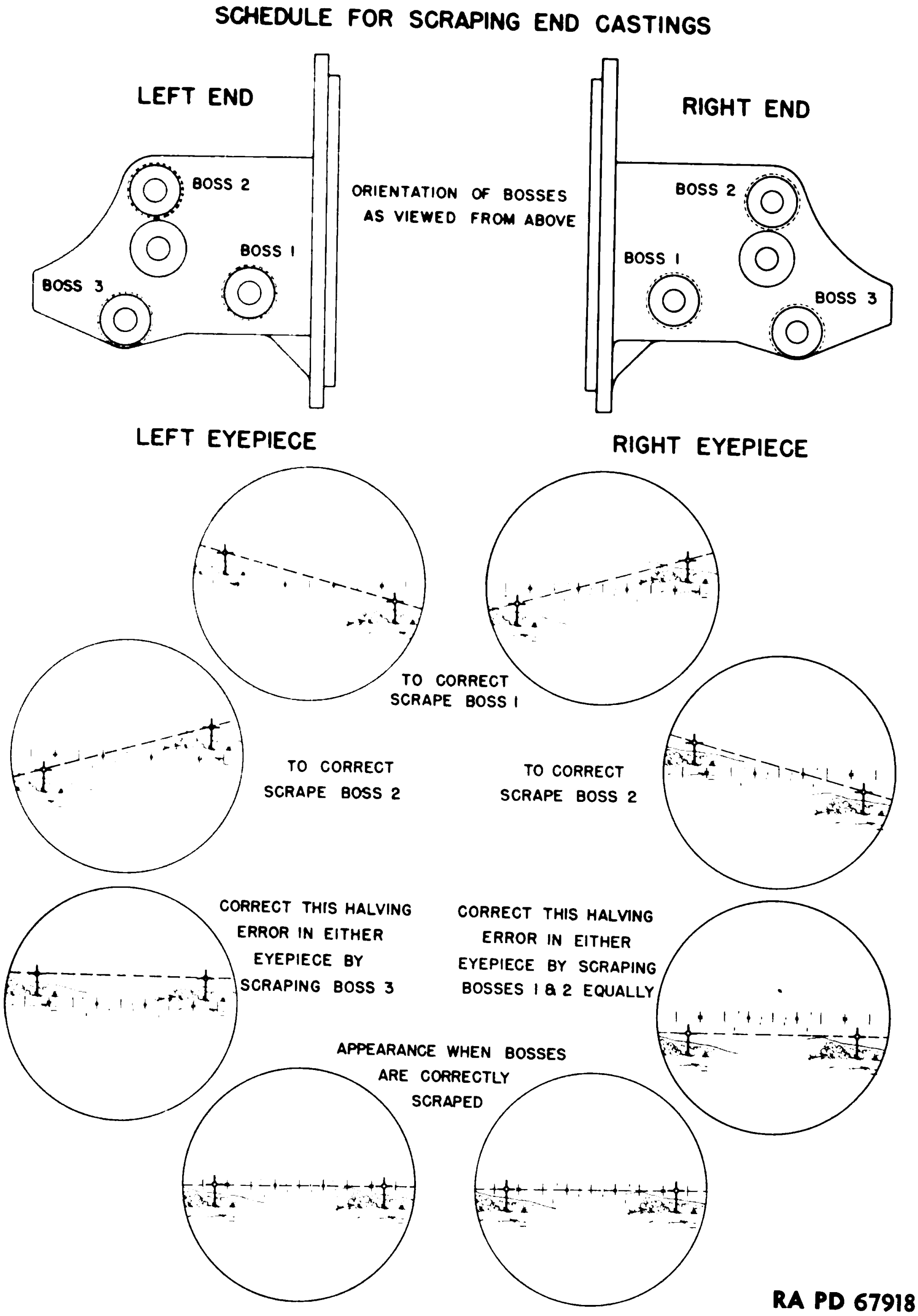

Figure 153 — Schedule for Scraping End Reflector Supports to Aline End Reflectors

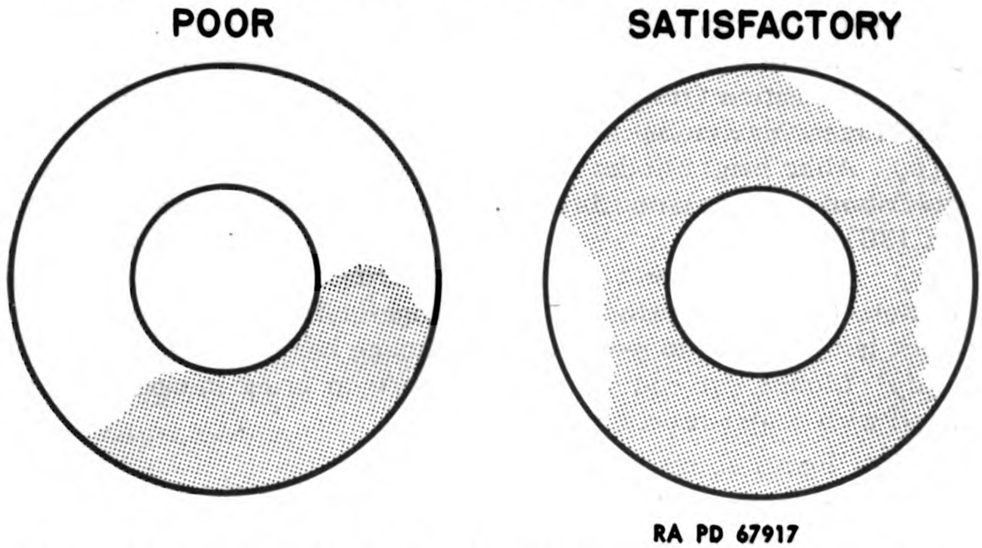

Figure 154 — Examples of Good and Poor Contact in Scraping Bosses of End Reflector Supports

(j) Replace and position end reflector on bosses, and check target image for height and tilt.

(k) Repeat substeps *(c)* through *(j)*, above, for left end reflector and reflector support. A small error in height of image can be removed most readily by rotating the end support on the inner tube.

(9) Install end reflectors.

(a) Carefully clean end reflector supports and inside both ends of height finder with vacuum cleaner.

(b) Place right mirror block in position indicated by scribe marks, and tighten set screw.

(c) Turn clamping nuts close to heads of mounting screws and insert the three screws, turning in snug *with fingers*, being careful not to move block.

(d) Tighten two nuts against the support to hold block against slipping, and tighten the third screw into mirror block; then tighten nut.

(e) Loosen one of the other nuts, tighten screw, and retighten nut. Repeat for third screw.

(f) Remove set screw, check nuts for tightness, tighten lock nuts.

(g) Recheck for tilt and vertical position of target image. Shellac nuts and bolts.

(h) Repeat substeps *(b)* through *(g)*, above, for left end reflector.

(i) Check tightness of screws holding end reflector supports, and shellac heads.

(j) Install end boxes (par. 61) to keep dirt out of instrument.

(10) Rough-adjust end windows (par. 60).

(a) With end windows removed, install compensator unit temporarily and set for known target distance. The wedges can be set

to approximate range by hand. Count turns of the measuring knob to turn drum from infinity to the target distance. Starting with wedges in neutral position (reference marks alined), turn range shaft two and a half times this number of turns counterclockwise.

(b) Aline height finder so that target images in the two fields are equidistant in opposite directions from the center reticle marks (fig. 130).

(c) Mount right end window and turn to bring image to lowest position; then turn further to aline image with center reticle mark. Check left eyepiece to see that target image has not been moved.

(d) Mount left end window and turn to bring image down and alined with center reticle mark.

(11) Focus objectives (par. 45).

(a) Set interpupillary distance and adjust eyepiece focus for best focus on reticles.

(b) Sight on distant target and turn compensator to bring into stereo contact.

(c) Check parallax movement between target image and right reticle, and focus right objective to eliminate (par. 45 c). Replace compensator when observing for parallax. Leave a small amount of "against" parallax if the target distance is less than 2,000 yards.

(d) Focus left objective to eliminate stereo parallax (par. 45 c). Replace correction wedge when observing parallax and use adjuster scale to make stereo contact when checking stereo parallax. Turn height adjuster to match height of image if halving error interferes with stereo reading.

(e) Make cross field readings to check equality of effect of optics on both sides of height finder. If readings at sides of field differ by more than 2½ units from reading at center, check analysis in paragraph 20 g.

(f) When parallax and cross field readings are satisfactory, check objectives for cleanliness, make sure that the objectives are pushed home in the optical tube, tighten locking nuts and objective cell set screws, and apply VARNISH, shellac, to nuts and set screws.

NOTE: If instrument is to be charged with helium, correct focus as described in paragraph 45.

(12) Install and seal compensator unit (par. 49).

(a) Set wedges to neutral position and install backlash mechanism.

(b) Check coupling for sliding fit on range unit drive shaft, tighten square-head set screw just enough to hold collar.

(c) Set measuring drum at infinity and height-range lever (if installed) at "range."

(d) Install range shaft, engaging coupling pins with spur gears.

(e) Apply COMPOUND, sealing, for height finders, insert unit into instrument, and engage its drive shaft in coupling.

(13) Set correction wedge image up (par. 46 c).

(a) Remove correction wedge unit and loosen three screws holding wedge cell.

(b) Aline height finder on target and bring into stereo contact by turning measuring knob.

(c) Set adjuster scale at 50 and correction wedge gear at mid-point, and replace wedge unit.

(d) Turn wedge cell with finger to establish stereo contact. Remove unit, tighten cell holding screws, and replace.

f. Installation and Adjustment of Internal Target System. After the main optical system has been installed and adjusted, the internal target system is installed and adjusted as described in paragraph 57.

g. Final Assemblies and Adjustments.

(1) After the main optical system and the internal target system have been put in proper adjustment, make the following final adjustments.

(2) Adjust the cradle levels (par. 41).

(3) Aline height adjuster disk (par. 55).

(a) Adjust set screws to get equal internal target readings at both limits of movement of height adjuster

(b) Seal and replace height adjuster knob.

(4) Adjust end windows for true range readings (par. 60).

(a) Set adjuster scale at average of internal target readings.

(b) Aline height finder on target of known range and set measuring drum for range.

(c) Adjust end windows for stereo contact.

(5) Install and pin "range" and "height" stops for height-range lever. (If stops are in place, check for 90-degree motion of height conversion ring. See paragraphs 41 b and 21 i).

(a) Mount and pin lever assembly to height conversion ring.

(b) Mount "height" stop assembly on right bearing housing and "range" stop on conversion ring cover (fig. 132).

(c) Level cradle and tube and check movement of height conversion ring between range and height positions (par. 41 d).

(d) Adjust stops for 90-degree movement and pin.

(6) Adjust compensator unit for range (range-infinity, height-infinity) and height (range-infinity, height-900) as described in paragraph 48.

(7) Adjust elevation index on left main bearing (par. 63).

(8) Adjust eyepiece diopter scales (par. 43).

(9) Seal on end boxes (par. 61), and end windows (par. 60).

(10) Mount, adjust, and aline M7 Tracking Telescopes (par. 71).

(11) Set elevation adjustment knob stops (par. 56).

(a) Use a measured target located at the proper distance to subtend an arc of 30 minutes.

(b) Loosen stops on elevation adjustment knob.

(c) Aline height finder to center bottom of target in elevation tracking telescope, turn elevation adjustment knob to center top of target in height finder reticle, and set rear stop.

(d) Reverse target position and set front stop.

(12) Desiccate or charge with helium (TM 9-1622).

(13) Make final adjustments of end windows (par. 60) to bring range readings within 1½ UOE of true range.

(14) Perform basic inspection (pars. 20 to 24) to check operation and performance of instrument.

h. Outline of Operations—Assembly of Mechanical Units.

(1) Assemble inner tube.

(a) Inspect for cleanliness, grease, remove right end adapter and right bearing ring.

(b) Insert and pin optical tube.

(c) Insert air tube assemblies.

(d) Mount internal target centering disk.

(2) Insert inner tube in height finder.

(a) Insert and mount measuring drum.

(b) Reassemble main bearings and replace carrier handles.

(c) Scribe and remove inner tube roller bearings.

(d) Insert inner tube, taking care to prevent striking measuring drum; replace right bearing ring.

(e) Assemble inner tube bearings.

(f) Replace right end adapter.

(3) Install mechanical units; seal to adapters.

(a) Elevation adjustment knob—adjust stops to hold inner tube in midposition.

(b) Adjuster prism shift assembly—prism links extend equal distances from inner tube (1⅜ in.).

(c) End reflector supports—scribe limits of adjustment and set in midposition.

(d) Change-of-magnification crank.

(e) Measuring drum window and index.

(f) Measuring knob.

(g) Adjust measuring drum bearings—free movement of drum, no backlash, no contact with inner or outer tubes.

(h) Eyepiece housing—do not tighten mounting screws.

(i) Set up height finder on cradle and tripod.

i. Outline of Operations—Assembly and Adjustment of Optical Systems.

(1) Adjust main optical system.

(*a*) Set base length—set angle of reflector blocks with template, move forward or back to correct cut-off, move in or out to center light spots from fixture ($\frac{3}{16}$-in. apertures over objectives).

(*b*) Rough-focus objectives.

(*c*) Adjust reticles for tilt—insert and calibrate cross hairs in eyepiece cells, aline reticles with deviation plane of compensator wedges and with each other.

(*d*) Mount eyepiece unit—adjust to center low-power moons and correct dipvergence.

(*e*) Install height adjuster in midposition.

(*f*) Install adjuster scale and correction wedge—"image up" and centered; close cover and tape.

(*g*) Scrape end reflector supports—correct tilt and vertical position of external field with respect to reticles (should be necessary only with new end reflector blocks or supports).

(*h*) Install end reflectors—clamp in position, apply VARNISH, shellac, to bolts; replace end boxes.

(*i*) Rough-adjust end windows—set compensator for target distance, balance image positions in two fields, mount end windows, and turn to bring image down and centered.

(*j*) Focus objectives—remove parallax from right objective, adjust left objective to eliminate stereo parallax, check cross field readings. NOTE: If instrument is to be filled with helium, correct focus as described in paragraph 45.

(*k*) Install compensator unit.

(*l*) Set correction wedge image up and centered with adjuster scale at 50.

(2) Adjust internal target system (description and operations charts, par. 57).

(3) Make final adjustments.

(*a*) Set cradle levels.

(*b*) Aline height adjuster and install knob.

(*c*) Adjust end windows for stereo contact.

(*d*) Mount and pin range-height stops — 90-degree rotation between stops when tube is level.

(*e*) Adjust compensator — range (range-infinity, height-infinity) and height (height-infinity, height-550).

(*f*) Set elevation index.

(*g*) Adjust eyepiece scales.

(*h*) Seal end boxes and end windows.

(*i*) Adjust and aline tracking telescopes.

(*j*) Set elevation adjustment stops — 30-minute movement above and below center.

(*k*) Desiccate or charge with helium.

(*l*) Fine-adjust end windows.

(4) Inspect for performance.

Section XII

ELBOW TELESCOPE M7—ADJUSTMENT, REPAIR, AND DISASSEMBLY

	Paragraph
General	68
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68. GENERAL.

a. These instructions cover alinement, adjustments, and complete disassembly and assembly of the M7 Telescope as supplied on the height finder, serial numbers 33 and later. Some of the specific instructions and part numbers do not apply to the telescope originally furnished on height finders 1 to 32. The newer model telescope can be adapted to these earlier height finders by means of a special adapter.

b. 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 elevation adjustment will be approximately in midposition. These relations are shown in figure 155, 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 parallax. In addition, the telescope must function properly in all optical and mechanical respects.

c. It must be noted that the azimuth and elevation telescopes are not interchangeable, and differ in one important respect. The reticles differ as shown in figure 40. For this reason, the name plate specifies "Azimuth" or "Elevation."

d. These telescopes are sealed optical units. They can be alined, focused to remove parallax, or removed from the height finder

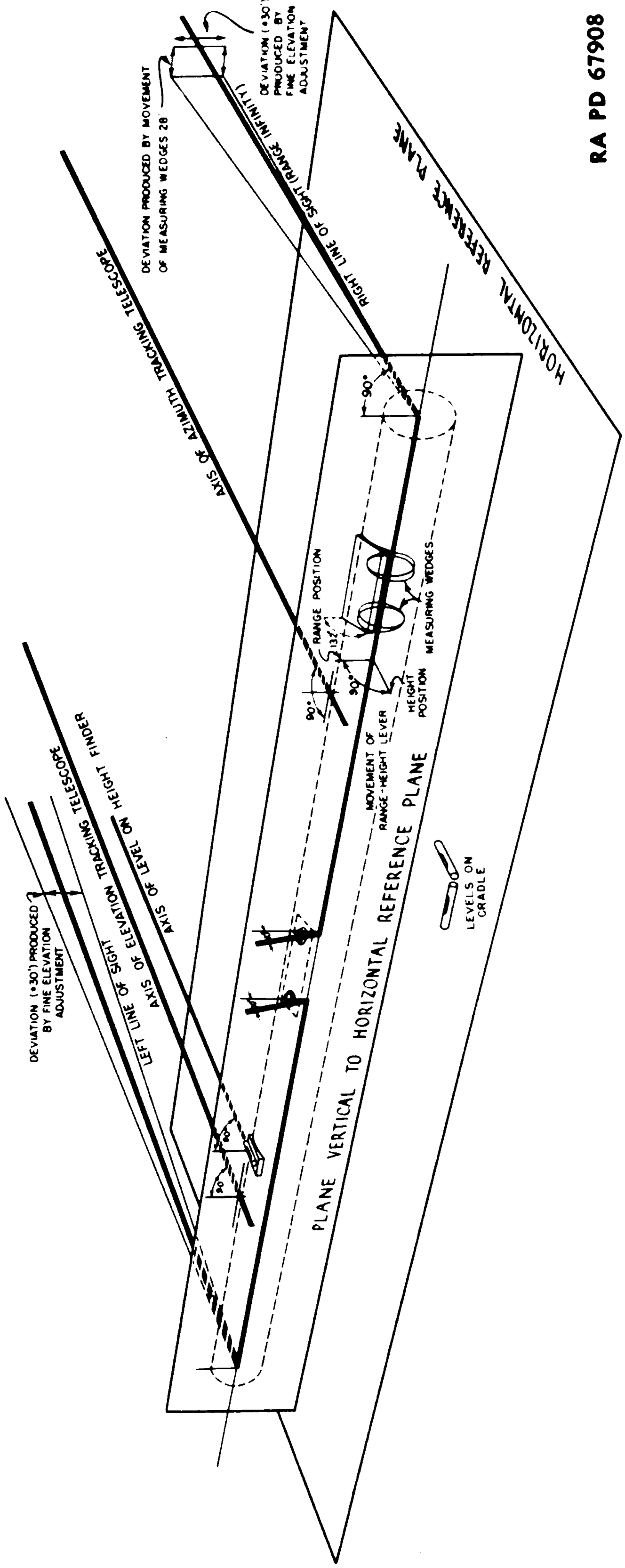

Figure 155 — Relations Between the Various Axes of the Height Finder Cradle and Telescope and the Tracking Telescopes

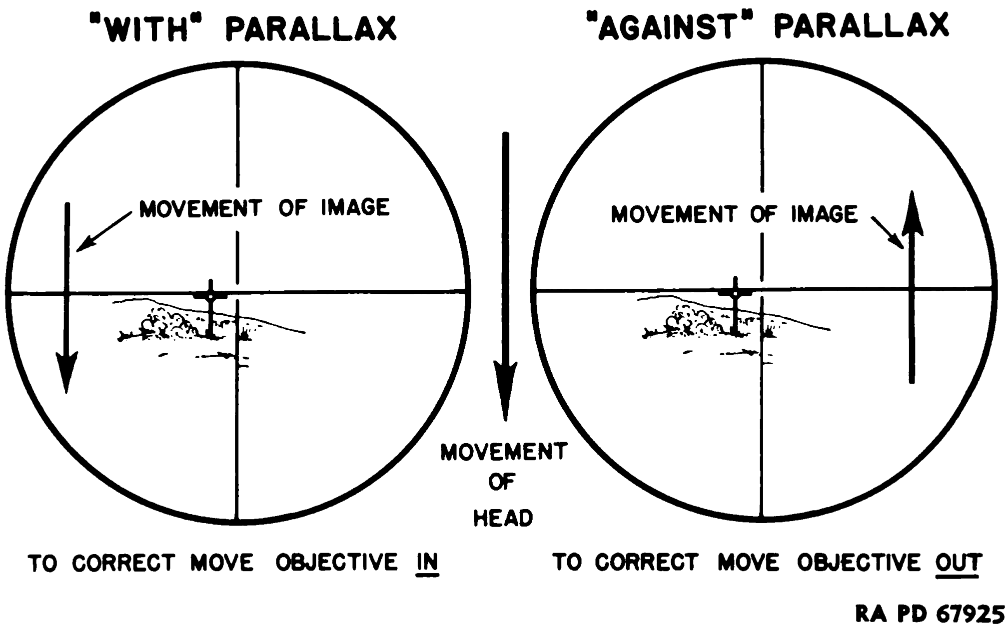

Figure 156 — Parallax Correction in M7 Telescope (Focusing Objective)

without breaking the hermetic seal of either unit. Disassembly or replacement of any optical parts, or cleaning internal optical surfaces involves breaking the seal, and should be done in a dust-free room. Resealing, but not desiccation, is required.

e. The M7 Telescope is described in detail in paragraph 7.

69. CHECKING THE EYEPIECE 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. 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 collimating 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 diopter on the plus side or half a diopter on the minus side, there is probably some condition which needs correction. The locking ring which bears the index line may have become loose and backed off, or the eyepiece may have been disassembled and reassembled incorrectly. The correct assembly is shown in figure 164. Disassembly (par. 75 d) will require resealing. If a scale correction is still needed, it can be done quite simply by scribing a new index line on the locking ring at the point indicated by the diopter test. The new line can be scribed or engraved and filled with FILLER, graduation, white, and the old line filled with FILLER, graduation, black, to obliterate it.

70. FOCUSING THE OBJECTIVE TO REMOVE PARALLAX.

a. Explanation. If the objective is in such a position that the image of the target falls in front of or behind the reticle plane, a stationary target image appears to move sideways relative to the reticle as the eye is moved sideways. This situation is known as parallax. If the target image, relative to the reticle, moves in the same direction as the eye's movement, the image lies ahead of the reticle. Conversely, apparent movement opposite in direction indicates 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, the elevation telescope by a vertical eye movement. If parallax exists, it can be eliminated by focusing the objective as explained below.

b. Requirements.

(1) A collimator or an outside target at a distance greater than 1,000 yards.

(2) A dust-free room is not required, since the seal is not broken.

c. Method.

(1) Remove the sunshade (A, fig. 157).

(2) Loosen set screw in the focusing ring (C and B, fig. 157), and loosen the set screw (G, fig. 157) with the Bristo wrench.

(3) Sight on the collimator or a distant target and move the head across the eyepiece, noticing the parallax against the M7 Reticle Line. If the parallax is "with" the eye, the objective should be moved in, and if "against" the eye, the objective should be moved out (fig. 156).

(4) Move the objective in by loosening the ring (B, fig. 157) and pushing the objective assembly in until the ring is snug against the body of the telescope. Move the objective out by tightening the ring, which will draw the objective assembly out of the body. (If necessary loosen the guide screw J, figure 157.)

(5) When the parallax is brought within tolerance, tighten set screw (G, fig. 157), the adjusting ring, and set screw (C, fig. 157).

(6) Replace the sunshade.

71. ALINEMENT OF M7 TRACKING TELESCOPES.

a. General.

(1) The telescopes which were supplied with Height Finders M1, serial numbers 1 through 32, were not provided with an elevation adjustment, and it was necessary to file or shim the supporting lugs

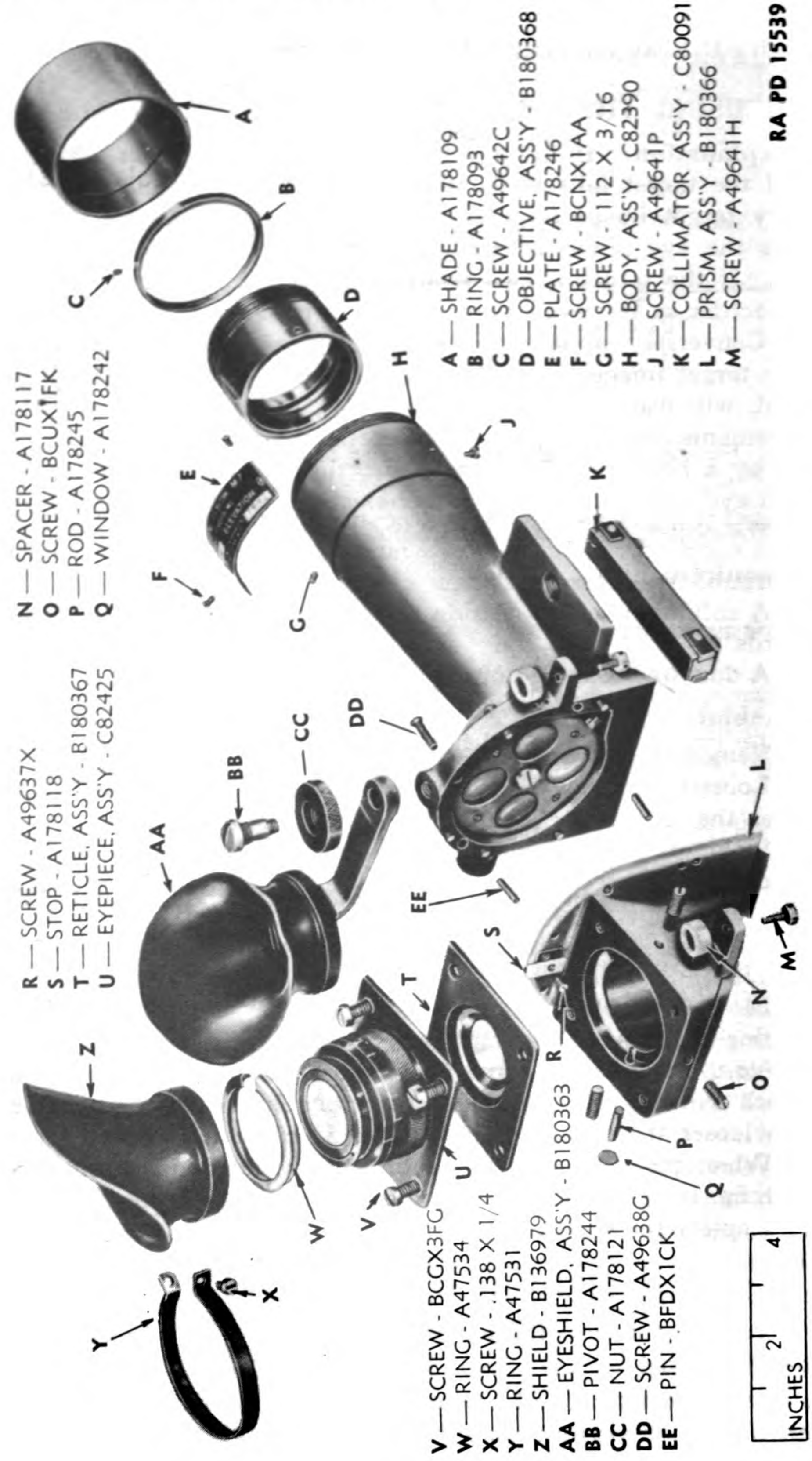

Figure 157 — Elbow Telescope M7 — Exploded View

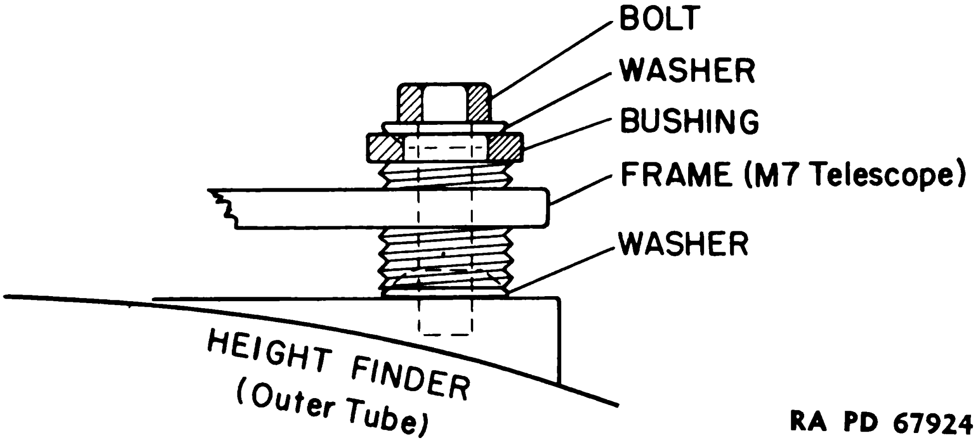

Figure 158 — Adjusting Bushing of M7 Telescope

on the bases when it was necessary to correct vertical alinement. The telescopes supplied with instruments number 33 and up are provided with adjustable mounting bushings.

b. Requirements.

(1) A distant target exactly level with the height finder.

(2) The height finder level must have been checked and adjusted against the movement of the height conversion ring (par. 41) and the height adjustment of the compensator unit adjusted to agree.

c. Method.

(1) Accurately level the instrument so that there is no movement of the cradle levels as the instrument is traversed through 360 degrees.

(2) Carefully level the height finder telescope. Check the accuracy of the 90-degree travel of the height conversion ring (par. 41).

(3) Aline the M7 Telescopes:

(a) Aline the M7 Telescopes in elevation by sighting on a known level point at least 1,000 yards distant, established by plunging a transit which is at the same height as the tracking telescope. Aline the M7 Telescope in azimuth by sighting the height finder and tracking telescopes on a target at approximately 5,000 yards.

(b) Slightly loosen the three clamping bolts and turn the bushings (fig. 158) so that they project downward about three turns. Keep the bolts fairly tight.

(c) Remove tilt from the horizontal reticle line by adjusting the right-hand bushing.

(d) Loosen the left-hand bolts enough to allow the telescopes to be pushed into correct azimuth alinement.

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Figure 159 — Adjusting Alinement of M7 Telescope

(e) Adjust the left-hand bushings for approximate elevation setting. Turn the two bushings by equal amounts but in opposite directions.

(f) Adjust precisely for correct azimuth alinement and tighten the bolts.

(g) If necessary, make slight adjustment on either left-hand bushing for correct elevation.

(h) Tighten the three bolts very tightly.

(4) Check the settings by elevating the height finder, releveling and checking the alinement.

(5) Check the motion of the elevation adjustment knob. The target should be centered in the height finder reticle field when the knob is at the midpoint of its movement. If necessary, readjust the stops (par. 56).

72. ALINEMENT OF OPEN COLLIMATOR SIGHT.

a. The open collimator peepsight (K, fig. 157) should be so alined that when the target is sighted over the top of the tube, the apex of the image of the triangular sight should appear at the same target point that appears at the center of the telescope reticle. Vertical adjustment can be made by filing the proper spacers (N, fig. 157). Azimuth adjustment can be made by loosening both screws, orienting the sight, and tightening the screws.

73. ADJUSTING THE RETICLE.

a. Making the Horizontal Line Horizontal. The horizontal reticle line should appear horizontal when the contact surfaces of the base of the telescope are level. Some departure from this (1 to 2 deg.) is not serious; it can be rectified by tilting the telescope as a whole by means of the leveling bushings. If a distant point will not stay on the horizontal reticle line while the leveled height finder is being traversed, adjustment is needed. Minor adjustment of the bushings (par. 71) is all that is usually necessary; it is also possible to rotate the reticle cell slightly. This can be done without breaking the seal. If, however, the reticle has become loose and has turned, major adjustment is needed which involves breaking the seal.

b. Requirements.

(1) Collimator or distant target level with telescope axis.

(a) Additional Requirements for Major Adjustment.

1. Dust-free room and COMPOUND, sealing, for height finders.

2. Special wrench for reticle retaining ring (par. 34).

c. Method for Minor Adjustment.

(1) Level the height finder accurately, and train on a distant target at the same level.

(2) Assuming the horizontal reticle line cannot be made level using the leveling bushings, proceed as follows:

(3) Loosen the four eyepiece assembly screws and the three reticle cell set screws (V and O, fig. 157). The three latter screws are sealed over.

(4) Rotate the reticle cell assembly (T, fig. 157) as required, so that when the height finder is traversed, the target image stays on the horizontal reticle line of the telescope.

(5) Tighten the eyepiece assembly screws and the three reticle cell set screws and seal the set screw heads.

(6) Check the telescope for elevation and azimuth alinement and adjust if necessary.

d. Method for Major Adjustment.

(1) Remove the four eyepiece assembly screws and the eyepiece assembly (U, fig. 157).

(2) Loosen the three reticle cell set screws (O, fig. 157) and lift off the reticle cell (T, fig. 157).

(3) Loosen the set screw which holds the retaining ring in the cell and loosen the retaining ring (fig. 160).

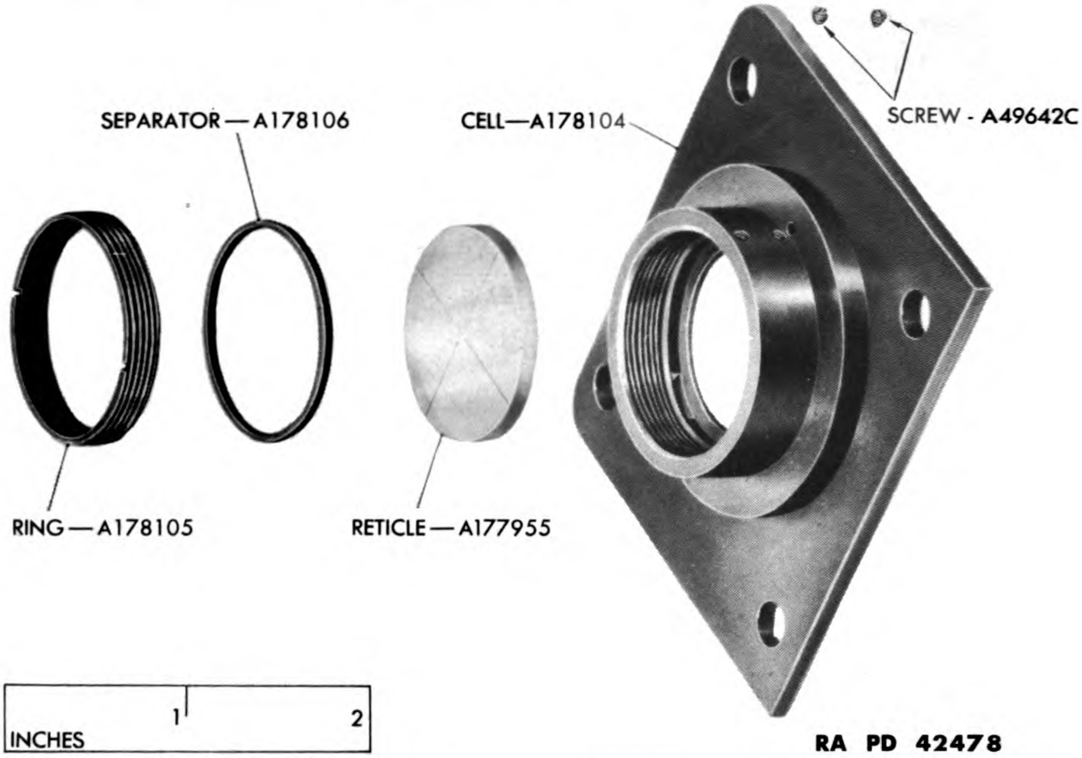

Figure 160 — Reticle Cell of M7 Telescope — Exploded View

(4) Loosen the set screw which holds the reticle and rotate the reticle in its cell to make the horizontal line parallel with the front or locating edge of the reticle cell (the corners of this edge are rectangular, not round). Alinement of the reticle with this edge is best accomplished by putting the cell on a sheet of squared paper or in a fixture improvised for the purpose. The reticle can be rotated by means of a scratch awl inserted through the reticle illuminating hole in the cell.

(5) Tighten the set screw on the reticle.

(6) Tighten the retaining ring and its set screw.

(7) Replace and seal the reticle cell on the telescope.

(8) Replace and seal the eyepiece assembly.

(9) Aline the reticle as described above under "Method for Minor Adjustment."

e. **Centering the Reticle.** It is possible to center the reticle by using the three set screws but there is rarely any need to do so. These set screws are used primarily to prevent the reticle cell from rotating. Slight decentering will not affect the functioning of the telescope as long as no unintended change of the reticle position can take place.

f. **Reticle Illumination.** This is covered under paragraph 82.

ELBOW TELESCOPE M7—ADJUSTMENT, REPAIR, AND DISASSEMBLY

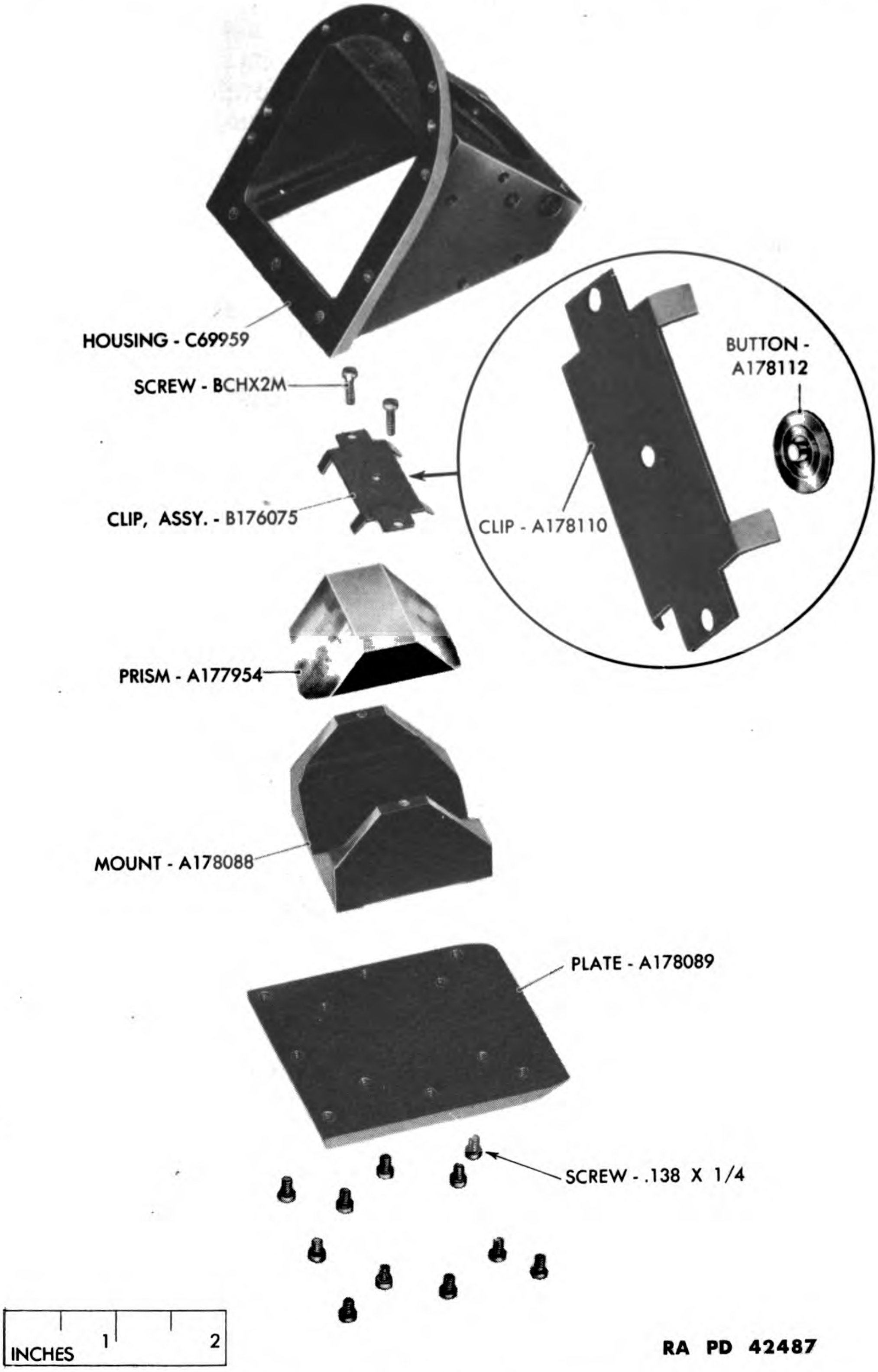

Figure 161 — Prism Assembly of M7 Telescope — Exploded View

74. ADJUSTING THE ROOF PRISM.

a. The prism assembly (fig. 161) can be removed and replaced without readjustment. The prism is fixed in position and probably will not need adjustment. Alinement of the prism, however, should be such that, with the base of the telescope level, the image of a target level with the axis of the telescope should coincide with the horizontal cross wire. Shims placed between the mount and the supporting plate A178089 will allow for vertical adjustment.

75. DISASSEMBLY OF ELBOW TELESCOPE M7.

a. **Requirements.**

(1) Special wrenches for removing lens retaining rings (par. 34).
(2) Straddle wrench to fit eyepiece locking ring.
(3) PAPER, lens, tissue, for wrapping optical parts.
(4) Cleaning materials for optical parts.
(5) COMPOUND, sealing, for height finders.

b. **Removing Telescope Assembly from Height Finder** (fig. 162). Remove the four screws holding the lamp cover and the lamp assembly. Remove the three clamping bolts and lift the telescope off the height finder.

c. **Objective.** Remove the sunshade and the objective cell locking screw (G, fig. 157) and guide screw (J, fig. 157). Withdraw the objective assembly D. Do not disturb the focusing ring (B, fig. 157). To disassemble, loosen the retaining ring set screw and remove the retaining ring (fig. 163). Withdraw the separator and objective lens from the cell.

d. **Eyepiece Assembly.**

(1) Remove the eyeshield clamping ring, the eyeshield, and its adapter ring.

(2) Remove the four eyepiece securing screws (V, fig. 157) and remove the eyepiece assembly (U, fig. 157) from the prism housing.

(3) Remove the eyeshield adapter A178097 (fig. 164), loosen the set screw securing the locking ring A178101, and remove this ring. Unscrew the focusing nut. Remove the screw and shoe A181014, and withdraw the cell from the adapter. To disassemble the eyepiece cell, loosen the set screw, remove the retaining ring A178100, and withdraw the separator A178099, the field lens A177956, the separator A178098, and the eyelens A177957.

e. **Reticle.** Loosen the three reticle adjusting screws (O, fig. 157) and lift off the reticle cell assembly (T, fig. 157). Loosen the two set screws (fig. 160), remove the reticle retaining ring A178105, and withdraw the separator A178106 and reticle A177955 from the cell.

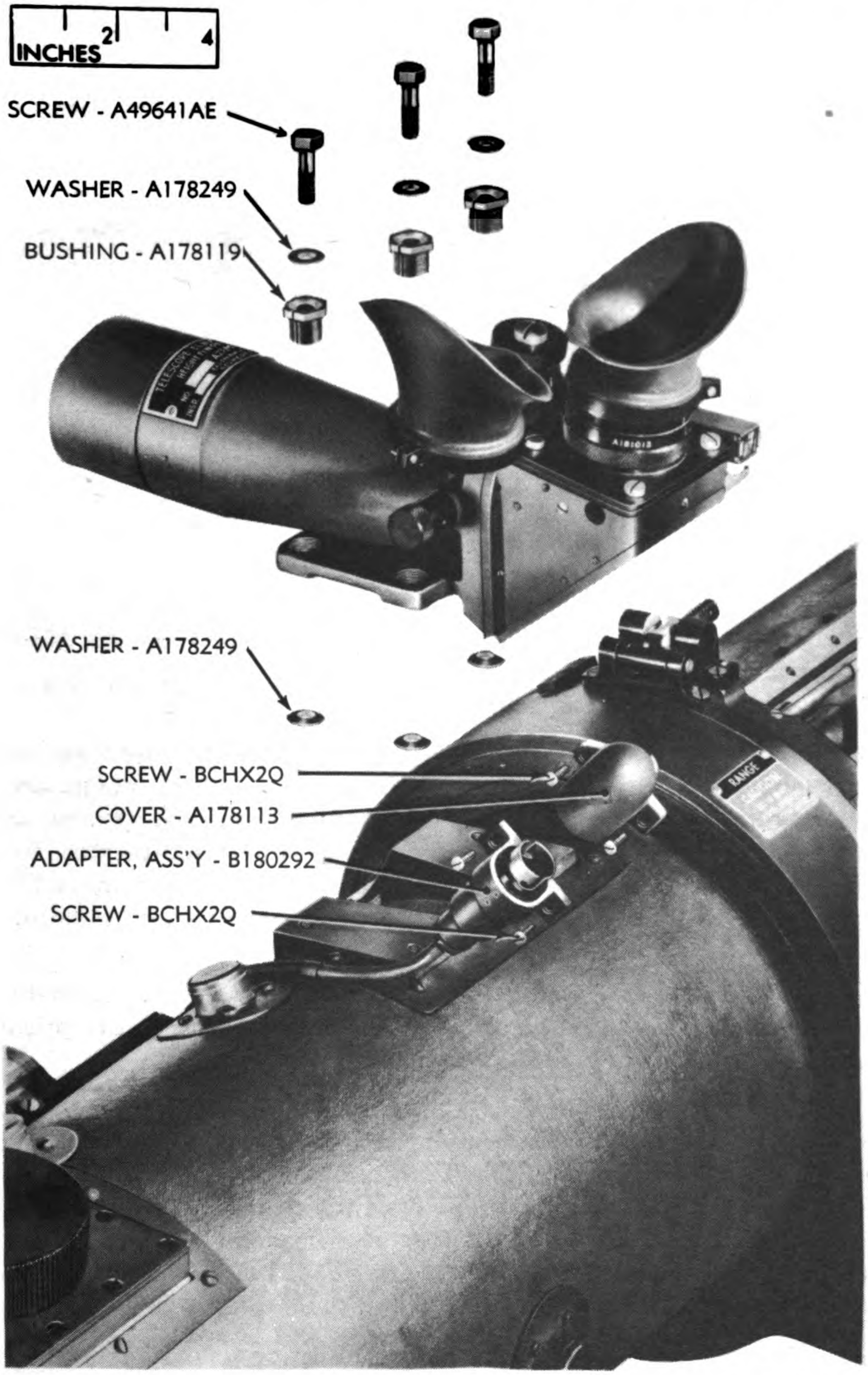

Figure 162 — Removal of Azimuth Tracking Telescope

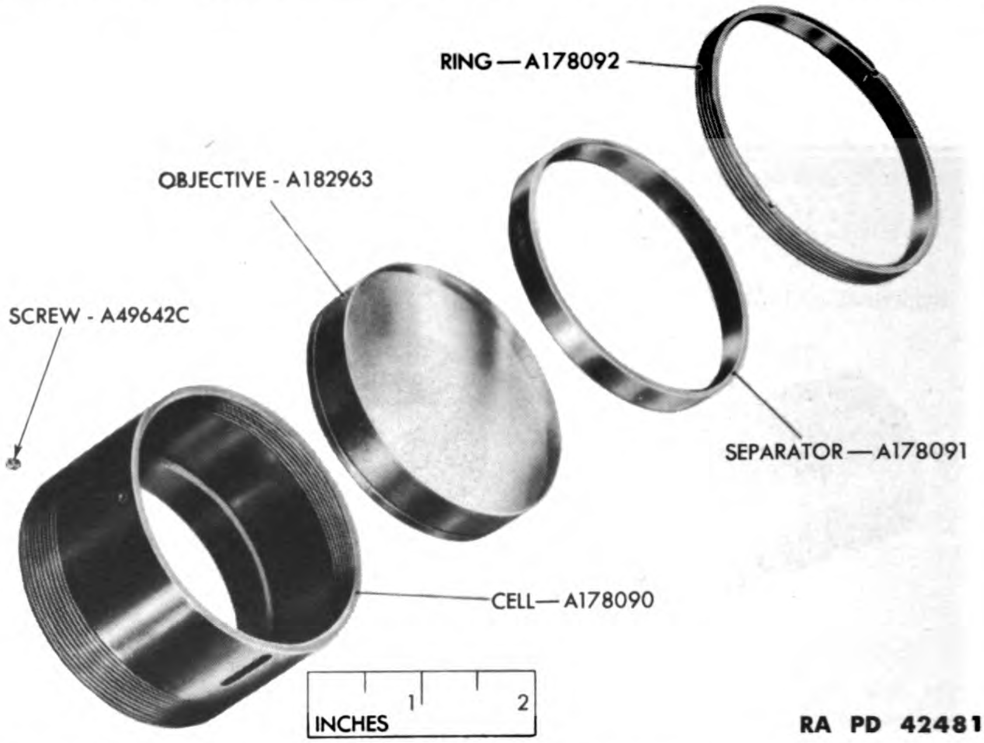

Figure 163 — Objective Assembly of M7 Telescope — Exploded View

f. **Roof Prism.** Remove the seven marginal screws securing the prism mounting plate (fig. 161), and withdraw the plate, mount, and prism assembly. Remove the four screws Y50541 securing the prism mount A178088 to the plate and remove the mount and prism. Remove the two screws securing the prism retaining clip and remove the prism A177954 from the mount. Observe extreme care in handling this prism—the slightest chip in the roof edge spoils the prism.

g. **Collimator Sight and Prism Housing.** Remove the collimator sight assembly (K, fig. 157) and the six screws securing the prism housing. Remove the housing from the telescope body.

h. **Filter Mechanism.**

(1) Remove the filter assembly securing screw (fig. 165) and withdraw the filter assembly. To disassemble, remove the four screws securing the holder to the plate. Remove the clear and colored filters, marking the angular orientation of each before doing so.

(2) Unpin and remove the bevel gear A178107 and withdraw the filter shaft assembly. Remove the three diaphragm screws and the diaphragm. Remove the two detent screws and assembly.

76. REASSEMBLY OF ELBOW TELESCOPE M7.

a. Reassembly is accomplished by reversing the procedure for disassembly. It is important to note the proper filter orientation in

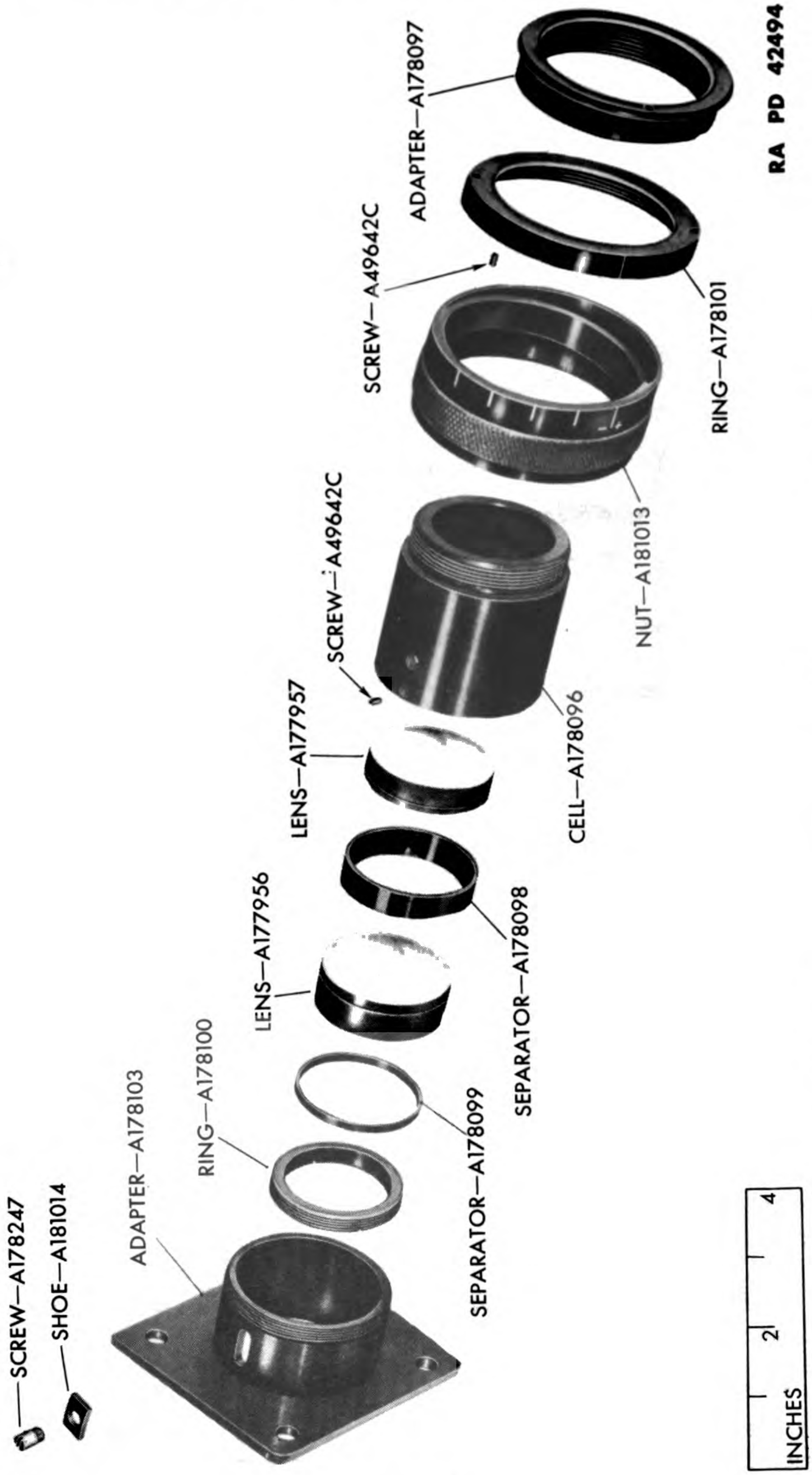

Figure 164 — Eyepiece Assembly of M7 Telescope — Exploded View

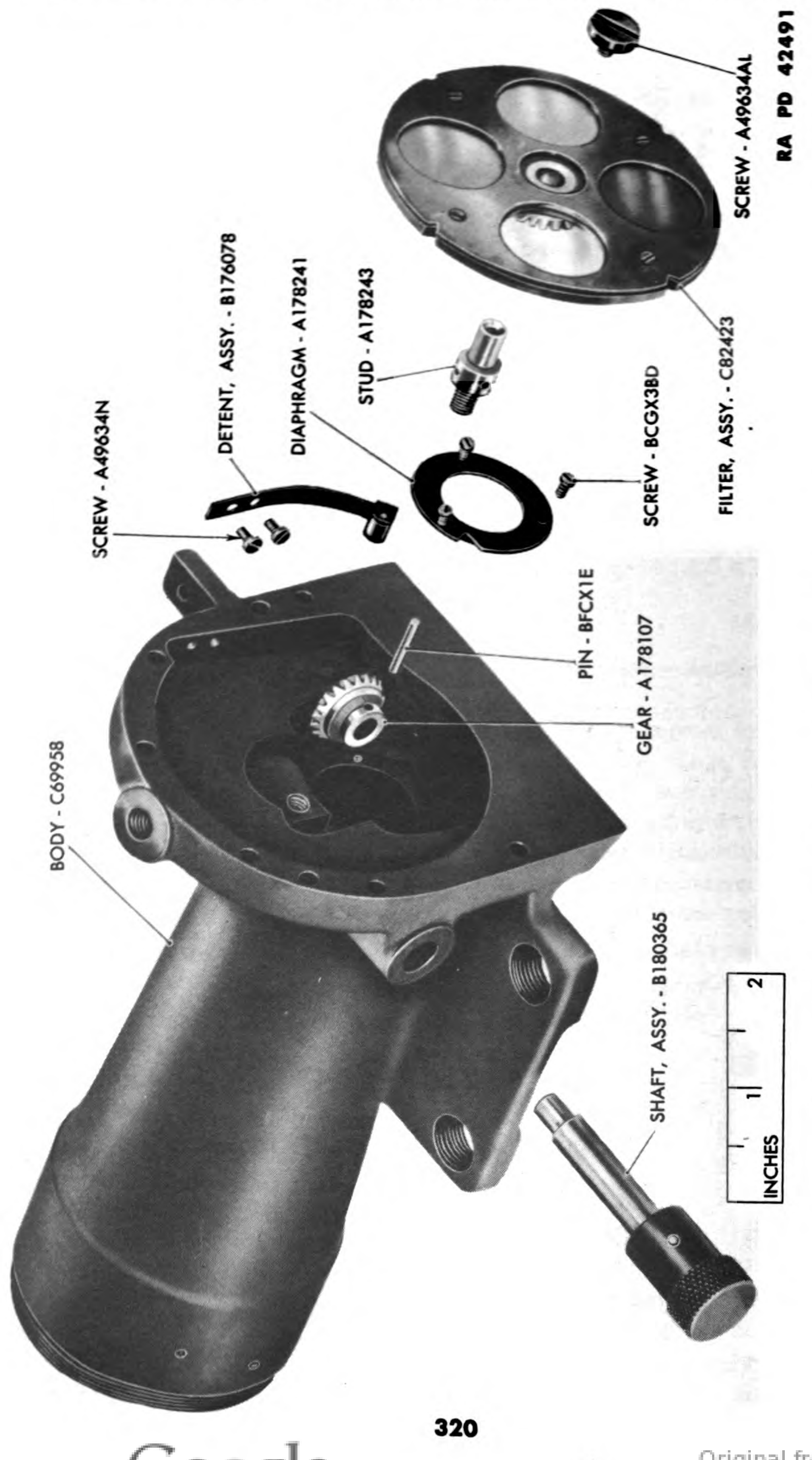

Figure 165 — Removal of Filter Assembly of M7 Telescope

the filter assembly. 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. Filters are marked on the rim, and the marks should be alined to come at the side when the filter is in place before the diaphragm. Care must also be exercised to assemble the reticle so the reticle line is not tilted and so that the unbroken line is vertical in the azimuth telescope and horizontal in the elevation telescope. After assembly, the telescope should be checked for the various items described under "Adjustment and Repair."

Section XIII

CRADLE M1 — ADJUSTMENT, REPAIR, AND DISASSEMBLY

Paragraph
Care and adjustment of cradle M1 77
Disassembly and assembly of cradle M1 78

77. CARE AND ADJUSTMENT OF CRADLE M1.

a. General.

(1) In addition to some electrical components, described in paragraphs 83 e and 84, the cradle (fig. 166) contains the gearing mechanisms of the traversing and elevation controls.

(2) When placing the height finder telescope on its cradle, do not tighten the cradle locking screw knobs excessively. Such tightening may cause binding of the height conversion ring or the vertical elevation drive.

(3) When removing the height finder telescope from the cradle, it is extremely important to disengage entirely both locking screws from the height finder bearing housings. Failure to observe this precaution will result in bent locking screws.

(4) Burring of the lower limit stop on the elevation drive may cause the traveling stop nut to hit the end stop one turn early and prevent full depression of the instrument.

(5) Keep the level vials covered when not in use, by rotating the outer cover on the level.

(6) Lubricate the cradle periodically according to the chart in paragraph 38.

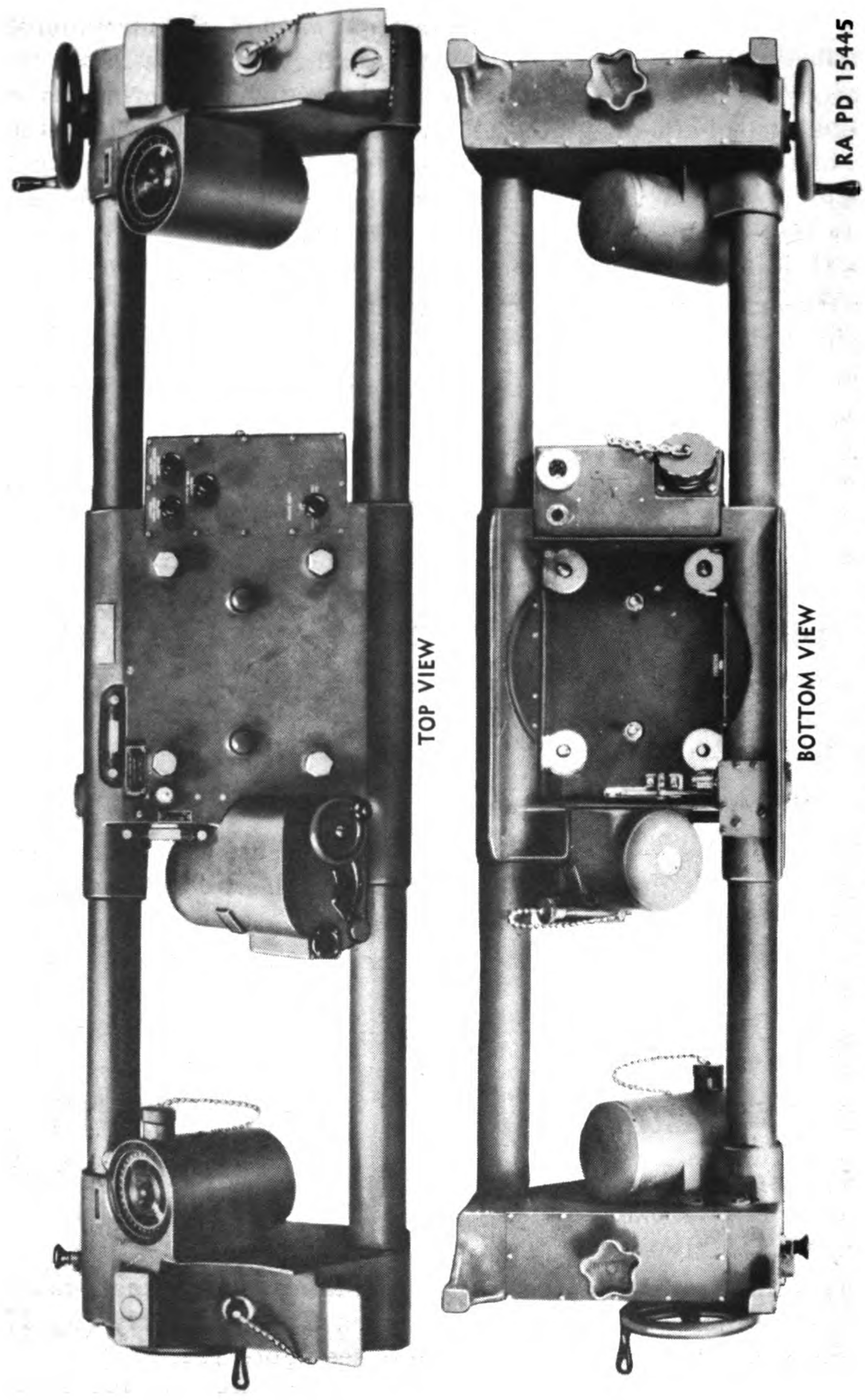

Figure 166 — General Views of Cradle, Top and Bottom

b. Adjustments.

(1) For checking, adjusting, or replacing cradle levels, refer to paragraph 41 c.

(2) If, when cradle and telescope are leveled, the mechanical index of the elevation indicator does not read zero, lift the height finder telescope off the cradle, turn the elevation handwheel to bring the index to zero, replace the height finder, and check. If the index is still more than one-half the line width off zero, adjust the index as follows:

(a) Using the special indicator wrench, remove the window and frame from the elevation indicator (fig. 175).

(b) Loosen the nut on the repeater shaft while holding the washer with the small end of the special wrench.

(c) Lift out the electrical (inner) dial adapter to expose the mechanical dial adapter. Move the index to zero and tighten the screws.

(d) Zero the electrical index as described in paragraph 84 c.

(3) For disassembly and adjustment of the elevating or traversing mechanisms, refer to paragraph 78.

(4) For adjusting the synchronous units, refer to paragraph 84.

78. DISASSEMBLY AND ASSEMBLY OF CRADLE M1.

a. General. The cradle may require disassembly for the purpose of replacing worn or damaged parts or for cleaning and lubrication. The cradle junction box is treated in paragraph 83 e.

b. Removal and Disassembly of Azimuth Indicator.

(1) Remove lower cover of the indicator case and disconnect the repeater wires at the soldered joints. Tag each wire to identify it and facilitate proper connection on reassembly.

(2) Remove the 12 screws and the right cradle body cover (fig. 172).

(3) Remove the three screws securing the indicator to the cradle body (fig. 167) and lift off the indicator, turning it as necessary to release the mechanical index drive from the floating drive shaft in the cradle tube.

(4) Remove the four screws holding the worm shaft bracket and withdraw the bracket assembly (fig. 168). For disassembly of the bracket assembly see figure 169.

(5) Unscrew the cap from the orientation clutch knob, take out the four screws and lift out the orientation clutch assembly (fig. 170). For disassembly of the clutch assembly see figure 171.

(6) Remove retaining ring A47477 and withdraw the repeater from its case (fig. 172).

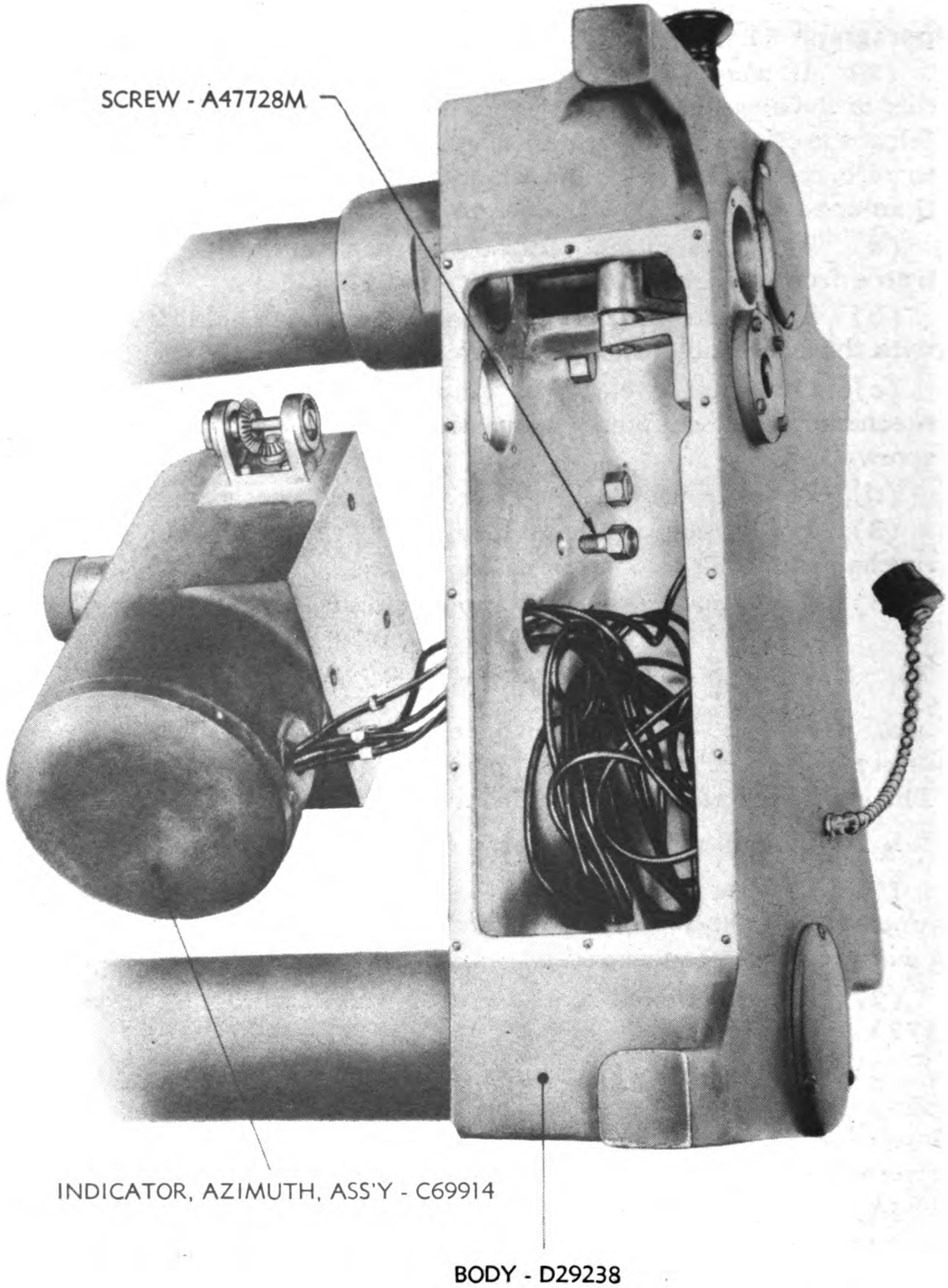

Figure 167 — Removal of Azimuth Indicator Assembly (Wires Should Be Disconnected)

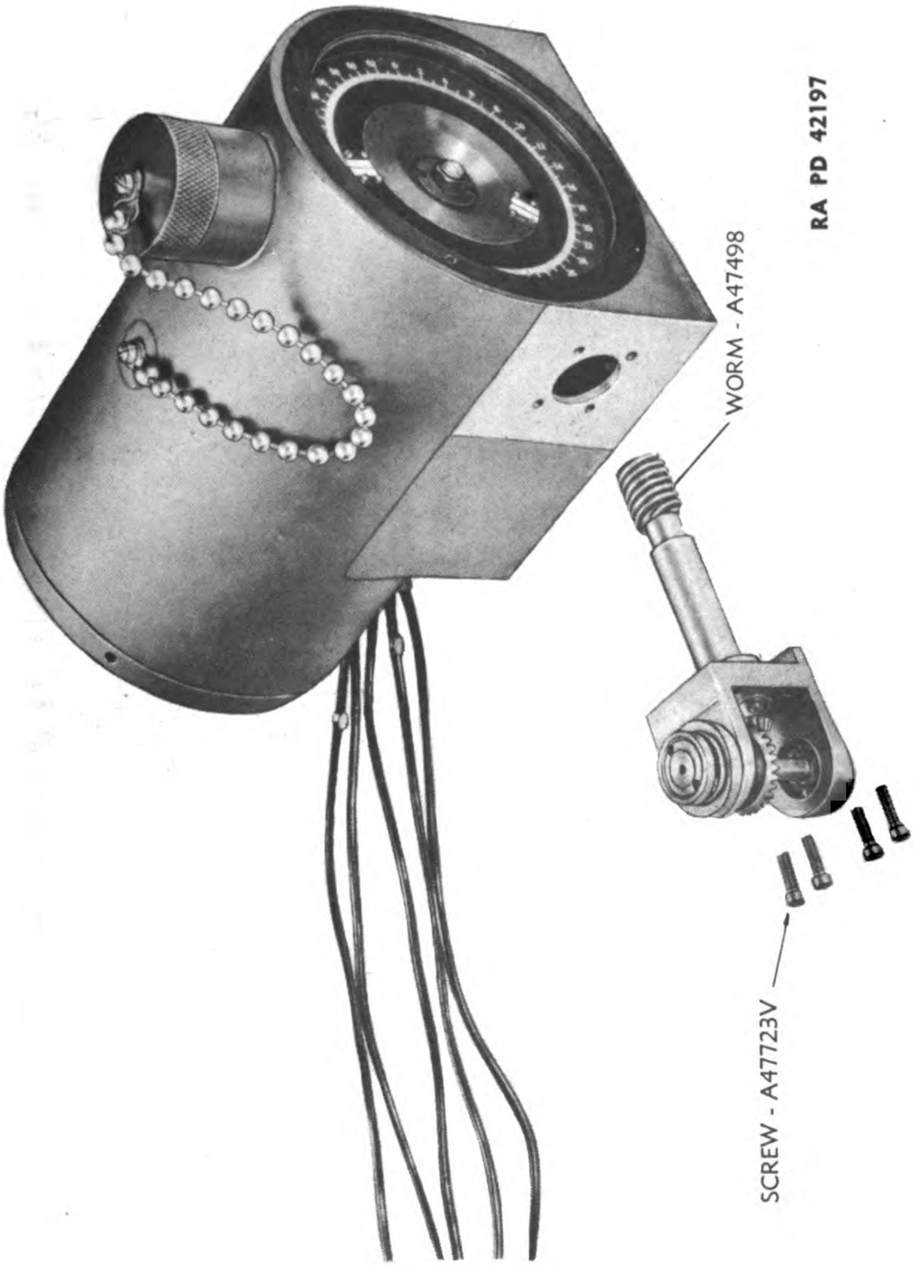

Figure 168 — Removal of Azimuth Indicator Worm Bracket Assembly

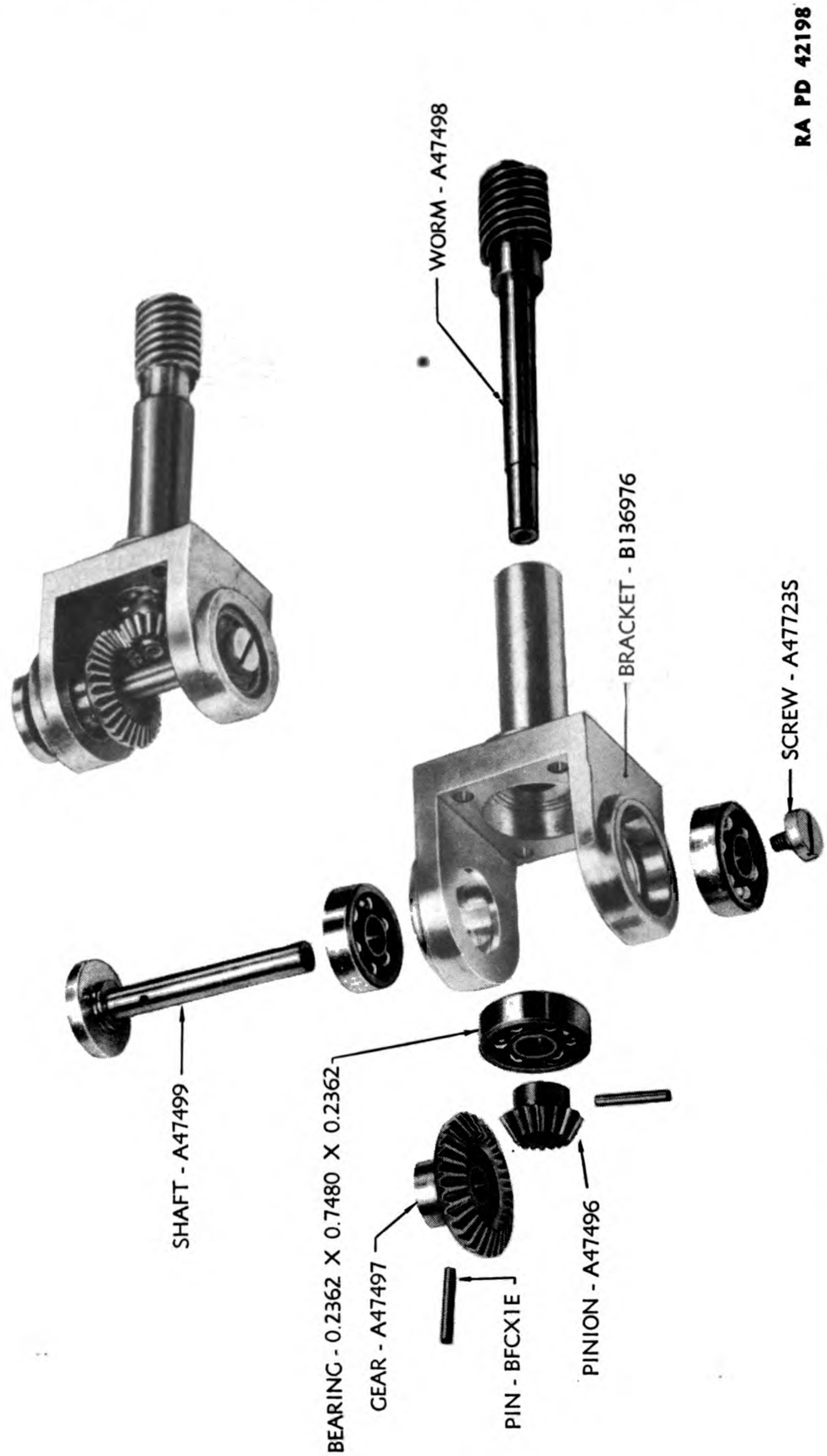

Figure 169 — Disassembly of Azimuth Indicator Worm Bracket Assembly

Figure 170 — Removal of Azimuth Indicator Orienting Clutch Assembly

(7) Remove the hexagonal nut on the repeater shaft (fig. 173), while holding the washer A46805 with the special indicator wrench. Lift off the electrical index adapter, adapter A46806, and the horseshoe washer. Remove nut A47491 and lift off the mechanical index adapter assembly. Its disassembly is shown in figure 209.

(8) With the special indicator wrench remove the frame and window assembly (fig. 175). Take out the four screws and lift out the scale.

NOTE: The repeater can be removed without removing the indicator assembly from the cradle. It is necessary first to disconnect the wires, step (1), above, and remove the window assembly and index adapters, steps (8) and (7), above, before withdrawing the repeater, step (6), above.

c. Reassembly and Adjustment of Azimuth Indicator.

(1) Reassembly is accomplished by reversing the procedure for disassembly.

(2) When replacing the indicator on the cradle, remove the plug in the cradle tube just below the indicator and insert a wire hook to support the floating shaft, in order to mate its coupling with the worm bracket assembly.

(3) For soldering instructions refer to paragraph 83.

(4) For electrical zeroing of the repeater, refer to paragraph 84.

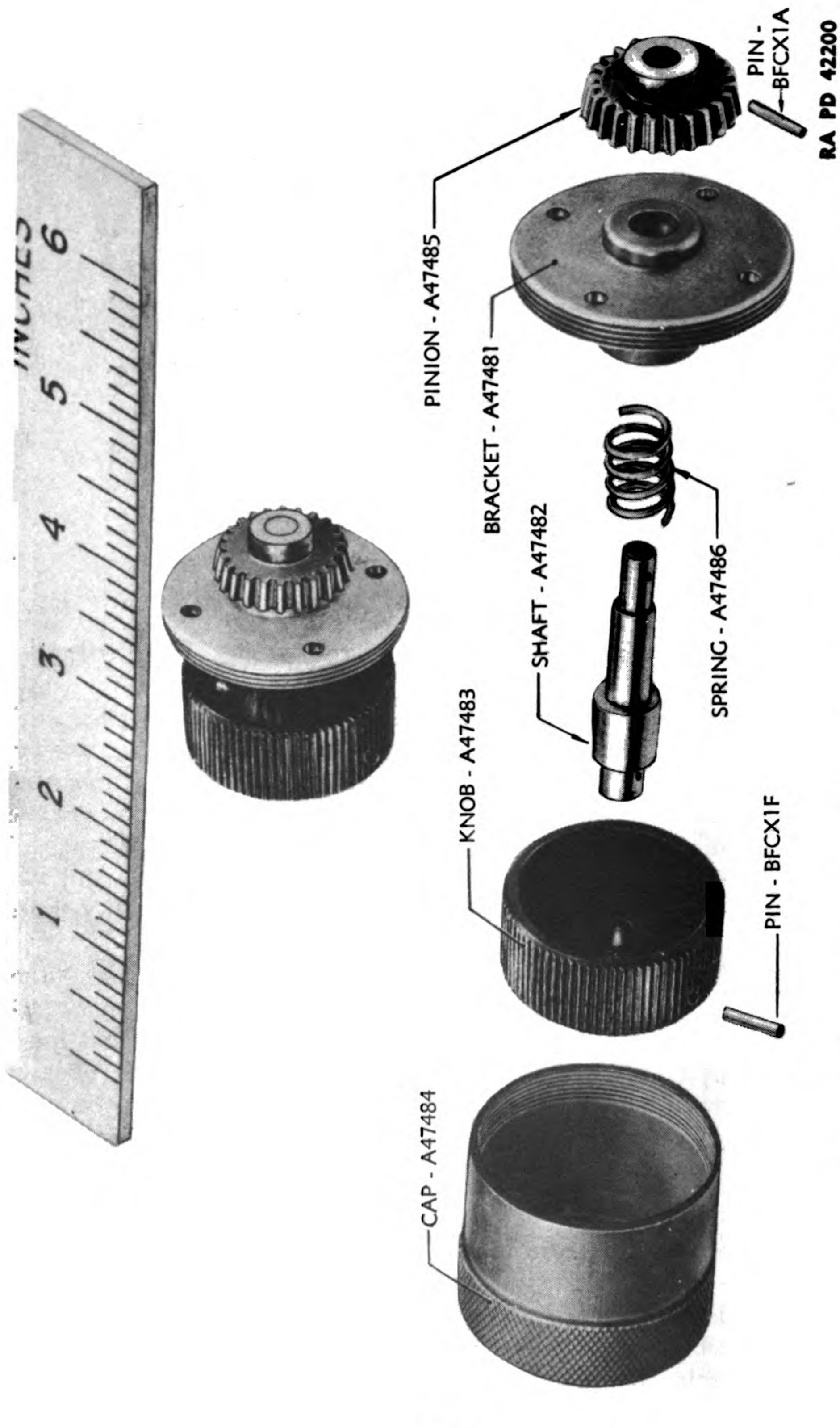

Figure 171 — Disassembly of Azimuth Indicator Orienting Clutch Assembly

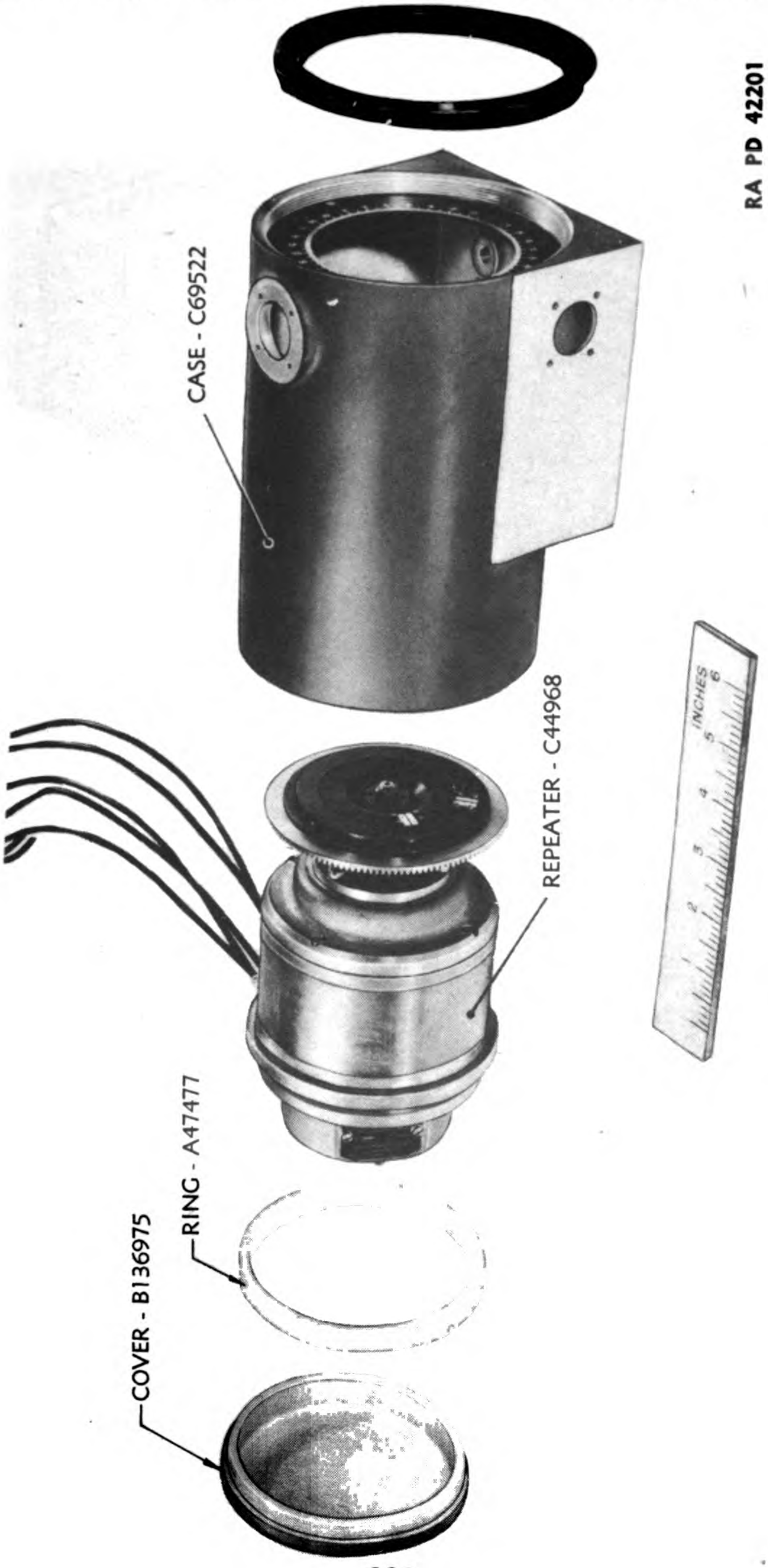

Figure 172 — Removal of Repeater from Azimuth Indicator

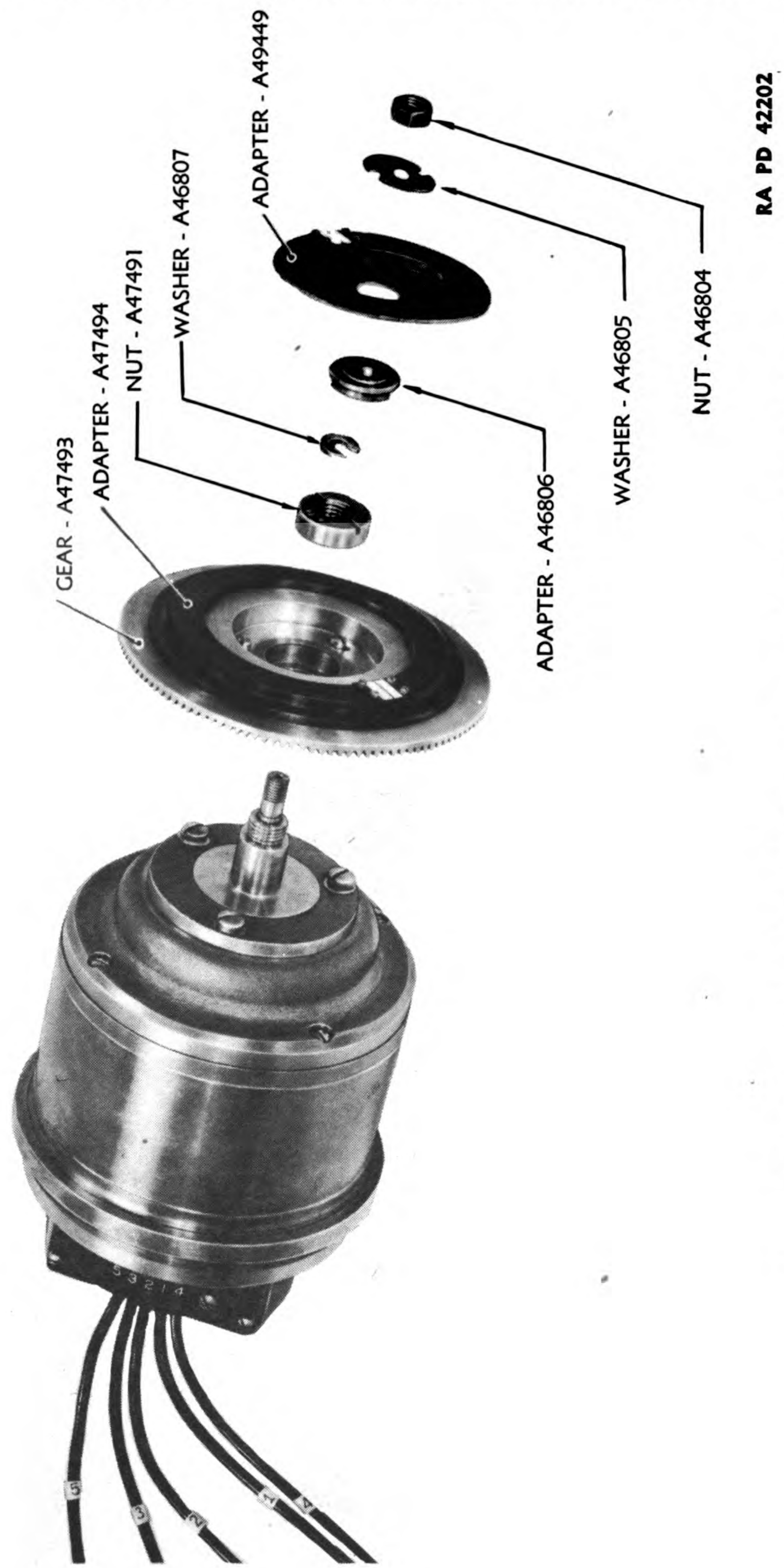

Figure 173 — Removal of Index Adapters from Azimuth Indicator Repeater

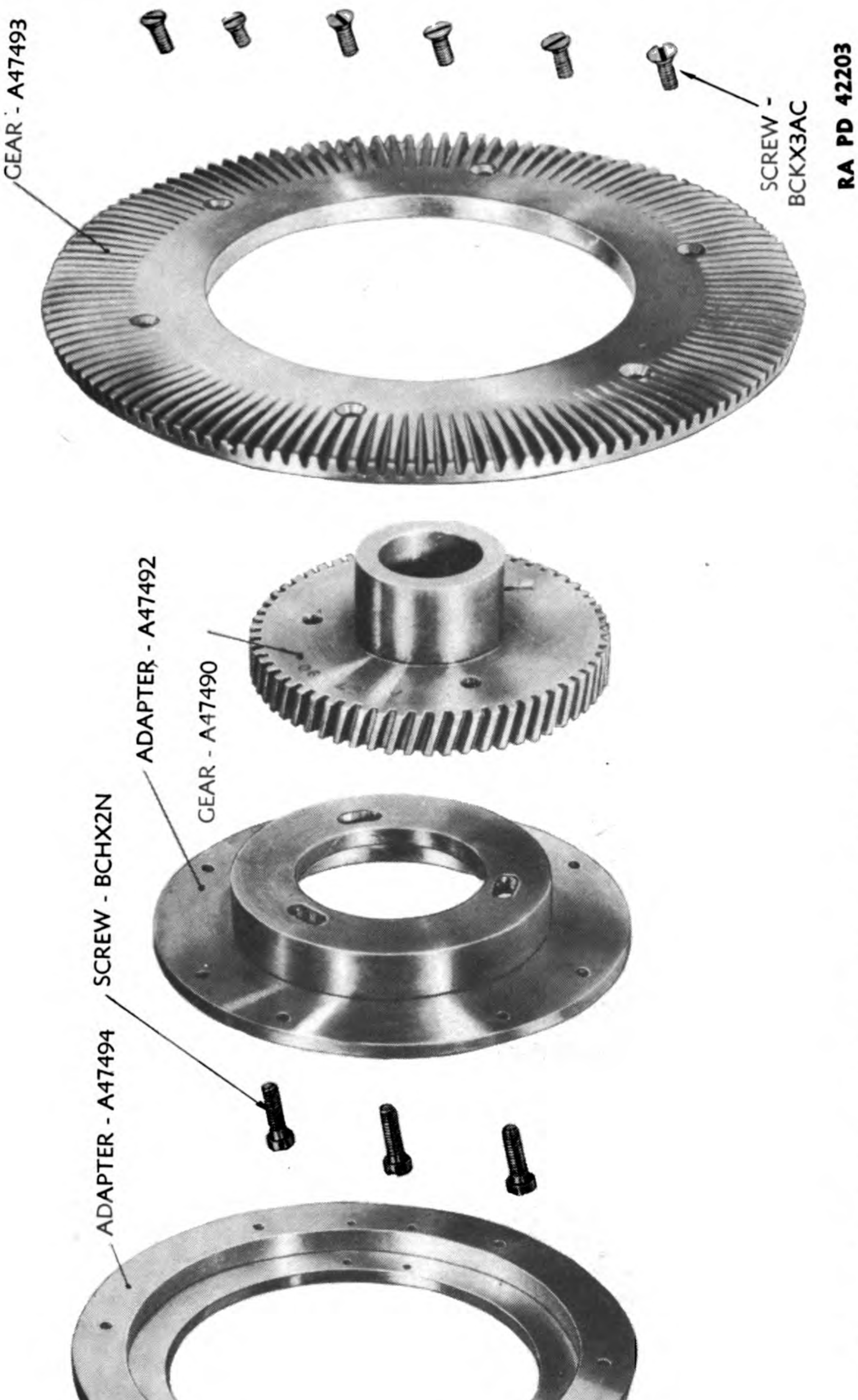

Figure 174—Disassembly of Azimuth Indicator Mechanical Index Adapter Assembly

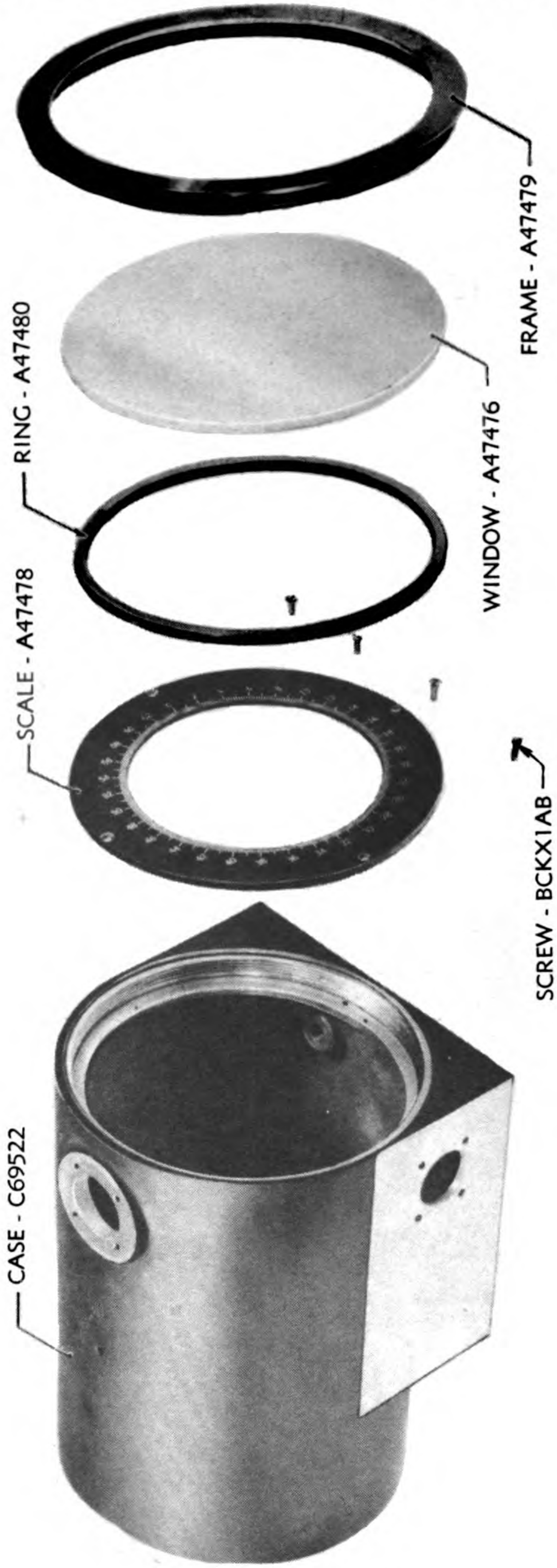

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Figure 175 — Removal of Window Assembly and Scale from Azimuth Indicator Case

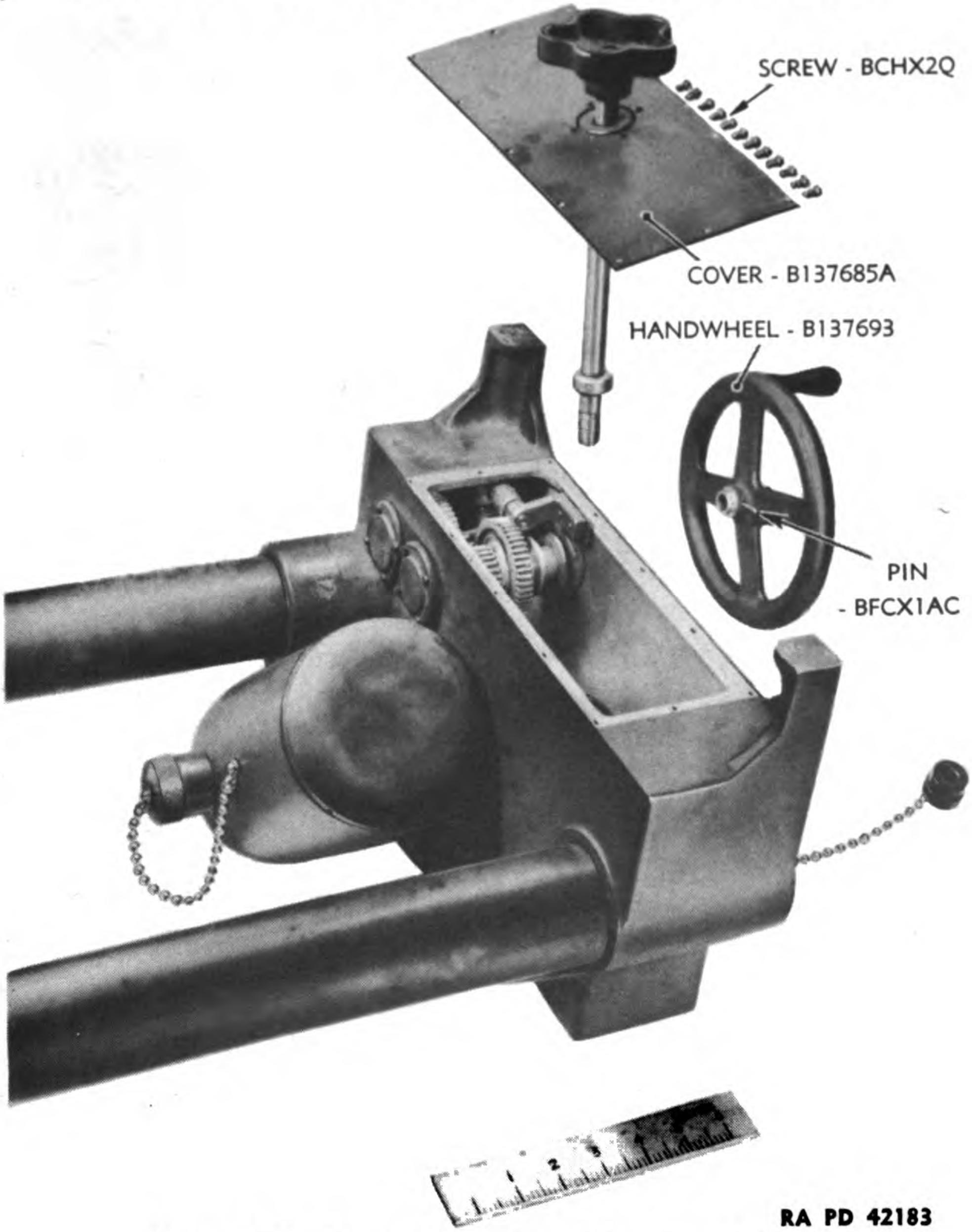


Figure 176 — Removal of Traversing Handwheel and Right Cradle Body Cover

d. Disassembly of Traversing Mechanism.

(1) Unpin and remove the traversing handwheel. Take out the 12 screws and remove the right cradle body cover (fig. 176).

(2) Take out the four screws and remove the retainer and bearing housing from the outer end of the handwheel shaft. Take out the four screws holding the inner bearing housing, pull out this housing and withdraw the shaft (fig. 177), supporting the gear B137692 as the shaft is withdrawn.

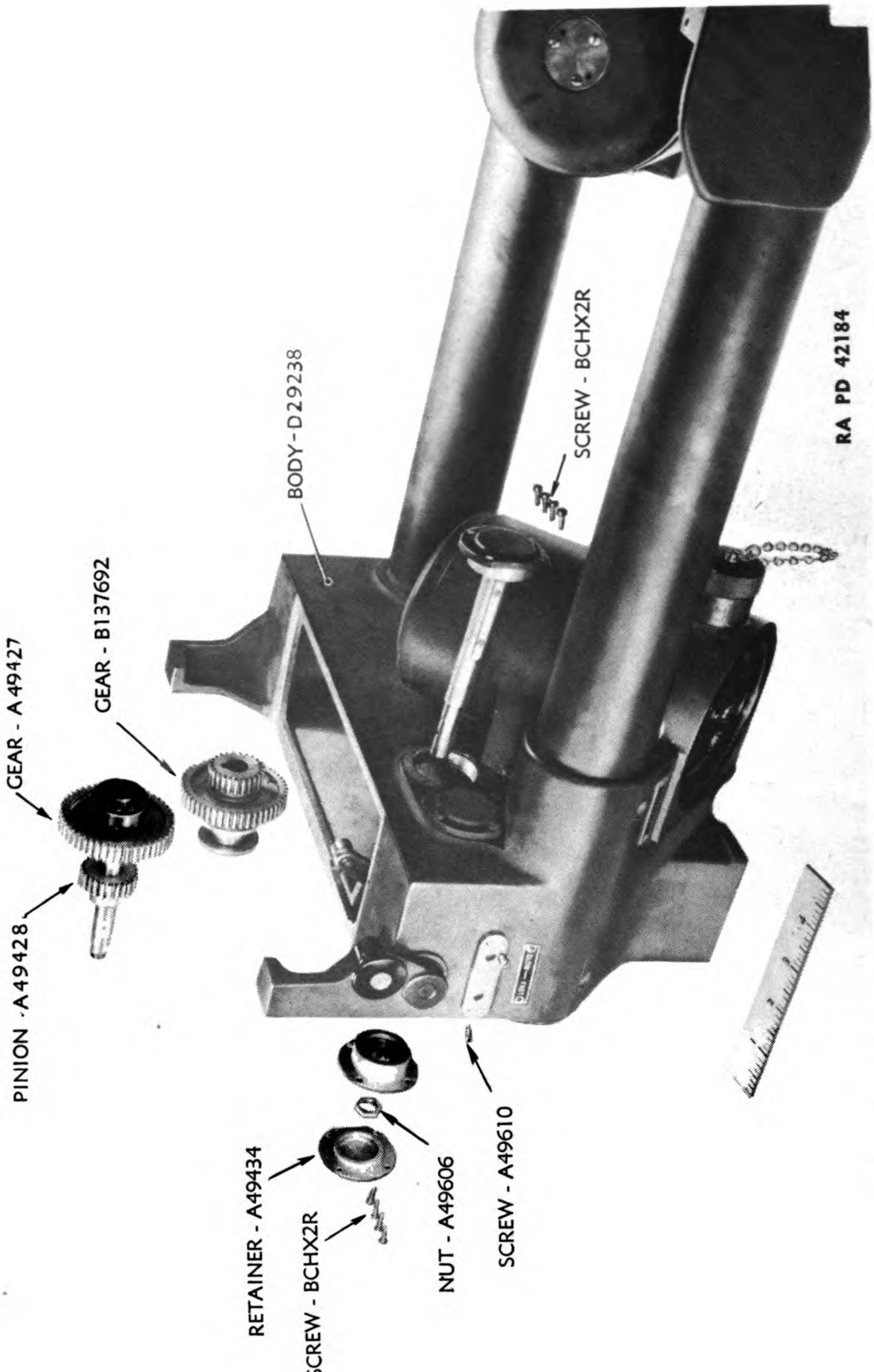


Figure 177 — Removal of Traversing Handwheel Shaft and Countershaft

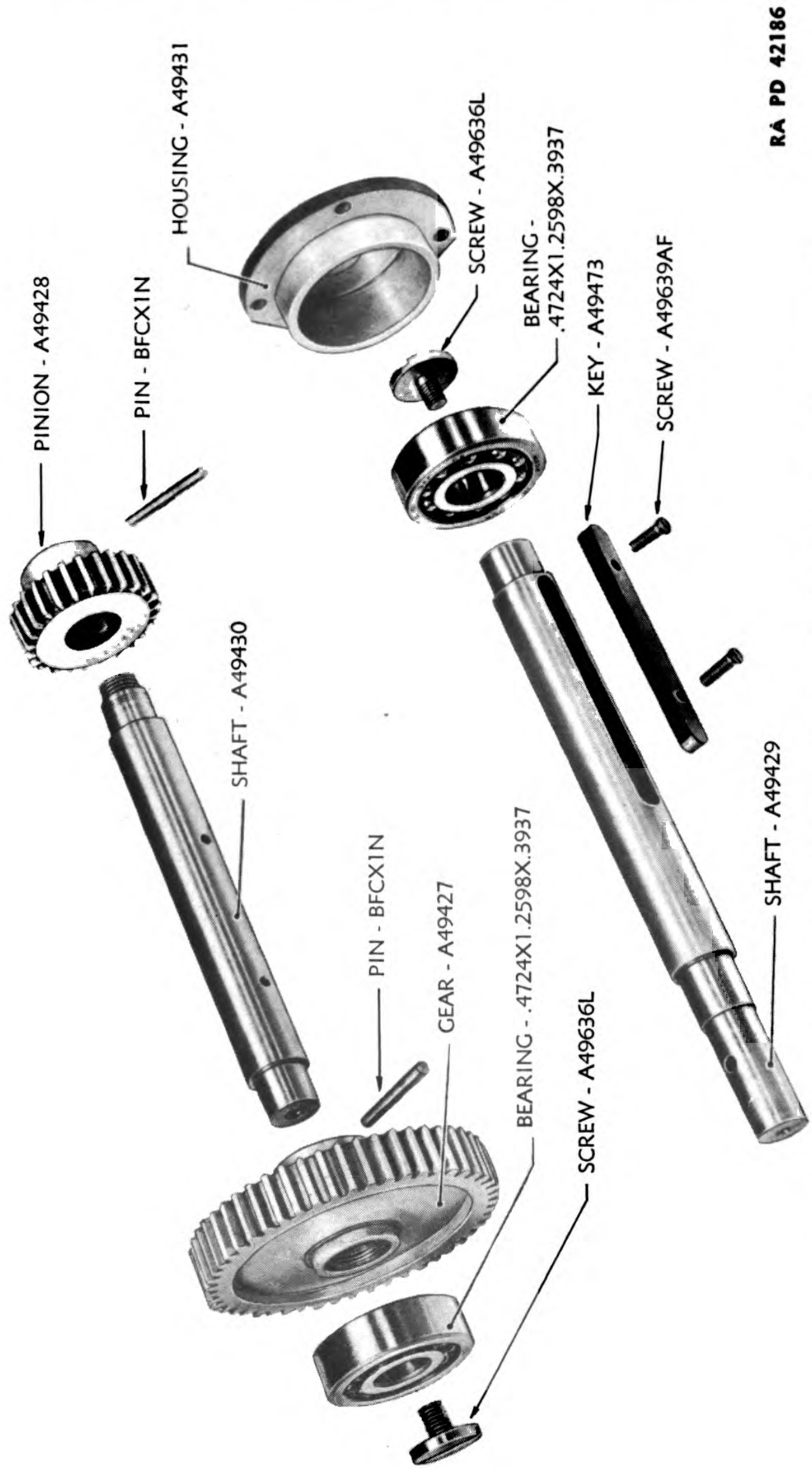


Figure 178 — Disassembly of Traversing Handwheel Shaft and Countershaft

(3) Remove the retainer from the outer bearing of the countershaft, remove the hexagonal nut from the end of the shaft, take out the bearing and remove the shaft. Further disassembly of the shafts is shown in figure 178.

(4) Remove the plug from the end of the cradle tube, take out the screw A49638AJ holding the drive shaft bearing bracket and remove the hexagonal nut from the end of the drive shaft. Insert two bolts into the threaded holes and withdraw the bearing bracket (fig. 179).

(5) Unpin and remove the change of speed crank. Remove the two screws BCGX3FG and take out the change of speed shaft assembly (fig. 180).

(6) Remove the central cradle body cover (fig. 181), take out the two screws to remove the indicator drive bracket assembly, and lift the small spring out of the hole under the bracket. Disassembly of the indicator drive is shown in figure 182.

(7) Remove the locking ring and plug from the coupling shaft bearing housing in the side of the cradle body and remove the screw from the end of the coupling shaft. Remove the bearing housing and bearing.

(8) Remove the screws holding the coupling shaft bracket assembly and the two large screws holding the drive shaft bearing bracket to the coupling shaft bracket (fig. 183). Using a punch, drive in the two small pins to loosen the drive shaft bearing bracket. Work loose the coupling shaft bracket and remove the assembly. Further disassembly is illustrated in figure 184.

(9) Holding the drive shaft out of the way, move the floating indicator shaft to the left until the right end appears and withdraw the shaft. Unpin and remove the large gear at the outer end of the drive shaft and withdraw the shaft. Further disassembly of these shafts is illustrated in figure 185.

e. Assembly of Traversing Mechanism.

(1) Assembly is accomplished in the reverse order of disassembly.

(2) Excessive looseness between the large drive shaft gear and the countershaft pinion can be taken up, if necessary, by rotating the drive shaft outer bearing bracket (fig. 179) to bring the shafts closer together. Drill and tap a new hole for the bracket locking screw A49638AJ and plug the old hole.

(3) Looseness between the bevel pinions of the coupling shaft and drive shaft can be taken up by shifting and repinning the drive shaft bearing bracket.

f. Removal and Disassembly of Elevation Indicator.

(1) Remove the lower cover of the indicator assembly and disconnect the wires at the soldered points. Tag the wires to facilitate assembly.

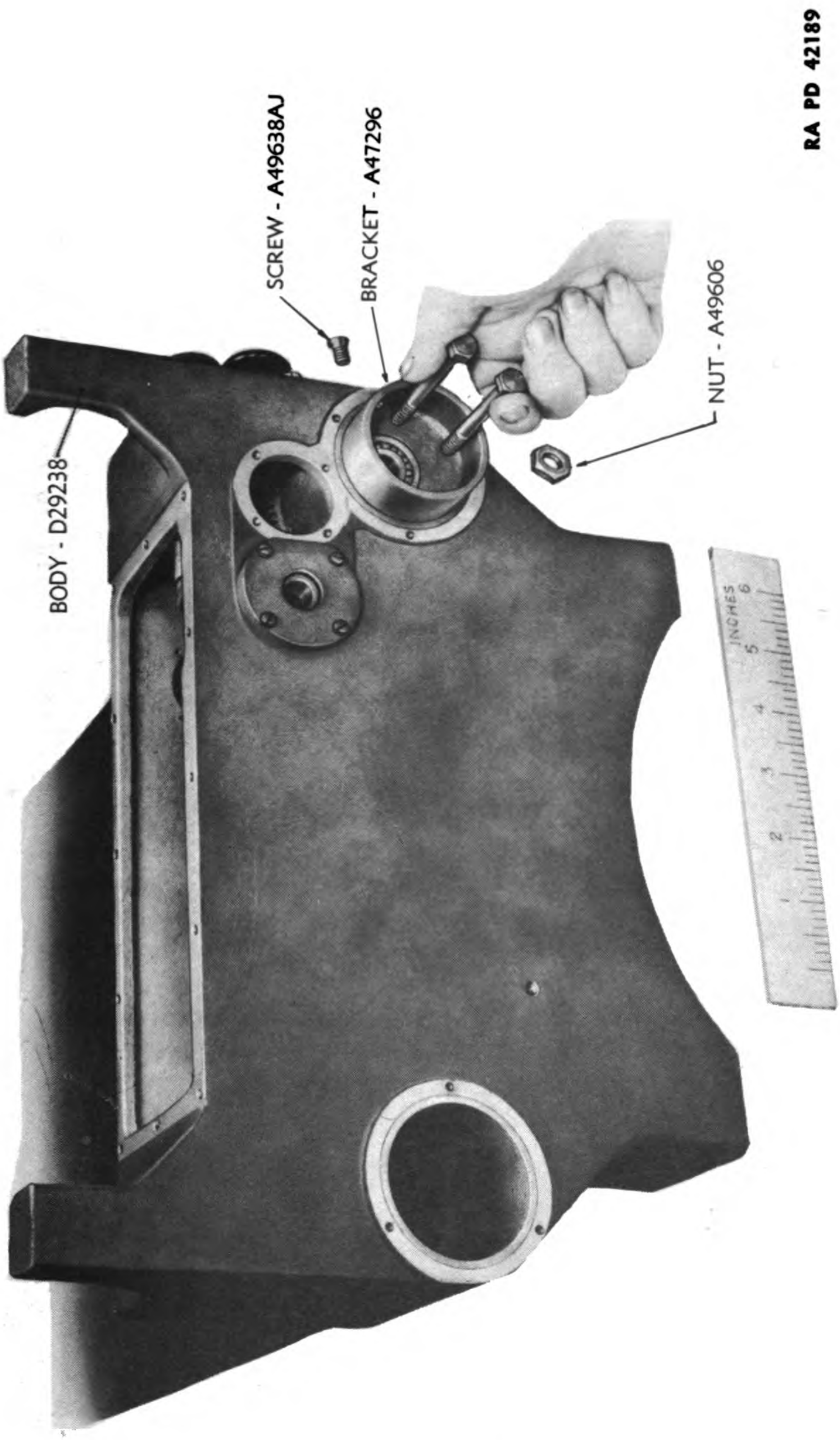


Figure 179 — Removal of Traversing Drive Shaft Outer Bearing Bracket

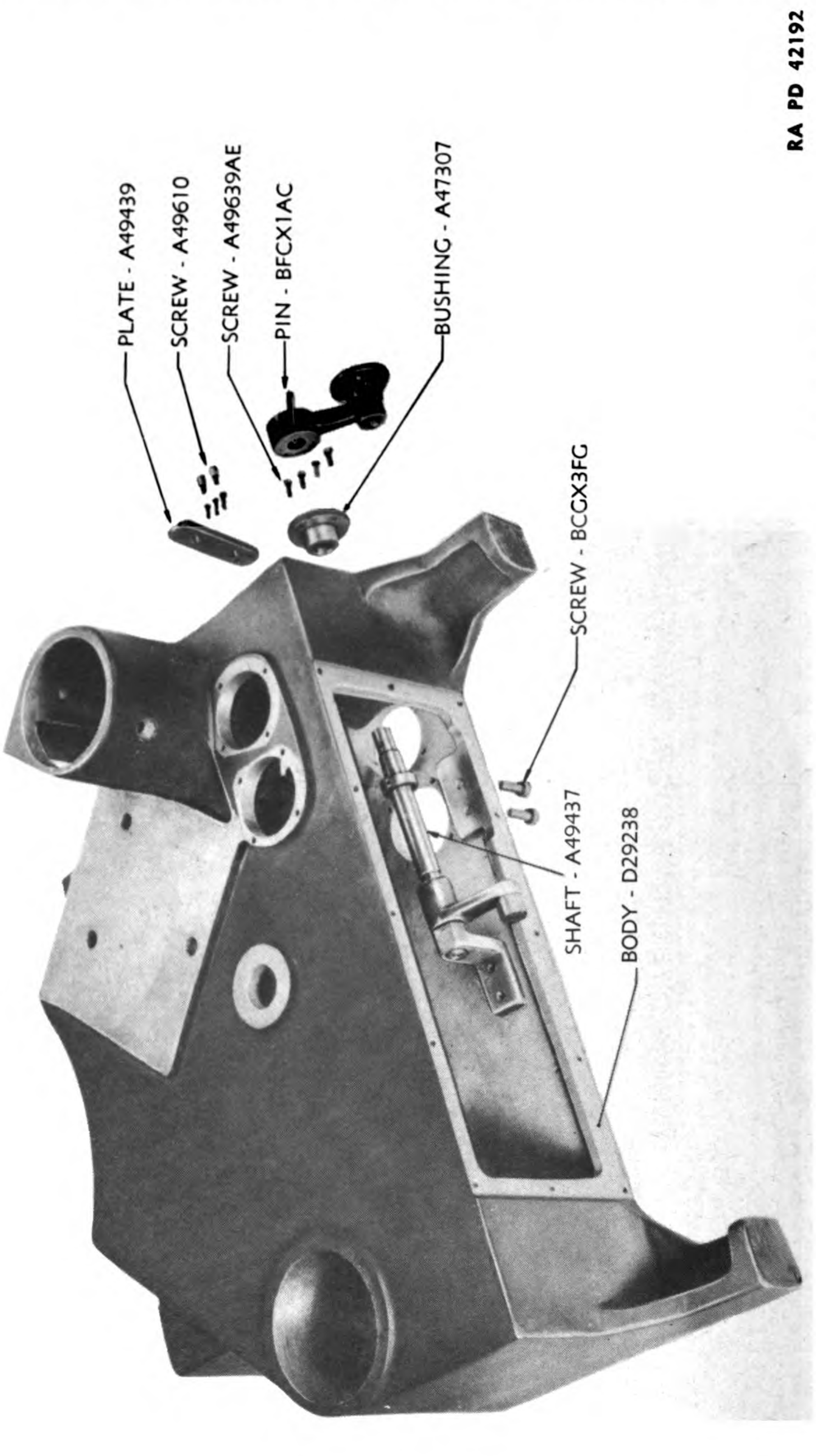


Figure 180 — Removal of Traversing Change of Speed Crank and Shaft Assembly

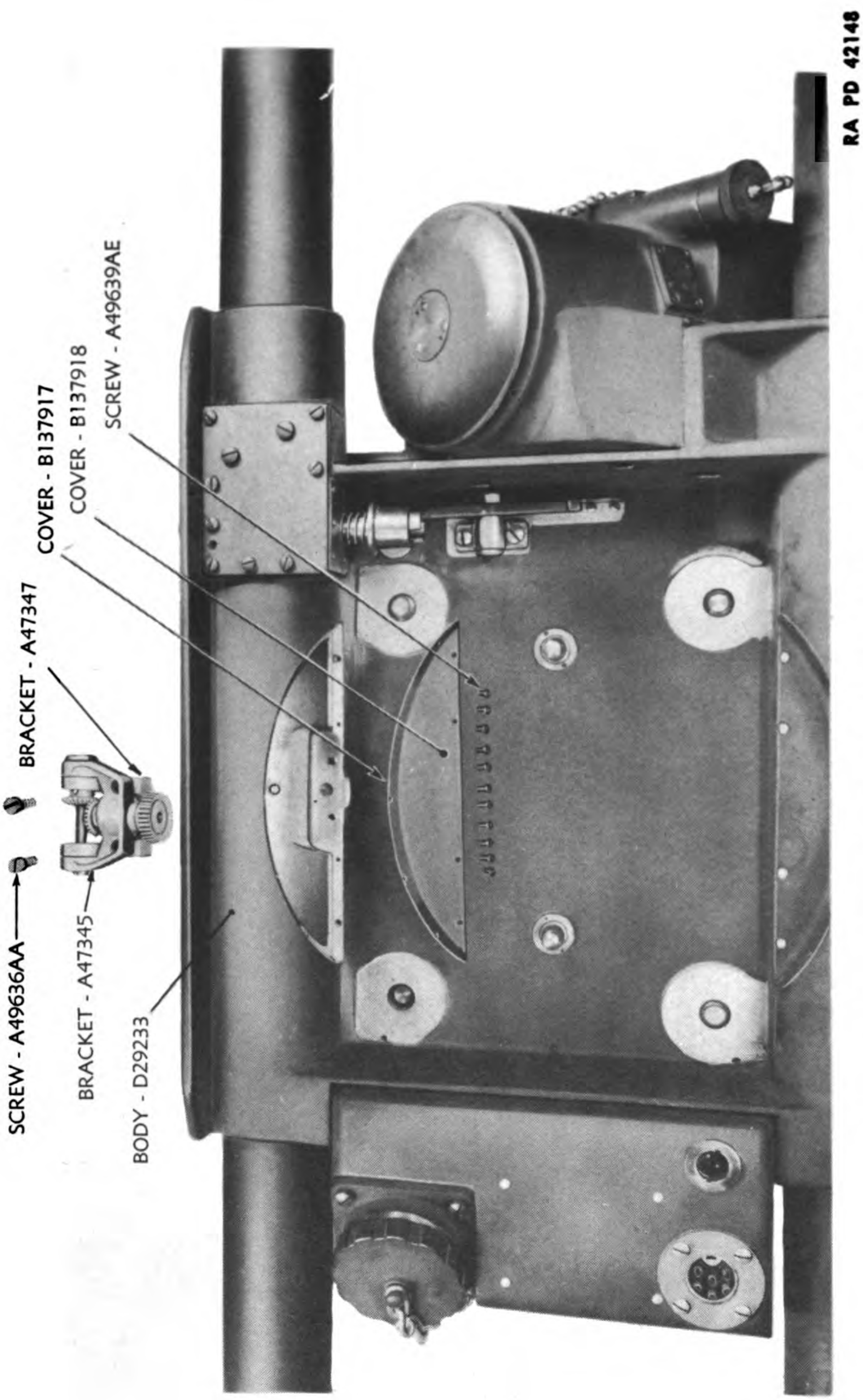


Figure 181 — Removal of Azimuth Indicator Drive Assembly

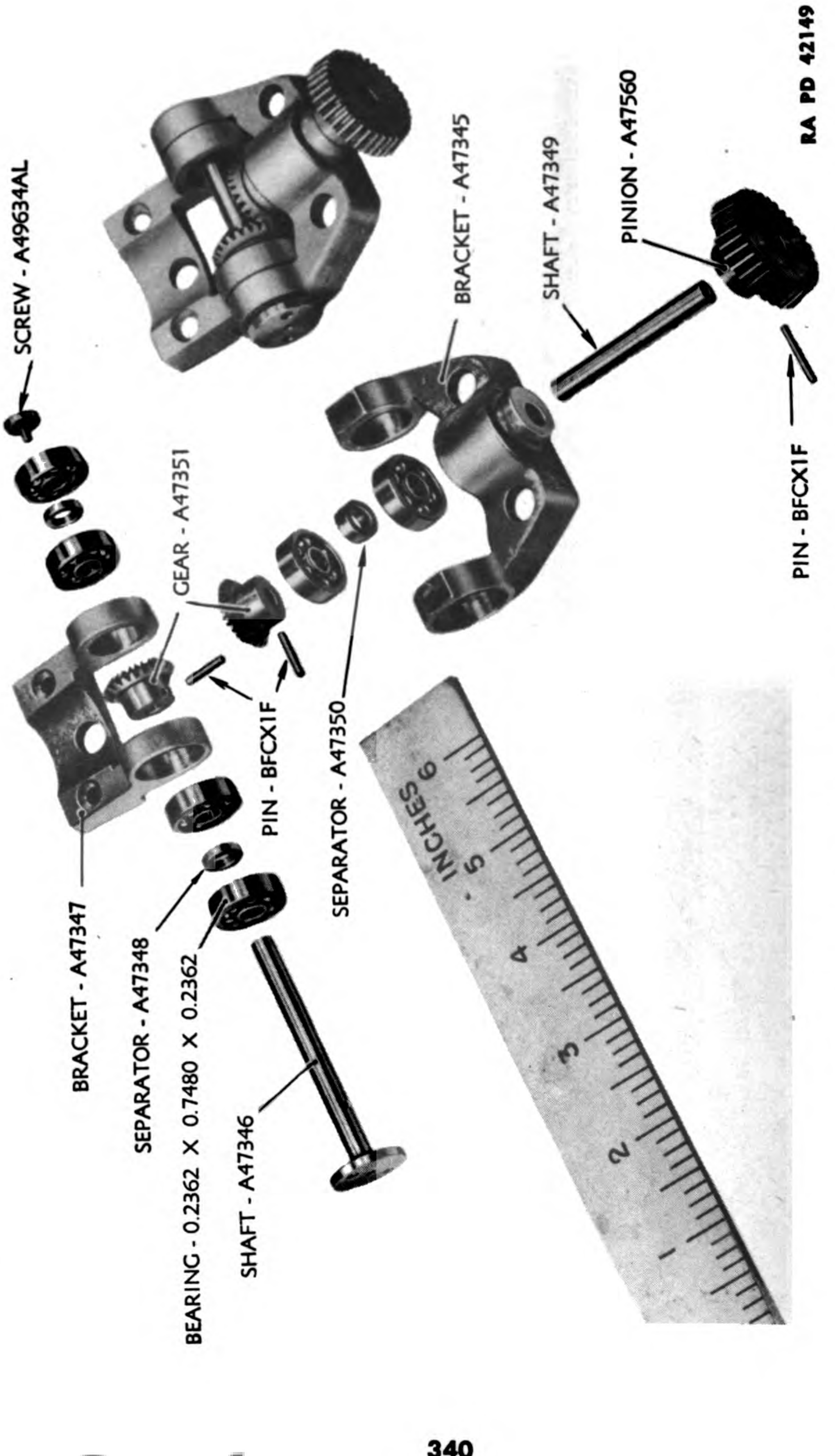


Figure 182 — Disassembly of Azimuth Indicator Drive Assembly

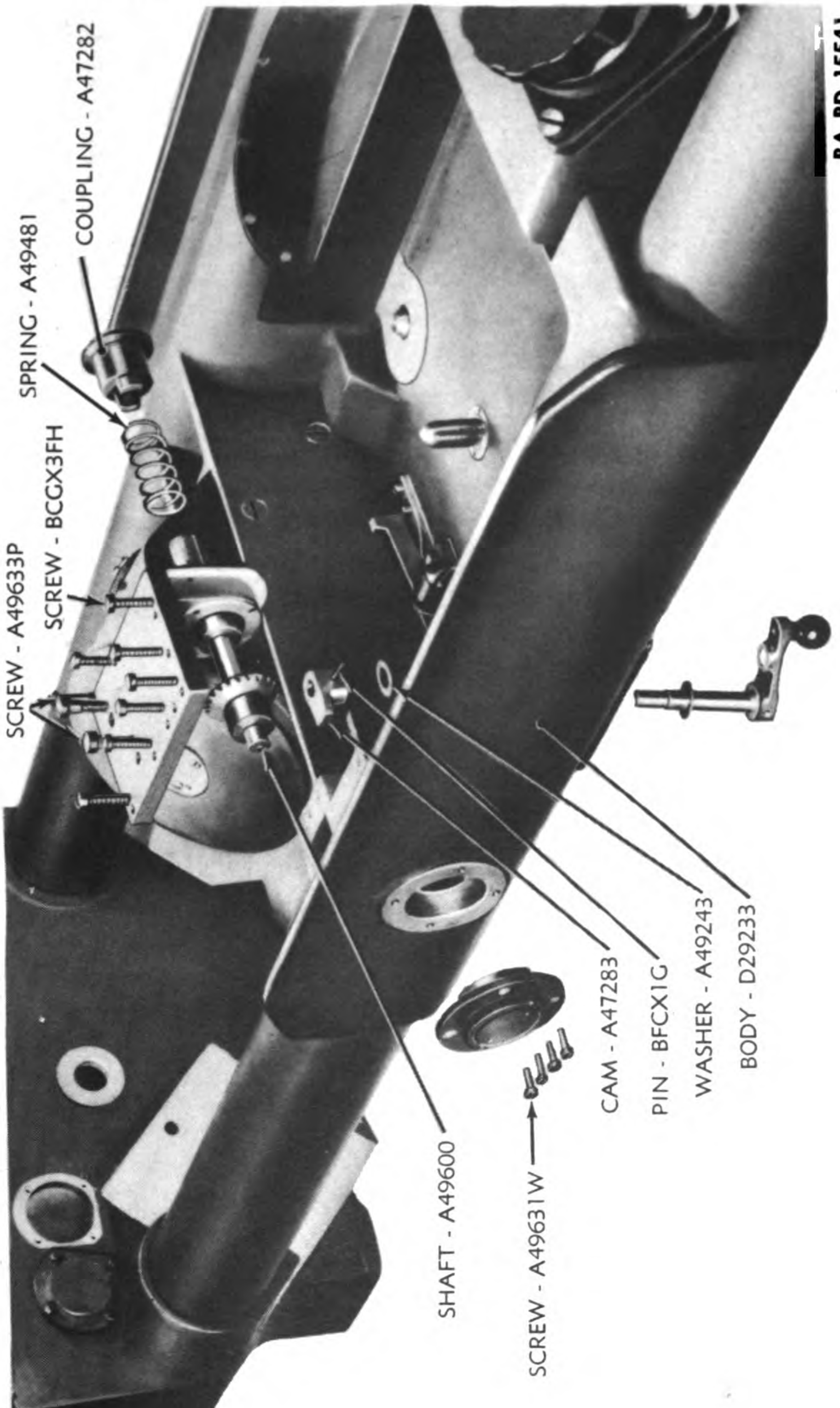


Figure 183 — Removal of Traversing Drive Coupling Shaft Assembly

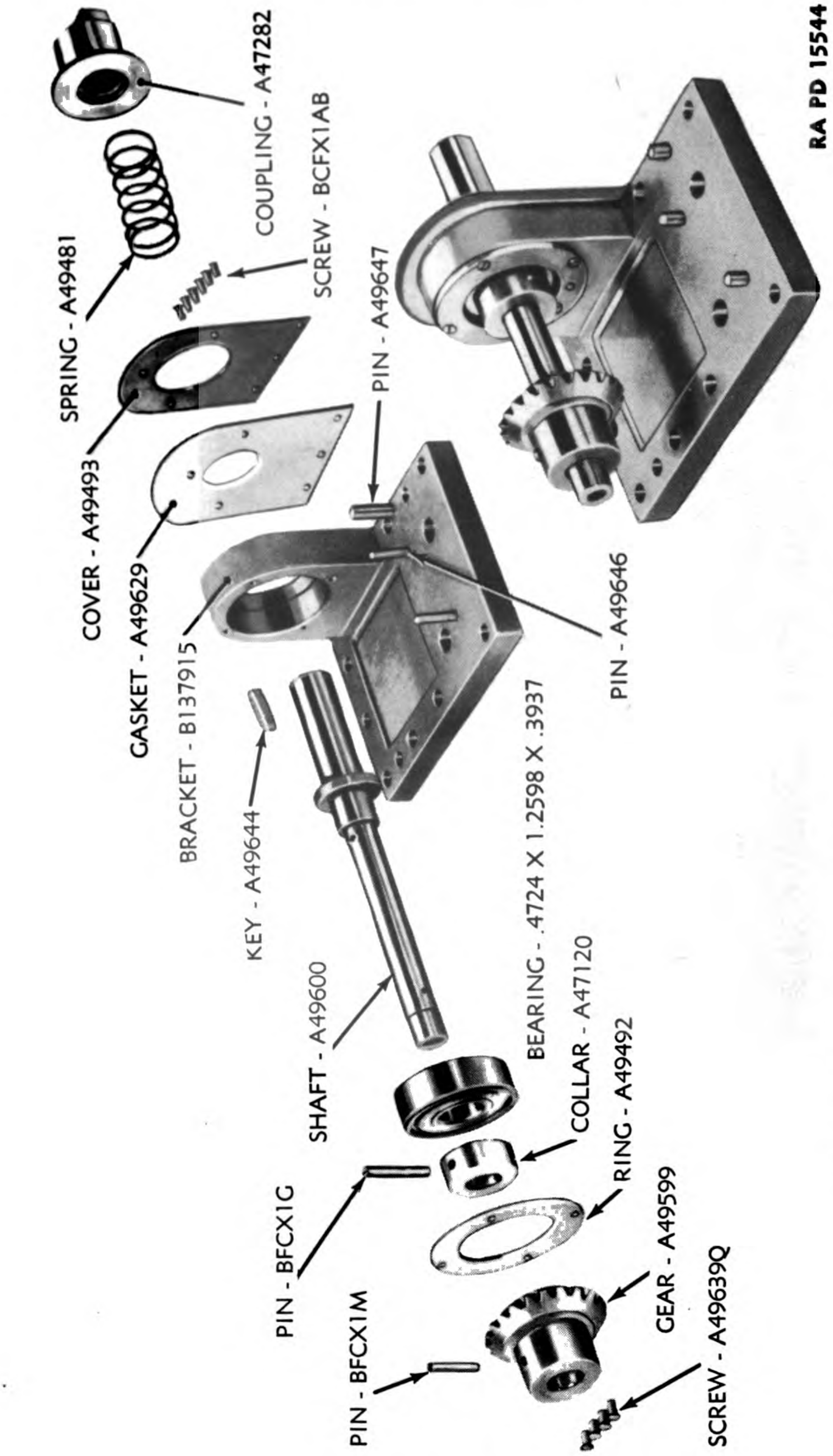


Figure 184 — Disassembly of Traversing Drive Coupling Shaft Assembly

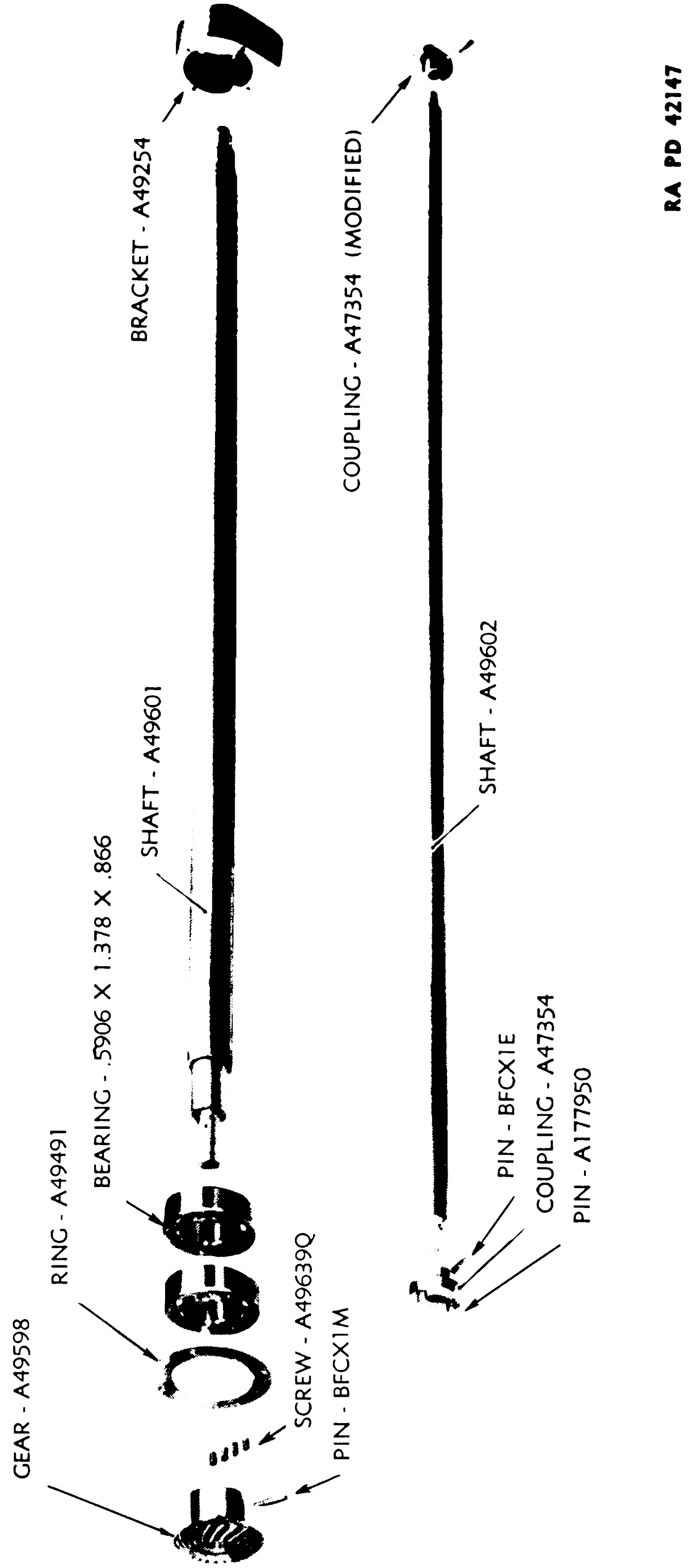


Figure 185 — Disassembly of Traversing Drive Shaft and Azimuth Indicator Drive Shaft

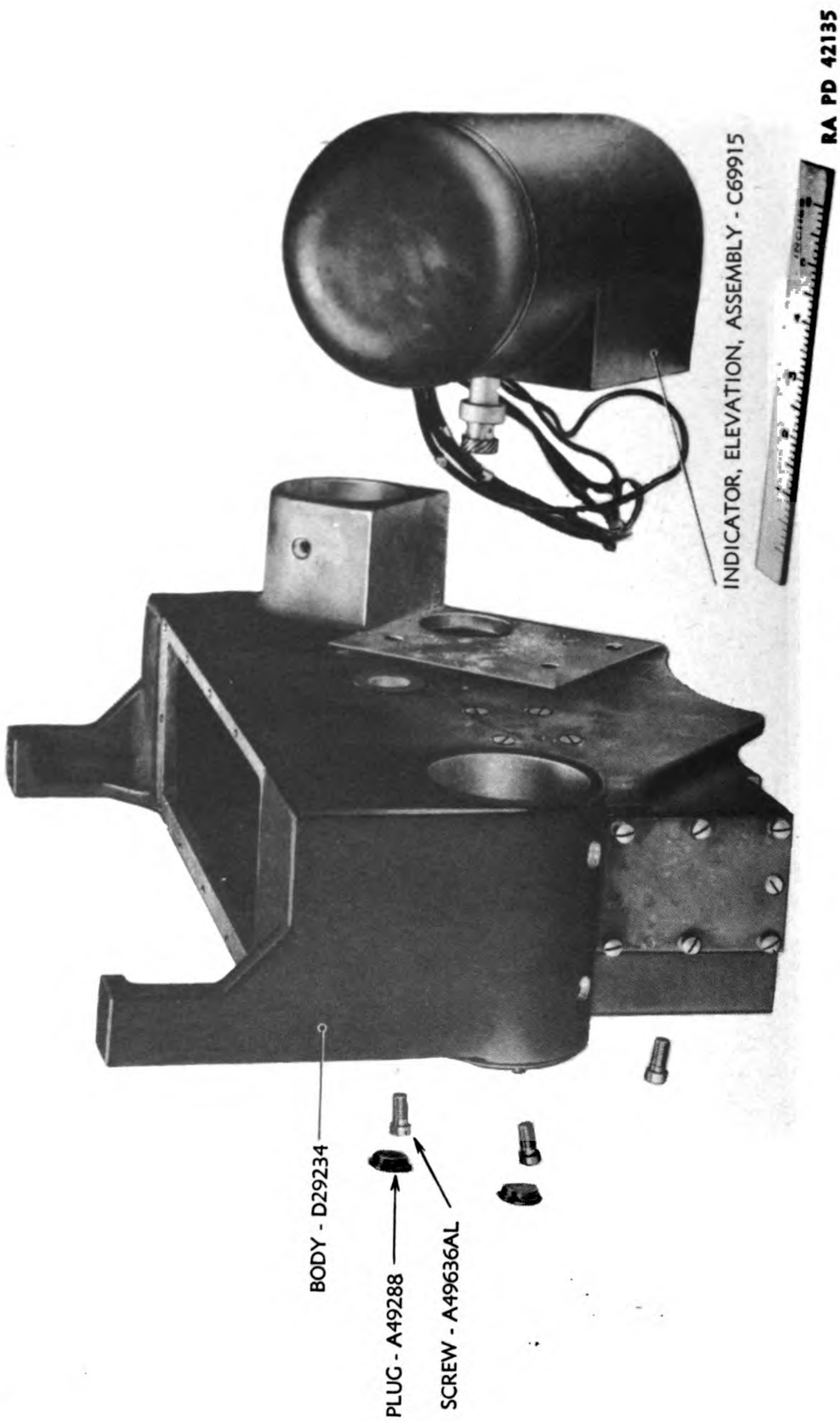


Figure 186 — Removal of Elevation Indicator Assembly

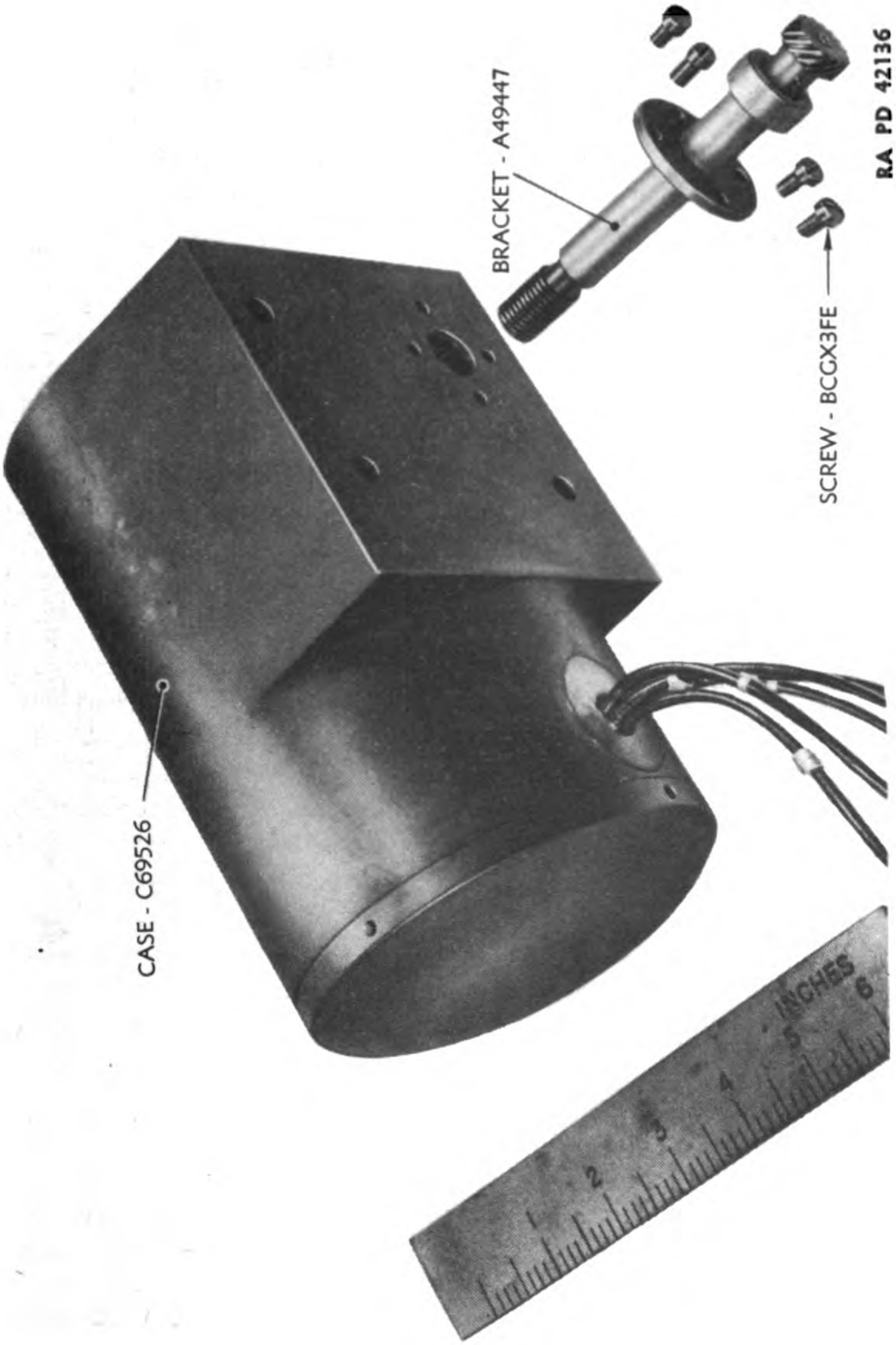


Figure 187 — Removal of Elevation Indicator Worm Bracket Assembly

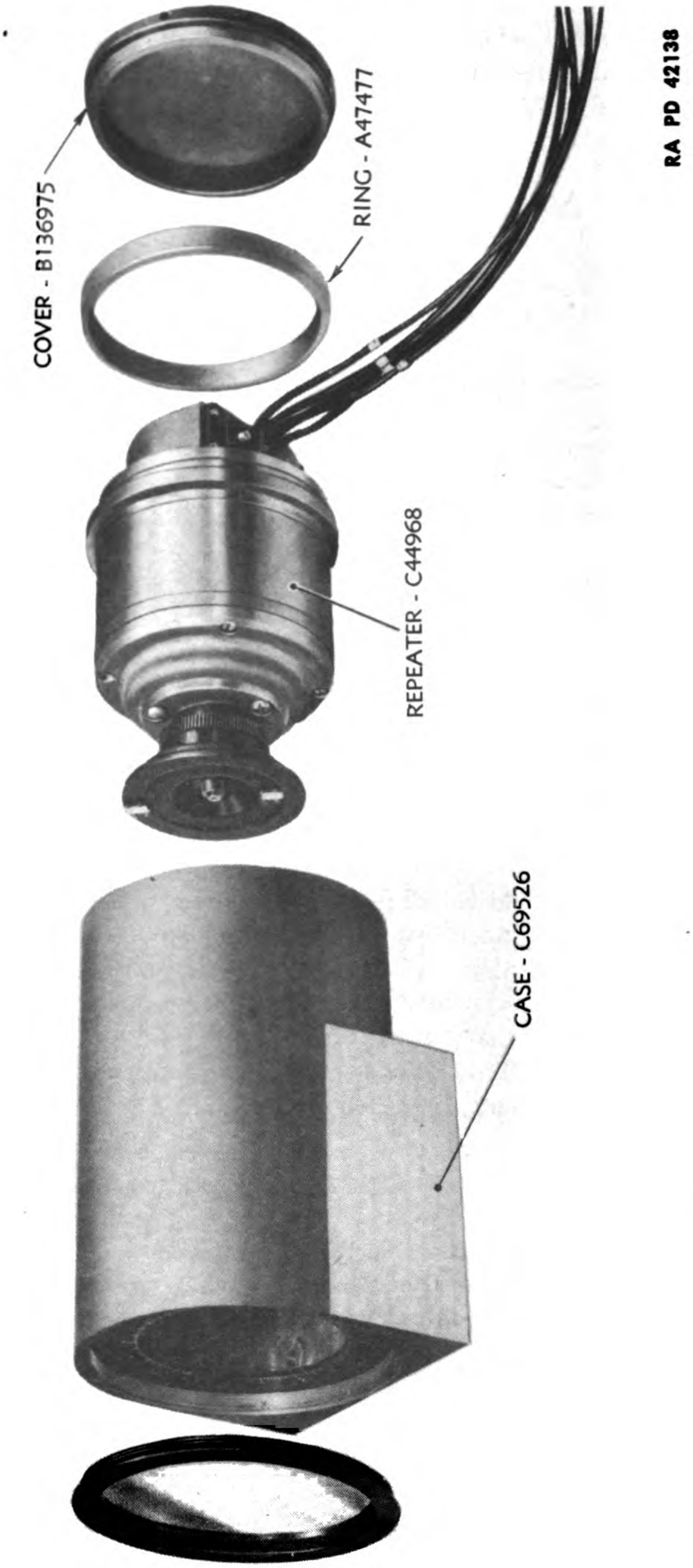


Figure 188 — Removal of Elevation Indicator Repeater

(2) With the special wrench, remove the indicator window. Turn the elevation handwheel to the lower stop and make a pencil mark on the elevation scale opposite the mechanical index. With the elevation handwheel at low speed, count and record the exact number of turns it takes to move the mechanical index from the lower limit to zero-mils elevation.

(3) Remove the two plugs from the left cradle body just above the change of speed crank. Remove the three indicator case securing screws (fig. 186).

(4) Remove the four screws and the worm bracket assembly (fig. 187).

(5) Remove the retaining ring and withdraw the repeater (fig. 188).

(6) Hold the notched washer with the special indicator wrench, and remove the hexagonal nut from the repeater shaft. Lift off the washer, the electrical index adapter, the inner adapter and the horseshoe washer (fig. 189).

(7) Remove nut A47491 and lift off the mechanical index adapter and its drive gear.

g. Assembly and Adjustment of Elevation Indicator.

(1) Assembly is accomplished in the reverse order of disassembly.

(2) If other parts of the elevating mechanism have not been disturbed, turn the elevation handwheel to the lower stop and set the indicator mechanical index at the point marked on the scale before replacing the indicator assembly. Check the setting of the mechanical dial and adjust it, if necessary, after the height finder telescope has been mounted on the cradle. The elongated screw holes in the mechanical index adapter will normally provide sufficient movement for this adjustment. The elevation stops should allow operation of the elevating mechanism to about 50 mils beyond each end of the scale.

(3) For soldering instructions see paragraph 83.

(4) For electrical zero of the elevation repeater see paragraph 84.

h. Disassembly of Elevating Mechanism.

(1) Remove the change of speed crank stop screw, take out the four screws holding the crank shaft adapter, and remove the adapter and crank assembly (fig. 190).

(2) Remove the 12 screws and left cradle body cover (fig. 191).

(3) Unpin and remove the handwheel, take out the four screws holding the outer bearing retainer, and remove the retainer and bearing (fig. 191). Withdraw the handwheel shaft enough to free the inner bearing and remove the shaft and gear. Disassembly of these units is shown in figure 192.

(4) With the elevation drive turned to the lower stop, mark the angular position of the coupling on the vertical shaft (fig. 193). Remove the six screws holding the telescope bearing shoe and lift off the

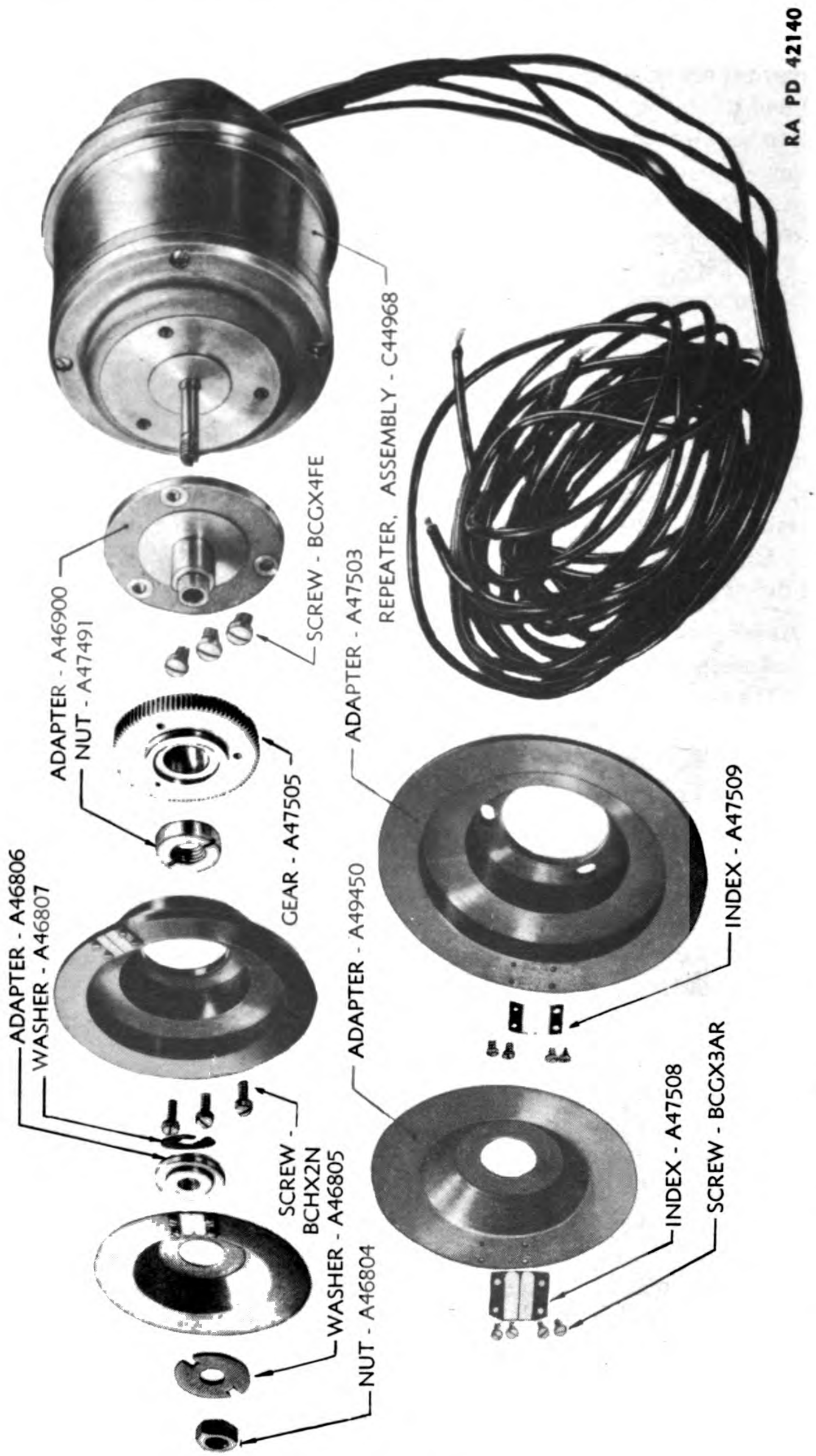


Figure 189 — Removal of Electrical and Mechanical Index Adapters from Elevation Repeater

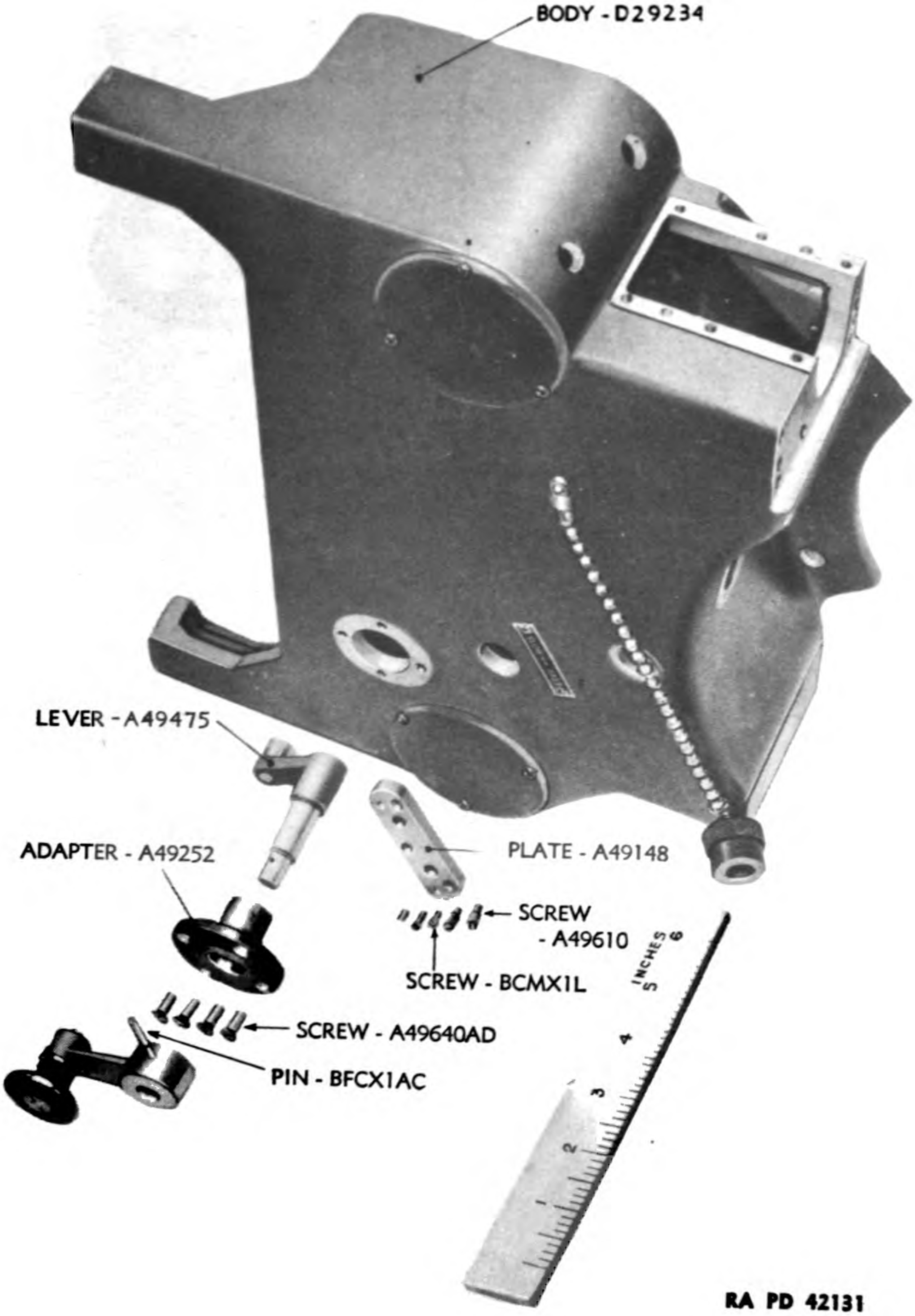


Figure 190 — Removal of Elevation Drive Change of Speed Crank Assembly

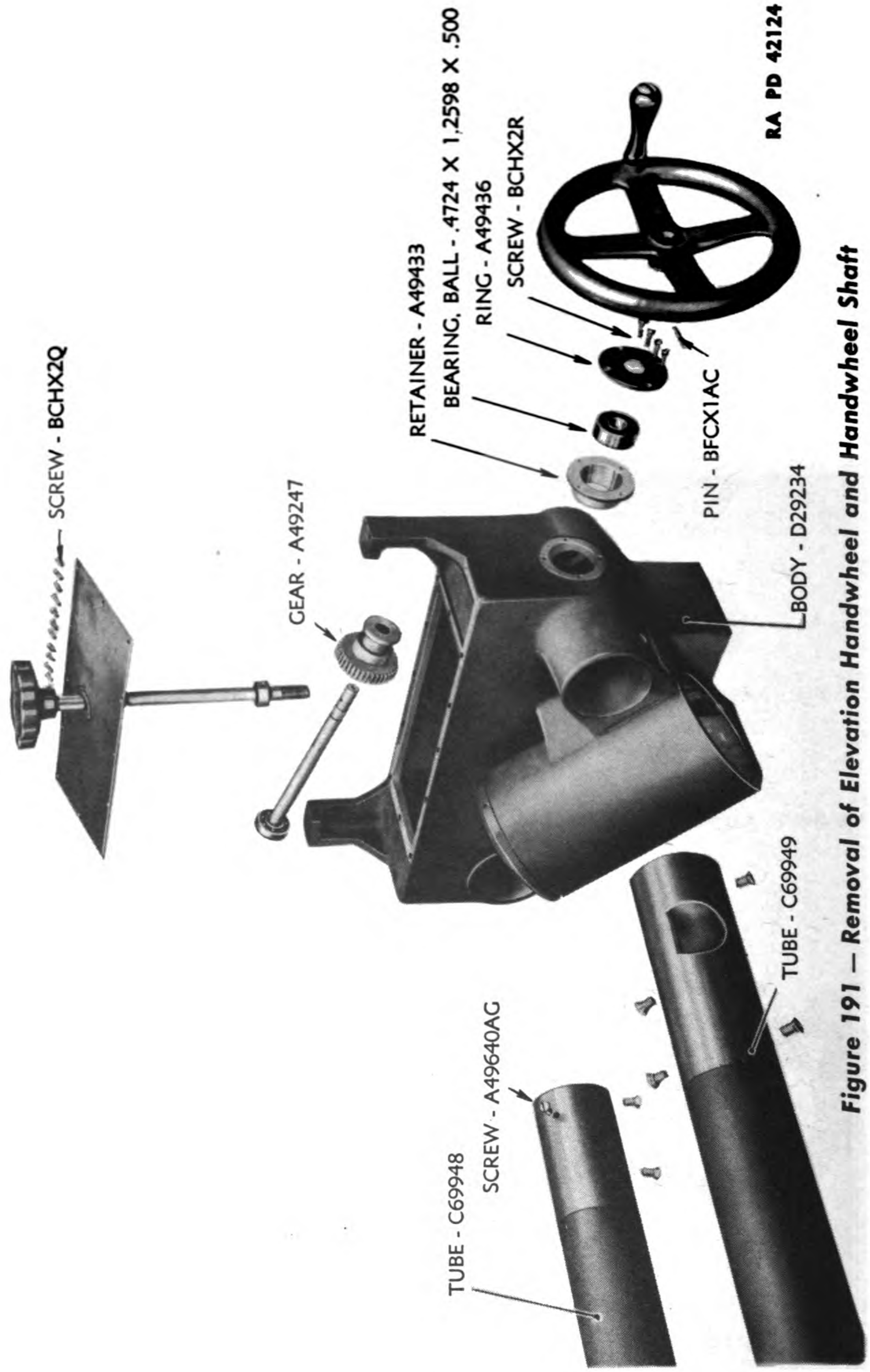


Figure 191 — Removal of Elevation Handwheel and Handwheel Shaft

CRADLE M1—ADJUSTMENT, REPAIR, AND DISASSEMBLY

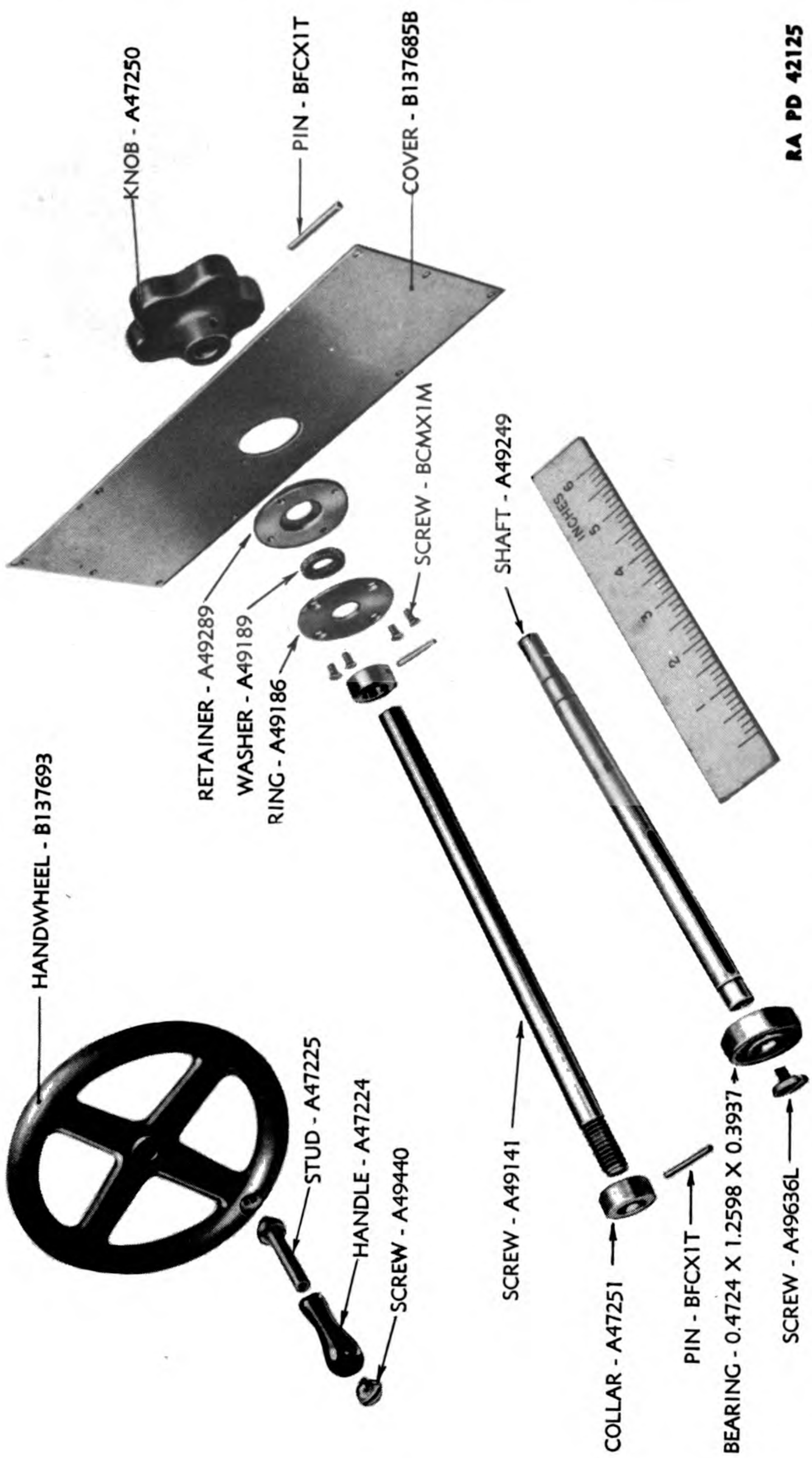


Figure 192 — Disassembly of Elevation Handwheel, Handwheel Shaft, and Body Cover with Locking Screw

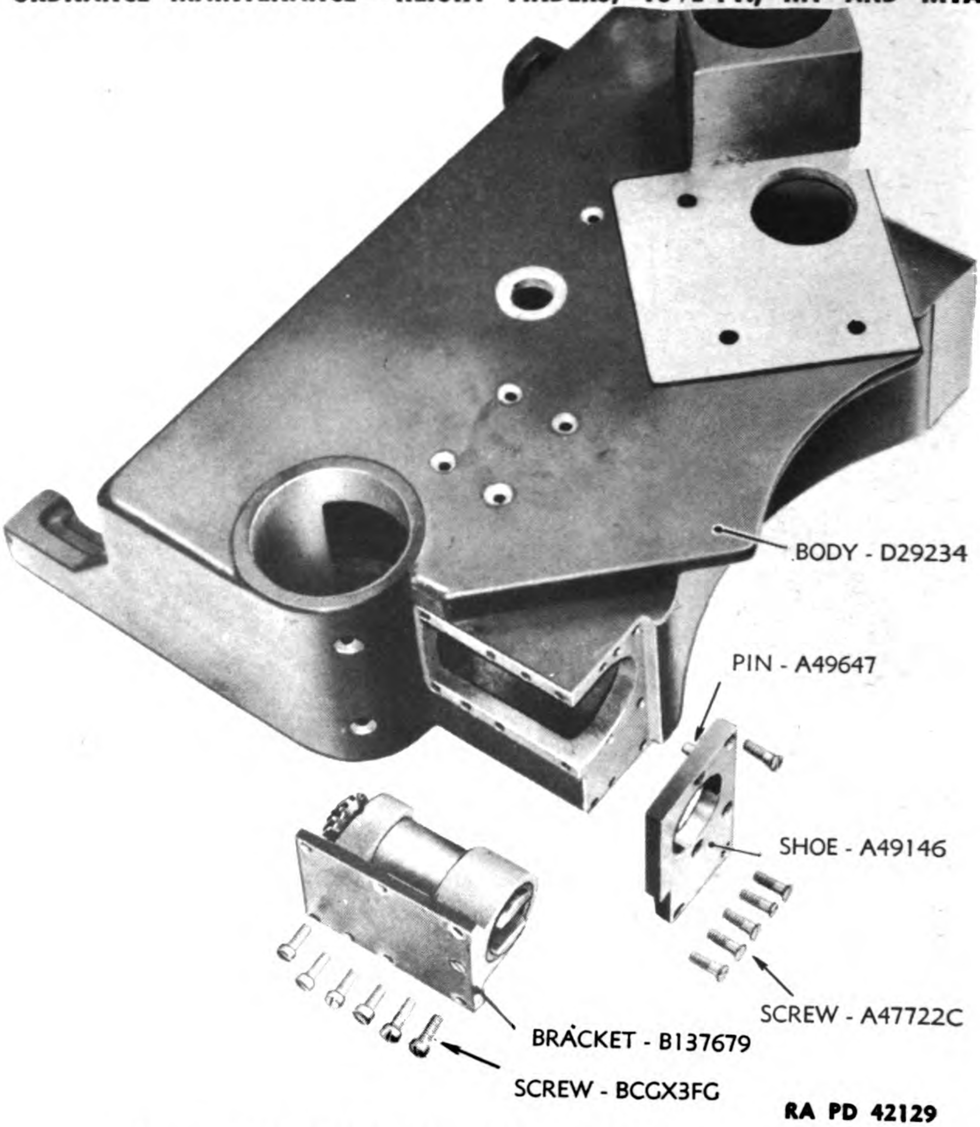


Figure 193 — Removal of Bearing Shoe and Elevation Vertical Drive Shaft

shoe. Take out the six screws holding the vertical shaft bracket and remove the assembly. Disassembly is shown in figure 194.

(5) Remove the six screws holding elevation stop bracket (fig. 195). Five screws are located on the inner wall of the cradle body. The sixth can be reached through the lower plug hole in the outer wall of the cradle body. Remove the stop bracket and stop assembly. Disassembly is shown in figure 196.

i. Reassembly and Adjustment of Elevating Mechanism.

(1) Reassembly is done in the reverse order of disassembly.

(2) In replacing the vertical shaft assembly, see that the stop shaft is at the lower stop and that the vertical coupling shaft is turned to the position marked. See also subparagraph g (2), above.

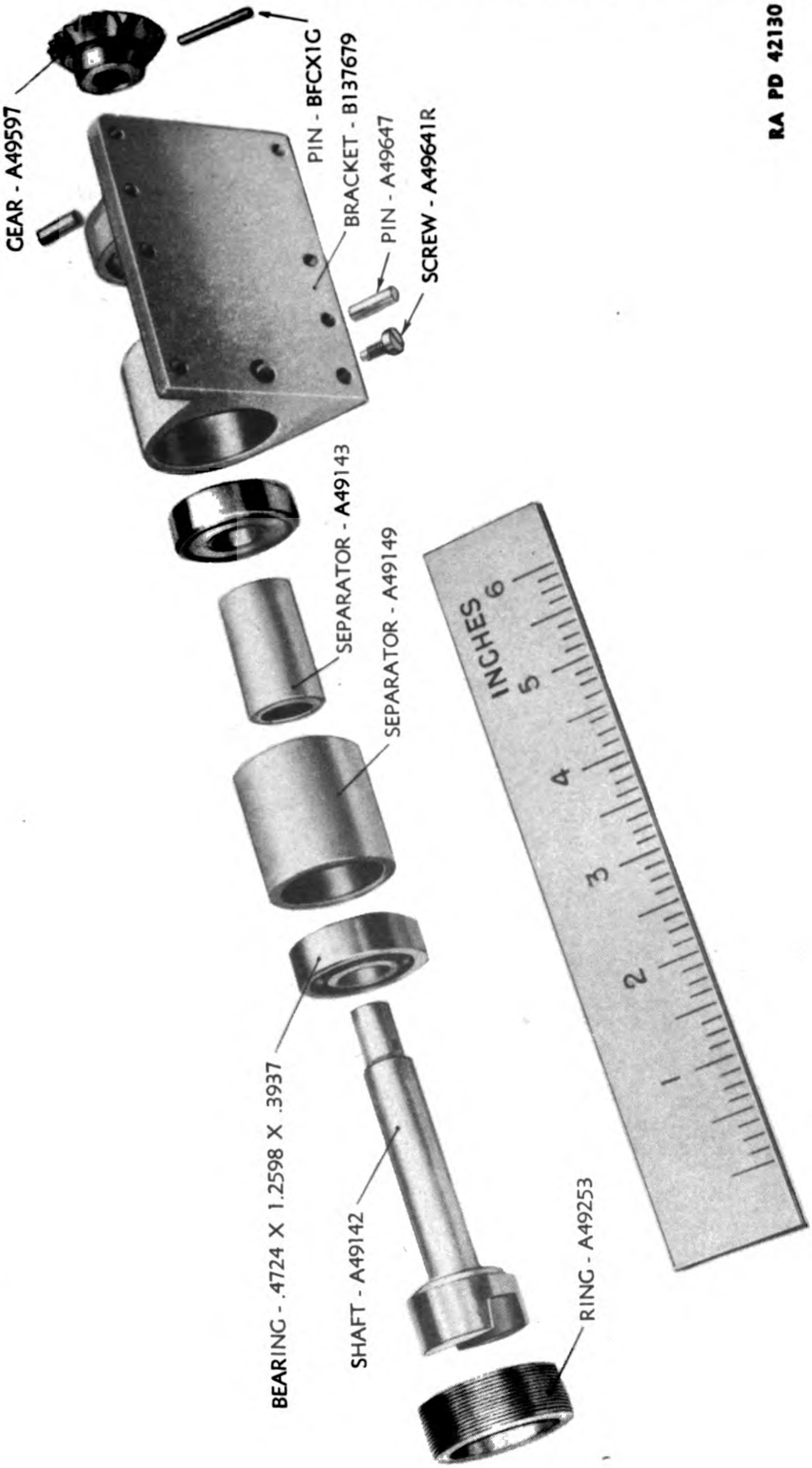


Figure 194 — Disassembly of Elevation Vertical Drive Shaft

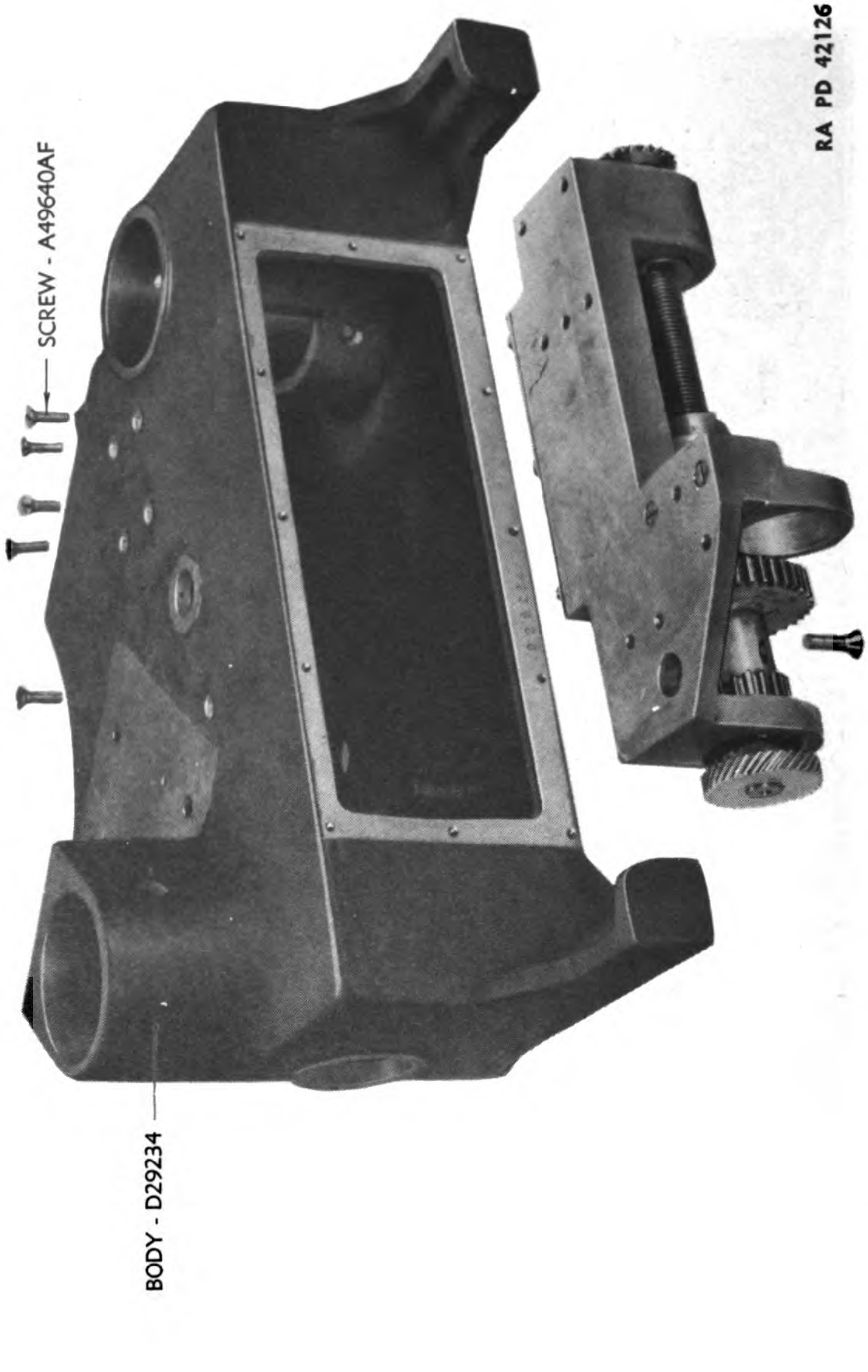


Figure 195 — Removal of Elevation Drive Stop Mechanism

CRADLE M1—ADJUSTMENT, REPAIR, AND DISASSEMBLY

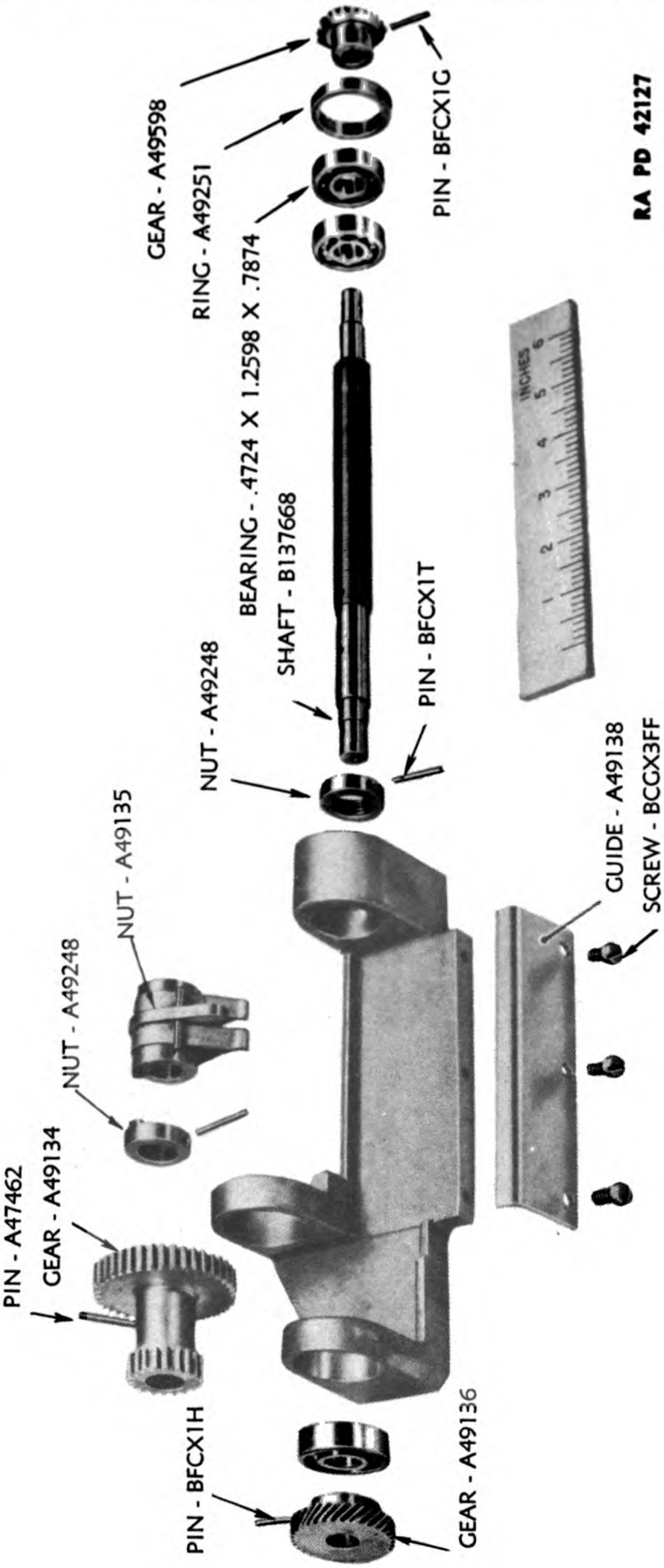


Figure 196 — Disassembly of Elevation Drive Stop Mechanism

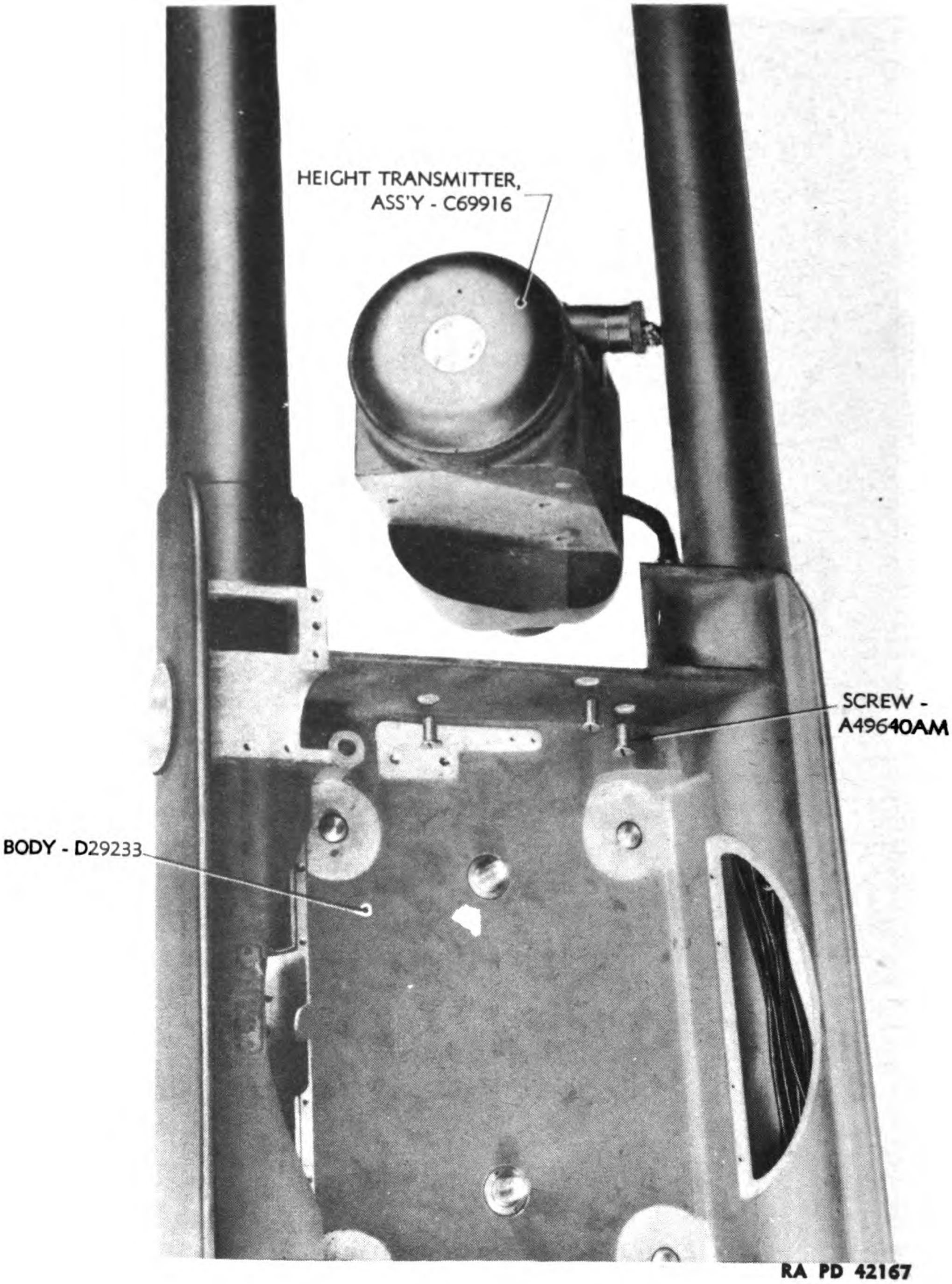


Figure 197 — Removal of Height Transmitter Assembly

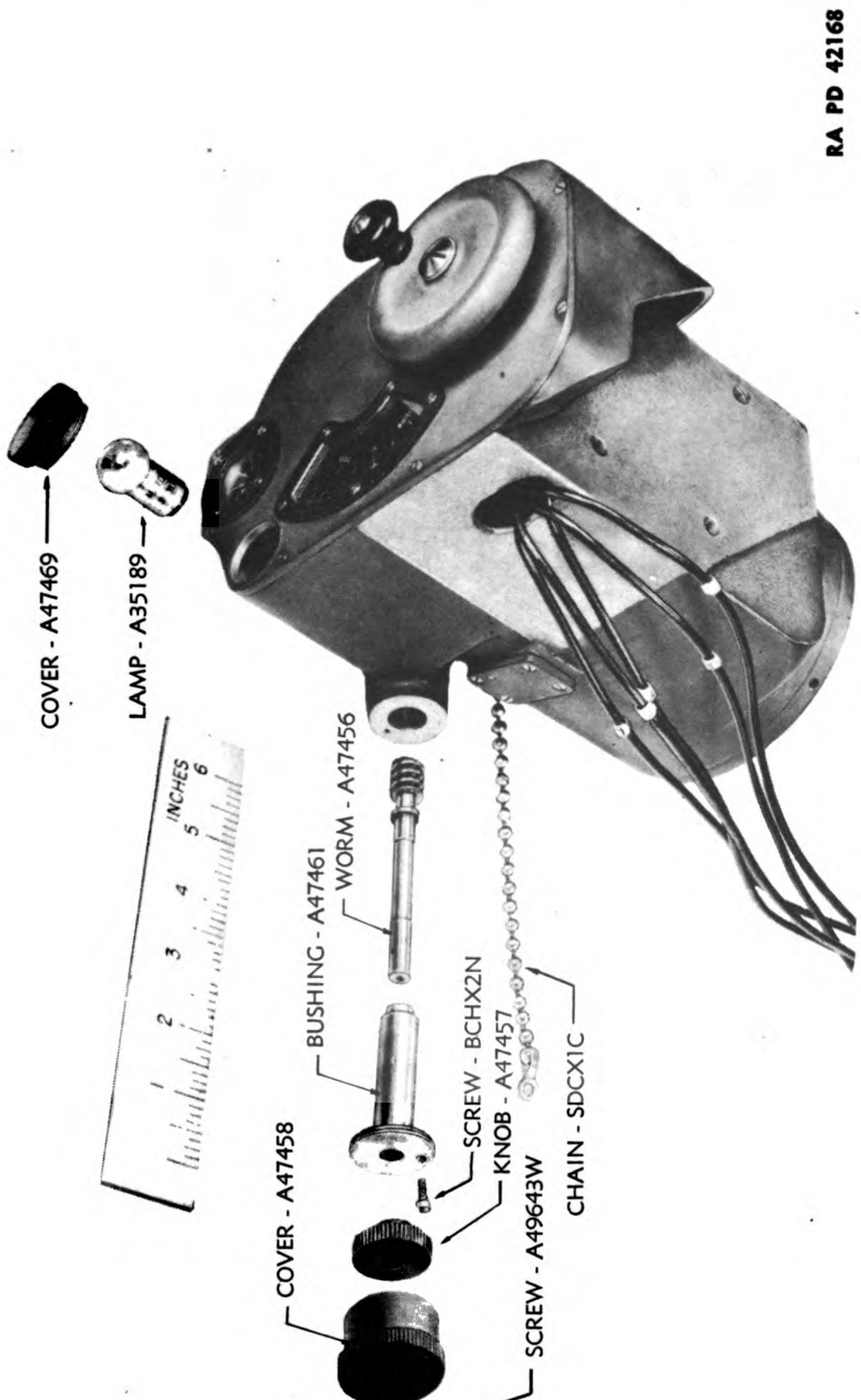


Figure 198 — Removal of Height Transmitter Correction Knob and Worm

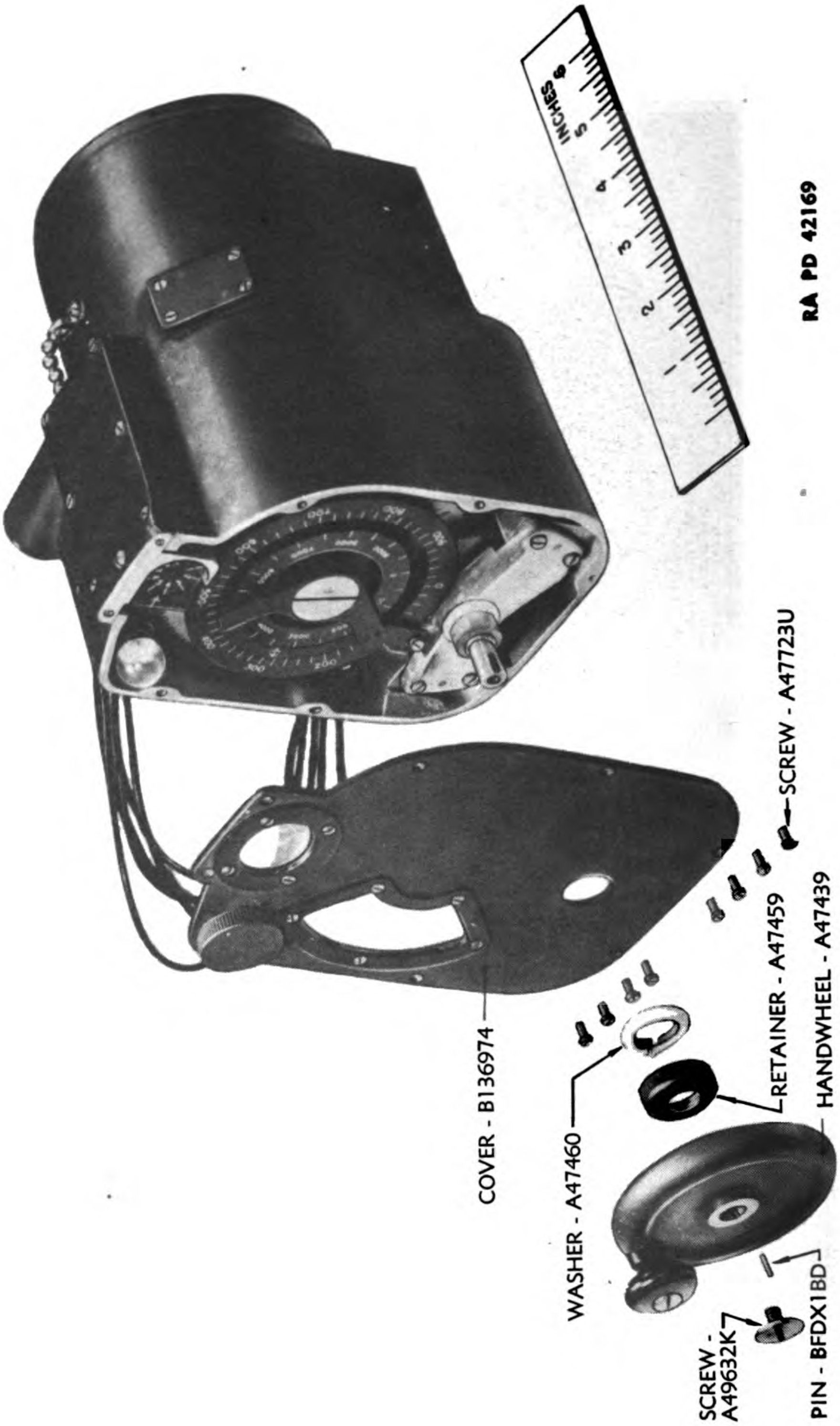


Figure 199 — Removal of Transmitter Handwheel and Cover

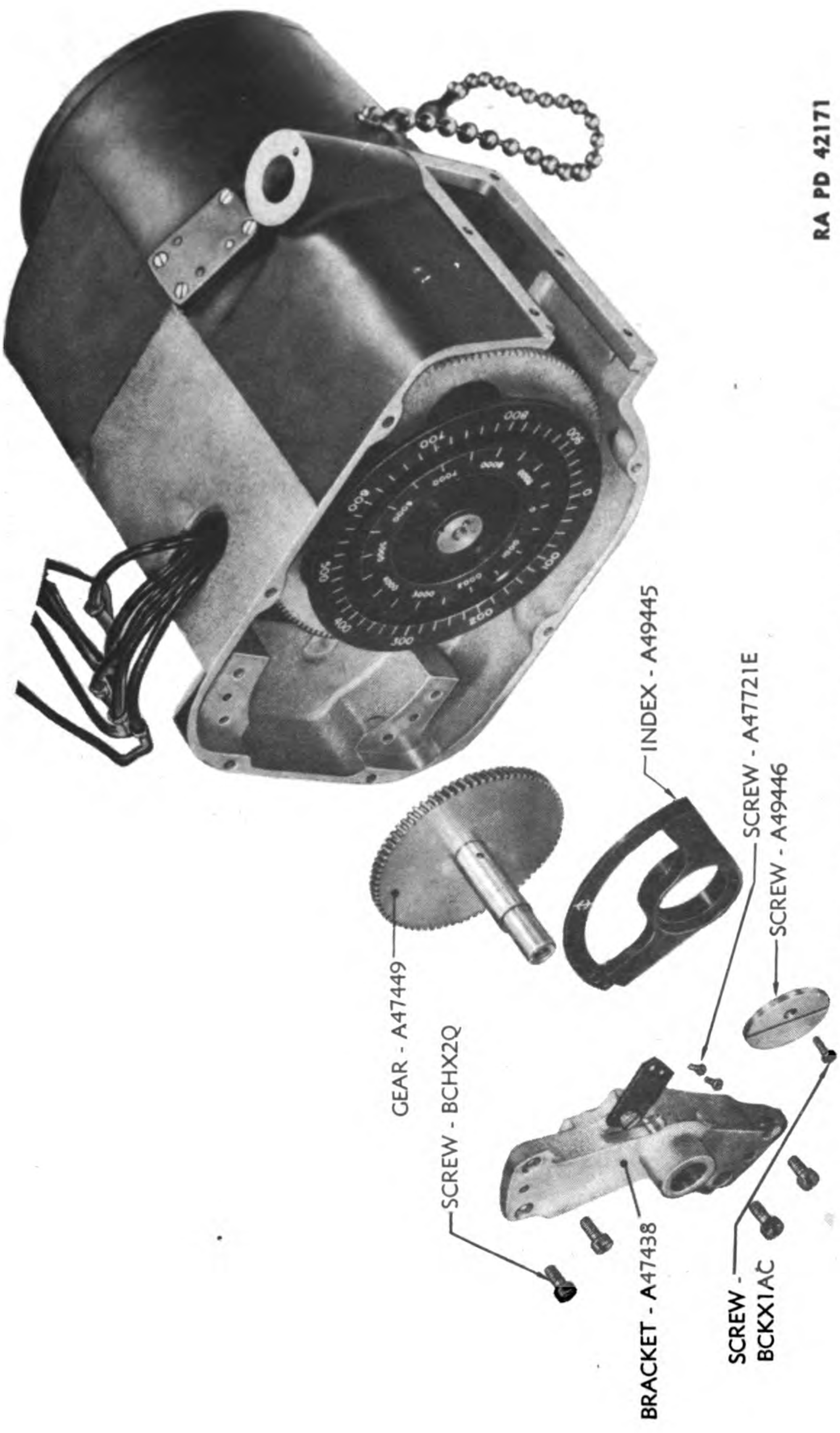


Figure 200 — Removal of Transmitter Handwheel

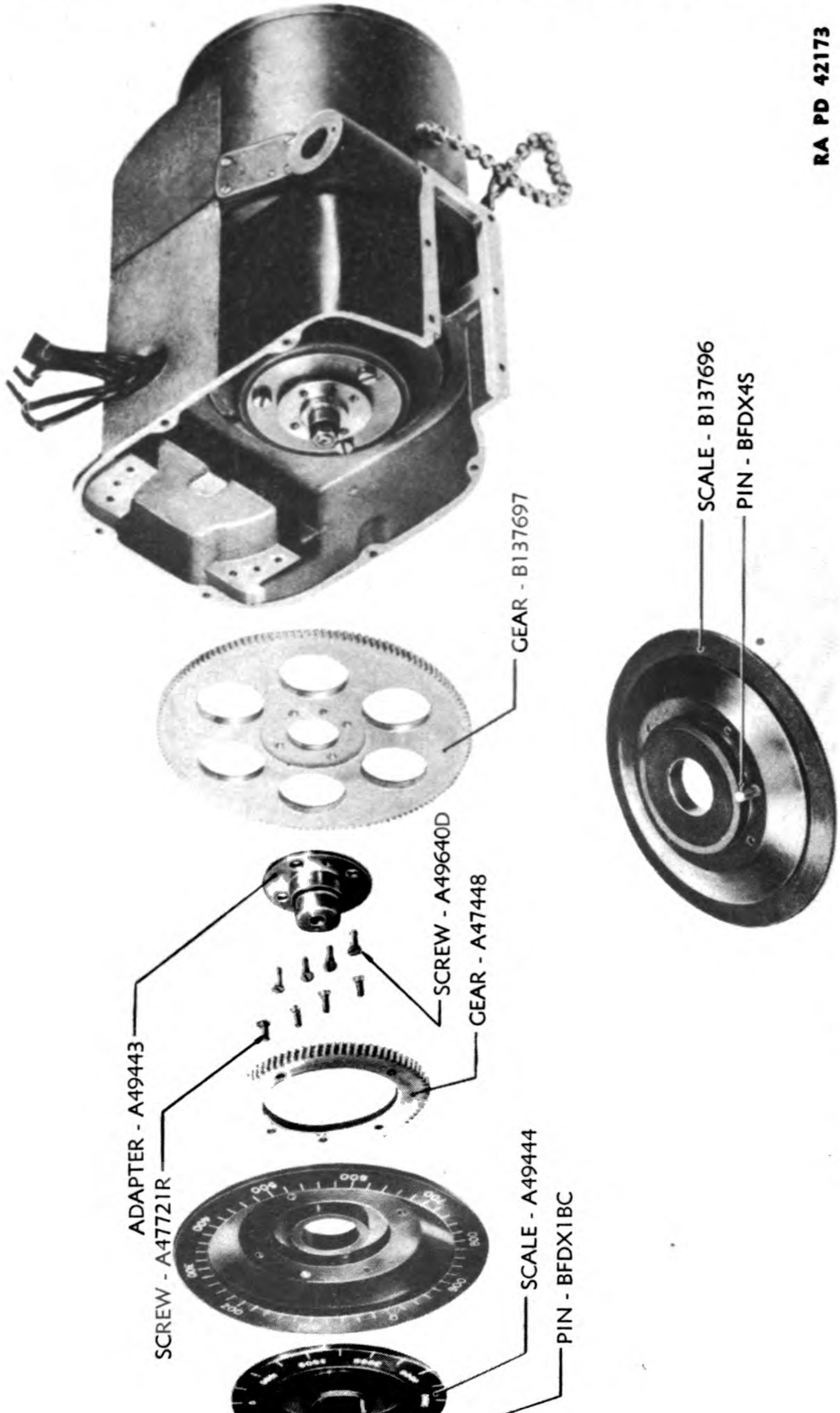


Figure 201 — Removal of Scales and Drive Gear from Transmitter Shaft

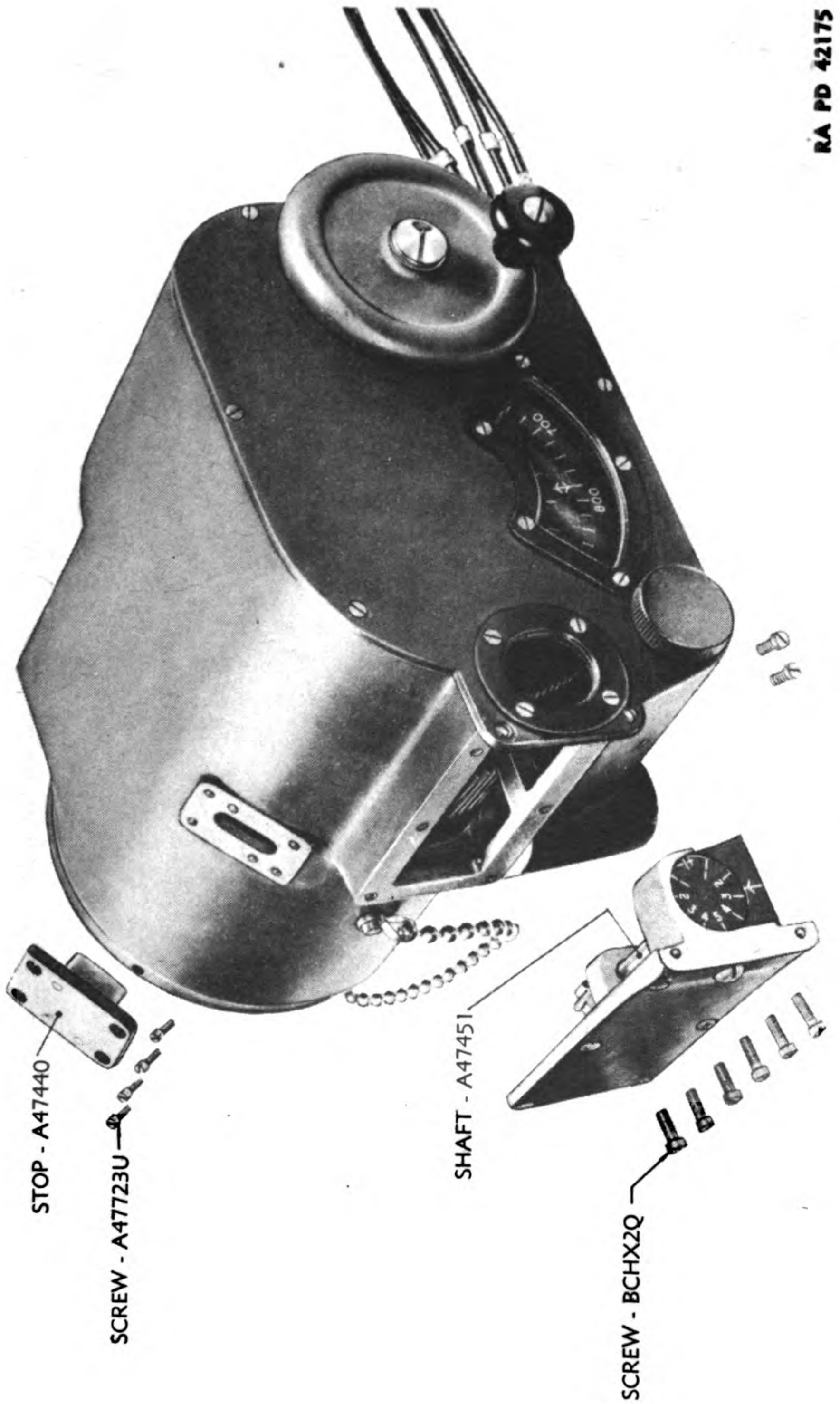


Figure 202 — Removal of Transmitter Dial Assembly and Correction Stop

Figure 203 — Removal of Correction Gear and Height Scale Adapter from Transmitter

j. Removal and Disassembly of Height Transmitter.

(1) Remove the lower cover of the transmitter case and disconnect the wires at the soldered joints. Tag the wires to facilitate reassembly. Remove the three screws holding the transmitter to the cradle (fig. 197).

(2) Unscrew the correction knob cover, unpin and remove the correction knob, take out the screw holding the bushing and withdraw the bushing and worm (fig. 198).

(3) Remove the screw holding the handwheel, work off the handwheel and remove the retainer and washer from the shaft. Remove the eight cover screws and the cover (fig. 199). Remove the lamp.

(4) Remove the large screw A49446 in the end of the transmitter shaft after removing its small locking screw (fig. 200). Remove the four screws holding the handwheel shaft bracket and lift off the bracket, index, and gear.

(5) Remove the inner (coarse) scale and its pin and lift off the outer scale with its gear. Remove the four screws holding the dial adapter and large gear to the transmitter shaft and remove the adapter and gear (fig. 201).

(6) Remove the six screws holding the correction dial assembly and remove the assembly (fig. 202).

(7) Support the transmitter and remove the four screws holding each of the two stops A47440 (fig. 202). Remove the stops and withdraw the transmitter.

(8) Removal of the correction gear and the scale adapter on the transmitter shaft is shown in figure 203.

NOTE: If desired, the transmitter can be disassembled without removing the case from the cradle.

k. Reassembly and Adjustment of Height Transmitter.

(1) Reassembly is accomplished by reversing the procedure for removal and disassembly.

(2) Replace the correction gear in a position to allow equal movement in either direction of the correction dial when set at zero.

(3) When making wire connections, refer to paragraph 83 e for soldering instructions.

(4) After reassembly, the transmitter should be electrically zeroed (par. 84).

Section XIV

TRIPOD M6—ADJUSTMENT, REPAIR, AND DISASSEMBLY

	Paragraph
Care and adjustment	79
Disassembly and assembly	80

79. CARE AND ADJUSTMENT.

a. Lubrication. See the lubrication chart in paragraph 38. Under no conditions will the tripod head be lubricated, except during assembly as outlined in paragraph 80 **d**, as a slight amount of lubricant falling on the friction mechanism will render it inoperative.

b. Slewing Adjustment. To change the force required for slewing the height finder in azimuth, adjust the six studs under the tripod head. This adjustment will vary the tension on the friction ring and lining. Equalize the tension on each stud and tighten the lock nuts.

80. DISASSEMBLY AND ASSEMBLY.

a. Tripod Leg and Foot Assembly.

(1) Remove the hinge pin nut and drive out the hinge pin (fig. 204). Loosen the set screw at the inner end of the spreader tube and drive out the pin. Remove the leg assembly. Repeat for the other leg assemblies.

(2) Loosen the set screw at the outer end of the spreader tube and drive out the pin (fig. 205). Remove the eight screws securing the ends of the tripod leg to the foot assembly and separate the leg from the foot assembly.

(3) Remove the tripod shoe from the ball at the lower end of the leveling nut by removing the six screws holding the split cap. Disassembly of the leveling screw and bearing is shown in figure 206.

b. Spindle.

(1) Remove the four screws and withdraw the plug from the lower end of the vertical tube.

(2) Back off the friction adjusting studs ½ inch or more. Remove the plug A49119 (fig. 207) in the top of the spindle. Remove the six spindle-securing screws which can be seen, as the spindle is rotated, directly under the opening left by removal of the plug.

(3) Using a wooden rod about 2 inches in diameter and 12 inches long, placed against the lower end of the spindle, carefully drive the

TRIPOD M6—ADJUSTMENT, REPAIR, AND DISASSEMBLY

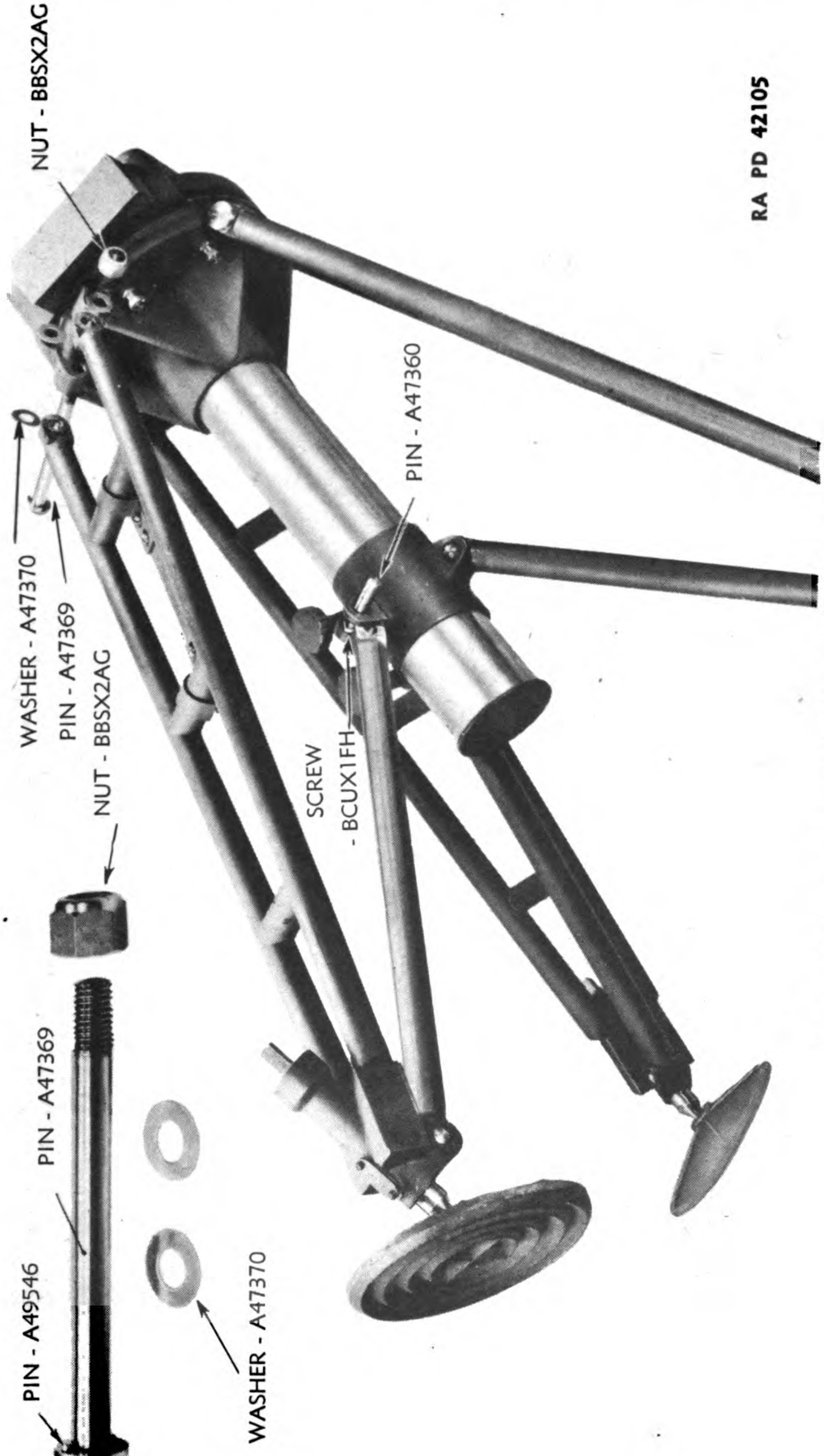


Figure 204 — Removal of Tripod Leg Assembly

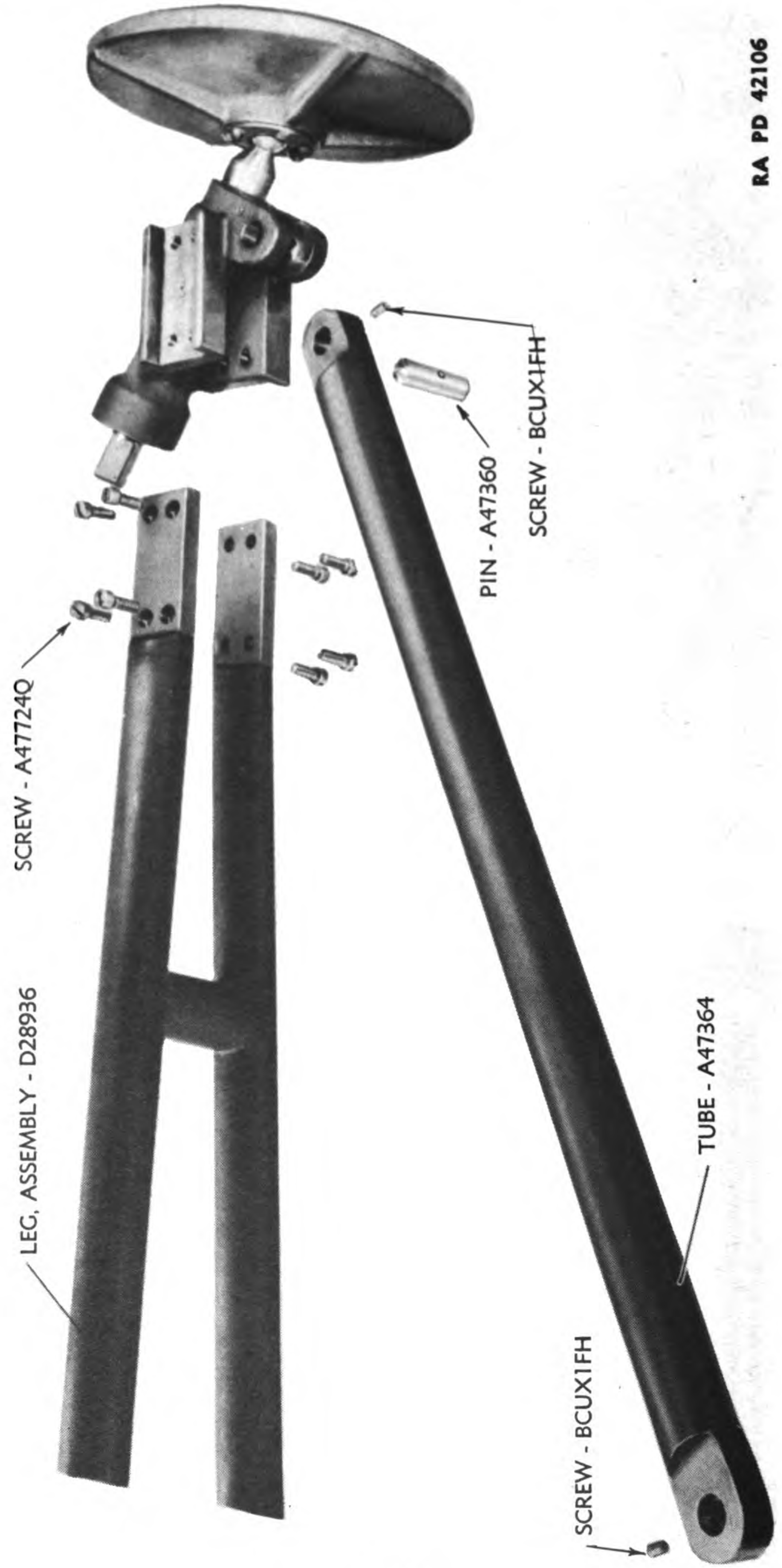


Figure 205 — Removal of Tripod Leveling Screw Assembly

TRIPOD M6—ADJUSTMENT, REPAIR, AND DISASSEMBLY

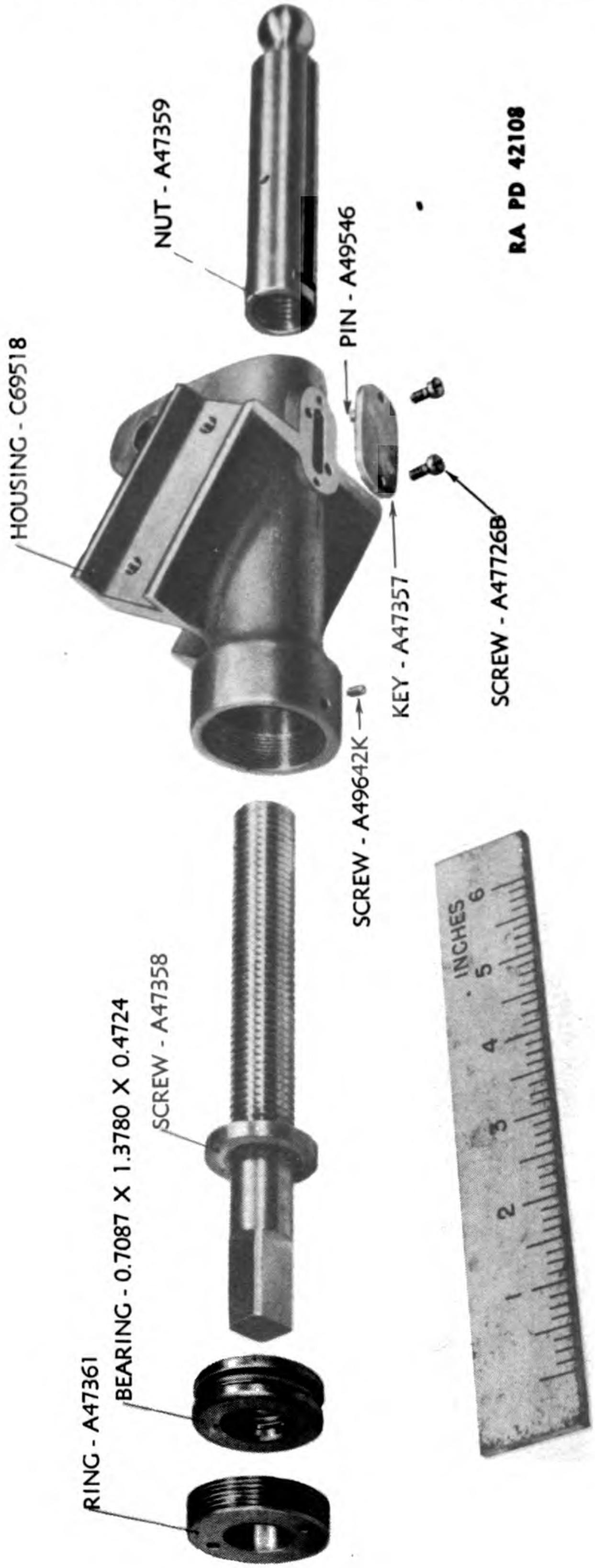


Figure 206 — Disassembly of Tripod Leg Assembly

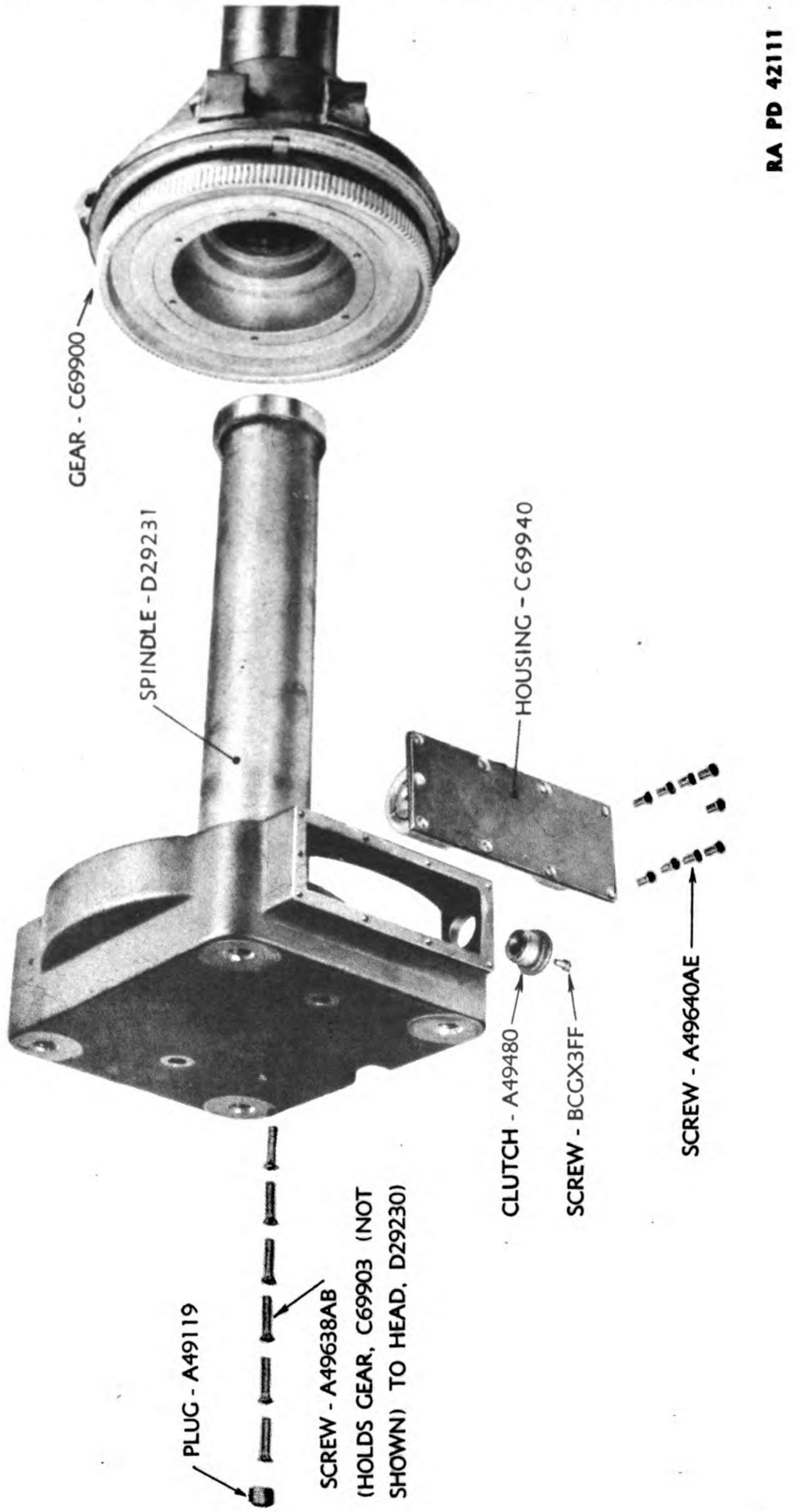


Figure 207 — Removal of Tripod Spindle and Traversing Worm Housing

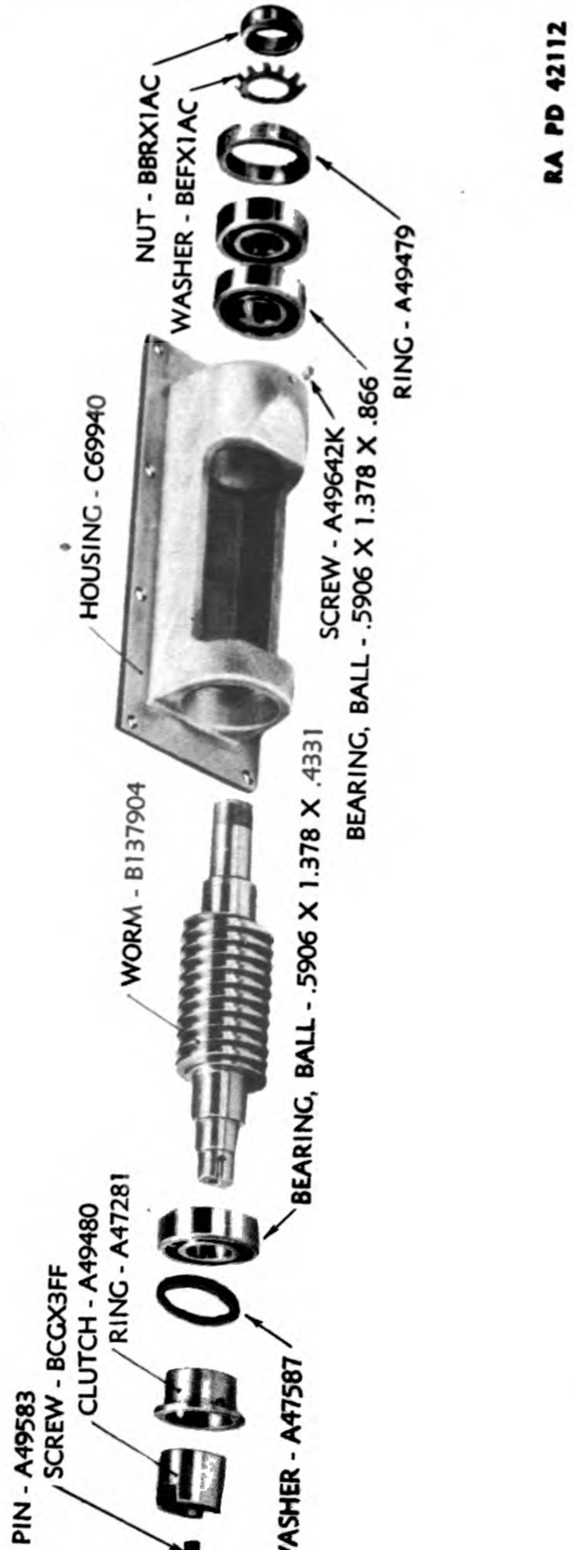


Figure 208 — Disassembly of Traversing Worm Housing Assembly

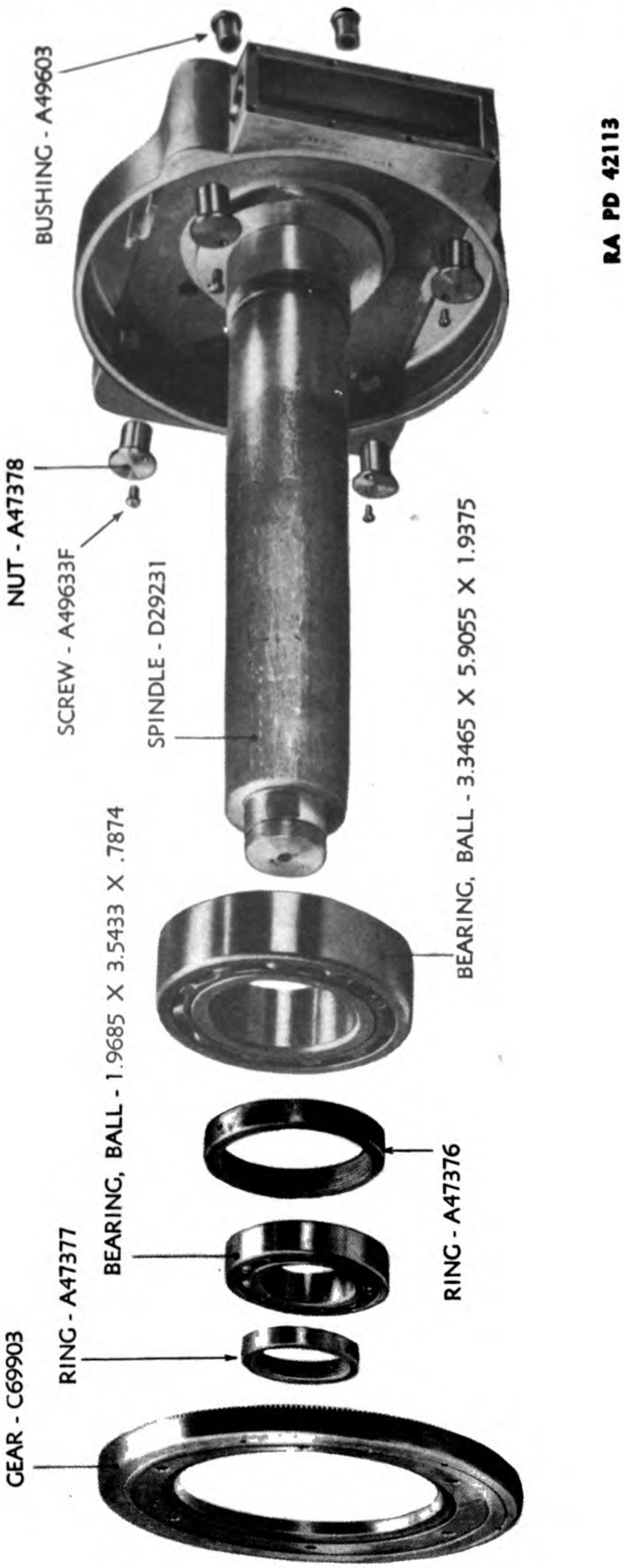


Figure 209 — Removal of Tripod Spindle Bearings

TRIPOD M6—ADJUSTMENT, REPAIR, AND DISASSEMBLY

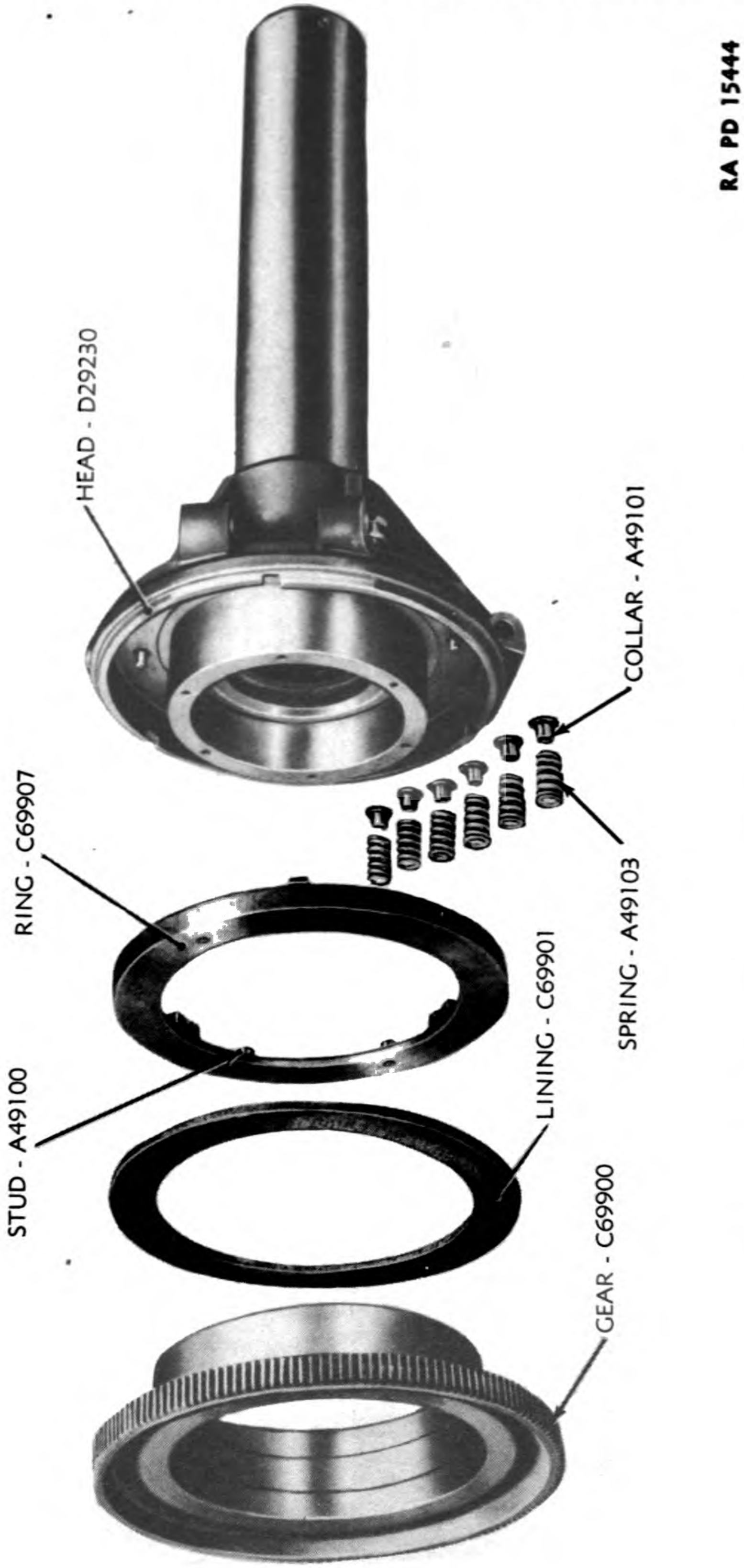


Figure 210 — Removal of Tripod Traversing Gear and Friction Ring

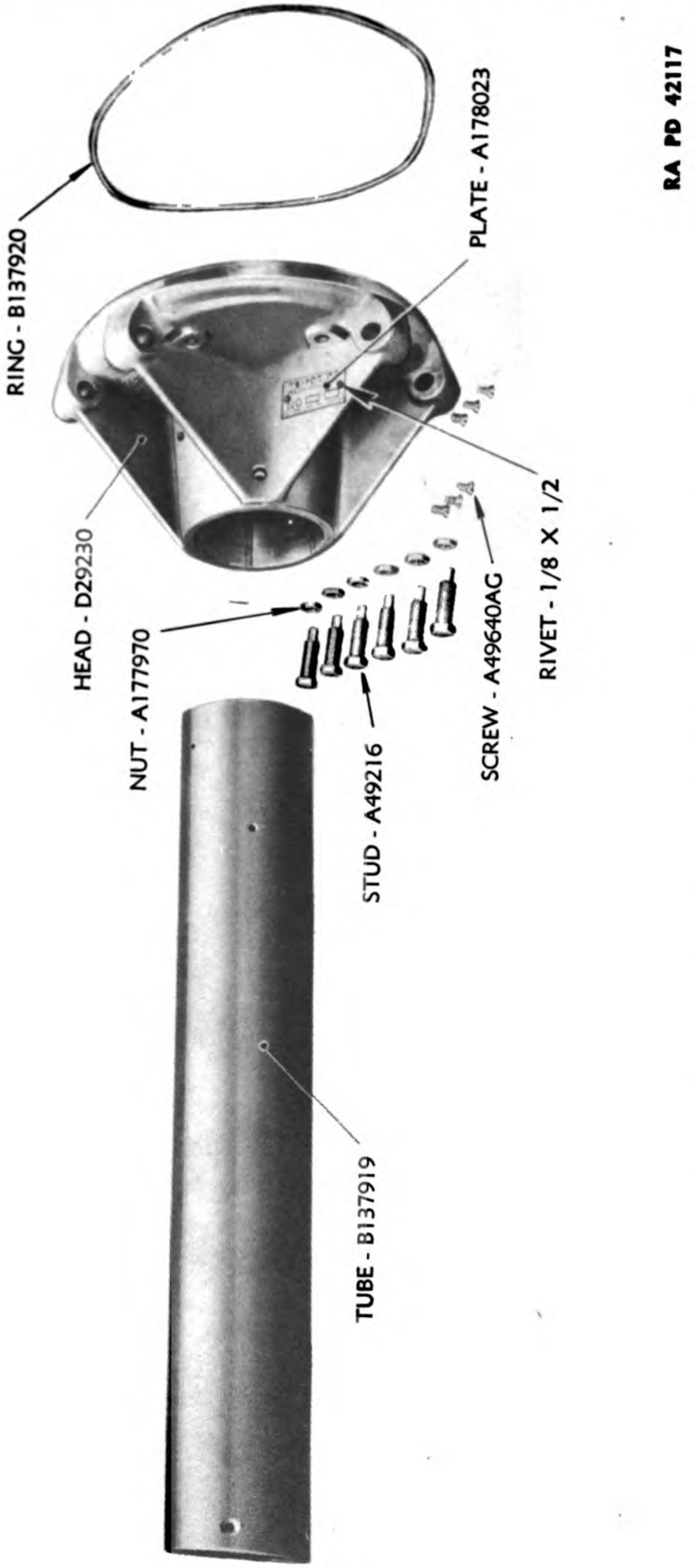


Figure 211 — Removal of Vertical Tube from Tripod Head

spindle upward until the bearings are clear of their seats. Lift the spindle out by the head.

(4) Remove the screw securing the clutch to the traversing worm shaft and force the clutch off the end of the shaft. Remove the nine screws securing the worm housing and remove the housing and worm assembly.

(5) Disassembly of the worm housing assembly is shown in figure 208.

(6) Remove the bearing retaining rings and the upper and the lower bearings from the spindle (fig. 209). Remove the azimuth indicator drive gear.

(7) If it is necessary to remove or replace the spindle bushings or cradle locking nuts, see figure 209.

c. Tripod Head.

(1) Lift off the traversing gear, friction lining, friction ring and remove the six springs and collars (fig. 210).

(2) Remove the six screws securing the vertical tube to the tripod head (fig. 211). The heads of these screws are concealed by a filler applied before painting. Remove the tube from the tripod head.

d. Assembly.

(1) Reassembly is accomplished by reversing the order of steps for disassembly.

(2) Before reassembly, clean all parts thoroughly. Lubricate the bearings. When assembling the spindle and tripod head, apply a very light coat of grease to the upper and lower ball bearings, the azimuth indicator drive gear, the traversing worm and the traversing gear. The grease must be applied very sparingly with a small stiff brush and care taken that none gets on the friction ring, lining, or the friction surface of the traversing gear.

(3) Adjust the six studs to control the force required for slewing the height finder in azimuth. Equalize the tension of each stud.

Section XV

ILLUMINATION AND ELECTRICAL COMPONENTS—ADJUSTMENT AND REPAIR

	Paragraph
Introduction	81
Illumination adjustment	82
Illumination failure	83
Synchronous units	84

81. INTRODUCTION.

a. The points of the height finder which receive illumination are: main reticles, internal target lines, reticles of the two tracking telescopes, measuring drum scale, and adjuster scale. In addition, a lamp is provided to illuminate the dial of the height transmitter. An electrical junction box near the center of the cradle contains the illumination controls.

b. 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.

c. 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 adjusting the position of the illuminating rods at the main reticles.

d. Illumination adjustment is considered in paragraph 82, and illumination failure in paragraph 83.

82. ILLUMINATION ADJUSTMENT.

a. Internal Target System.

(1) The illumination in both reticle fields of the internal target system should be equal. The lamp assemblies concerned are on the main tube, front side, next to the cradle bearings (fig. 212). 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 lit from the right internal target assembly. This should be remembered in making the following adjustments. It must also be remembered, that in order to obtain best illumination, the internal target condenser lenses must have been adjusted by being moved in

ILLUMINATION AND ELECTRICAL COMPONENTS—ADJUSTMENT AND REPAIR

or out in the bracket until the best position for proper illumination was found.

(2) Remove the three screws and the lamp cover (fig. 115, right, or fig. 116, left).

(3) Loosen the lamp socket set screw (nearest the lamp) with the Bristo wrench.

(4) Turn the lamp socket so that the lamp filaments are parallel to the illuminating window.

(5) Connect to proper voltage source and set the rheostat for the internal target to maximum intensity (for instruments No. 163 or above).

(6) Move the lamp socket in and out of its adapter (fig. 215) until the maximum intensity of light is seen through the proper eyepiece.

(7) Repeat for other lamp assembly, if necessary, to obtain equal brightness. If the second reticle field cannot be brought to the brightness of the first, readjust the first for lesser illumination.

(8) Tighten the set screws and replace the lamp covers.

b. Main Reticles.

(1) It is important that the two main 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 adjustment of the reticle illuminating rod for centering. The lamp assemblies concerned are on the outside of the tube at the bottom side when the line of sight is horizontal, about a foot either side of the center. The right reticle field illumination is dependent upon the lamp assembly and the reticle adjustment rod at the right reticle mount. The left reticle illumination is dependent upon the left side reticle assembly. First, adjust the position of the lamp as outlined below. If satisfactory illumination cannot be obtained by lamp adjustment alone, it will be necessary to adjust the reticle illuminating rod which requires breaking the seal of the instrument.

(2) ADJUST LAMPS.

(a) Remove the three screws and the lamp cover (figs. 94 or 95).

(b) Loosen the lamp socket set screw (nearest the lamp) with a Bristo wrench and turn the lamp socket so that the lamp filaments are parallel to the window.

(c) Connect to proper voltage source and set the rheostat for the height finder reticles to maximum brightness.

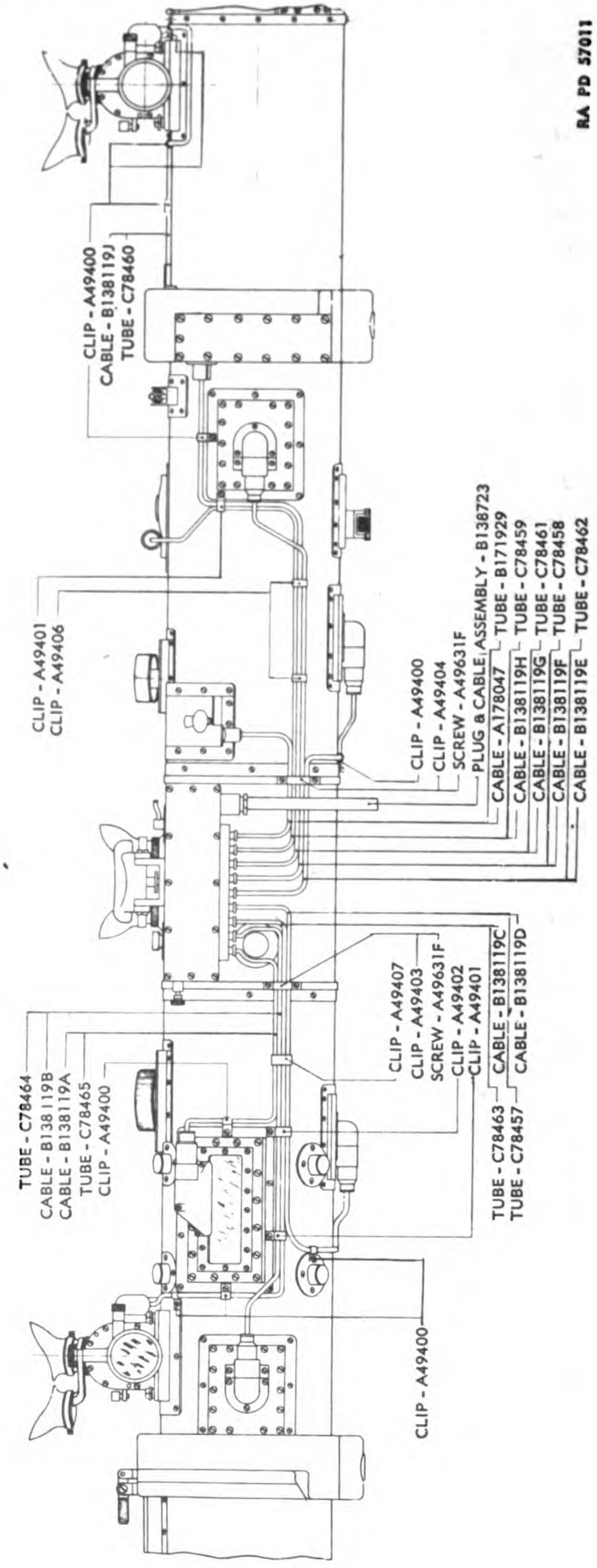


Figure 212 — Lay-out of Wiring Conduits on Height Finder Telescope

ILLUMINATION AND ELECTRICAL COMPONENTS—ADJUSTMENT AND REPAIR

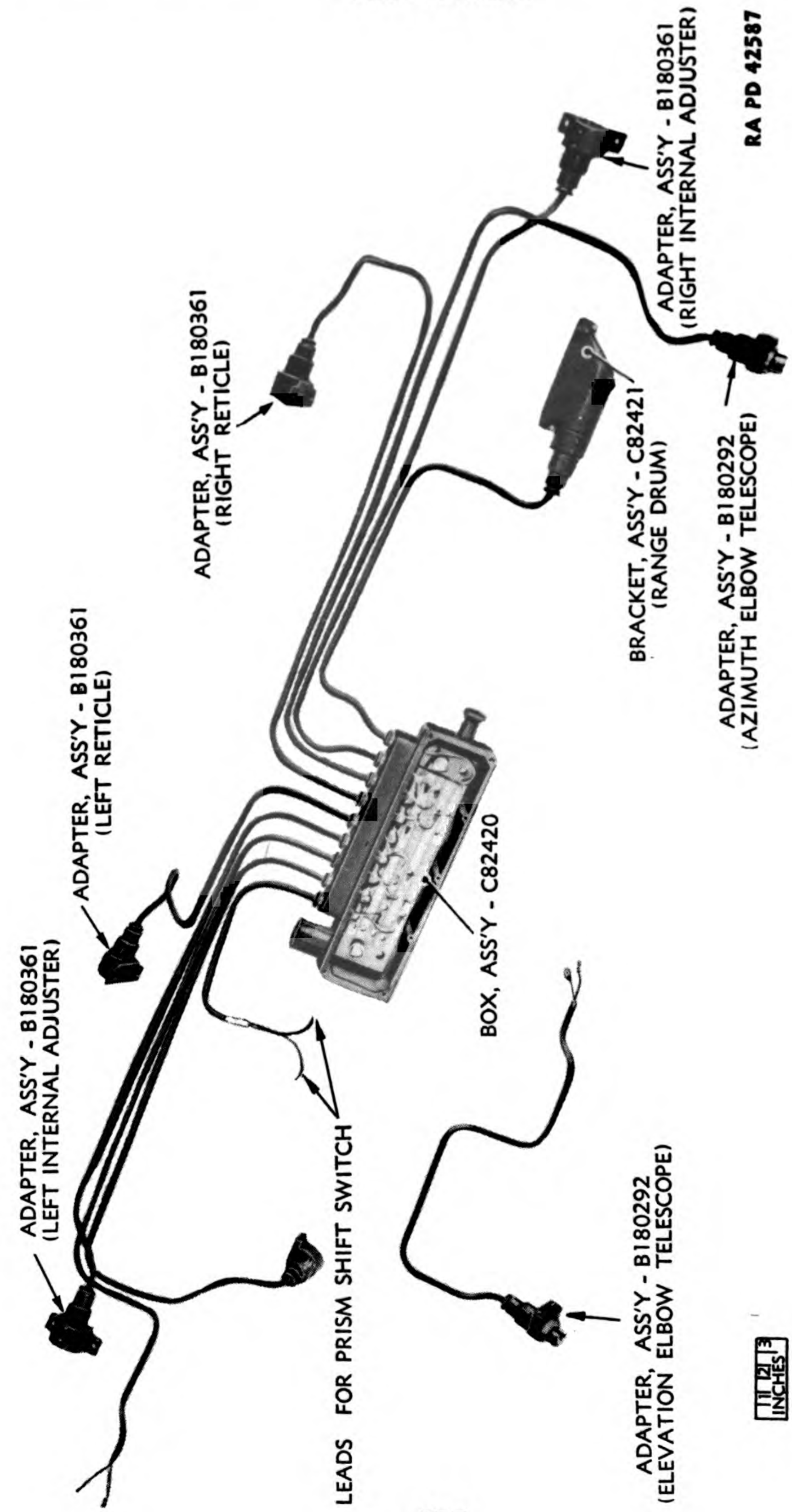


Figure 213 — Junction Box and Electrical Components Removed from Height Finder Telescope

(d) Move the lamp socket in and out of the adapter until the maximum amount of light is seen in the reticle field.

(e) Check the brightness in the other reticle field and adjust the other lamp if necessary for equal brightness.

(f) Tighten the set screw and replace the lamp cover.

(3) ADJUST THE RETICLE ILLUMINATING RODS.

(a) Since adjusting the reticle illuminating rod is a delicate job and requires breaking the hermetic seal of the instrument, it is best not to attempt it unless the illumination centering is very poor. Equal brightness can generally be obtained by lamp adjustment.

(b) Determine the reticle field requiring adjustment and remove the lamp assembly and the window assembly, thus breaking the seal.

(c) Loosen the flange at the end of the reticle illuminating rod tube (fig. 96). Make sure that the lucite rod holder is tightly secured to the reticle mount.

(d) *Turn* the rod with the fingertips until the illumination is equal on both sides of the reticle field. If one of the reticle marks appears brighter than the corresponding mark on the other side of the field, turn the rod until the over-all appearance of the illumination is the same on both sides. The lamp must be held at the end of the illuminating rod during these adjustments.

(e) Move the rod *in and out* of its tube without turning until the point is reached where the maximum illumination is obtained in that field.

(f) Tighten the flange on the tube for the reticle illuminating rod. If the tube does not clamp down tight on the rod, remove the flange and shorten its neck about $\frac{1}{16}$ inch.

(g) To check illumination, replace the window assembly, lamp, and cover, holding each with two screws. Lamp adjustment is then checked and illumination on both sides compared.

(h) Seal and replace the window assembly.

(i) Replace the lamp assembly and cover.

(j) Check illumination on both sides.

NOTE: If a reticle illuminating rod has been removed, it should be replaced with the shorter cut on the tip turned toward the center of the instrument.

c. Adjuster Scale Illumination. Adjustment is accomplished by loosening the set screw and sliding the socket back and forth in the lamp bracket and by rotating the cover until figures and index on the scale are well illuminated.

d. Elbow Telescopes M7.

(1) Remove the lamp cover (fig. 162).

(2) Loosen the socket set screw (nearest the lamp) and set the lamp socket so that the filaments are parallel to the entrance window of the telescope housing.

(3) Connect to proper voltage source and set the rheostat for the elbow telescopes to maximum brightness.

(4) Replace the cover and move the socket in and out of its adapter until illumination is brightest and is even throughout the reticle field and tighten the set screw.

(5) If illumination is weak, enlarge hole in cover so that more light can reach the reticle. Leave bore of hole bare metal or paint white.

83. 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 are described in the following paragraphs. Electrical wiring diagrams are in figures 216 and 217. The lower portions of the diagrams contain wiring and components located on the cradle, while the upper portion contains wiring and components located on the height finder telescope. 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 must be replaced. Double-contact lamps with bayonet sockets A35189 (Mazda G6, 6-cp) are used throughout. The steps to be taken in replacing a lamp are outlined below.

(2) Measuring drum illumination.

(a) Remove the three screws holding the lamp shade.

(b) Remove the shade and replace the lamp.

(c) Replace the shade and tighten the three screws.

(3) Height transmitter illumination.

(a) Remove the lamp cover and lamp (fig. 198).

(b) Replace the lamp and slip on the cover.

(4) In replacing the main reticle lamps, refer to paragraph 82 **b**.

(5) In replacing the lamps for the internal target system, refer to paragraph 82 **a**.

(6) In replacing lamps of the elbow telescopes, refer to paragraph 82 **d**.

c. Height Finder Junction Box and Wiring.

(1) Defective wiring or connections should be checked, using a

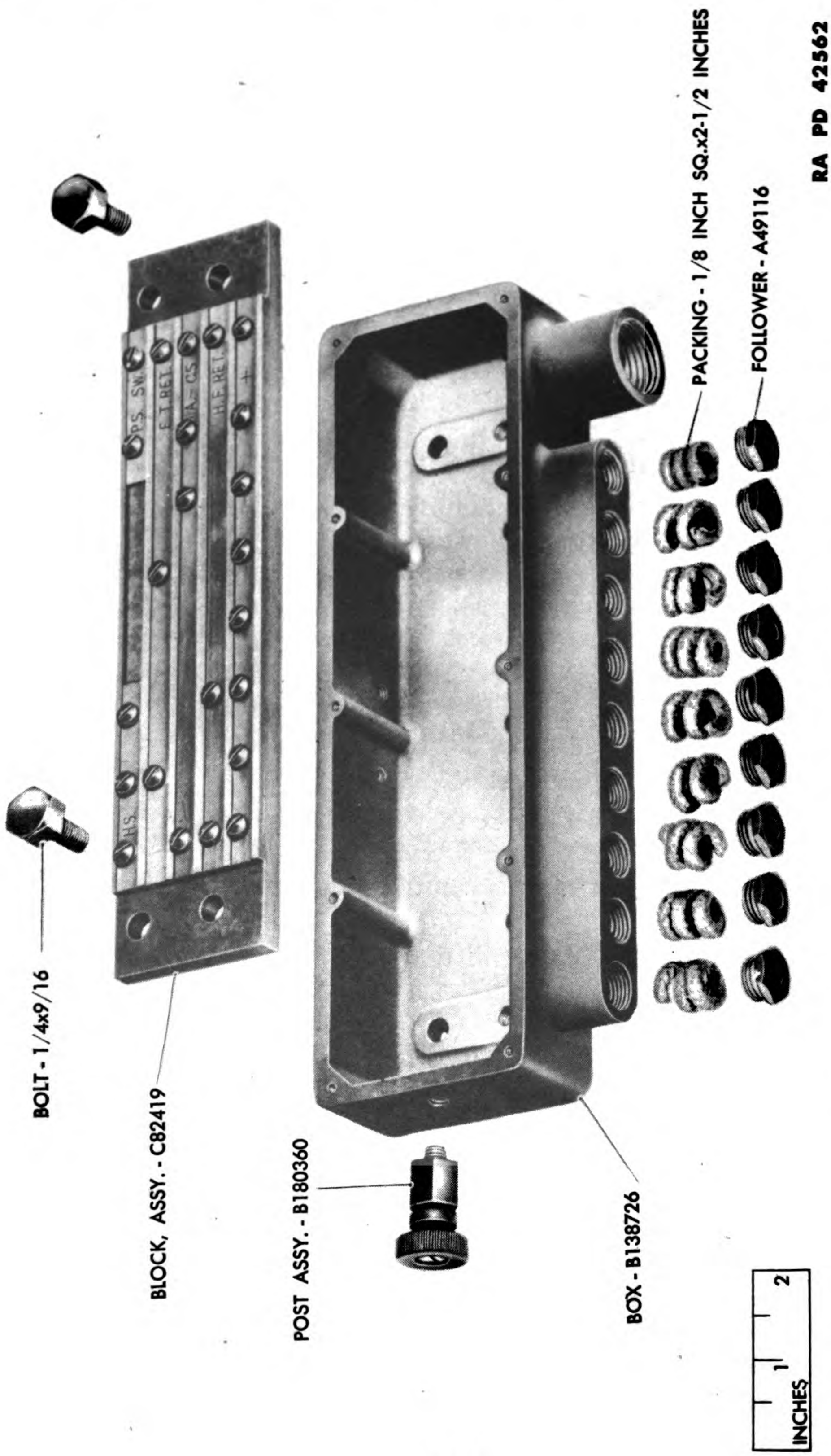


Figure 214 — Height Finder Junction Box — Exploded View

ILLUMINATION AND ELECTRICAL COMPONENTS—ADJUSTMENT AND REPAIR

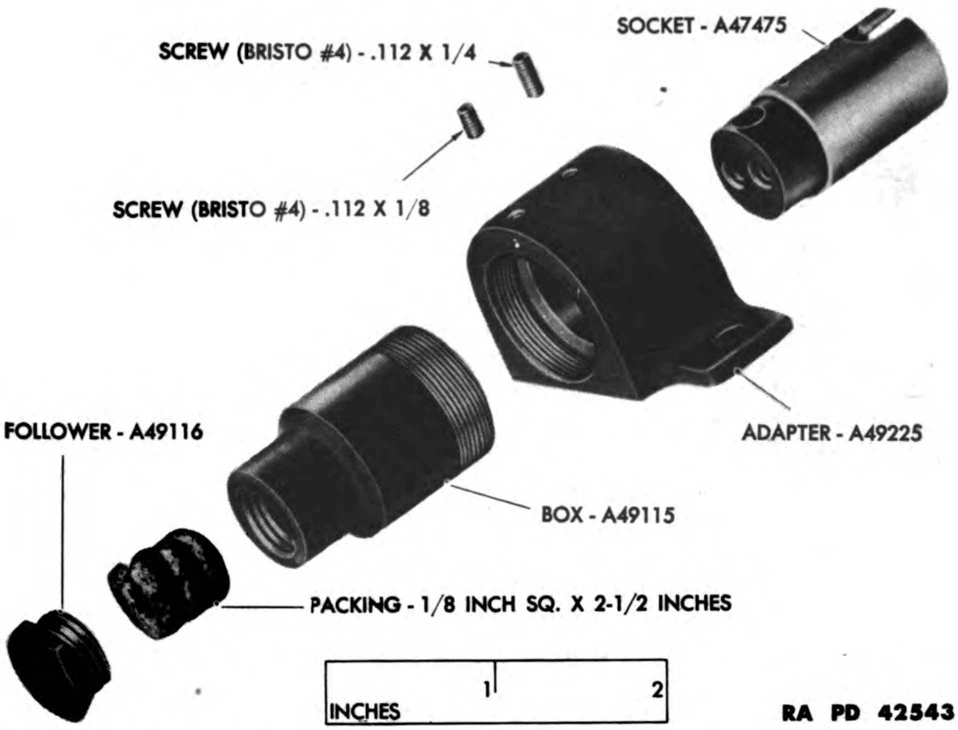


Figure 215 — Lamp Socket — Exploded View

tester lamp, with reference to the wiring diagrams shown in figures 216 or 217, and the actual wiring lay-out shown in figures 212 and 213. Check for continuity and short circuits. Repair according to good electrical practice.

(2) Remove the cover of the junction box (fig. 213) and check the terminal connections of the lamp socket cables (figs. 214 and 217).

(3) Check the terminal connections of the cable and plug assembly.

(4) Check the lamp socket assemblies.

(5) If necessary, remove the follower, packing, and box of the socket assemblies (fig. 215), and make the required repairs or replacements.

(6) For illumination of the elevation telescope, remove the two covers and check the wiring and terminals in the small junction boxes (fig. 218).

(7) Seal and replace all covers removed in testing. The covers and packing followers should be watertight.

d. Prism Shift Switch.

(1) To repair the prism shift switch directly under the prism shift crank proceed as follows:

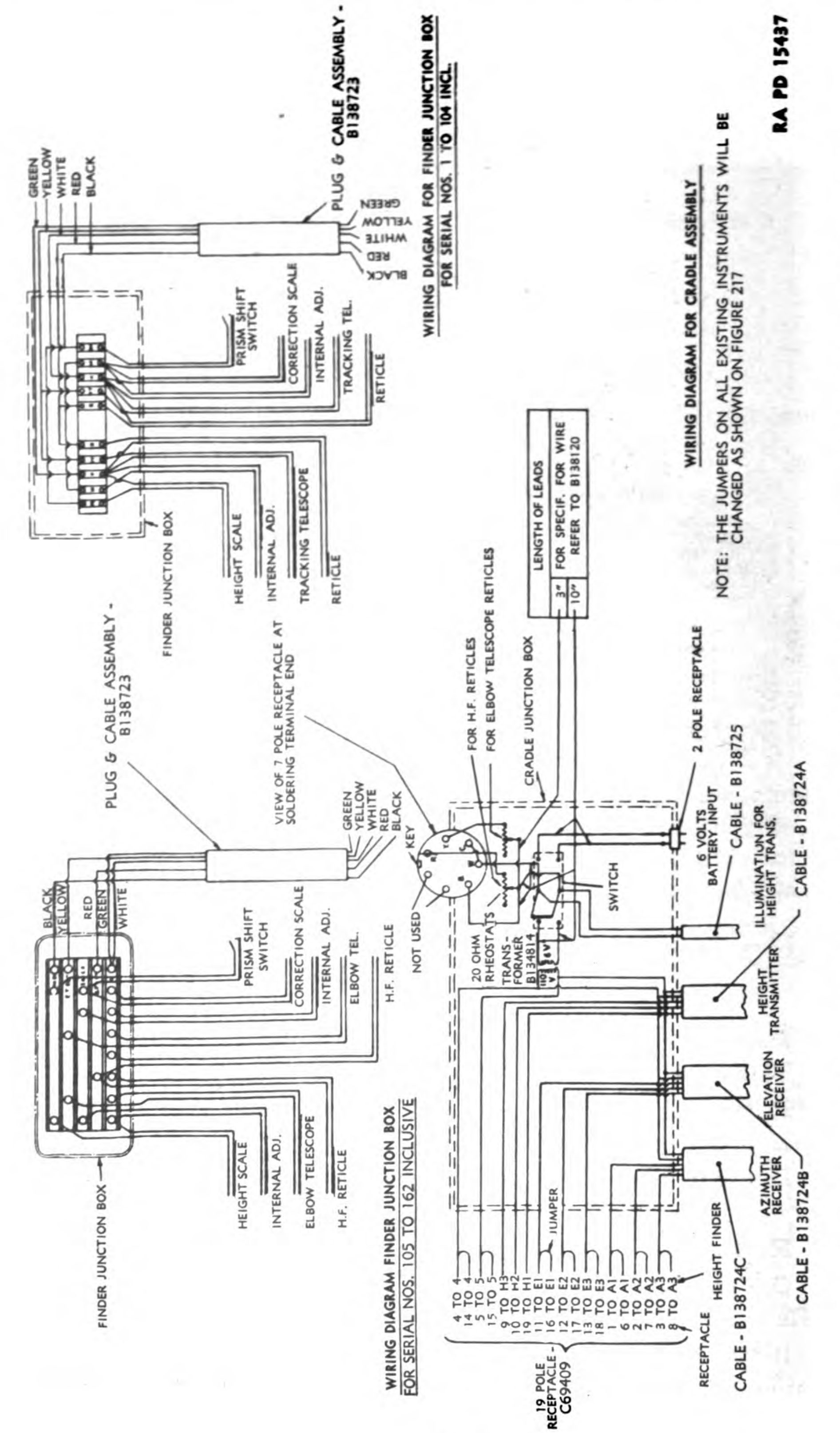
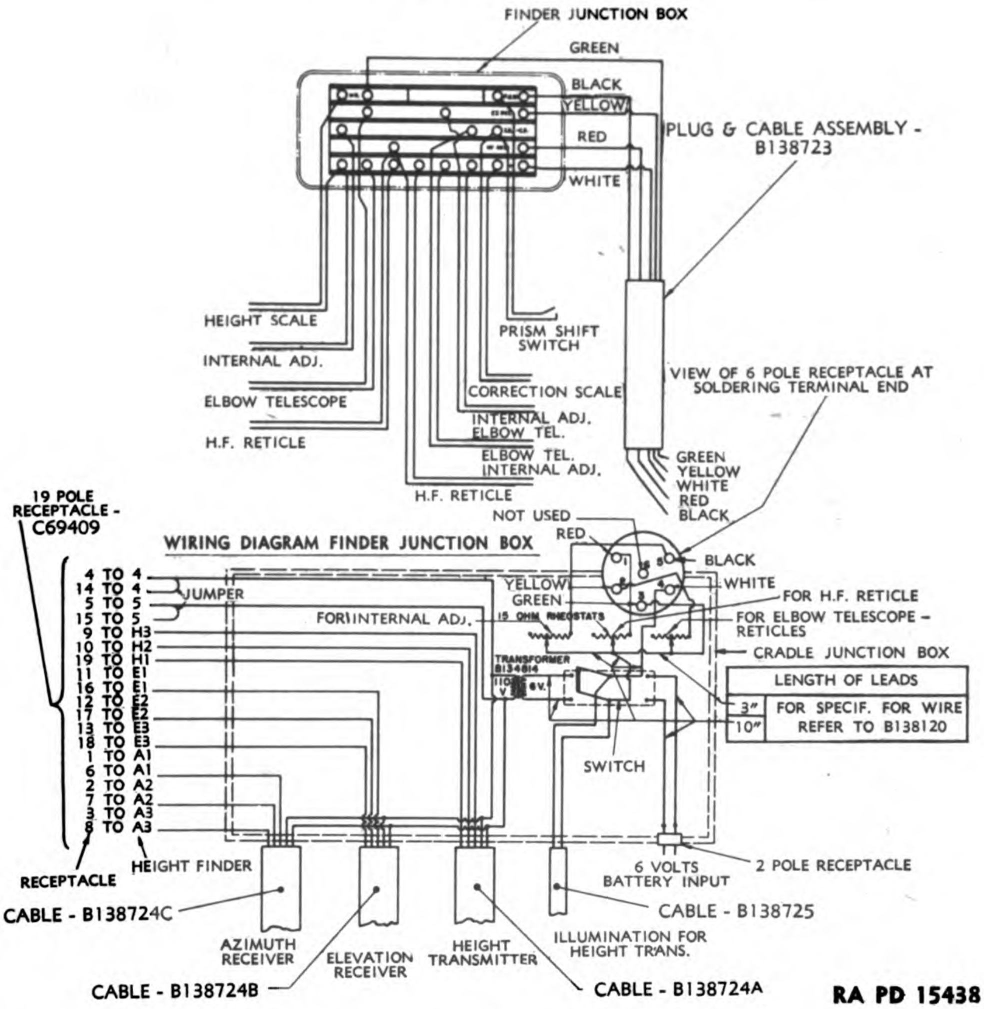


Figure 216 — Wiring Diagram for Height Finder Telescope and Cradle (Serial Nos. 1 to 162)

ILLUMINATION AND ELECTRICAL COMPONENTS—ADJUSTMENT AND REPAIR



RA PD 15438

Figure 217 — Wiring Diagram for Height Finder Telescope and Cradle (Serial Nos. 163 and Up)

(2) Remove the three screws and the switch plate assembly (fig. 125). (This does not break the hermetic seal.)

(3) Remove the contacts by loosening the exposed nuts and washers. Clean or replace the contacts.

(4) Disassemble the switch plate assembly and examine the switch button.

(5) Reassemble and test for good contact.

(6) One cause of light failure may be that the switch button is too short. Repair by replacing.

(7) If satisfactory illumination is not obtained in the internal target systems, but both lamps are lit, a penta prism may be inncorrectly positioned, and adjustment should be made as outlined in paragraph 58.

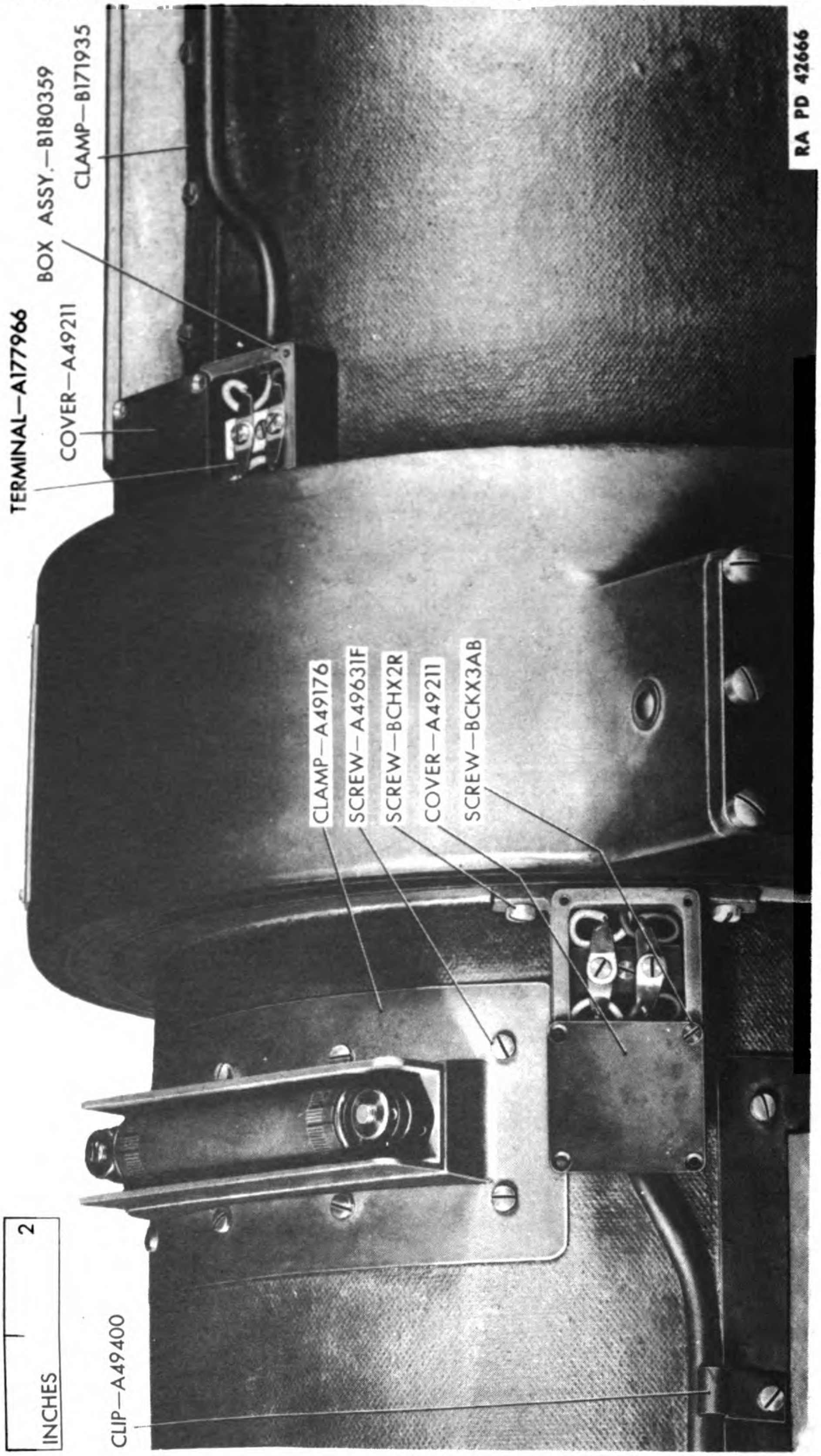
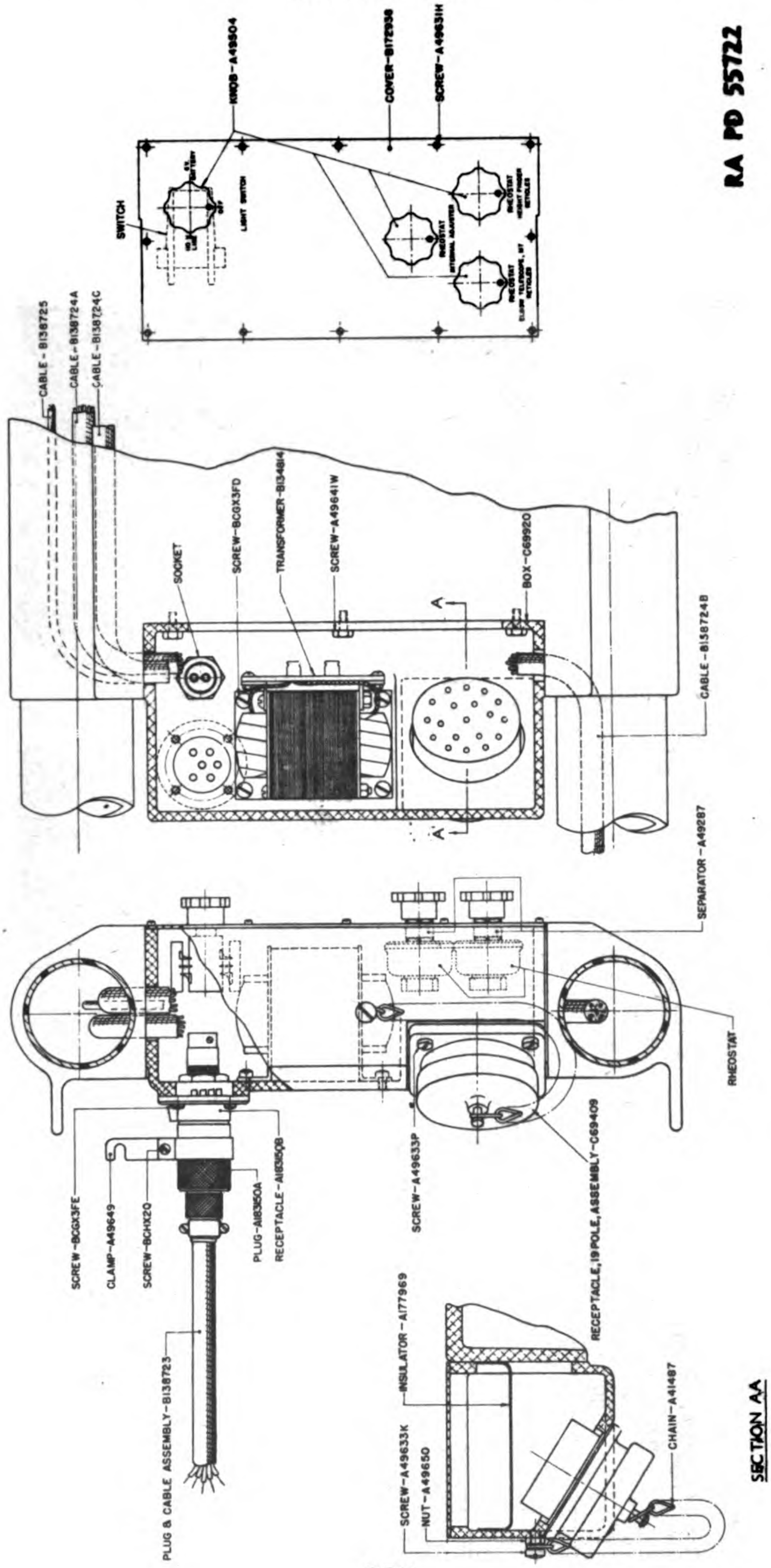


Figure 218 — Wiring Junction Boxes at Left Main Bearing

ILLUMINATION AND ELECTRICAL COMPONENTS—ADJUSTMENT AND REPAIR



RA PD 55722

Figure 219 — Cradle Junction Box — Sectioned Views

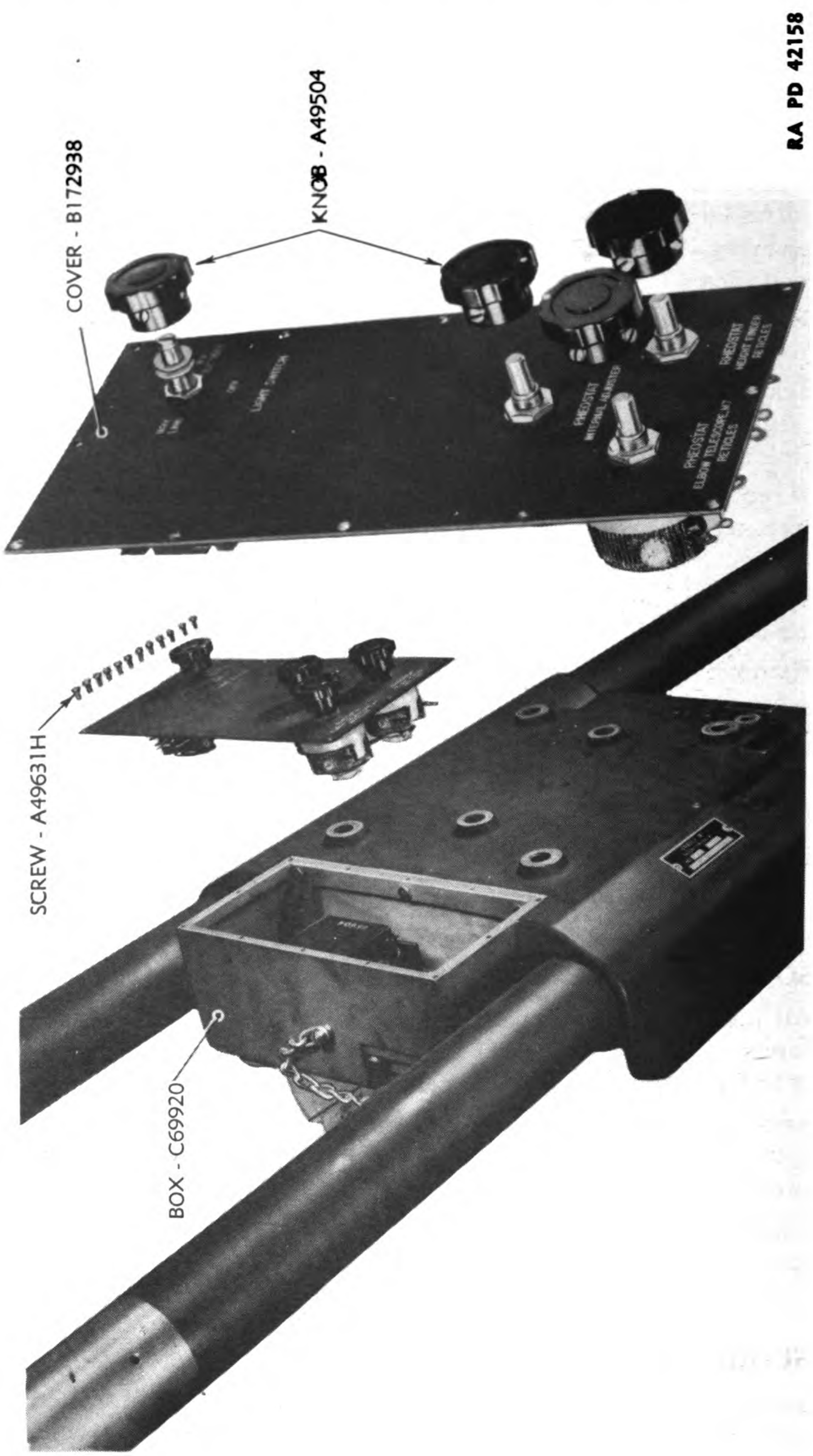


Figure 220 — Removal of Switch and Rheostats from Cradle Junction Box Cover

(8) Continued failure may be caused by a broken or a badly misalined mirror or by having the internal target bracket in backwards (left to right) (par. 57).

e. Cradle Junction Box.

(1) Details of the cradle junction box are shown in figure 219. The height finder telescope must be removed from the cradle to reach the cradle wiring. Check for continuity and short circuits; repair where required as follows.

(2) Remove the 12 cover screws and the cover of the junction box (fig. 220).

(3) Loosen the set screws and remove the four knobs (three knobs on cradles up to serial No. 162), 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 the switch or rheostats. See figures 216 and 217 for wiring diagram.

(5) Remove, if necessary, the four securing screws and the transformer, and replace with a new one.

(6) Remove, if necessary, the four securing screws and the 19-pole receptacle assembly (fig. 221).

(7) Remove, if necessary, the 6-pole receptacle for the cable and plug assembly from the height finder junction box.

(8) Repair and reassemble according to good electrical practice. Instructions for soldering and taping of joints are given in subparagraph f below.

f. Soldering and Finishing Electrical Connections.

(1) SOLDER, tin-lead, grade A, 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, tinned as a group by dipping in RESIN, flux, and then in molten solder.

(3) After soldering, wash the joint very carefully in ALCOHOL, denatured, to remove any traces of flux, and then coat with GLYPTAL, black, to prevent corrosion.

(4) TAPE, rubber, insulating, must be used where required, as friction tape causes deterioration of the insulation.

84. SYNCHRONOUS UNITS.

a. General. The azimuth indicator, the elevation indicator, and the height transmitter are adjusted so that dials indicate zero when

Figure 221 — Removal of 19-pole Receptacle Assembly

the units are at "electrical zero."* Adjustment should only be required when a unit is replaced or when the rotor dial has been disturbed. If any synchronous unit does not function properly, it should be replaced. If adjustment is required, proceed as follows.

b. Azimuth and Elevation Indicators—Electrical Zero.

(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:

(a) 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; to make connections, use small metal fingers to grip the receptacle prongs. Numbered connections to the receptacle are shown in figures 216 and 217. The 1, 2, 3, 4, and 5 leads from the elevation indicator are respectively connected to 16, 17, 18, 4, and 5 of the 19-pole receptacle. The 1, 2, 3, 4, and 5 leads from the azimuth indicator are respectively connected to 6, 7, 8, 4, and 5 of the 19-pole receptacle. The 1, 2, 3, 4, and 5 leads from the height transmitter are respectively connected to 19, 10, 9, 4, and 5 of the 19-pole receptacle. Where the poles cannot be identified on the receptacle, refer to figure 222, which shows how the poles are oriented with respect to the notch in the receptacle body.

(b) Without otherwise disturbing the connections made above, break the connection to the unit terminal marked 2, leaving it open. With the power circuit energized, the rotor, if unrestrained, will assume the electrical zero position.

NOTE: When terminal 2 is removed, there are two possible rotor positions, the electrical zero position or 180 degrees therefrom. The procedure in substep *(a)* will distinguish between the two positions.

*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.

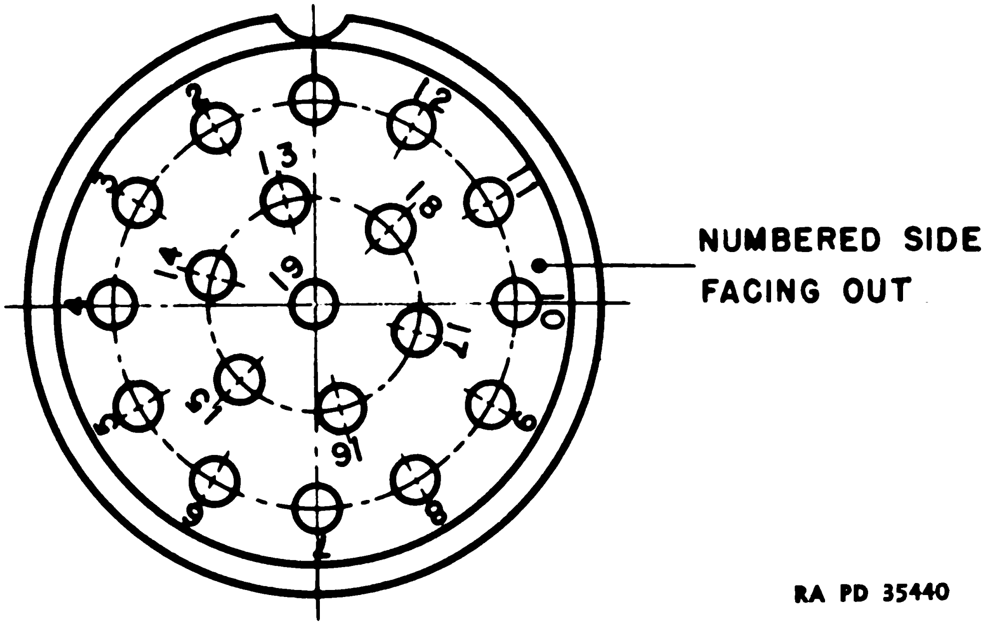


Figure 222 — Arrangement of Poles in 19-pole Receptacle

(*c*) With the special cradle wrench furnished with the height finder, remove the window and adjust the electrical index adapter to aline with zero on the scale. Adjustment can also be made by rotating the repeater assembly in the case. First remove the lower cover and loosen the clamping ring. Then rotate the repeater to aline zero on the scale with the index of the rotor.

(*d*) After once establishing the electrical zero of an indicator unit, it can be used in determining the electrical zero of another indicator or the transmitter. Connect the two units phase to phase, that is, 1 to 1, 2 to 2, 3 to 3, 4 to 4, and 5 to 5, and apply power to 4 and 5. Here again connections may be made at the 19-pole receptacle if desired. When the standardized unit indicates zero, the other unit should be adjusted to agree as described above.

c. Height Transmitter—Electrical Zero.

(1) If the electrical testing equipment for the height finder or an antiaircraft director is available, proceed as outlined in subparagraph **b**, above.

(2) As an alternative, connect the transmitter phase for phase (subpar. **b**, above) with a zeroed indicator unit. Be certain that the correction dial of the height transmitter assembly is functioning properly and indicates zero, for any introduced correction will be added to or subtracted from the indicator rotor but will not show up on either the inner or outer height transmitter dials.

(3) Make minor adjustments by shifting the index slightly or by resetting the correction dial.

(a)—Turn transmitter dials so that zeros line up with index.

(b) Remove the screw on left side of transmitter housing near correction dial.

(c) Turn correction knob until head of set screw in correction dial can be seen through hole from which the screw was just removed.

(d) Insert Bristo wrench in head of set screw and loosen. Leave wrench in screw.

(e) Turn correction knob until testing unit or indicator reads zero.

(f) Using Bristo wrench as a lever, turn correction dial so that zero position lines up with index.

(g) Tighten Bristo screw.

(h) Replace plug screw.

(4) If the amount of the correction is large, remove the handwheel, transmitter cover, and scales (par. 78). Replace coarse scale in the correct position and repin to the shaft. Remesh the fine scale gear with the handwheel gear, so that the coarse and fine scales indicate zero simultaneously. Reassemble and recheck the zero settings.

Section XVI

ELECTRIC COVER M404

	Paragraph
Description	85
Inspection	86
Maintenance and repair	87

85. DESCRIPTION.

a. The Electric Cover M404 for the Height Finder M1 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 9-623.

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.

86. INSPECTION.

a. **Visual Inspection.** 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	1,182	10.75	10.2
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	623	5.65	19.4

Values given are average. Actual reading on individual covers may vary from + or − 5 percent for ohms resistance to + or − 10 percent for watts input.

c. **Operational Inspection.**

(1) 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).)*

(2) COMPLETE COVER.

(a) 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.

(b) 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.

(c) 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 with the test lamp across the terminals of the connecting cord. If the lamp does not light, the cord should be repaired or replaced.

(3) INDIVIDUAL COVER SECTIONS.

(a) 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 preceding data table.

(b) 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.

(c) 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.

(4) OPERATIONAL THERMOSTAT.

(a) 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 (±1.7C), 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).

(b) 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.

(c) 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.

(5) The safety thermostats limit the maximum temperature of the cover and, since they are set so 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).

87. MAINTENANCE AND REPAIR.

a. Mechanical Repairs.

(1) 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 ½ inch and securely fastened. The thread used for the outer shell is THREAD, cotton, machine, soft finish, olive-drab, 3-cord, No. 40, inner shell No. 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 COMPOUND, treating, for canvas leggings and duck, to the repaired area so that it is completely sealed.

(2) REPLACEMENT OF CORD LOCKS OR HOOKS.

(a) 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).

(b) 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.

(3) 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 COMPOUND, treating, for canvas leggings and duck. 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.

(4) REPLACEMENT OF SPRING LEVER BUCKLES AND TURN BUTTON FASTENERS.

(a) 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.

(b) The turn button fasteners consist of four parts—an eyelet with a washer, and a stud with a washer. To replace a turn button fastener, use an attaching tool, No. 450 (A198) for the eyelet and No. 171 for the stud, from the United Carr Fastener Co., Cambridge, Mass. If the cover is torn, it should be repaired, as described in step (1), above, before the new fastener is applied.

(c) 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 over the prongs.

(d) 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 over the prongs.

NOTE: Care should be used to avoid piercing or cutting any wire or wires in the wired lining insert.

b. Electrical Repairs.

(1) 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, unsolder and unscrew the connecting cord leads from the bus bar. Apply the new cord assembly

by soldering 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.

(2) Replacement of Operational Thermostats.

(a) The thermostat housing is securely attached to the inner surface of the cover section to make intimate contact with he height finder. If the thermostat proves erratic or becomes inoperative, replace as follows.

(b) 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.

(c) 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.

(d) Remove the textolite cover plate from the thermostat housing. Apply enough heat to the housing to melt the Holowax or Zophar 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.

(e) Insert the new thermostat subassembly and pour in melted Holowax or Zophar Wax around the thermostat in order to completely seal it.

(f) Replace the textolite cover plate and bring the wires through the cover section to the terminal box. Re-bar tack the wires to the cover section by hand sewing. If slit in the inner shell has been made, resew and coat with COMPOUND, treating, for canvas leggings and duck.

(g) Screw and solder the wires to bus bar in terminal box and replace the cover plate.

(h) Resew the leather attachment piece of thermostat housing to the inner shell.

(3) Replacement of Safety Thermostats.

(a) 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.

(b) 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.

(c) Replace the defective thermostat assembly with a Spencer No. C-2851 from the Spencer Thermostat Company, Attleboro, Vermont.

(d) Resew the wires to the wiring insert up to the terminal box.

(e) Screw and solder the thermostat wires to bus bar in terminal box and sew the thermostat pocket closed.

(f) Resew slit which was made in the inner lining of the cover section and coat with COMPOUND, treating, for canvas leggings and duck.

(4) REPLACEMENT OF TERMINAL BOX.

(a) 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.

(b) Slit the inner shell over the textolite back plate of terminal box, exposing it.

(c) Pull all wires through the back of the terminal box.

CAUTION: Note position of each wire for replacement.

(d) Break off the textolite back plate, separating it from the base plate of the terminal box.

(e) With a pair of heavy wire cutters, clip off the mushroom end of the rivets and remove the base plate from the cover section.

(f) To replace, position the new terminal box in the same location as the old.

(g) Insert three No. 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.

(h) Insert the five rivets on top of the base plate.

(i) Position the base plate on the section in the same position, with the rivets protruding through the cover.

(j) 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.

(k) Reinsert the wires as before, screw and solder all connections, wash soldered joints with alcohol, and apply GLYPTAL, black.

(l) Apply a coating of COMPOUND, treating, for canvas leggings and duck, over the entire top surface of the base plate.

(m) Replace the textolite cover plate of the terminal box with the three screws provided.

(n) Resew the slit in the inner lining and coat with COMPOUND, treating, for canvas leggings and duck.

(5) POWER ADAPTER. No attempt should be made to repair the power adapter. It should be replaced as a complete assembly. No. D-82646.

Section XVII

REFERENCES

	Paragraph
Publications indexes	88
Standard nomenclature lists	89
Explanatory publications	90

88. 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. Ordnance Publications for Supply Index (index to SNL's) .... ASF Cat. ORD-2 OPSI

b. Index to Ordnance Publications (listing FM's, TM's, TC's, and TB's of interest to ordnance personnel, FSMWO's, BSD, S of SR's, OSSC's, and OFSB's; and includes Alphabetical List of Major Items with Publications Pertaining Thereto .... OFSB 1-1

c. List of Publications for Training (listing MR's, MTP's, T/BA's, T/A's, FM's, TM's, and TR's concerning training) .... FM 21-6

d. 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

e. Military Training Aids (listing Graphic Training Aids, Models, Devices, and Displays) .... FM 21-8

89. STANDARD NOMENCLATURE LISTS.

Cleaning, preserving and lubricating materials; recoil fluids, special oils, and miscellaneous related items .... SNL K-1

Director, A.A., M4 .... SNL F-167

Director, A.A, M7 .... SNL F-167

Directors, A.A., M9 and M10 .... SNL F-243

Finder, height, 13½ft., M1 .... SNL F-171

Harbor defense, railway and antiaircraft artillery sighting equipment and fire control instruments .... SNL F-2

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