TELESCOPES
MARK 90 MODS 0 AND 1
AND
MARK 91 MODS 0 AND 1

PRINCIPLES OF OPERATION
AND
INSTRUCTION FOR SHIPBOARD MAINTENANCE

A BUREAU OF ORDNANCE PUBLICATION 29 MARCH 1946

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NAVY DEPARTMENT

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RESTRICTED

ORDNANCE PAMPHLET 1398

TELESCOPES MARK 90 MODS 0 AND 1 AND MARK 91 MODS 0 AND 1—PRINCIPLES OF OPERATION AND INSTRUCTIONS FOR SHIPBOARD MAINTENANCE

1. Ordnance Pamphlet 1398 describes the construction, operation, and shipboard maintenance of Telescopes Mark 90 Mods 0 and 1 and Mark 91 Mods 0 and 1.

2. The telescopes described herein are optical instruments which are carefully assembled and adjusted and should be treated as such. Repairs and adjustments, other than those incident to normal operation, should not be attempted except under supervision of properly qualified personnel.

3. This pamphlet does not supersede any existing publication.

4. This publication is RESTRICTED and shall be safeguarded in accordance with the security provisions of U. S. Navy Regulations, 1920, Article 76.

G. F. Hussey, Jr.
Vice Admiral, U. S. Navy
Chief of the Bureau of Ordnance

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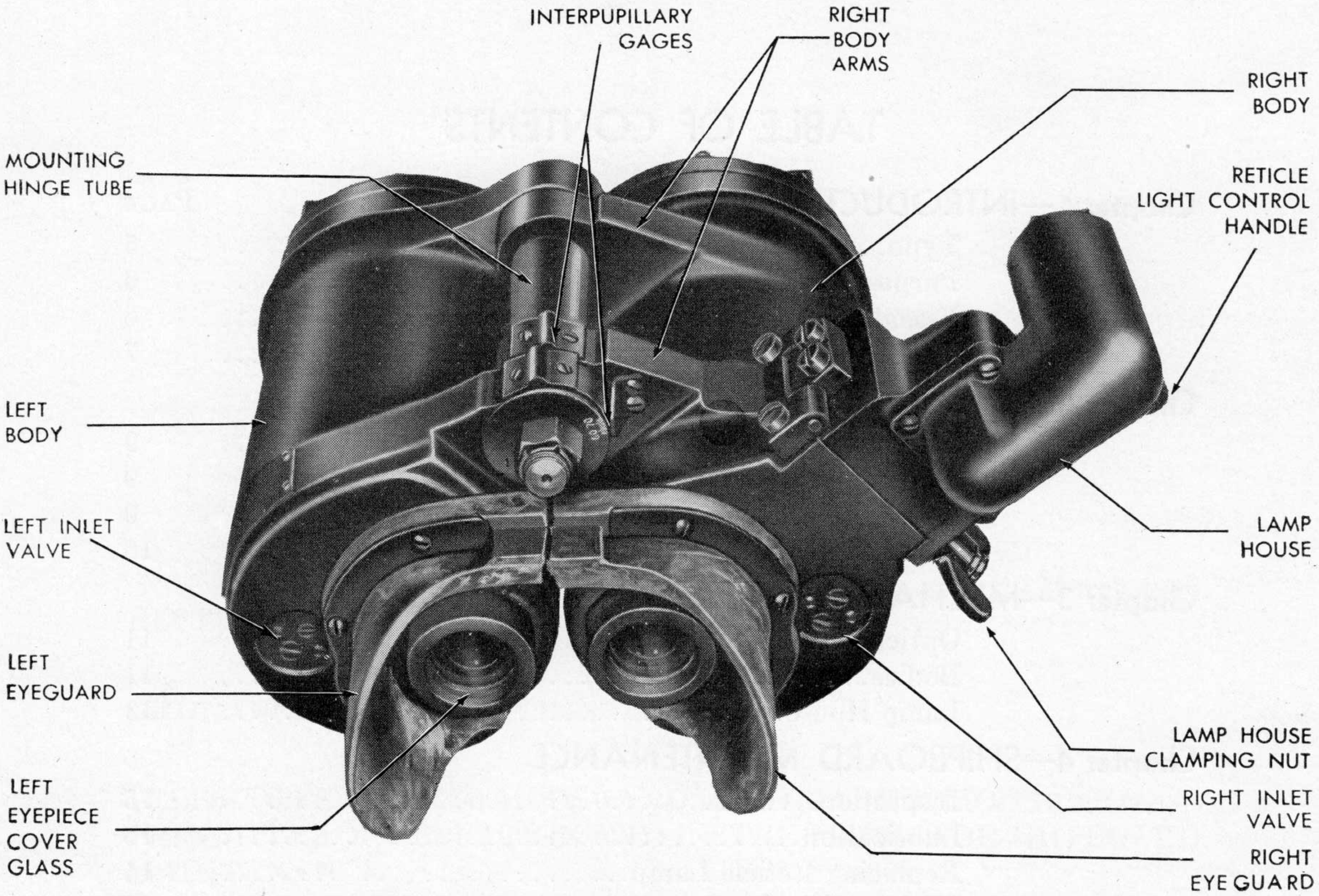

Figure 1—Telescopes Mark 90 Mods 0 and 1, Rear View

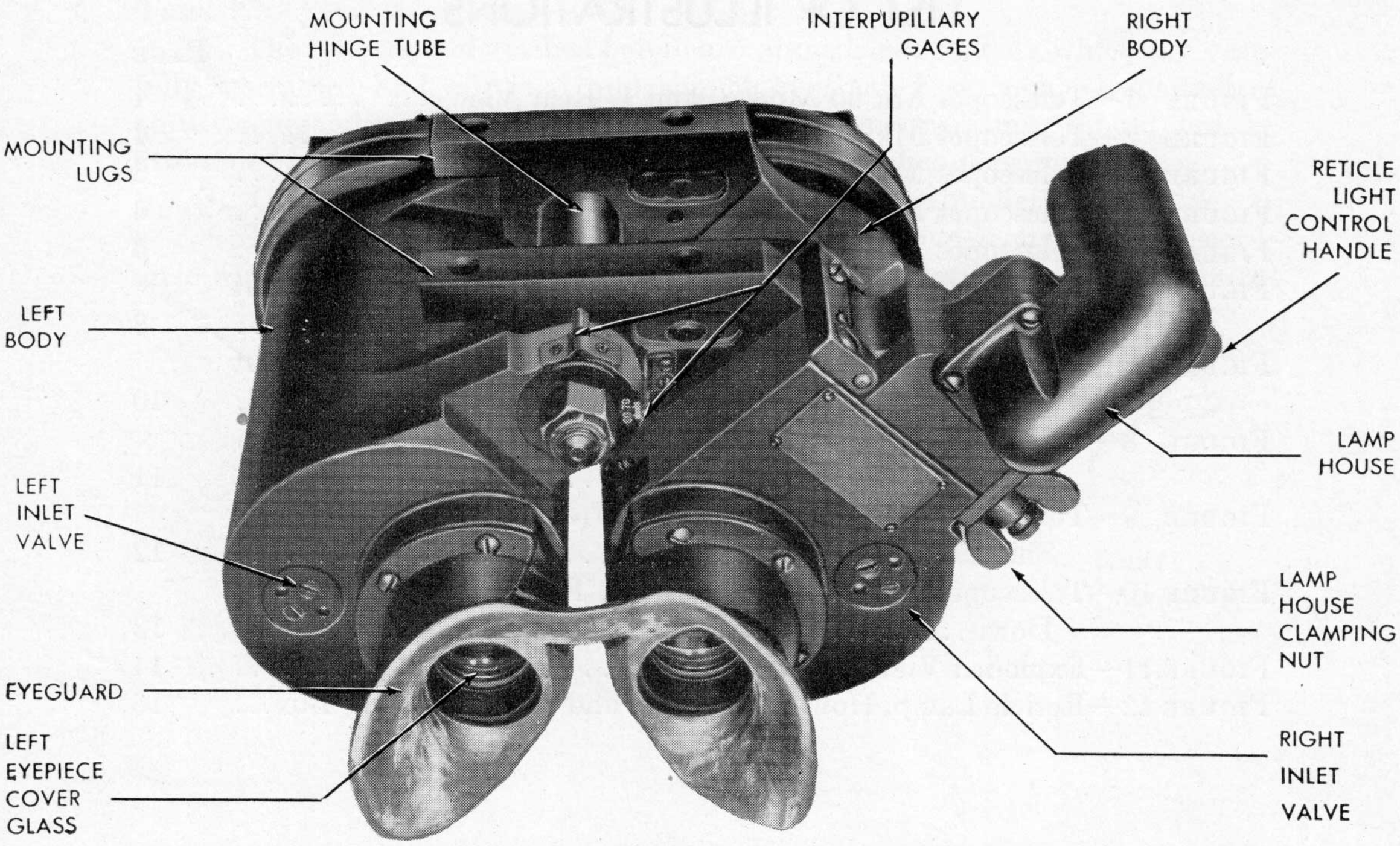

Figure 2—Telescopes Mark 91 Mods 0 and 1, Rear View

Chapter 1

INTRODUCTION

Type

Telescopes Mark 90 Mods 0 and 1 and Mark 91 Mods 0 and 1 are pressure-proof binocular-type magnifying instruments. These telescopes are permanently mounted and are not hand-held instruments.

The optical systems in the two bodies of the telescopes are sealed against entrance of moisture to withstand external hydrostatic pressures of 300 pounds per square inch. In addition, the front or objective end of each body carries a hinged metal shield to be lowered over the objective cover glass when the telescope is not in use in order to provide protection while submerged.

The rear, or eyepiece, ends of the bodies carry a soft rubber eyeguard which provides a protective rest for the head and locates the eyes at the proper distance behind the eyepiece.

The optical systems of both telescope bodies are nonadjustable, being pre-set and sealed at a position that gives a sharp reading for normal eyes of all objects within the desired range of vision. However, the interpupillary distance between the optical systems of the right and left bodies is adjustable from 56 to 74 mm. to provide for an interpupillary correction to suit the individual operator.

In the right body of each telescope is a cross-line pattern, or reticle, consisting of a vertical and horizontal line intersecting at the center of the field. For daytime use the lines appear dark on a light background, while at night the reticle can be illuminated and appears as red lines against a dark background. The intensity of reticle illumination may be controlled to suit conditions or may be completely extinguished, as desired, by an adjustable handle provided on the reticle lamp housing hinged to the right body.

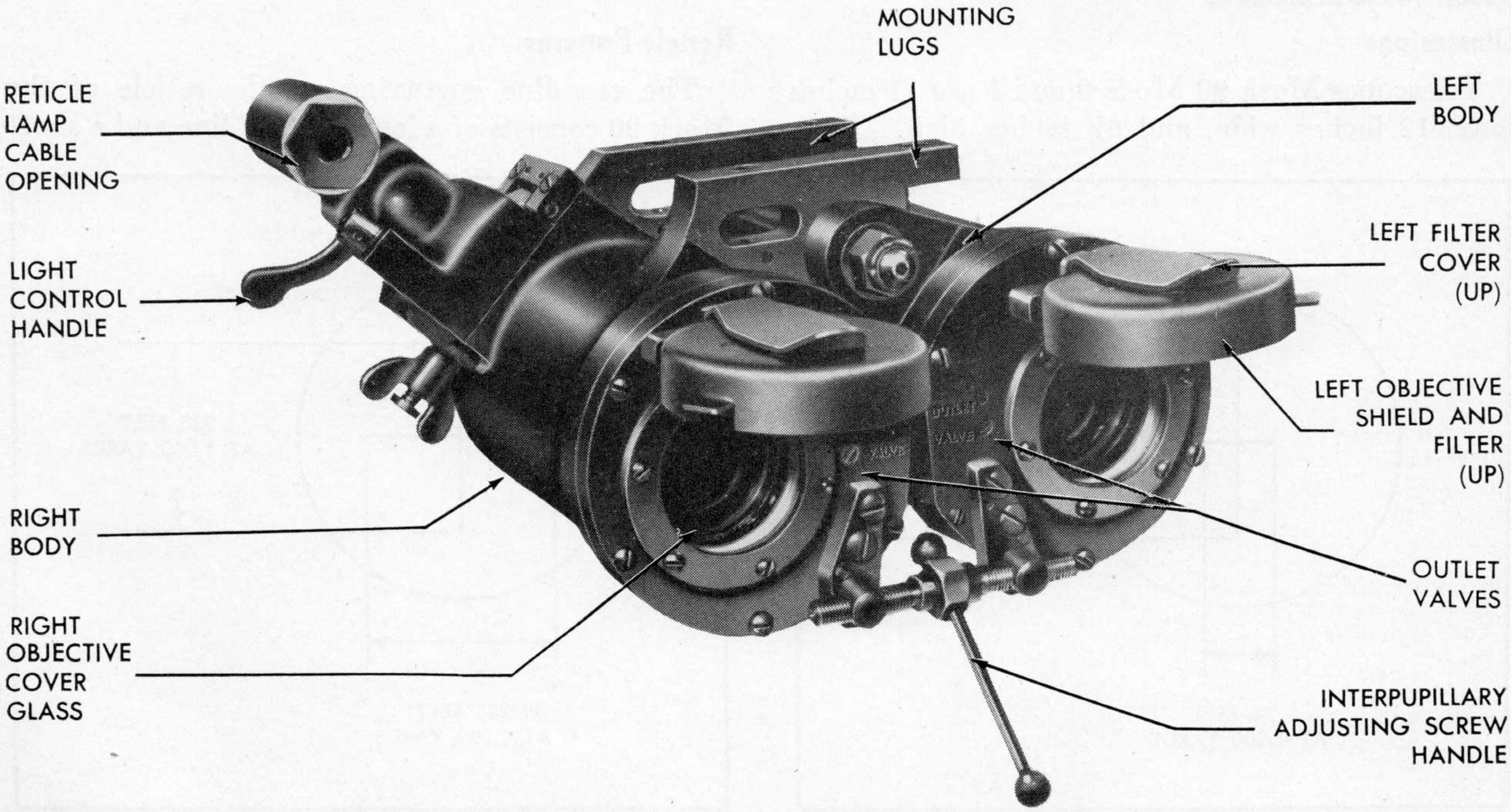

Figure 3—Telescopes Mark 91 Mods 0 and 1, Front View

Purpose

Telescopes Mark 90 Mods 0 and 1 and Mark 91 Mods 0 and 1 are mounted interchangeably as permanent sights for the Target Bearing Transmitter Mark 8 and Mark 9 on board submarines. Telescopes Mark 91 Mods 0 and 1 are also used on 5-inch Mount Mark 40 Mod 0, Sight Mark 42 Mod 2, and on 40-mm. Sight Mark 8 Mod 0 installed on 40-mm. Mount Mark 3 Mods 5 and 6.

These telescopes enable the observer to see an apparently magnified erect target with the crosslines superimposed. Also, because of the exact known length of the horizontal and vertical reticle crosslines, the reticle crossmark pattern may be used either to approximate the size of a target of known range or to approximate the range of a target of known size. At a range of 1,000 yards, the horizontal cross line on the Mark 90 reticle is equivalent in target size to a length of 78 feet. (See fig. 4.) At the same range, the horizontal crossline on the Mark 91 reticle is equivalent in target size to a length of 233 feet. (See fig. 5.) The vertical crossline of both reticles is the same length, being equivalent in size to 233 feet at 1,000 yards.

Essential Differences

Dimensions

Telescopes Mark 90 Mods 0 and 1 are 11 inches long, 12 inches wide, and 6⅞ inches high. Each telescope weighs 35½ pounds. Telescopes Mark 91 Mods 0 and 1 are 12 inches long, 12¼ inches wide, and 7 inches high. Each telescope weighs 40 pounds. Telescopes Mark 90 Mod 0 and Mod 1 are identical as to exterior dimensions, appearance, and construction. Telescopes Mark 91 Mod 0 and Mod 1 are identical as to exterior dimensions, appearance, and construction.

Mountings

The Mark 90 is mounted on a hinge tube connected between the two right body arms. (See fig. 1.) The cradle cap on the target bearing transmitter clamps this hinge tube to the cradle. The Mark 91 is provided with a similar hinge tube for target bearing transmitter mounting, but also carries two mounting lugs integral with the top of the right body by which the telescope may be attached to the desired gun mounts. (See figs. 2 and 3.)

Magnification

The Mark 90 has a magnification of seven diameters, indicating that an image seen through the telescope will be seven times larger than when viewed with the naked eye. The Mark 91 has a magnification of six diameters.

Reticle Patterns

The crossline engraving on the reticle of the Mark 90 consists of a long vertical line and a short

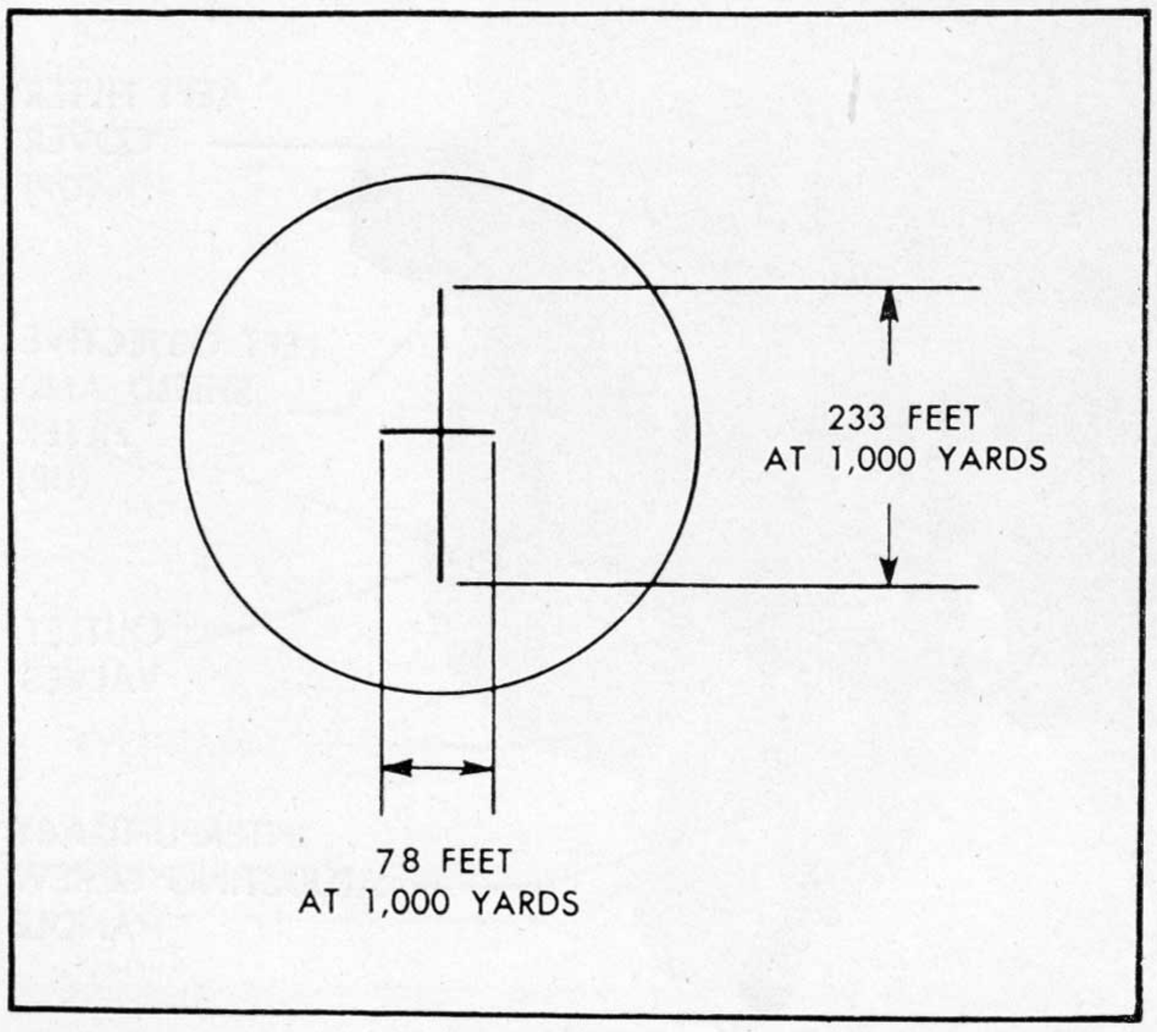

Figure 4—Telescopes Mark 90 Mods 0 and 1, Reticle Pattern

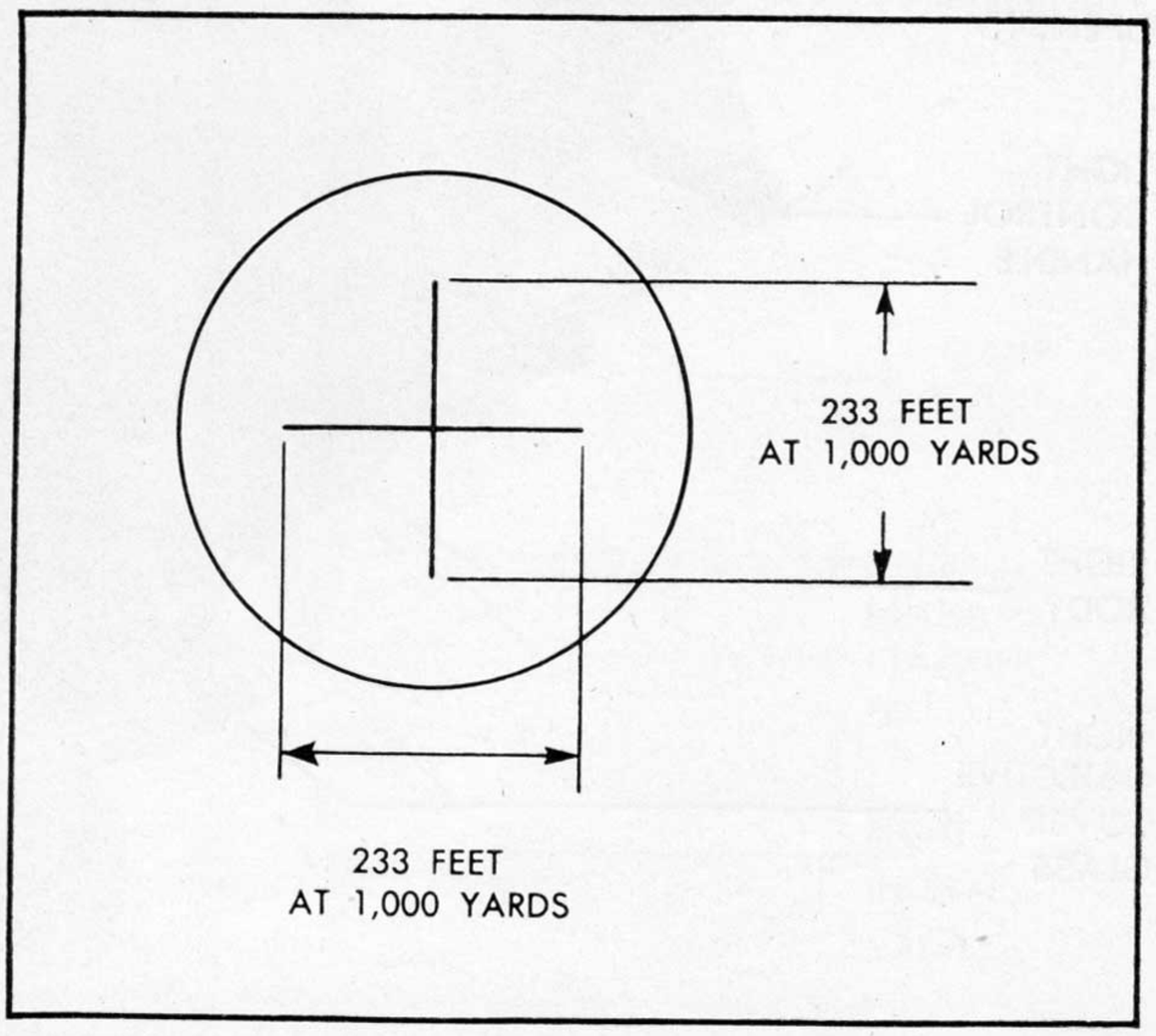

Figure 5—Telescopes Mark 91 Mods 0 and 1, Reticle Pattern

horizontal line. The apparent length of the short horizontal line is 78 feet at 1,000 yards. The crossline engraving on the reticle of the Mark 91 consists of long vertical and horizontal lines of equal length. The apparent length of the horizontal line is 233 feet at 1,000 yards.

Objective Shields

The objective shield on the front of each Mark 90 body consists of a simple metal protective cover hinged above the objective cover glass to be lowered before submersion or when the telescope is not in use, and raised before operation. (See fig. 9.) The objective shield on the Mark 91 bodies, however, carries in its center a neutral color glass filter which is positioned in front of the objective cover glass when the shield is lowered in order to clarify the detail of images in bright light by reducing the effect of glare. (See fig. 8.) In addition, a smaller cover is hinged over the center of the objective shield to act as a cover for the filter itself when submerged.

Table of Optical Characteristics

Characteristic	Mark 90 Mods 0 and 1	Mark 91 Mods 0 and 1
Magnification	7X	6X.
Objective free aperture	50 mm	50 mm.
Exit pupil	7 mm	8.3 mm.
True field of view	6° 49′	7° 0′.
Equivalent field of view at 1,000 yards.	358 ft	368 ft.
Eye distance (Eye to cover glass).	10.7 mm	25.0 mm.

Table of References

5-inch Gun Mount Mark 40	OP 1029
Target Bearing Transmitter Mark 8	OP 1189
Target Bearing Transmitter Mark 9	OP 1448
Methods of Drying and Charging Optical Instruments	NAVORD OD 2847

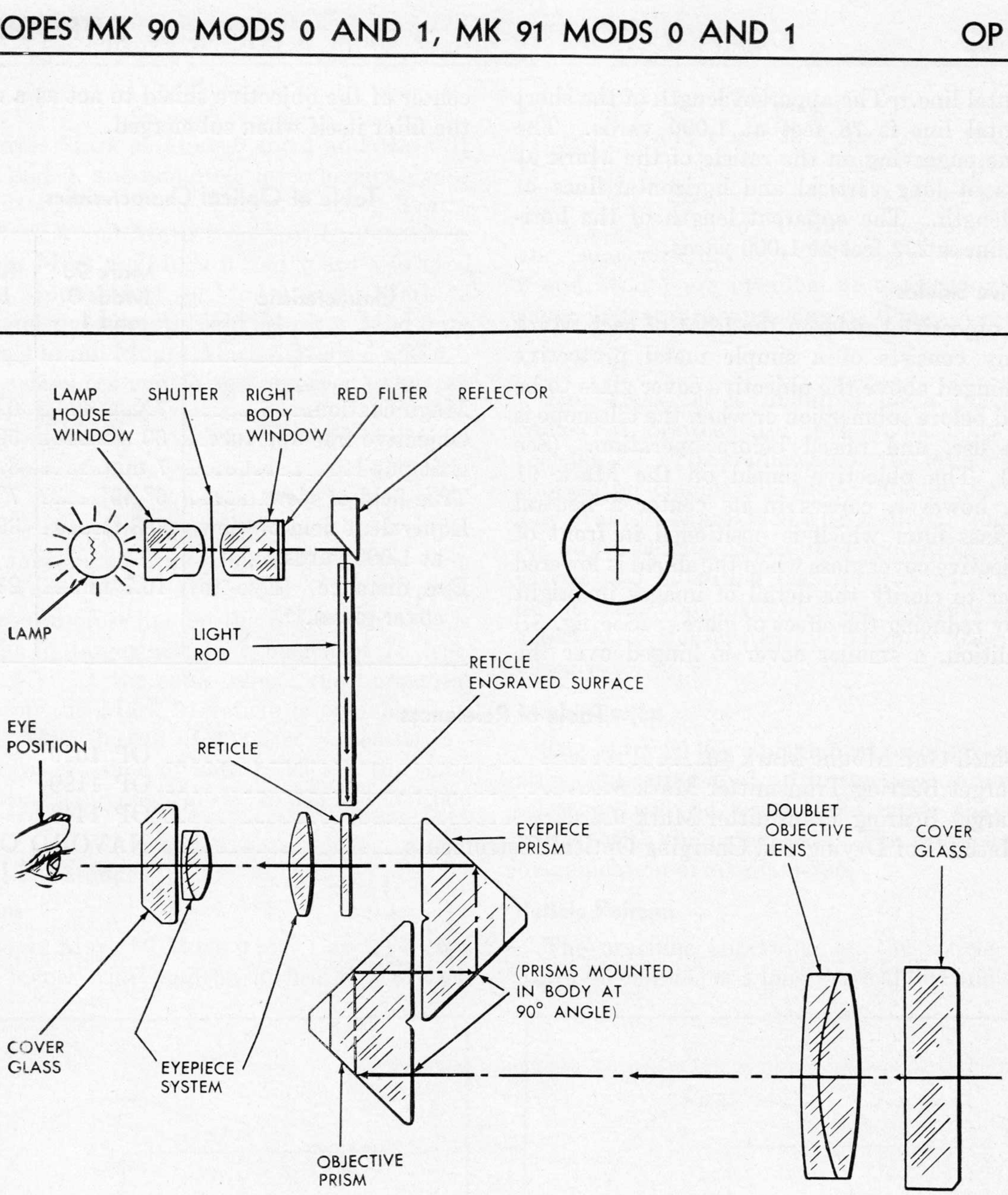

Figure 6—Telescopes Mark 90 Mods 0 and 1, Optical System, Right Body

Chapter 2

OPTICAL SYSTEMS

The functioning optical systems of the Telescopes Mark 90 Mods 0 and 1 and Mark 91 Mods 0 and 1 are basically the same, consisting essentially of an objective lens, two Porro prisms, a reticle, and a fixed focussed eyepiece in each right telescope body. All of the air surfaces of the telescopes' optical elements, except the illuminating system, are coated with a low reflection film which reduces the light losses. The optical system in the left body of each telescope is identical to that of the right system, except that the reticle is replaced by an open diaphragm and certain optical distances between the inner units are changed slightly to compensate for the replacement.

The objective lens forms an image, the two prisms reverse and invert this image, and the eyepiece magnifies it. The crossline is engraved on the objective side of the reticle and is located in the focal plans. The crossline intersection appears in the center of the field of view.

Telescope Mark 90 Mod 0 Optical System

The detailed principles of operation for the optical system of Telescope Mark 90 Mod 0 are illustrated in the schematic diagram of the right body. (Fig. 6.) Both bodies contain optical systems which operate in the same basic manner with the difference that, in the left body, the reticle is replaced by an open diaphragm of the same aperture. The sequence of image transmission is as follows:

1. The rays of light coming from the object under observation are transmitted through the cover glass in the front end of the telescope body to the 50-mm objective lens inside the body.

2. The 50-mm objective lens collects the rays of light and transmits them on through the prisms to form an image of the object at the engraved surface of the reticle (focal plane). The two prisms, which are positioned perpendicular to one another, reverse and invert the image, making it appear erect and giving it the true aspect when viewed through the eyepiece.

3. The night illumination system for the reticle pattern consists of a small lamp, two light windows with a shutter between, a red filter, a 90-degree reflector, and a plastic light rod. The two windows act both to transmit the light to the reflector and to converge the rays of light from the lamp onto the center of the light rod. The light rod, in turn, transmits the red light to the edge of the reticle where it is dispersed over the engraved pattern. The position of the shutter between the windows governs the amount of light transmitted and therefore the brightness of the reticle pattern.

4. The image is magnified seven times by the eyepiece.

5. The enlarged image is viewed through the eyepiece cover glass and the eyepiece when the eye is placed at the exit pupil (eye point).

Telescope Mark 90 Mod 1 Optical System

The optical system for Telescope Mark 90 Mod 1 is identical to that for Telescope Mark 90 Mod 0 (fig. 6) except that the cover glasses for the objective lens and eyepiece are of increased thickness.

Telescope Mark 91 Mod 0 Optical System

The detailed principles of operation for the optical system of Telescope Mark 91 Mod 0 are illustrated in the schematic diagram of the right body. (Fig. 7.) The functioning of this optical system is basically the same as that of Telescopes Mark 90 Mods 0 and 1. The individual physical units in the system, however, vary somewhat in design.

The optical system of Telescope Mark 91 Mod 0 includes a hinged filter in front of the objective cover glass, through which the rays of light pass before entering the cover glass when the filter is in position. In addition the eyepiece lenses

are of different design and are positioned accordingly to produce a magnification of six times, while the objective lens and eyepiece cover glass are similar but slightly different in dimensions.

The illumination system for the reticle of Telescopes Mark 91 Mods 0 and 1 is identical to that for Telescopes Mark 90 Mods 0 and 1 except for a small difference in the shape of the light rod.

Telescope Mark 91 Mod 1 Optical System

The optical system for Telescope Mark 91 Mod 1 is identical to that for Telescope Mark 91 Mod 0 except that the Mod 1 includes a reticle cover glass between the eyepiece prism and the reticle. (See fig. 7.) The mounting position of the objective lens in the right body is moved slightly to compensate for the addition.

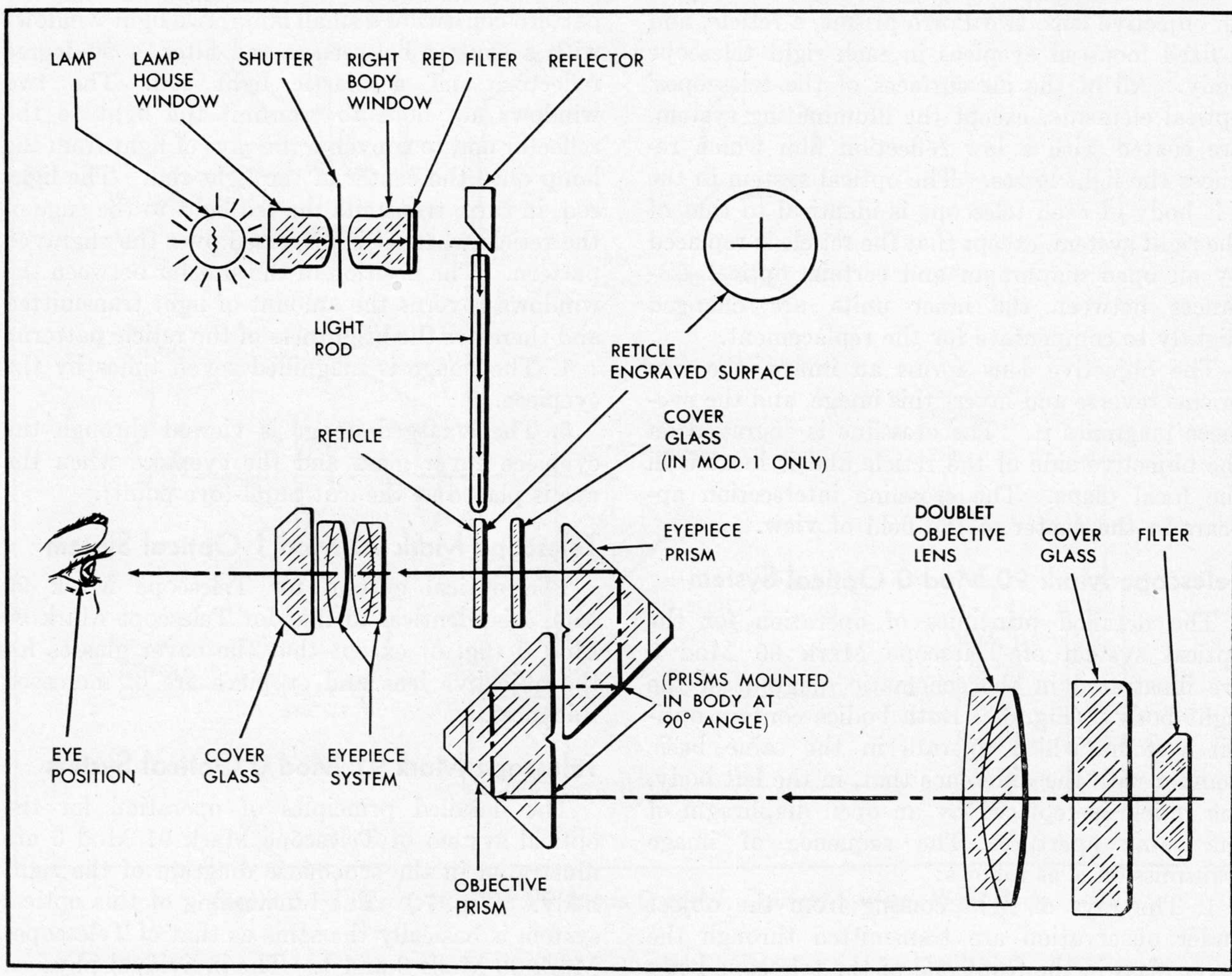

Figure 7—Telescopes Mark 91 Mods 0 and 1, Optical System, Right Body

Chapter 3

MECHANICAL FEATURES OF DESIGN

Telescopes Mark 90 Mods 0 and 1 and Mark 91 Mods 0 and 1 are essentially similar in general design. The simple differences in mechanical detail are primarily due to the certain provisions necessary for mounting the units to the particular instruments with which they are to be used and to accommodate optical systems of different power. Both telescopes are designed with two inner optical telescope units, two hinged bodies in which the optical units are sealed, and a lamp house unit to supply the light for the reticle in the right body.

Optical Telescope Units

Each optical telescope assembly, consisting of objective, prisms, reticle, and eyepiece, is mounted on a cylindrical frame unit. The frame unit, in turn, is set into a cylindrical pressure-tight housing body and sealed by cover glasses and gaskets at both the objective and eyepiece ends to protect the rest of the optical system. (See figs. 1, 2, 3, and 9.) In addition, the right body carries a small sealed illumination window at its rear top to transmit light from the reticle lamp housing mounted on the body above. (See fig. 10.)

Bodies

At the top of each telescope body casting are two integral angular lugs through which the right and left bodies are joined together by a common axle. The optical axes of both bodies are constructed to be parallel to the center axle when mounted together. The center portion of the axle is encircled with a symmetrical hinge tube by means of which the telescope is mounted to the target bearing transmitter. (See figs. 1 and 2.)

For gun mounting purposes, the right body lugs of Telescopes Mark 91 Mods 0 and 1 are also built

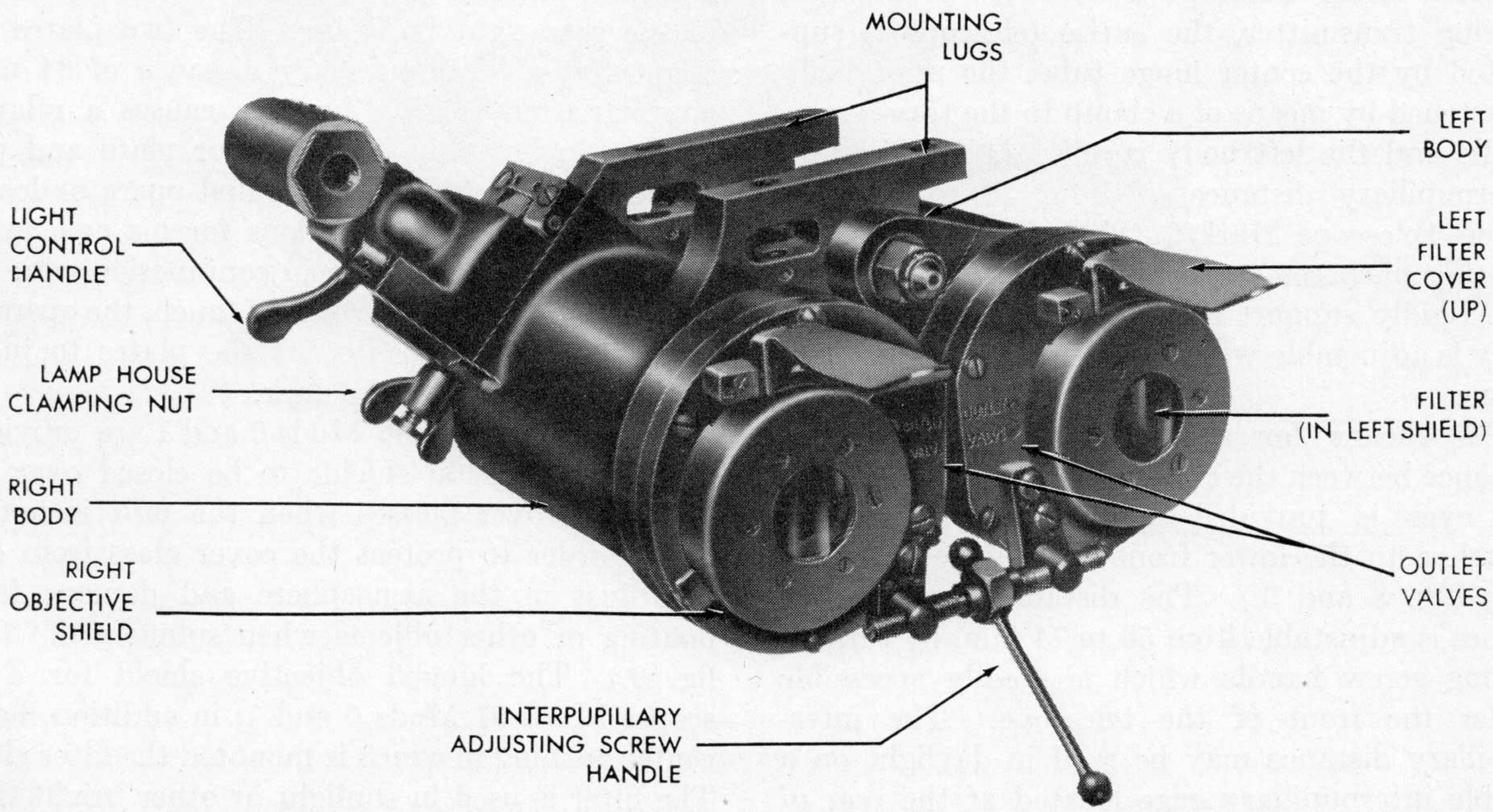

Figure 8—Telescopes Mark 91 Mods 0 and 1, Front View with Filter Covers Up

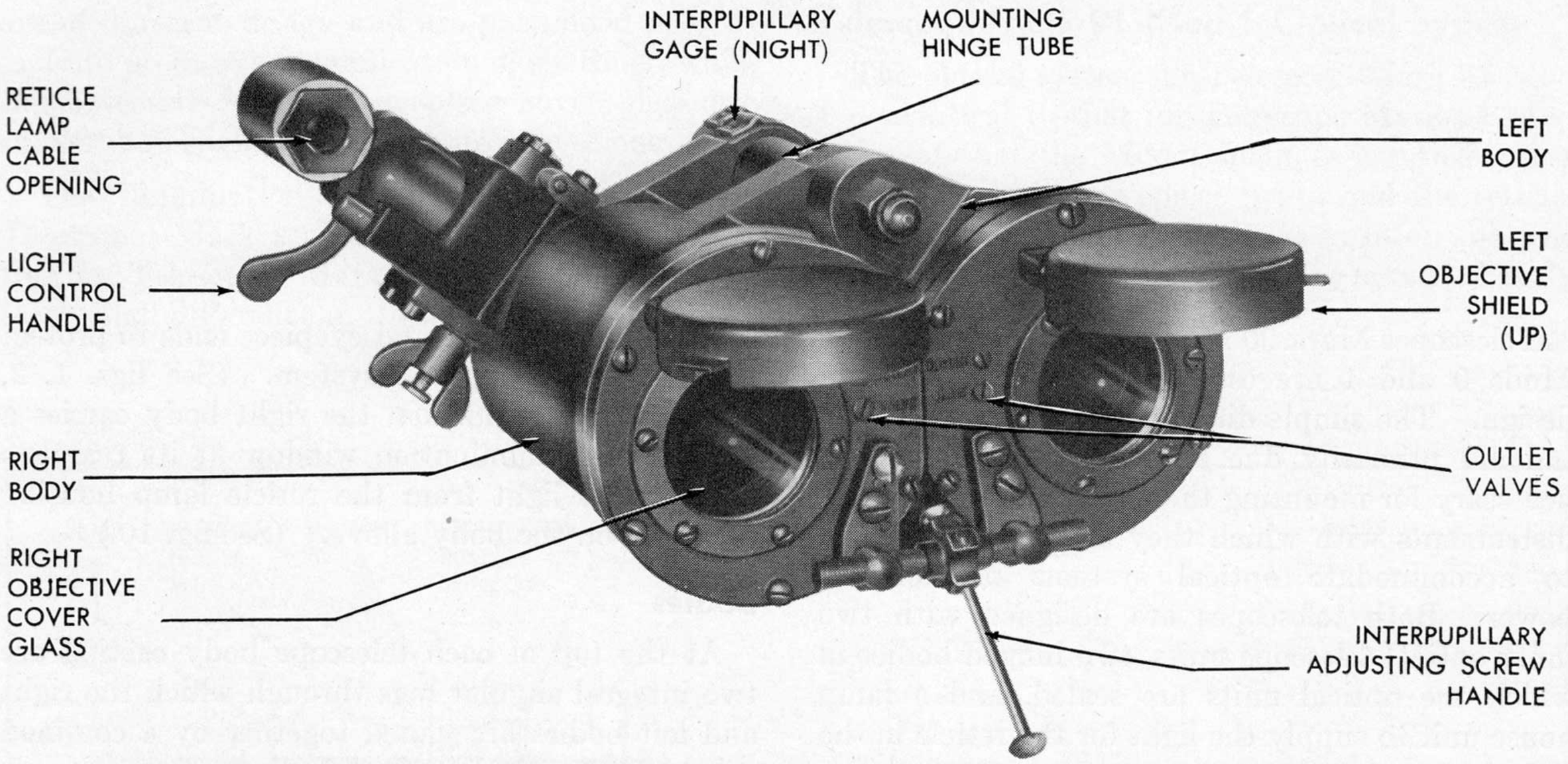

Figure 9—Telescopes Mark 90 Mods 0 and 1, Front View with Objective Shields Up

up to form a horizontal mounting plane across the top of the telescope. (See figs. 8 and 10.) In order to provide for accurate gun mounting, the locating surfaces of the mounting lugs are constructed and tested to be both parallel and perpendicular to the optical axis of the right body to within plus or minus 10 minutes of arc.

When either telescope is mounted to a target bearing transmitter, the entire telescope is supported by the center hinge tube, the right body is fastened by means of a clamp to the transmitter cradle and the left body is adjustable, giving an interpupillary distance of from 56 to 74 mm. When Telescope Mark 91 Mod 0 or 1 is used for sighting purposes on a gun mount, the mounting lugs rigidly support the right body, and the left body is adjustable within the same interpupillary range.

The means for adjusting the interpupillary distance between the two eyepieces to suit individual eyes is provided by an adjusting screw attached to the lower front ends of both bodies. (See figs. 8 and 9.) The distance between the bodies is adjustable from 56 to 74 mm. by turning a long screw handle which is readily accessible under the front of the telescope. The interpupillary distance may be read in daylight on a legible interpupillary gage located at the rear of the telescope above the eyeguard (see figs. 1 and 2.) This gage consists of a graduated disk attached to the adjustable left body lug which is read against an index pointer attached to the stationary right body lug. For night use the telescopes are also provided with a second interpupillary gage consisting of a protruding plate attached to the top center of the rear left body lug and a second plate or pin attached to the top center of the rear right body lug. The two plates are aligned at an interpupillary distance of 64 mm; any variation in this distance causes a relative separation between the plates or plate and pin. Thus, in daylight, the individual operator learns the feel of the plate positions for his own interpupillary distance setting in conjunction with the legible gage. Then, by sense of touch, the operator uses the relative position of the plates to judge his correct setting in the dark.

Telescopes Mark 90 Mods 0 and 1 are provided with hinged metal shields to be closed over the objective cover glasses when the unit is not in use in order to protect the cover glass from dirt and dust in the atmosphere and damage from floating or other objects when submerged. (See fig. 9.) The hinged objective shield for Telescopes Mark 91 Mods 0 and 1, in addition, has a center opening in which is mounted the filter glass. The filter is used in sunlight or other bright light to reduce the transmission of glaring light. (See

fig. 8.) Since the objective shield may be raised or lowered at will, the use of this filter is optional. (See figs. 3 and 8.) The Mark 91 carries a smaller cover hinged to the same pin as the objective shield to function as a cover for the filter itself. The objective shield and filter cover, when lowered together, provide the complete shield for the objective when the telescope is not in use. (See fig. 10.)

The eyeguard of the Mark 91 is designed in conjunction with the optical system to provide a greater eye distance (25.0 mm.) than that of the Mark 90 (10.7 mm.) in order to give the operator more protection when the telescope is used as a gun mount sight. In addition to supporting the head and locating the eyes, the one-piece construction of the eyeguard of Telescope Mark 91 serves to protect the eyes from gun blasts, and the greater eye distance serves to cushion the head against recoil. This allows the operator to keep his head and eyes continuously in the operating position without fear of physical harm from the blast or recoil.

Lamp House

The purpose of the lamp house is to provide light for the illumination of the reticle at night when the background is dark. It is mounted to the upper right side of the right body and contains the lamp cable, socket, lamp, and one window, all of which are sealed in the housing against ingress of moisture. (See fig. 11.) The light shutter, however, is located outside the housing but is protected when the lamp house is clamped down to the body (see fig. 8) and is not affected by moisture.

The lamp house window is aligned directly over the window in the right body (see fig. 10), so that the light passes through the two windows and red filter to the reflector and light rod in the body and on through the rod to the reticle. The engraved pattern on the reticle is filled with white opaque material which looks black by day against a light background and, when illuminated, looks red by night against a black background.

The housing for the lamp house is constructed in two pieces in order to allow replacement of

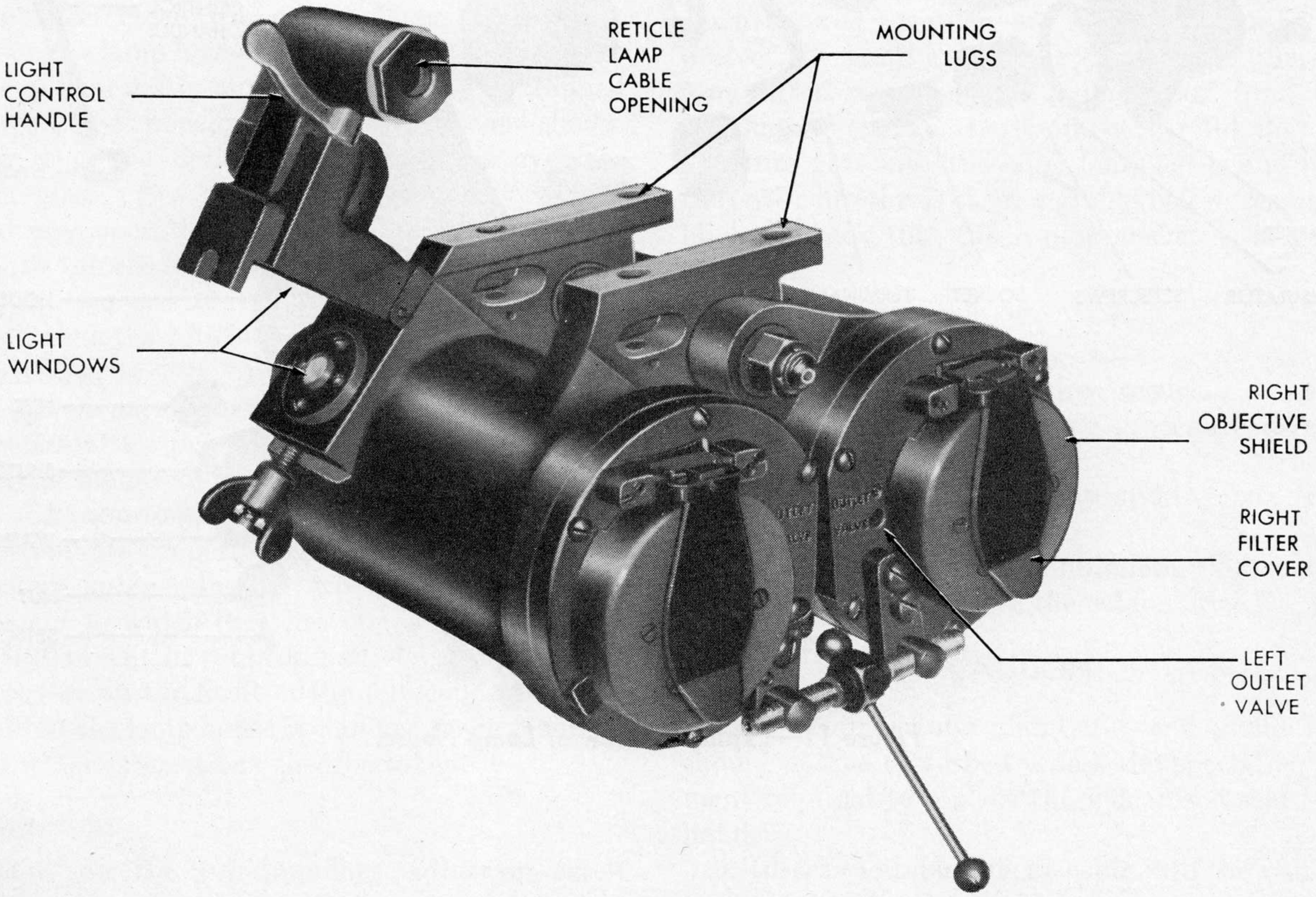

Figure 10—Telescopes Mark 91 Mods 0 and 1, Front View with Covers Down

the lamp. (See fig. 11.) The two housings are mounted together by removable screws and sealed with a gasket. One housing carries the cable and socket, the other the window and shutter. The lamp is a 0.25-ampere, 6- to 8-volt, Navy type TB–11, bayonet base, double pole contact.

The shutter controlling the intensity of reticle illumination is locked to the lower end of an axle running through the right side of the lamp housing. It is rotated by a light control handle fastened to the upper end of the axle above the housing. (See fig. 10.) The shape of the shutter blade is designed to provide a minimum change in the lower level of illumination with maximum movement of the control handle. Care should be taken not to rotate the shutter beyond the normal stop position.

The entire lamp house unit is hinged to the top of the body so that, after being submerged, it may easily be lifted up out of the way and any trapped water or dirt may be quickly cleaned from the windows. (See fig. 10.) When the unit is lowered into position on the body it may be securely fastened by a simple wing nut.

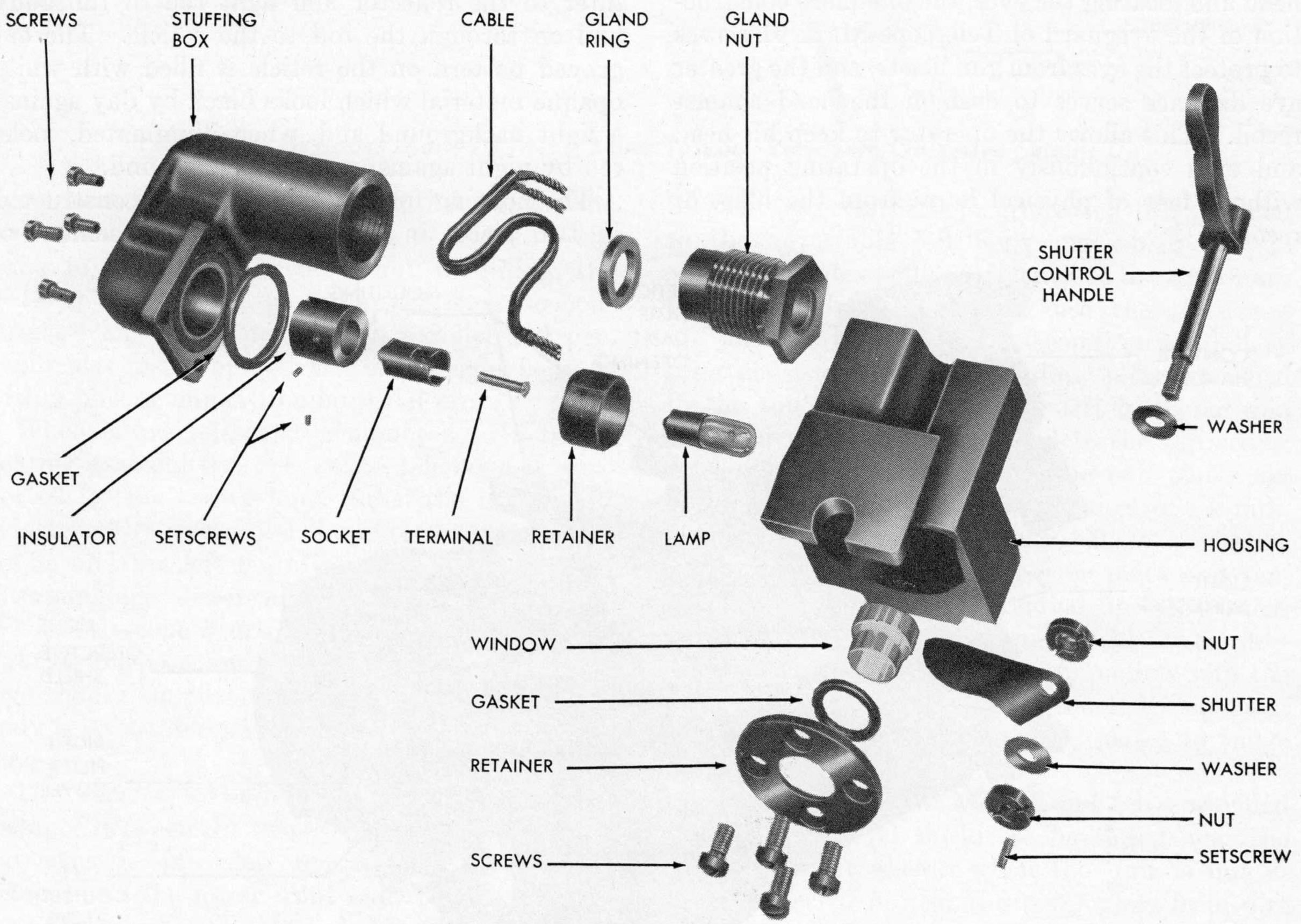

Figure 11—Exploded View of Lamp House

Chapter 4

SHIPBOARD MAINTENANCE

After being installed on the submarine, Telescopes Mark 90 Mods 0 and 1 and Mark 91 Mods 0 and 1 require only a simple procedure of exterior cleaning, inspection, and general maintenance. If the interior of the telescope becomes defective, repair shall be performed by a base optical shop. A 300-pound external hydrostatic pressure test is required after repairs have been completed. For maintenance of air pressure, follow instructions given in NAVORD OD 2847, Methods of Drying and Charging Optical Instruments.

Keep the cover glasses, filters, and light windows clean at all times. Use lens tissue, a clean handkerchief, or clean cotton batting.

Inspection

After submersion, raise the telescope objective covers and clean the cover glasses and filters. Loosen the lamp house clamping nut and swing the base upward to free any water that may be trapped between the housing and the telescope body. Clean the two light windows and the eyepiece cover glass. See that the interpupillary adjustment is in operating condition.

With the electrical current on, look through the telescope to see that water has not leaked in. Check that the reticle lamp and light shutter are operating correctly, and that the cover glasses and light windows are clean and secure. Rotate the transmitter or gun mount to which the telescope is mounted through its range in azimuth and elevation to see that the instrument and telescope operate properly together.

Before submerging, or when securing the instrument to which the telescope is mounted, lock the instrument in rotation and elevation. Lower the covers on the front of the telescope and make sure that the lamp house is clamped down securely. No further precautions need be taken.

Lubrication

Lubricate the interpupillary adjusting screw and lamp house clamping nut after each submersion, using a nonslicking light gun mount grease. Oil the light control shutter axle. Repaint all exposed body parts periodically with paint No. 39 in accordance with Ordnance Standard 52.

Replacing Reticle Lamp

If the reticle lamp in the telescope burns out, it may be easily replaced by removing the four screws that hold the lamp stuffing box to the housing. (See fig. 12.) The stuffing box, with the cable, gland nut, socket, retainer, gasket, and lamp can then be removed as a single unit and the lamp replaced.

CAUTION

The lamp house stuffing box and housing units, when secured together, are sealed by a gasket to protect the lamp against water pressure. Therefore, after removing the stuffing box from the housing to change the lamp, be careful that no moisture gets into the inner lamp space and that the entire interior is clean and dry before reassembling. Check that the sealing gasket is in good condition.

Wiring of Reticle Lamp

If the reticle lamp requires rewiring or cable replacement, use the following procedure to wire the cable to the socket.

1. Remove the reticle lamp stuffing box from the lamp housing.

2. Disassemble the gland nut, gland ring, socket, and retainer, and remove the cable. (See fig. 12.)

CAUTION

The terminal tube gland nut and gland ring should not be disturbed unless the special equipment required to replace the vulcanized seal is at hand.

3. Insert the replacement cable into the stuffing box with a vulcanized rubber washer in place.

4. Solder one conductor in the hollow terminal protruding from the center base of the socket. Insert the other conductor in the side slot of the insulator and solder it to the side base of the socket.

5. Check the operation of the lamp.

6. Reassemble and replace the stuffing box on the housing.

7. Tighten the terminal tube gland nut.

8. Recheck the operation of the lamp.

Repair

Repairs other than minor ones shall be performed by an optical shop. In case any of the cover glasses become broken or one of the bodies develops a leak, use the following procedure to prevent sea water from corroding the internal parts of the telescope beyond repair. Remove the lamp housing from the telescope and tape it to the transmitter or gun mount to protect the cable. Remove the telescope from the instrument. Remove the broken glass or take out one of the air valves. Rinse out the body two or three times with fresh water to remove all traces of salt water. Fill the body with fuel oil. This will prevent any further corrosion of the parts until the telescope can be turned over to the repair shop for cleaning and overhaul.

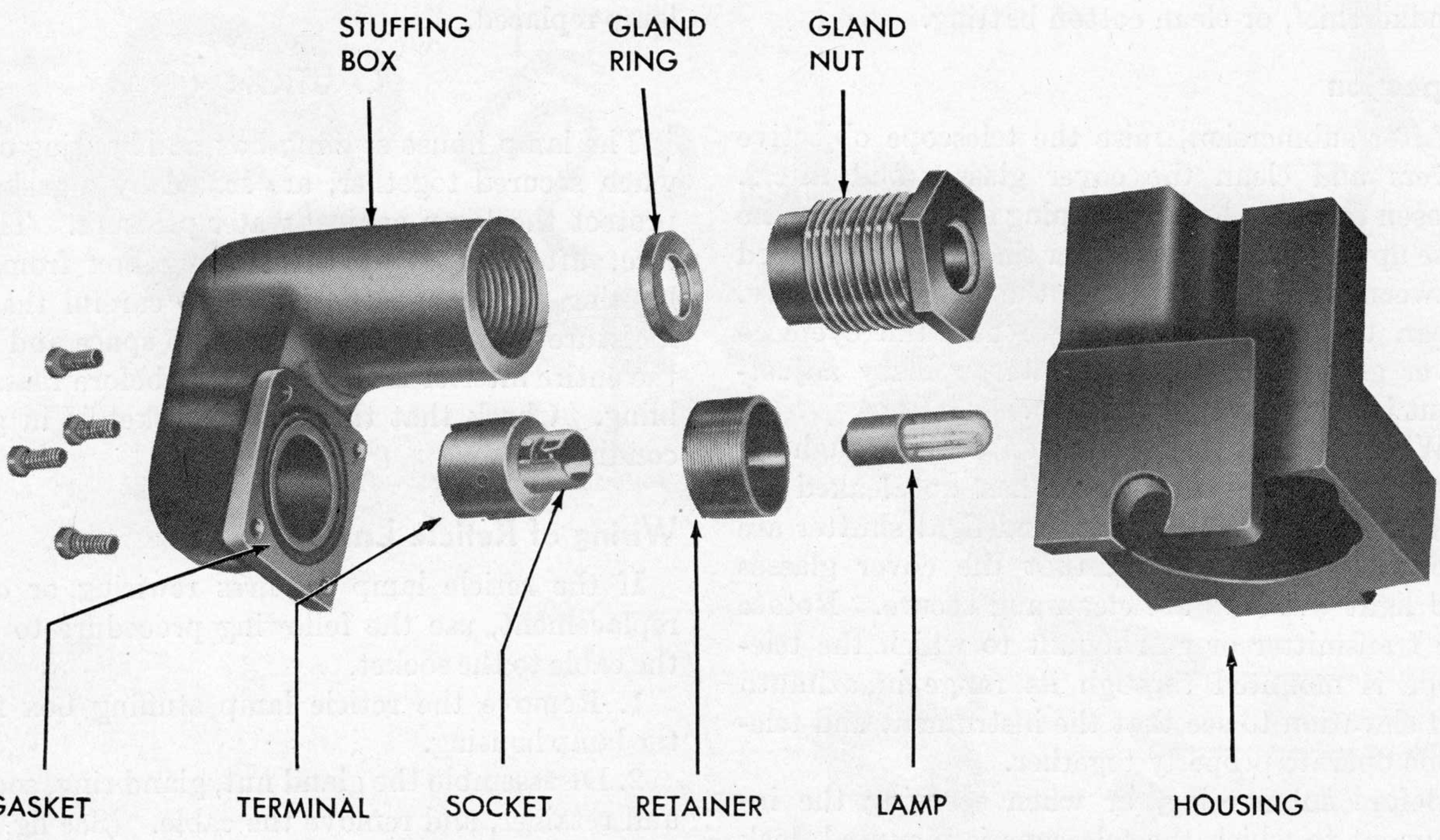

Figure 12—Reticle Lamp, Housing, Socket, and Cable Stuffing Box

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