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MILITARY HANDBOOK

LIGHTING
ON
NAVAL SHIPS
(METRIC)

AMSC N/A FSC 62GP

DEPARTMENT OF DEFENSE
NAVAL SEA SYSTEMS COMMAND

Washington, DC 20362-5101

Lighting on Naval Ships

1. This standardization handbook is approved for use by the Naval Sea Systems Command, Department of the Navy and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

The purpose of this handbook is to disseminate up-to-date information necessary for the optimum utilization of lighting fixtures and lighting installations on Naval ships. The criteria contained herein are based on both new requirements and past practices in general use. It should be noted, however, that the nature and peculiarities of certain types of ships or certain areas of application may necessitate a deviation from these criteria, thereby requiring a judicious application of same.

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1. SCOPE

1.1 General. This handbook establishes standard design requirements and procedures, and identifies the configurations and applications of lighting systems on naval ships.

1.2 Application. These criteria apply to new construction only when invoked by the Ship Specifications or similar contractual document. They may be considered in the conversion or alteration of existing ships as specified by the activity preparing the instructions for the work. Certain portions of the General Specifications for Ships have been reproduced in this handbook for coherence and clarity of the material presented herein; however, in the event of any conflict between this handbook and the General Specification for Ships, the latter shall govern.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

W-L-116	Lamps, Fluorescent (General Specification).
W-L-116/3	Lamp Fluorescent Trade No. F8T5/CW, Preheat, 8 Watt, T-5 Bulb Cool White, Miniature Bipin Base (Detail Specification).
W-L-116/13	Lamp Fluorescent Trade No. F15T12/CW, Preheat, 15 Watt, T-12 Bulb Cool White, Medium Bipin Base (Detail Specification).
W-L-116/16	Lamp Fluorescent Trade No. F20T12/CW, Preheat, 20 Watt, T-12 Bulb Cool White, Medium Bipin Base (Detail Specification).
W-L-116/18	- Lamp Fluorescent Trade No. F20T12/D, Preheat, 20 Watt, T-12 Bulb Daylight, Medium Bipin Base (Detail Specification).
W-S-755	- Starter, Fluorescent Lamp.

MILITARY

MIL-L-573	- Lights, Marker Distress and Night Replenishment.
MIL-L-970	- Lampholders and Starter Sockets, General Specification for (Naval Shipboard Use).
MIL-L-970/6	- Lampholder, Base Mounted, Medium Screw, 250-Volt, 660-Watt, Two or Three Contact.
MIL-L-970/10	- Lampholder, Miniature Bi-Pin for Fluorescent Lamps, 250-Volt, 75-Watt.
MIL-L-970/11	- Lampholder, Medium Bi-Pin for Fluorescent Lamps, 250-Volt, 660-Watt.

MILITARY (Continued)

MIL-L-970/13 – Lampholder, Socket, Fluorescent Lamp Starter, 250-Volt, 75-Watt.

MIL-L-970/15 – Lampholder, Miniature Bi-Pin, Heat Resistant, For Fluorescent Lamps, 250-Volt, 75-Watt.

MIL-L-970/18 – Lampholder, Medium Bi-Pin, Heat Resistant, For Fluorescent Lamps, 250-Volt, 660-Watt.

MIL-L-970/19 – Lampholder, Socket, Fluorescent Lamp Starter, Heat Resistant, 250-Volt, 75–Watt.

MIL-F-3747 - Flashlights: Plastic Case, Tubular (Regular, Explosion-Proof, Explosion-Proof Heat Resistant, Traffic Directing, and Inspection-Light).

DOD-P-15146 – Paint, Exterior, Dull Black (Formula No. 104). (Metric)

MIL-S-15743 - Switches, Rotary, Enclosed.

MIL-F-16377 - Fixtures, Lighting; and Associated Parts; Shipboard Use, General Specification for.

MIL-F-16377/5 - Fixtures, Lighting; Fluorescent, General Lighting, 15 Watts, 120 Volts, 60 Hertz, Watertight, Symbols 338.1, 338.2, 339.1 and 339.2.

MIL-F-16377/6 - Fixtures, Lighting; Fluorescent, General Lighting, Directional, 16 Watts, 120 Volts, 60 Hertz, Watertight, Symbols 149.4 and 149.5.

MIL-F-16377/7 - Fixtures, Lighting; Fluorescent, General Lighting, 16 Watts, 120 Volts, 60 Hertz, Watertight, Symbols 70.3, 70.4, 78.2, 336 and 336.1.

MIL-F-16377/8 - Fixtures, Lighting; Fluorescent, General Lighting, 20 Watts, 120 Volts, 60 Hertz, Watertight, Symbols 331.1, 331.2, 347.2, and 347.3.

MIL-F-16377/9 - Fixtures, Lighting; Fluorescent, General Lighting, 24 Watts, 120 Volts, 60 Hertz, Watertight, Symbols 73.3, 73.4, 346.2 and 346.3.

MIL–F-16377/10 – Fixtures, Lighting; Fluorescent, General Lighting, Directional, 32 Watts, 120 Volts, 60 Hertz, Watertight, Symbols 145.4 and 145.5.

MIL-F-16377/11 - Fixtures, Lighting; Fluorescent, General Lighting, 40 Watts, 120 Volts, 60 Hertz, Watertight, Symbols 77.4, 77.5, 344.2 and 344.3.

MIL-F-16377/12 - Fixtures, Lighting; Fluorescent, General Lighting, 60 Watts, 120 Volts, 60 Hertz, watertight, Symbols 333.1, 333.2, 341.1, 341.2, 342.2 and 342.3.

MIL-F-16377/13 – Fixtures, Lighting; Fluorescent, General Lighting, 180 Watts, 120 Volts, 60 Hertz, Dripproof, Symbols 74, 74.1, 75 and 75.1.

MIL-F-16377/14 - Fixtures, Lighting; Fluorescent, General Lighting, 8 Watts, 120 Volts, 60 Hertz, watertight, Symbols 79.1, 79.2, 80.1 and 80.2.

MIL-F-16377/20 - Fixtures, Lighting; Incandescent, General Lighting, 50 Watts, 120 Volts, Dripproof 15 Degrees, Symbols 64.1 and 65.

MILITARY (Continued)

MIL-F-16377/21 - Fixtures, Lighting; Incandescent, General Lighting, 100 Watts, 120 Volts, Dripproof 15 Degrees, Symbols 89 and 90.2.

MIL-F-16377/23 - Fixtures, Lighting; Incandescent, General Lighting, 200 Watts, 115 Volts, Watertight, Symbols 57, 57.1, 69, 69.1 and 103.

MIL-F-16377/25 - Fixtures, Lighting; Incandescent, General Lighting, 110 Watts, 120 Volts, Explosionproof, Symbols 48.2 and 68.2.

MIL-F-16377/26 - Fixtures, Lighting; Incandescent, General Lighting, 110 Watts, 120 Volts, Watertight Symbols 112, 113 and 113.1.

MIL-F-16377/27 - Fixtures, Lighting; Incandescent, General Lighting, 50 Watts, 100 Volts, Watertight, Symbols 92.2 and 93.2.

MIL-F–16377/40 – Fixtures, Lighting; Locks Fluorescent Lamp.

MIL-F-16377/41 - Fixtures, Lighting; Shockmounts, For Lighting Fixtures.

MIL-F-16377/42 - Fixtures, Lighting; Filters, Plastic, Tubular Shaped for Fluorescent Lamps.

MIL-F-16377/44 - Fixtures, Lighting; Ballast, For One 20-Watt T-12 Fluorescent Lamp.

MIL-F-16377/45 - Fixtures, Lighting, Ballast, For One 8-Watt T-5 Fluorescent Lamp.

MIL-F-16377/57 - Fixtures, Lighting; Fluorescent, General Lighting, 60, 80 and 120 Watts, 120 Volts, 60 Hertz, Dripproof, Symbols 348, 349 and 350.

MIL-F-16377/58 - Fixtures, Lighting; Fluorescent, Detail Lighting For Mirrors, 30 Watts, 120 Volts, 60 Hertz, Dripproof, Symbols 351, 351.1, 352 and 352.1.

MIL-F-16377/59 - Fixtures, Lighting; Fluorescent, Detail Lighting for Step Illumination, 8 Watts, 120 Volts, 60 Hertz, Watertight, Symbols 353, 353.1 and 353.2.

MIL-F-16377/62 - Fixtures, Lighting; Incandescent Floodlights, 500 Watts, 120 Volts, Watertight, Symbols 300 and 300.1.

MIL-F-16377/65 - Fixtures, Lighting; Fluorescent, General Lighting, 30 Watts, 120 Volts, 60 Hertz, Watertight, Symbols 81, 81.1, 345.2 and 345.3.

MIL-F–16377/66 - Fixtures, Lighting; Fluorescent, General Lighting, 45 Watts, 120 Volts, 60 Hertz, Watertight, Symbols 82, 82.1, 343.1 and 343.2.

MIL-F-16377/67 - Fixtures, Lighting; Window Assemblies, Clear White Shielded, To Be Used for Replacement Parts Only.

MIL-D-16791 - Detergents, General Purpose (Liquid Nonionic).

MIL-S-16938 – Searchlights, Incandescent Signaling, 8-Inch.

MIL-S-19551 - Searchlights, Incandescent Lamp and Mercury-Xenon Vapor Lamp, Signaling, 12-Inch.

MILITARY (Continued)

MIL-P-24441 - Paint, Epoxy-Polyamide (General Specification for).

MIL-P-24441/4 - Paint, Epoxy-Polyamide, Exterior Topcoat, Black, Formula 153-R_0 = 1.8, Type I.

STANDARDS

FEDERAL

FED-STD-595 - Colors.

MILITARY

MIL-STD-1310 - Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety.

MS15586 - Lamps, Incandescent, A-19, Medium Screw.

MS16569 - Switch, Toggle, Double Pole, Single Throw (For Use in Lighting Fixtures).

MS17315 - Light, Polarity - 150 Watt, Symbol 215.

MS18297 - Cable, Navy, Insulation Resistance.

MS24489 – Filter, Marker Light, Airport Approach, Glass.

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this handbook to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

DRAWINGS

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

803-5001027 - Electric Plant Installation Standard Methods.

803-5184170 - Lighting on Naval Ships, Typical Installation Methods.

805-1630833 - Traps, Light – Arrangement and Details.

805-1630834 - Traps, Light, Details.

815-1197050 - Panel, Support, Control, Telltale Panel Symbol 969.

PUBLICATIONS

MILITARY

Naval Warfare Publications - 14 (series) Replenishment at Sea.

NAVSEA

DDS 304-1 - Electric Cable Voltage Drop Calculations.

DDS 304-2 - Electrical Cables, Ratings and Characteristics.

0283-236-0000 - Electrical Shock and its Prevention.

0901-422-0000 - Naval Ships - Searchlights, Chapter 9660.

S9AA0-AA-SPN-0l0/GEN-SPEC. - General Specification for Ships of the U.S. Navy.

NAVSEA (Continued)

SO300-AT-GTP-010/EsL	- Standard Electrical Symbol List for Equipment Covered by Specifications.
S9086-KC-STM-000/CH 300 R1	- Electric Plant, General.

U.S. COAST GUARD

Command and Instruction M16672.2A - 23 Dec 1983.

Public Law 95-75, the International Navigational Rules Act of 1977, 33 USC Sections 1601-1608.

(Application for copies should be addressed to the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.)

NAVAL AIR SYSTEMS COMMAND (NAVAIR)

NAVAIR Visual Landing Aids, General Service Bulletin.

(Application for copies should be addressed to the Naval Air Engineering Center, Lakehurst, NJ 08733.)

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the issue of the DoDISS specified in the solicitation. The issues of documents which have not been adopted shall be those in effect on the date of the cited DoDISS.

ILLUMINATING ENGINEERING SOCIETY

Lighting Handbook, 5th Edition.

(Application for copies should be addressed to Publications Office, Illuminating Engineering Society, 345 E. 47th St., New York, NY 10017.)

National Electrical Code, 1981 Edition.

(Application for copies should be addressed to National Fire protection Association, 470 Atlantic Ave., Boston, MA 02210.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

3. GENERAL DESIGN CONSIDERATIONS

3.1 Principles of light.

3.1.1 Light. Light is radiant energy of those wavelengths that are capable of affecting the eye to produce vision. Visible energy is an exceedingly small portion of the electromagnetic spectrum, a tremendous range of radiant energy which travels through space in the form of electromagnetic waves. All of these radiations are similar in nature and in the speed at which they travel (186,300 miles per second). They differ only in wavelength and frequency, and in the ways in which they manifest themselves. The present known spectrum ranges from cosmic rays with a wavelength of 1 x 10^{-15} centimeters, and a frequency of 3 x 10^{25} hertz (Hz) to 60-Hz alternating current (ac) waves 3100 miles long.

3.1.1.1 The human eye is tuned to respond only to the energy within the limits of the visible spectrum which constitutes a narrow portion of the complete spectrum and includes red , orange, yellow, green, blue and violet rays (see figure 1). The range of wavelengths in the visible spectrum varies from 380 nanometers (rim) for violet rays to 760 nm for red rays. The spectrum extends beyond these limits into regions that are invisible to the eye. Radiation of greater wavelength beyond the red end is infrared and that of lesser wavelength beyond the violet end is ultraviolet.

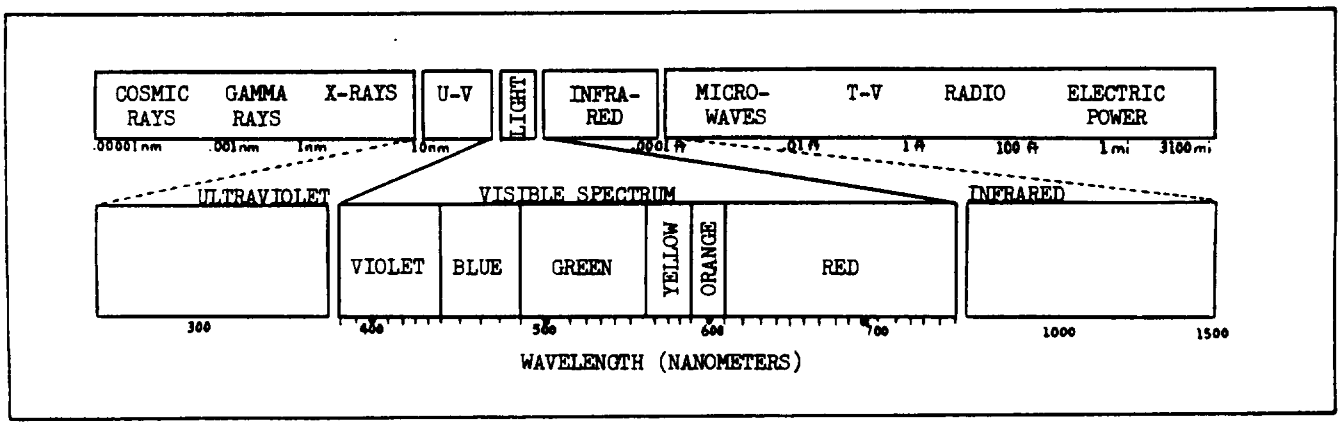

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FIGURE 1. The electromagnetic radiation spectrum and the visible spectrum.

3.1.2 Propagation. The natural sources of light are the sun, stars, moon and planets. The artificial sources include the electric-arc lamp, incandescent lamp, and fluorescent lamp. These sources of radiation (except the fluorescent lamp) are bodies at high temperatures , which produce vibration of the particles of matter. The radiated light travels in straight lines and behaves like wave mot ion in which the waves are transverse to the direction of propagation.

3.1.2.1 Light waves are of different wavelengths; different colors of light correspond to different frequencies of vibration; and electromagnetic waves of all wavelengths travel with the same velocity in free space, but with different velocities in different media. Hence, light waves obey the fundamental equation of wave motion,

$$f = \frac{v}{\lambda} = \frac{3x\ 10^{10}}{\lambda} \qquad \text{Equation 1}$$

Where:

v = the velocity of light (3×10^{10} centimeters per second)

f = the frequency of vibration (number of waves passing a given point per second)

λ = the wavelength in centimeters

3.1.2.2 Light waves travel in straight lines in a homogeneous medium. When these rays, or lines, of propagation encounter a medium of greater or lesser density, some of the energy is absorbed and the remainder is either reflected by the boundary between two media or is refracted in passing obliquely from one medium into another, or through a medium of varying density.

3.1.3 Reflection. Reflection occurs when light rays strike an object and are deflected back from the surface in a different direction (see figure 2). When light falls on a smooth, polished surface, it is reflected in a definite direction and is called regular reflection. The light from the source to the polished surface is the incident ray. The point at which the incident ray strikes the polished surface is the point of incidence (P). The ray that leaves the point of incidence is the reflected ray. The line perpendicular to the polished surface at the point of incidence is the normal to the surface (N). The angle between the incident ray and the normal to the surface, is the angle of incidence (i). The angle between the reflected ray and the normal to the surface is the angle of reflection (r).

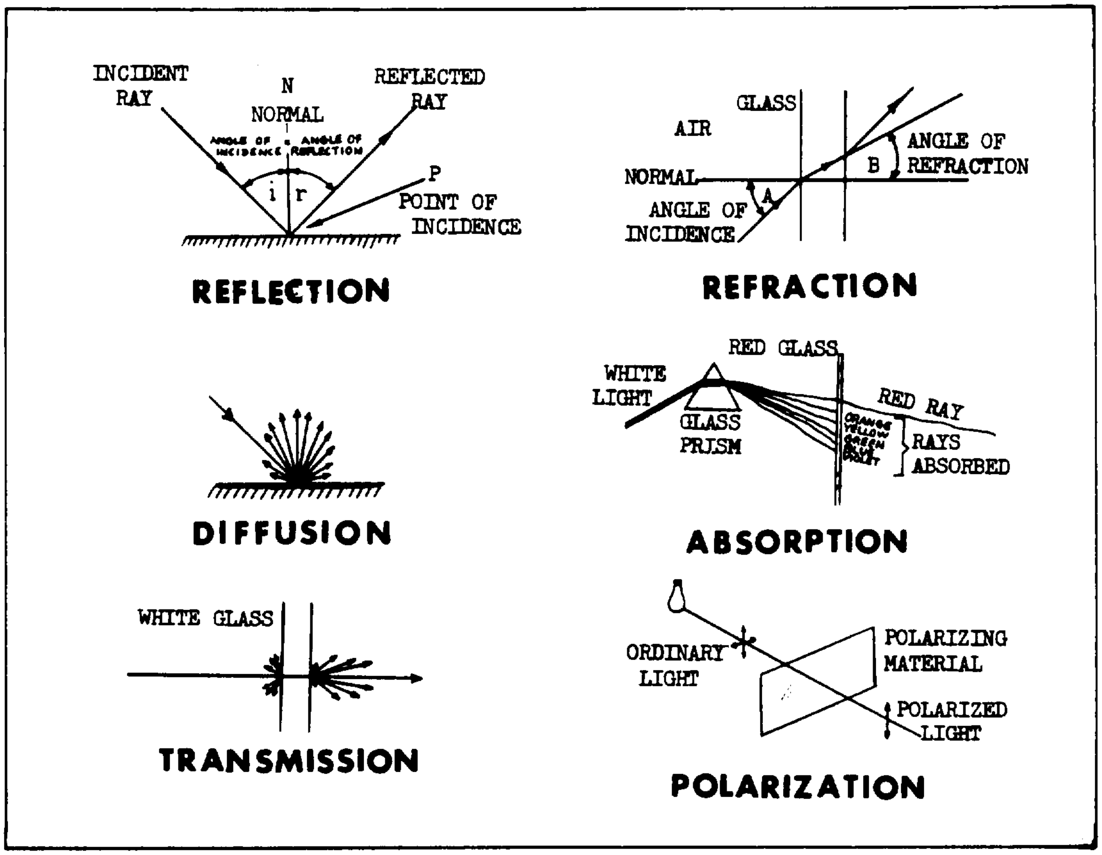

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FIGURE 2. Reflection, diffusion, transmission, refraction, absorption and polarization of light.

3.1.3.1 The incident ray, reflected ray, and normal to the point of incidence lie in the same plane, and the angle of reflection is equal t o the angle of incidence. This condition is true for both plane and curved mirror surfaces. The incident and reflected rays travel with the same velocity because they t rave 1 in the same medium.

3.1.3.2 The way in which an object reflects light is the most important characteristic as far as sight is concerned. The eye sees things only because of reflected light or recognizable variations of color, brightness and shadow.

3.1.3.3 When the eye sees a colored object, the characteristic of color results from selective reflection by the surface; in other words, some spectral energy waves are reflected while others are absorbed.

3.1.4 Diffusion. The term diffusion means the scattering of light in all directions (see figure 2). When light falls on a rough, unpolished surface, it is reflected in all directions and is called diffuse (irregular) reflection. The only essential difference between regular and diffuse reflection is that diffuse reflection takes place from an infinite number of infinitesimal plane surfaces oriented in all directions.

3.1.5 Transmission. The measure of the ability of a medium to transmit light is called its transmission factor or transmittance. Transmission of light through a material is affected by the reflection at each surface of the material and the absorption and reflection within the material (see figure 2).

3.1.5.1 Transparent materials such as clear glass or plastic permit the transmission of 80 to 90 percent of the incident light when it strikes normal to the surface; about 8 to 10 percent will be reflected at the surfaces, and the remainder absorbed and converted into heat. The amount of light reflected depends upon the angle of incidence, and may become a very high percentage for grazing angles.

3.1.5.2 Diffuse transmitting materials, such as those used for windows in lighting fixtures are often fairly dense with transmittances in the range of 55 to 70 percent. Overall efficiency of the fixture is often much higher than this because light not transmitted directly from the source is reflected and re-reflected, with partial transmission occurring each time. The determining factor in the efficiency of a diffusing enclosure, therefore, is not the transmittance of the material, but its absorptivity.

3.1.5.3 Transparent, clear, and colored materials are used for cover plates and similar devices to protect equipment or alter the color of light with little alteration of light distribution. These characteristics are particularly good where protection is required (from weather, and so forth) without destroying the beam control from reflecting contours.

3.1.6 Refraction. When a pencil or straw is placed in a glass of water and viewed at an angle, it appears to bend at the surface of the water. This phenomenon, called refraction, always occurs where light is transmitted from one medium to another in which the speed of light is different.

3.1.6.1 If the light enters the second medium at an angle other than perpendicular, the rays will be bent either toward or away from a normal to the surface depending on the relative speeds of light through the media. In passing from a medium in which its velocity is greater to one in which it is smaller, light is bent toward the normal; in passing from a medium in which its velocity is smaller to one in which it is greater, light is bent away from the normal. The ratio of the speeds of light in the two media is equal to the ratio of the indices of refraction of the media.

3.1.6.2 The ratio of the indices of refraction (n_1 and n_2) of any pair of media is related to the sines of the angles of incidence and refraction according to Snell's Law, in other words

$$\frac{n_1}{n_2} = \frac{\sin B}{\sin A} \qquad \text{Equation 2}$$

where A and B are the angles formed by the light ray and a normal to the surface of the transmitting medium (see figure 2).

3.1.7 Absorption. Absorption is the loss of energy that occurs when light rays strike an object and are dissipated in the form of heat. The amount of absorption depends on the nature of the object, the molecular construction, the wavelength or color of the incident light and the angle at which the light strikes an object. All objects do not absorb light of different wavelengths in the same proportion. This phenomenon accounts for the characteristic color of objects illuminated by either sunlight or artificial white light.

Ordinarily, the absorption of light by reflectors, shades, louvers, and baffles is considered a disadvantage because it reduces the lighting efficiency. In designing parts for lighting fixtures, it is usually desirable to choose a material or finish which will reflect and diffuse the light efficiently rather than one which will absorb nearly all the light or a considerable portion of it. However, using dark colors on such media is often the best method of controlling stray light or light which may be projected or reflected in undesirable directions.

3.1.7.1 The most important use of absorption in light control is in producing colored light from white light sources. A selective-color filter is placed between the white light source and the surface which is to receive colored light. This filter absorbs parts of the spectrum, and allows other parts to be transmitted.

3.1.7.2 When colored light is produced by using colored filters, the absorbed energy is converted into heat. Therefore, the temperature of a selective transmitting medium is higher than a clear transmitting medium would be if it were used in place of the selective filter.

3.1.8 Polarization. Ordinarily, light rays are considered to vibrate in all directions perpendicular to the direction of travel of the light. Light rays can be modified by polarization so that the vibrations are predominantly in one plane. This polarization of the direction of vibration can be caused by a variety of transmitting and reflecting media. Special polarizing plastic materials, transparent materials which have been internally stressed, and multilayers of glass or plastic are examples of man-made polarizing materials.

3.1.8.1 Polarized light is not reflected from specular surfaces the same as unpolarized light and can be used in the proper circumstances to reduce glare. It requires a polarized light source and a polarizing viewer. If the plane of polarization of the viewer is at right angles to the polarization of the light source, direct glare from the source, and reflected glare from a specular surface, can be markedly reduced. Irregular or diffuse surfaces have a depolarizing effect and do not lend themselves to this technique.

3.1.8.2 Another application of polarization is the variable control of the effective transmission of light by suitable combinations of polarizing media. When clear plastic models of mechanical parts are stressed to produce internal strains and are placed between a cross-polarizer viewer, the areas of equal strain in the material appear as visible color streaks or patterns. This characteristic has been effectively used in a device called a polariscope in which plastic mockups of actual metal parts are subjected to the type of stress encountered in their use. The points of greatest internal strain can be determined, and the design of the part can be modified where needed. Windows for lighting fixtures are also checked with a polariscope for stresses.

3.1.9 Color. As Previously stated, light of different colors, travels through space with the same velocity. Hence, in accordance with the fundamental equation of wave motion (see equation 1), the frequencies are different for different colors and are inversely proportional to their wavelengths as,

$$f = \frac{V}{\lambda}$$

Where:
f = frequency
v = velocity
λ = wavelength.

3.1.9.1 The impression of color depends on the frequency of light that is reflected or transmitted to the eye. The primary colors of light in the visible spectrum are red, green, and blue. Light of any one of these colors cannot be produced by combining light of any other color. However, light of any color other than these three can be produced by combining, in the proper proportion, light of any two or all three of the primary colors.

3.1.9.2 Objects absorb a certain amount of the light that falls on them, but all objects do not absorb the same proportion of light of different wavelengths. If all objects absorbed light in the same proportion, they would appear to have the same color. An object must be observed under white light for it to appear in its true colors. White light contains (in the proper proportion) all three primary colors.

3.1.9.3 If an object absorbs all or nearly all of the light that falls on it, the object appears black in color. If it absorbs all the green and blue portions of white light that fall on it, the object appears red in color because only the red light is reflected to the eye. In other words, only the reflected light is seen. Those components of the visible spectrum absorbed by the object are not seen.

3.1.9.4 An object appears in Its true colors only when the light falling on it contains light of the wavelengths that the object reflects or transmits. Thus, the light falling on a red object must contain red light for it to appear red in color. A red object observed under a light that contains only green and blue rays will appear black in color because the object absorbs the green and blue rays and reflects or transmits only red rays (which are not present).

3.2 Light and vision.

3.2.1 General. Basic to any planning of a lighting system is an understanding of the structure and function of the eye and the seeing process. A well designed lighting system plays a vital role in the ability to see. Therefore, the lighting system engineer must have an understanding of the mechanics of the eye and the way it operates in order to provide an adequate lighting system so that visual tasks can be performed with maximum speed, accuracy and comfort, and minimum effort and fatigue. The following does not intend to treat the eye from a medical point of view but rather from a point of view of its relation to lighting.

3.2.2 Light and how the eye sees. Although the eye is frequently compared to a camera (see figure 3), close examination shows it to be far more complex than the most sophisticated cameras. In simplest terms, the eye catches light rays reflected from objects, focuses these rays by means of a lens, senses the image by means of specialized nerve endings in the inner lining of the eyeball and transfers the image to the brain by means of the optical nerve.

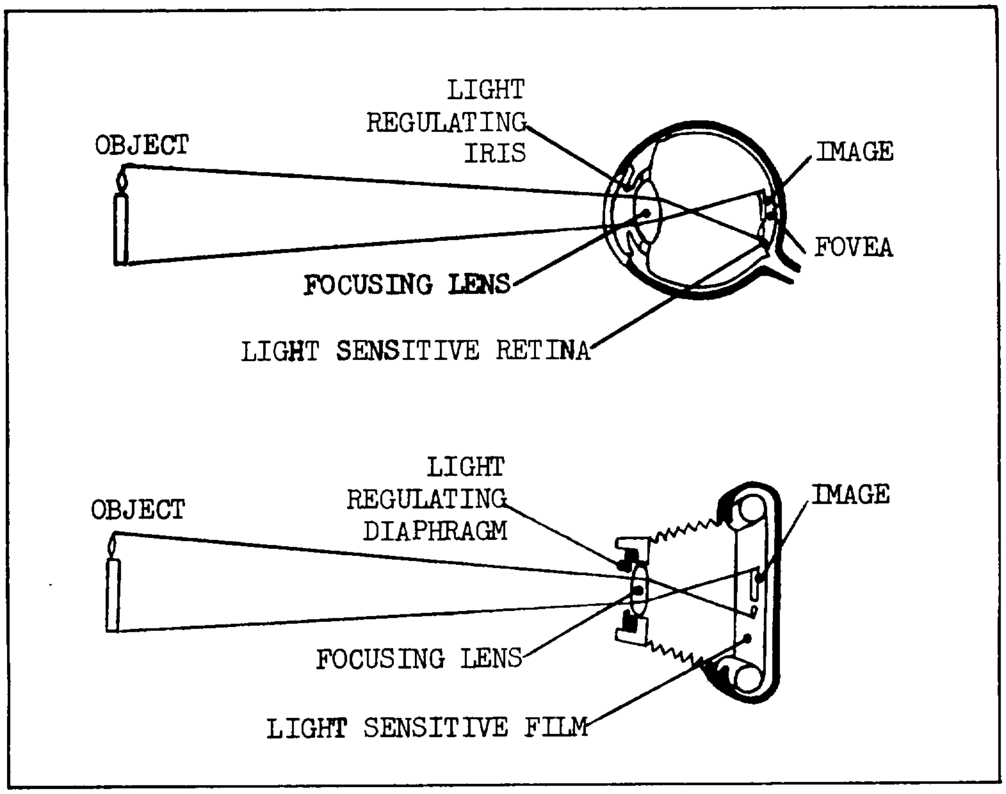

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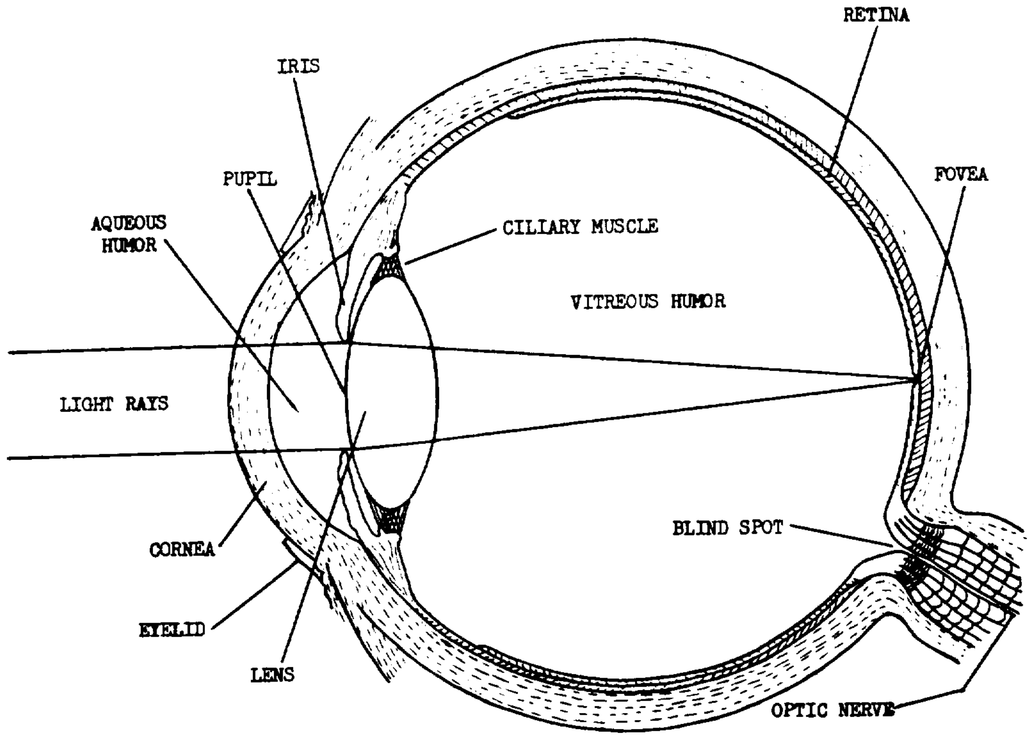
FIGURE 30 Similarities of the camera and the eye.

3.2.2.1 In detail, when electromagnetic radiations with wavelengths between 380 nm and 760 nm pass through the transparent protective outer layers of the eye, the cornea, they are bent or refracted; from the cornea they pass through the aqueous humor and through the pupil (see figure 4). The amount of light coming through is controlled automatically by the contraction or expansion of the pupil. Light passes through the pupil and through the lens, which focuses the rays through the vitreous humor and onto the retina. Here the cones and rods come into action. From this point on, the process is electrochemical. Pulsations are set up and are carried from the cones and rods to the optic nerve, which transmits them to the brain where they are interpreted as light or where they cause the sensation of vision. The brain and the eye cooperate in transforming radiant energy into the sensation of sight. Figure 4 shows the parts of the eye and a brief description of their relation to vision.



Eyelid--A flap of skin that Protects the eye, and under renditions of extremely high brightness helps to regulate he amount of light reaching it.

Cornea--A transparent portion of the outer membrane surroundlng the eye. It serves as part of the refractive system.

Iris--The colored (blue, brown) portion of the eye, which function as a dtaphragm, controlling the amount of light entering the eye.

Pupil--The opening in the center of the iris through which light enters the eye. The size of the pupil opening is controlled by the action of involuntary muscles.

Lens--A transparent capsule behind the iris whose shape can be changed in order to focus objects at various distances,

Ciliary Muscle--A ring-shaped muscle which adjusts he tension on the lens, thereby changing its curvature to focus near or distant objects.

Retina--The light-sensitive surface at the back of the eyeball. It contains a delicate film of nerve fibers branching out from the optic nerve, and ending in minute cone-red-rod-shaped structures.

Cones--The receptors in the retina which make possible the discrimination of fine detail and the perception of color. They are insensitive at low levels of illumination. The cones are found principally near the center of the retina, with the greatast concentration in the fovea, an area about 0.3 mm in diameter which is composed of cones alone. It is at the fovea that the eye involuntarily focuses the image of an object that must be examined in minute detail.

Rods--The receptors in the retina which are sensitive to low levels of illumination. They have no color response. Rods are found only outside the foveal region, increasing in number with distance from the fovea. The outer portions of the retina, composed chiefly of rods, do not afford distance vision, but are highly sensitive to movement end flicker.

Visual Purple (rhodopsin)--A purple liquid found in the rods. It is light-sensitive, and bleaches rapidly when exposed to light. Its regeneration is an important factor in dark adaption.

Blind Spot--The point on the retina where the optic nerve, which carries light impulses to the brain, enters the eye. At this point there are no rods and cones, and therefore a light stimulus gives rise to no sensation:

Aqueous humor--The aqueous humor is a water solution between the cornea and the iris.

Vitreous humor--The vitreous humor is found behind the lens and fills the remaining space in the eyeball, It is a jellylike mass. Its purpose is to work in conjunction with the lens to refract or bend light rays into the fovea (or near fovea region for night vision).

SH 964-4

FIGURE 4. The parts of the eye and their relation to vision.

3.2.3 Two kinds of vision. The rods and cones are responsible for two kinds of vision. The cones, concentrated in the fovea, function in bright light and are required for color vision. The rods, in the periphery of the visual field, function in dim light and respond only for black and white vision. Rods and cones have chemicals in them which are activated by light. When light falls on one of these nerve endings, the chemical in it is “bleached”, thus changing chemical composition and causing the nerve to send a signal from that point in the visual field to the brain.

3.2.3.1 Rods and cones contain different kinds of photosensitive chemicals that respond to different frequencies in the light spectrum. For instance, the cones see all frequencies in the visible spectrum, while the rods respond to all frequencies except those of red light. The rods report all these other frequencies of light as black, white, or shades of gray.

3.2.3.2 The rods are about a thousand times more sensitive to light than the cones. Cones will not respond to light much dimmer than moonlight, but the rods are sensitive to light only about a hundredth as bright as starlight. After a long exposure to very bright light, the chemical in the rods, known as visual purple, is bleached out, causing temporary night blindness. In the dark or in red light the visual purple rejuvenates itself with the help of vitamin A. It takes about 1/2 hour for complete restoration. Because of this chemical process, the dilation of the iris and change in the nerves, the dark-adapted eye is 100,000 times as sensitive as the light-adapted eye.

3.2.4 Accommodation. Accommodation is simply the process of adjustment of the crystalline lens by the ciliary muscles so that images viewed at different distances are focused directly on the retina. When an object is brought closer and closer to the eye, a Point is reached at which even the strongest contraction of the ciliary muscle will not result in a clear image of the object. The rays from it are so divergent that the refractive surfaces cannot bring them to a focus on the retina. Therefore, each luminous point that makes a diffusion point at which an object can be distinctly seen, with full accommodation, is called the near point. The distance between the near point and the eye increases with age, slowly in early life, most rapidly in the early 40s, and very slowly after 50. Recession of the near point is usually ascribed to a progressive loss of the plasticity of the lens, so that the lens is less and less capable of being molded into a more convex form. This change of accommodative power with age is called presbyopia, or old-sightedness.

3.2.4.1 In the normal eye, parallel rays are brought to focus on the retina from infinity. If large enough, objects at distances greater than 20 feet are seen distinctly without accommodation, in other words with the eye at rest. Practically, then, a distance of 20 feet is considered the far point of the normal eye.

3.2.5 Adaptation. Adaptation is simply the process of eye adjustment to respond to a tremendous range of illumination levels to which it is sensitive. It involves a change in the size of the pupil opening and a change in the photochemical substances of the retina. The size of the pupil opening is primarily a function of the amount of light received at the eye. In very dim light the pupil opens wide, but at higher illumination the opening becomes smaller. This is particularly apparent when going from a well-lighted area to a much darker one, or when a glaring light source comes within the range of vision. The retinal change involves a balancing of the rate of regeneration of the photochemical substances in the retina against the requirements of the eye for a given situation.

3.2.5.1 Dark adaptation. A person going from a brightly lighted area to a darkened area suffers an immediate impairment of vision. At first, the person can see little; gradually his eyes become dark-adapted and he can see more. The process of dark adaptation is substantially complete in 25 to 30 minutes, although it has been shown to continue for about 1-1/2 hours. Since the rods by which night vision is performed are relatively insensitive to red light, dark adaptation can be more easily acquired under low level red illumination while performing useful seeing tasks. This saves time. Furthermore, personnel can move back and forth between darkened areas with low level red illumination without serious temporary impairment of vision in either location. It should be noted that a person operating in low level red illumination is red-adapted, not dark-adapted. Red adaptation reduces the transition time to dark adaptation. One way to speed up the process of dark adaptation when bright lights are present is to wear red goggles for about 30 minutes prior to going into the dark. The red lens filters out all colors except red, and since the rods do not respond to red, they are as unaffected as if they were in the dark. Meanwhile, the cones are being used for vision. When the dark is entered and the goggles removed, cones will be ineffective but vision will be maintained with rods. Dark adaptation is a separate process in each eye. Since bright light quickly destroys night vision, the closing of one eye during exposure to a bright light at night will allow retention of half vision. In addition, if lights are necessary at night, use dim lights (red if possible) and use them sparingly.

3.2.5.2 Light adaptation. Light adaptation, the reverse of the process just discussed, is much more rapid than dark adaptation. In general, the eye can change from a state of complete dark adaptation to light adaptation in about 2 minutes. Nevertheless, vision may be so severely handicapped during this period of transition, particularly if the illumination is of high intensity, that the eyes are of little use.

3.2.6 Eye sensitivity curve. The eye is not equally sensitive to energy of all wavelengths, in other words, to all colors. The standard spectral luminous efficiency curve graphically indicates the relative ability of the eye to evaluate radiant energy at the various wavelengths in the visible spectrum. This curve is also called the eye sensitivity curve (see figure 5), which shows the Purkinje effect on the wave length of maximum sensitivity.

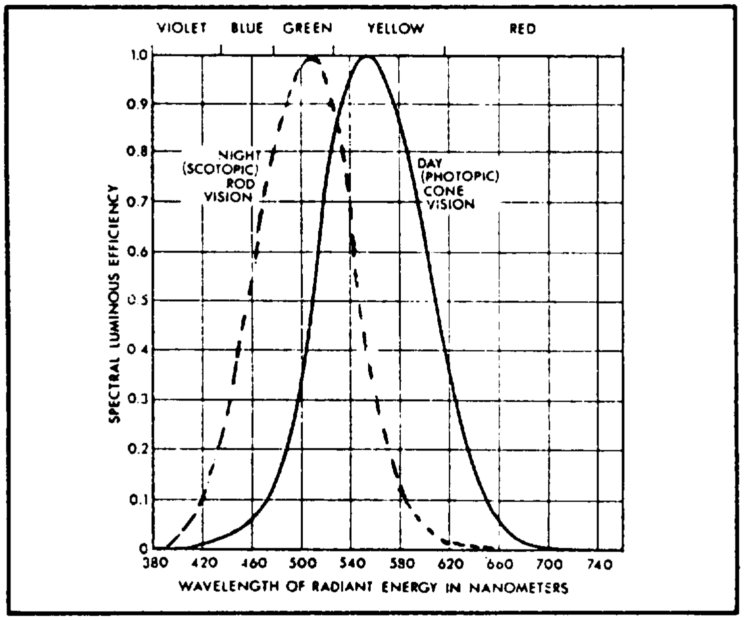


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FIGURE 5. Eye sensitivity curves for photopic (cone) and scotopic (rod) vision showing the Purkinje effect on the wavelength of maximum sensitivity.

3.2.6.1 Tests on a large number of observers have established an eye sensitivity curve which gives the response of the average eye to equal amounts of energy at the various wavelengths of light. The maximum sensitivity is in the yellow-green, at a wavelength of about 555 nm, and the sensitivity at the blue and red ends of the spectrum is very low by comparison. This means that approximately nine units of red energy at a wavelength of 650 nm are needed to produce the same visual effect, or brightness, as one unit of yellow-green. The eye sensitivity curve must always be taken into account in evaluating visible energy in terms of sensation.

3.2.7 Purkinje effect. The standard (photopic) eye sensitivity curve is based on "cone vision"- that is, ordinary daylight levels of illumination in which the cones are the visual mechanism involved. At very low levels of illumination, where the brightnesses are of the order of 0.001 footlambert or less, the cones no longer function and the rods take over the entire seeing process. In rod, or scotopic vision a new sensitivity curve becomes effective. The curve is the same shape as the photopic curve, but displaced 48 nm toward the blue end of the spectrum. This shift, which is known as the Purkinje effect, places the maximum sensitivity of the eye at 507 rather than at 555 nm (see figure 5).

3.2.7.1 The result is that in dim light, although vision is entirely colorless, the eye becomes very sensitive to energy at the blue end of the spectrum, and almost blind to red. Thus, if a beam of red light and a beam of blue light, of equal intensity at photopic levels, are reduced in the same ratio to the region of scotopic vision, the blue light will appear very much brighter than the red. The Implications of the Purkinje effect are important in lighting installations involving very low illumination levels, and failure to recognize them may lead to serious errors in the measurement of low brightness and candle-power values.

3.2.8 Visual field. When a person with a normal seeing apparatus looks at an object with both eyes at the same time, the visual fields of the two eyes intermesh as shown on figure 6.

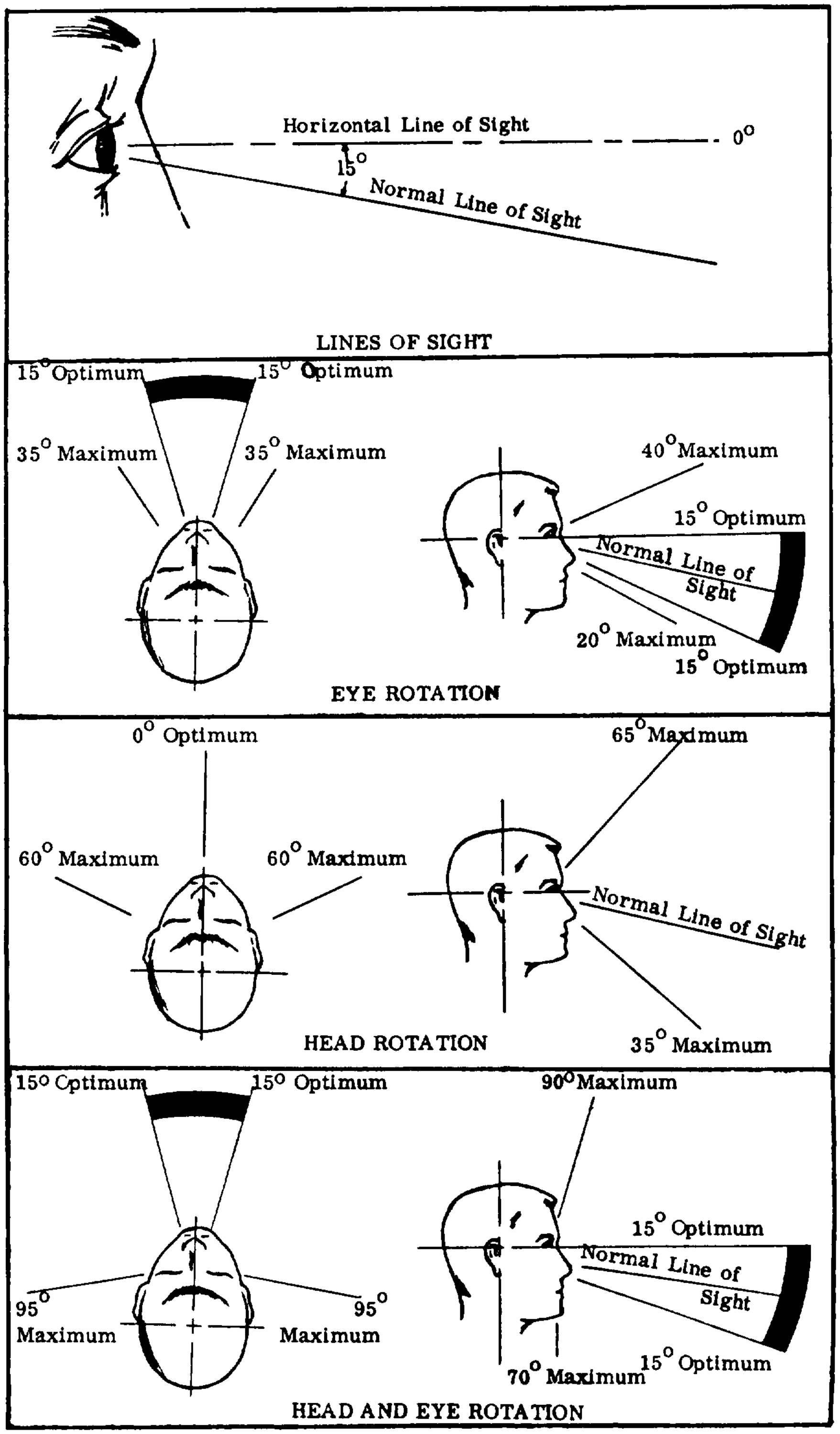

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FIGURE 6. Vertical and horizontal visual field.

3.2.8.1 The areas seen by the two eyes are not coextensive because a portion of the field of each eye is blocked off by the nose, eyebrow, and cheek. Thus, the visual field for both eyes includes more space than the field of either eye. The binocular field is that seen by both eyes simultaneously and is approximately 70 degrees.

3.2.8.2 The maximum visual field extends approximately 190 degrees in the horizontal plane and 160 degrees in the vertical plane, 90 degrees above the normal line of sight and 70 degrees below. The fovea, where most seeing and all discriminations of the fine details are done, subtends an angle of less than 1 degree at the center. The limits of what may be called the central field, that is, the visual task and its background, vary with the task. The surroundings are usually considered as extending from the outer limits of the central field to a circle approximately 30 degrees from the optical axis. At 30 degrees, visual acuity is only about 1 percent of its value at the fovea. Vision is very indistinct in the outer portions of the field beyond this angle, although changes in brightness or movement can be readily detected.

3.3 Principal factors affecting vision.

3.3.1 Physiological factors. Seeing is a complex process involving many variable factors. The physical construction and the age of the eyes, the extent to which optical errors are corrected, the degree of nervous tension, the potency and nature of distractions competing for the attention of the observer, and many other physiological and psychological factors combine to determine how well an individual will see under given circumstances. The four most common causes of defective vision are as follows (see figure 7):

(a) Astigmatism (the inability to bring horizontal lines and vertical lines into focus at the same time). The focal length of the astigmatic eye is different in two planes at right angles to one another. This condition results from irregularities in the curvature of the cornea and the lens.
(b) Myopia (nearsightedness). The focal length of the myopic eye is too short, and parallel light rays focus in front of the retina, rather than sharply on it. The nearsighted person sees near objects clearly, but distant ones appear blurred.
(c) Hypermetropia (farsightedness). Here the focal length of the eye is too great, and the focal point for parallel rays is behind the retina. The farsighted person cannot see close objects clearly.
(d) Presbyopia (loss of accommodating power of the lens). In middle and old age the lens becomes progressively less elastic, and the process of accommodation for near vision is more and more difficult. The result is a condition similar to farsightedness.

All four of these visual defects can usually be corrected by properly fitted eye glasses.

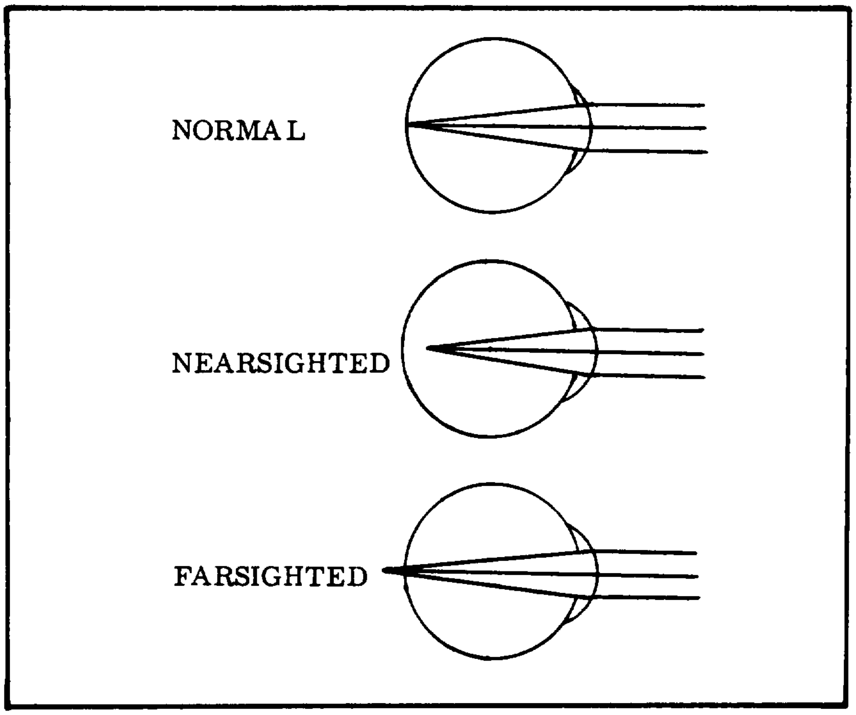

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FIGURE 7. Normal, nearsighted, and farsighted eye.

3.3.2 Physical factors. More easily appraised than the intangible internal factors are the external factors affecting the visibility of any object. These are size, brightness, contrast, and time (see figure 8).

(a) Size. Visual size is usually expressed in degrees and refers to the angle at the eye subtended by an object. Thus, the visual size of an object depends upon its actual size and its distance from the observer. The smallest object that can be seen by the normal eye, under the most favorable conditions, will subtend an arc of slightly less than 1 minute. In general, the larger the visual size of an object, the greater its visibility. Visual acuity, expressed as the reciprocal of the visual angle in minutes, is a measure of the smallest detail that can be seen. Since visual acuity increases markedly with increase in illumination, light is sometimes said to act as a "magnifier", making visible small details that could not be seen with less light.

(b) Brightness. Seeing occurs when light emitted or reflected from objects in the field of view enters the eye and is focused on the retina. As the amount of light entering the eye is increased, the visual sensation becomes strong (the scene or object looks brighter). The brighter an object, the greater is its visibility. A white surface will have a much higher brightness than a black surface receiving the same illumination. However, by adding enough light to a dark surface it is possible to make it as bright as a white one. The darker an object or a visual task, the greater the illumination necessary for equal brightness and, under like circumstances, for equal visibility.

(c) Contrast. If there were no graduations in brightness or color, the eye would be unable to distinguish objects from their background. Contrast is necessary not only to enable the eye to detect the presence, size and shape of objects, but also to reveal every detail that can be seen. In general, it can be said that visibility Improves as contrast is increased. Thus, for example, other things being equal, black print on white paper is easier to read than black print on gray paper because the former combination represents the greatest attainable brightness contrast in ordinary printing between object of interest and background. The difference in the visual effort required to read the two halves of figure 8(c) is a simple demonstration of the effectiveness of contrast. High levels of illumination partly compensate for low brightness contrasts, and are of great assistance where poor contrast conditions cannot be avoided.

(d) Time. The eye cannot register an accurate image if the time available for seeing is too short. Here again, the camera may be used for illustration: A picture can be taken in very dim light if the exposure is long enough, but for a fast exposure a great deal of light is necessary. The eye can see very small details under low levels of illumination, if sufficient time is allowed and eyestrain is ignored. But more light is required for quick seeing.

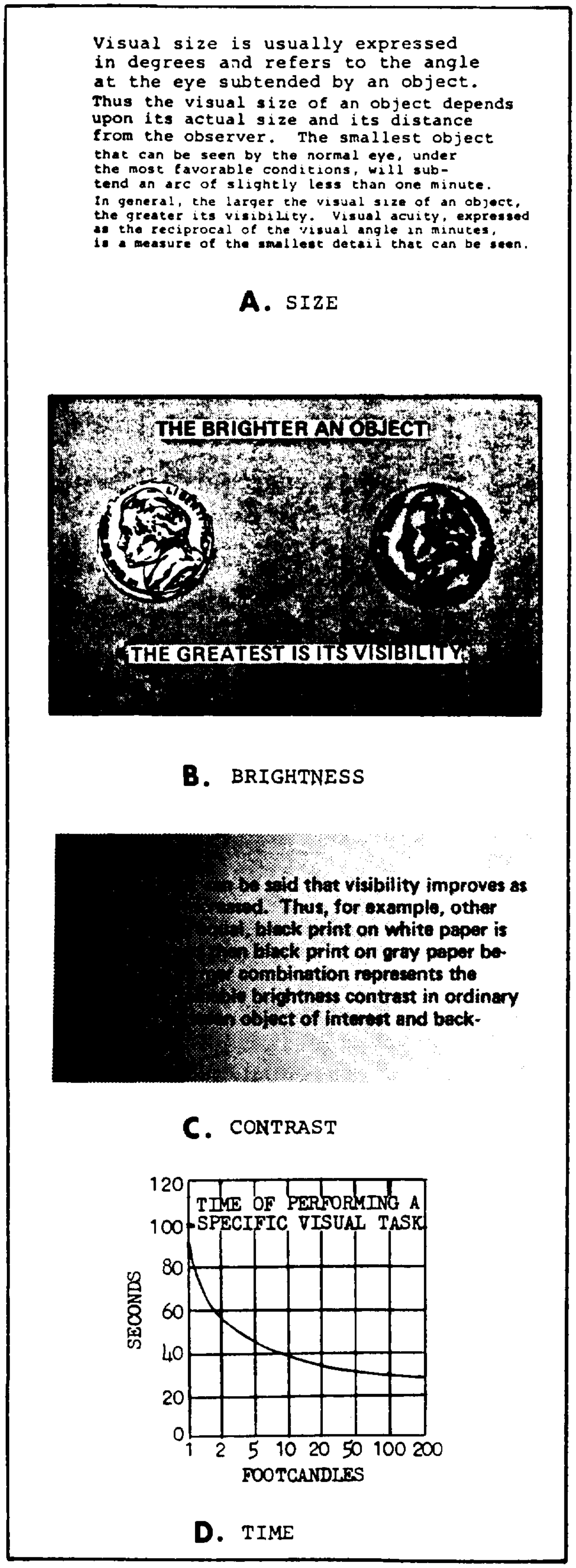

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FIGURE 8. External factors affecting vision.

3.3.2.1 Figure 8(d) illustrates the way in which the speed of performance of a specific visual task increases with increased illumination. Since human muscular activity has a definite limit, it is logical to find the curve leveling off as that limit is approached. However, the attainment of maximum speed does not preclude the possibility that the benefits of greater illumination may continue to be realized, beyond that point, in the form of less nervous energy required to perform the task. The time factor is particularly important where the visual object is in motion. High lighting levels actually make moving objects appear to move more slowly, and greatly increase their visibility.

3.3.2.2 Size, brightness, contrast, and time are mutually interrelated and interdependent. Within limits, a deficiency in one can be made up by an adjustment in one or more of the others. In most cases, size is a fixed factor of the visual task, with brightness, contrast, and time subject to some degree of modification. Of these, brightness and contrast are usually most directly under the control of the illuminating engineer. Properly employed, they can be a tremendous aid in overcoming unfavorable conditions of small size and limited time for seeing.

3.3.3 Illumination levels. The human eye is sensitive to light over a tremendous range of intensities. While there is honest difference of opinion as to what levels of illumination may be considered best for various seeing tasks, it is generally agreed that the best values are often higher than practical limitations imposed by space, bulk and weight of fixtures, the available power supply, heat generated, cost and various other considerations arising from the particular applications involved. On shipboard these limitations are particularly stringent; hence, lighting on naval ships should not be appraised only by criteria that apply to installations ashore.

3.3.3.1 The brightness of any object of given reflectivity depends upon the amount of illumination falling on it. Generally, for any specific seeing task the size of the critical detail that must be seen, the degree of contrast and (where there is motion) the time available for seeing are factors determined by the nature of the task. Differences in visibility as affected by the factors of size, contrast, and time may be compensated for by varying the illumination as necessary. This is the chief reason why all areas below decks on shipboard are not illuminated to the same value. The lighting is provided as required by the difficulty of the seeing task that must be performed in each area.

3.3.3.2 Once a lighting installation is made, it may appear that the illumination becomes a fixed rather than a controllable factor. This is largely true when there is no choice in locating or positioning the work but not when the location and position of the seeing task may be selected at will. It iS natural to move closer to the light source when seeing is difficult, and when this is done, improvement in visibility usually results. When the seeing task is prolonged for any appreciable length of time, however, improvement in visibility is not the only consideration to be borne in mind. It is also necessary to take into account the quality of the lighting as affected by glare and background illumination.

3.3.4 Glare. Glare is light that hinders rather than aids vision. It may come from an exposed light source in the field of view (direct glare) or from some shiny surface that reflects a bright source of light toward the eye (reflected glare, veiling reflections). In either case, glare is objectionable. At best It is unpleasant , and at worst it can cause eyestrain, headache, and fatigue.

3.3.4.1 Many Navy lighting fixtures provide some protection against direct glare from the normal viewing angles, but in some locations it is impossible to mount the fixtures so no glare is in the field of view. Other fixtures have no shielding at all. On a naval ship, it is more important for the lighting fixtures to be simple and rugged and provide the essential illumination than to produce only comfortable illumination. The best protection against the harmful effects of glare on a naval ship is the realization by all hands that prolonged exposure to glare should be avoided. Usually, it is possible to position the seeing task and to locate oneself in respect to it so that direct glare or uncomfortably bright reflected glare is not seen.

3.3.5 Background illumination. The quality of the lighting is affected by the ratio of the illumination on the task to the illumination on the surroundings. The eyes do not remain constantly fixed on any task until it is completed. Instead, they frequently glance up from the work for a moment or two, often involuntarily. If the brightness of the surroundings is greatly different from the brightness of the task area, the pupils of the eyes, which automatically accommodate to the amount of light entering the eye, must make an adjustment every time the eyes glance away from, and back to, the task. The muscles of accommodation are not likely to be overworked if the ratio of brightnesses of the task area to the surroundings does not exceed those specified in 4.3.2.5. If the ratio is substantially greater than this, eye fatigue will result if the work is continued for an extended period. This explains why high levels of supplementary lighting at work points do not produce comfortable lighting when the background is not adequately illuminated.

3.4 Terminology and lighting equations.

3.4.1 Lighting terms. Lighting terminology is not difficult to understand; however most people have difficulty remembering the difference between a footcandle and a footlambert or between illuminance and luminance because of the many different terms used to describe the same item. Despite the fine effort of several standards committees, there exists disagreement as to some exact definitions of lighting terms. For the purpose of this publication, the following concepts will be used:

3.4.1.1 Luminous flux. Luminous flux is the time rate of the flow of light and indicates the intensity of a source. The unit of flux is the lumen. Light is actually a form of radiant energy in motion. In ordinary practice, however, the time element can be neglected and luminous flux is only considered as a definite quantity.

3.4.1.2 Candlepower (luminous intensity). Candlepower is the luminous flux per unit solid angle in a given direction. The following are used in connection with candlepower:

(a) The unit of luminous intensity is the candela. The value of the candela is determined by the light emitted by a laboratory device called a "blackbody" operating at a specified temperature and pressure. (In 1964, the U.S. Congress officially changed the unit of luminous intensity from the candle to the candela. The difference between the candela and the old candle is so small that only measurements of high precision are affected.) An ordinary wax candle has a luminous intensity in a horizontal direction of approximately 1 candela.

(b) The candlepower of a uniform light source is the same in all directions about the light source, but the candlepower of most light sources varies somewhat in different directions.

(c) Candlepower measured around a light source in a horizontal plane is known as horizontal candlepower. The average candlepower in this plane is called mean horizontal candlepower.

(d) The average candlepower in all directions about the light source is the mean spherical candlepower. Unless otherwise stated, the candlepower rating of a lamp is regularly given in mean spherical candlepower.

(e) Beam candlepower refers to the candlepower in the beam of a directional light source such as a searchlight. The candlepower is almost never constant over the cross section of the beam. Beam candlepower ratings give the maximum candlepower in the beam.

(f) The luminous intensity of a source expressed in candelas is its candlepower. Candlepower is used not only to indicate the luminous intensity of a source in one particular direction, but measurements taken at various angles around a source can be plotted and used to develop a candlepower distribution curve. Such a curve shows luminous intensity in any direction and from it illumination calculations can be made (see 3.5.1.1).

3.4.1.3 Lumen. The lumen is the unit of luminous flux. A lumen is the light flux falling on a surface 1 square foot in area, every part of which is 1 foot from a point source having a luminous intensity of 1 candela in all directions. Such a surface is a 1 square foot section of a sphere of 1 foot radius, with a 1 candela uniform point source at its center. The same concept may be expressed by saying that a lumen is the light flux emitted in one unit solid angle by a 1 candela uniform point source. The lumen is used to express a quantity of light flux; total output of a source, output within a specified angular zone, amount of light reflected, absorbed or transmitted by an object, amount of light incident on a surface, and so forth. The beam-lumen method of predicting illumination levels (see 3.5.3.4) is based on the lumen outputs of sources and the distribution of flux within the area.

3.4.1.3.1 The lumen output of any light source is four times its mean spherical candlepower, in other words;

$$\text{Mean spherical candlepower} = \frac{\text{Lumen output}}{12.57} \qquad \text{Equation 3}$$

(Since a sphere of l-foot radius has a surface area of 4π (12.57) square feet, a uniform point of 1 candela must produce 12.57 lumens. The same relationship exists between the mean spherical candlepower of any source and its total lumen output.)

3.4.1.4 Illumination (illuminance). Illumination can be defined as the density of luminous flux incident (falling) upon a surface. A typical unit is the footcandle which is equal to the illumination falling on a surface 1 foot from a l-candlepower source. One footcandle is equal to 1 lumen per square foot. A meter-candle equals the illumination falling on a surface 1 meter from a l-candlepower source, or 1 lumen per square meter.

3.4.1.5 Footcandle. The footcandle is the most commonly used unit of illumination. It is the illumination produced on a surface all points of which are at a distance of 1 foot from a uniform point source of 1 candela. It iS also the illumination on a surface on each square foot of which there is a uniformly distributed amount of light equal to 1 lumen. From the definition of a lumen it is obvious that 1 lumen uniformly distributed over 1 square foot of surface produces an illumination of 1 footcandle.

$$\text{Footcandles incident on a surface} = \frac{\text{Lumens}}{\text{Area (sq. ft.)}} \qquad \text{Equation 4}$$

Footcandle readings are used to indicate the illumination at a specific point, or the average illumination on a surface. The inverse square law is the basis of calculation in the point-by-point method of lighting design (see 3.4.2.3 and 3.5.2.1).

3.4.1.6 Brightness (luminance). Brightness is the photometric brightness of an illuminated surface. (The technical term is “photometric brightness” or “luminance”. In informal usage, “brightness” is often adequate.) A surface emitting or reflecting light in a given direction at the rate of 1 candela per square inch of projected area has a brightness in the direction of 1 candela per square inch. A surface which has a brightness in a given direction equal to the uniform brightness of a perfectly diffusing surface emitting or reflecting 1 lumen per square foot has a brightness in that direction of 1 footlambert. The footlambert is also the average brightness of any surface emitting or reflecting 1 lumen per square foot (see 3.4.3 for basic equations). A lambert is the brightness of a surface emitting or reflecting 1 lumen per square centimeter. Brightness is expressed in two ways, in candelas per unit area, or in lumens per unit area. Relatively high brightness, such as those of light sources, are usually expressed in terms of candelas per square inch. Since the brightness (in footlamberts) of a matte surface can be calculated by multiplying the illumination in footcandles by the reflectance (see fundamental equations), the footlambert is a very convenient unit in which to express the brightness of illuminated surfaces.

3.4.1.7 Footlambert. The footlambert is perhaps the most convenient of the several units used to express brightness. It is equal to the uniform brightness of a perfectly diffusing surface emitting or reflecting 1 lumen per square foot, or to the average brightness of any surface emitting or reflecting 1 lumen per square foot. The average brightness in footlamberts of any reflecting surface, therefore, is the product of the illumination in footcandles by the reflection factor of the surface.

3.4.1.8 Reflection factor (reflectance). The reflection factor of any surface is the ratio of the light reflected by the surface to the light falling upon it. If all of the illumination falling on a perfectly diffusing surface were re-radiated by the surface, then the brightness would numerically equal the illumination. But, since this does not happen, the reflection factor of the surface must be accounted for.

$$\text{Reflection factor (K)} = \frac{\text{Reflected light}}{\text{Incident light}} \qquad \text{Equation 5}$$

Thus brightness equals illumination multiplied by the reflection factor. A typical unit of brightness is candelas per square foot. Expressed mathematically,

$$B = \frac{KE}{\pi} \qquad \text{Equation 6}$$

where B is the surface brightness in candelas per square foot, E is footcandles incident, and K is the reflection factor. To avoid having to divide by π all the time, the footlambert was invented. It is defined as $1/\pi$ candelas per square foot. Thus the above relationship becomes

$$B_L = KE \qquad \text{Equation 7}$$

and B_L is now expressed in footlamberts.

3.4.1.9 Transmission factor (transmittance). The transmission factor of a medium is the ratio of the light transmitted by the medium to the light falling upon it. In a formula, this can be expressed as:

$$\text{Transmission factor (T)} = \frac{\text{Transmitted light}}{\text{Incident light}} \qquad \text{Equation 8}$$

3.4.2 Lighting laws and equations.

3.4.2.1 Inverse square law. The inverse square law states that the illumination (E) at a point on a surface varies directly with the candlepower (I) of the source, and inversely as the square of the distance between the source and the point. If the surface at the point is normal to the direction of the incident light, the law may be expressed as follows:

$$E = \frac{I}{D^2} \qquad \text{Equation 9}$$

Where:

E = illuminance in footcandles or metercandles
I = intensity of source in candlepower
D = distance of the surface from the source in either feet or meters.

This equation holds true within 1/2 percent when D is at least 5 times the maximum dimension of the source as viewed from the point on the surface. For short distances, the illumination varies approximately inversely as the distance. For example, if the source of figure 9 were a 24-inch fluorescent tube, the illumination at 2 feet would be approximately one-half that at 1 foot; at 3 feet, it would be approximately one-third. Similarly, illumination can be calculated by:

$$E = \frac{F}{A}$$ Equation 10

Where:

F = incident flux in lumens
A = area of illuminated surface

This formula applies only when the area is illuminated evenly. Figure 9 shows diagrammatically a point source of light which produces 1 candlepower in all directions that intersect the surface shown. The illumination on any surface perpendicular to the rays from the light source is inversely proportional to the square of the distance from the source, 1 footcandle at 1 foot, 1/4 footcandle at 2 feet, 1/9 footcandle at 3 feet and so forth. This relationship follows from the fact that the total amount of light in the cone of light is the same at all distances from the source , while the surface over which it is spread increases with the square of the distance. Consequently, the illumination, which is the amount of light per unit of surface, is inversely proportional to the square of the distance. At any distance from the source, the illumination is directly proportional to the candlepower. Note that while the candlepower is the same in all directions about a theoretical uniform light source, the candlepower distribution of lamps and fixtures is non-uniform.

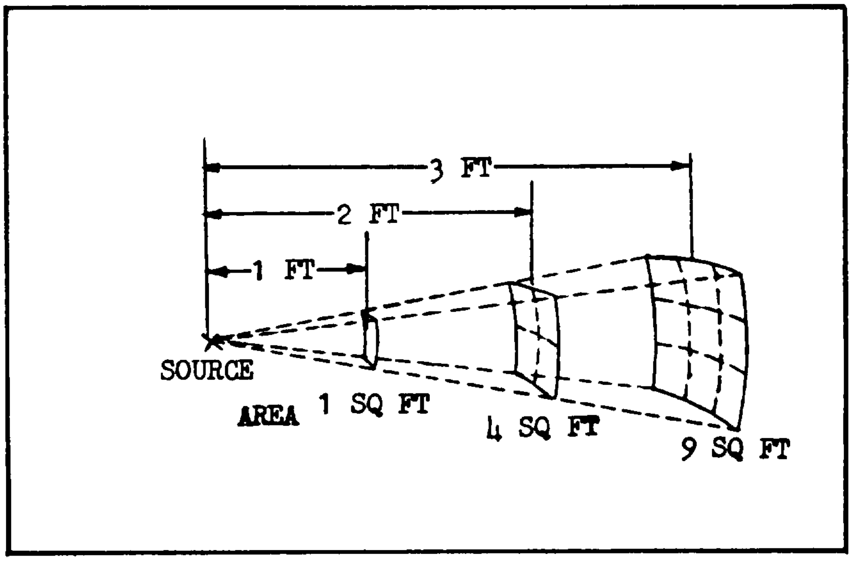

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FIGURE 9. Illumination on a normal plane.

When calculating the illumination produced in any given direction, it is necessary to use the candlepower in that direction. The inverse square law is used to calculate the amount of illumination from an individual light source on planes perpendicular to the beam. Strictly speaking, it applies only to illumination on a small surface from a point source. In practice, however, a point source is considered to be one whose dimensions are negligible compared with its distance from the surface.

3.4.2.2 Cosine law. The cosine law states that the illumination of any surface varies as the cosine of the angle of incidence. Thus, the illumination on a tilted plane is equal to the illumination on a normal (perpendicular) plane times the cosine of the angle of incidence. The angle of incidence θ is the angle between the normal to the surface and the direction of the incident light. The inverse-square law, and the cosine law, can be combined as follows:

$$E = \frac{I}{D^2} \cos\theta \qquad \text{Equation 11}$$

When a surface is not perpendicular to a beam of light, the illumination on it is less because the light is spread over an area of greater size. Figure 10 shows diagrammatically the distribution of light flux striking a surface at angles other than normal. The ratio of the base of a right-angle triangle to its hypotenuse is the cosine of the angle ABC. For 60 degrees, the ratio is one-half of 0.5. The average light on a surface tilted at this angle is one-half of that on the surface normal to the beam of light (the tilted surface is twice as large). As shown on figure 10, the width of the tilted surface is the same as the width of the perpendicular surface, but its length and area are increased depending upon the angle of tilt. If θ equals 60 degrees (cosine 60 degrees equals 1/2) then the tilted area is twice as large from that of the perpendicular area and the average illumination on it is therefore half as much.

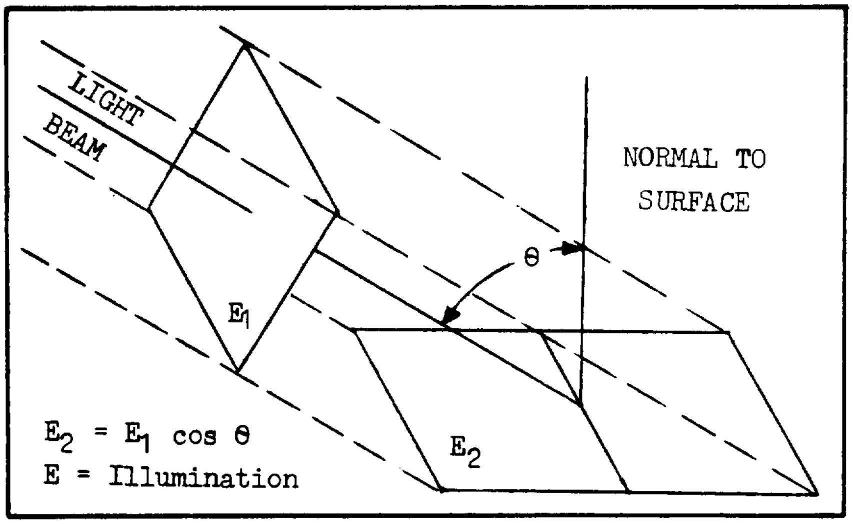

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FIGURE 10. Illumination on a tilted plane.

3.4.2.3 Cosine-cubed law. A useful extension of the cosine law is the "cosine-cubed" equation (see figure 11). By substituting H/cos θ for D, the cosine law equation may be written.

$$E = \frac{I\cos^3 \theta}{H^2} \qquad \text{Equation 11a}$$

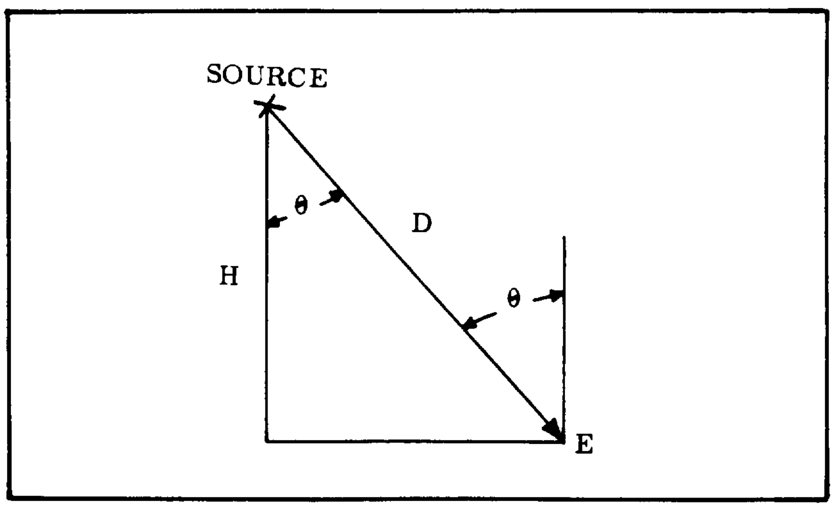

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FIGURE 11. The cosine-cubed law explaining the transformation of the formula.

3.4.3 Conversion factors. Tables I and II provide conversion factors for the most commonly used lighting terms.

TABLE I. Illumination conversion factors.

(Illumination incident upon a surface)

	Footcandles	Meter-candles	Lumens/ft^2	Lumens/meter^2 (lux)
Footcandles	1	10.764	1	10.764
Meter-candles	0.0929	1	0.0929	1
Lumens/ft^2	1	10.764	1	10.764
Lumens/meter^2	0.0929	1	0.0929	1

1 lumen = 1/673 lightwatt
1 lumen-hour = 60 lumen-minutes
1 footcandle = 1 lumen/ft^2
1 watt-second = 10^7 ergs
1 phot = 1 lumen/cm^2
1 lux = 1 lumen/m^2 = 1 metercandle

TABLE II. Brightness conversion factors.

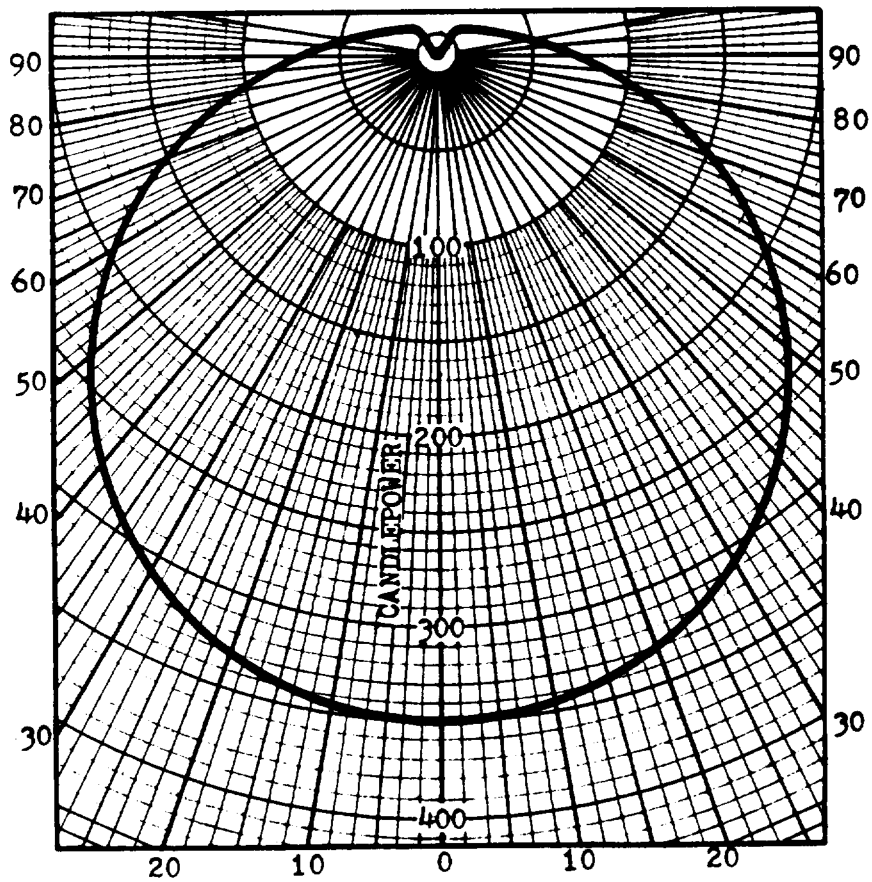
	Candelas/foot^2	Candelas/meter^2	Footlamberts	Apostllbs	Lamberts (lumens/cm^2)
Candelas/foot^2	1	10.764	π	10.764	$\frac{\pi}{929}$
Candelas/meter^2	0.0929	1	0.0929π	π	π x10^{-4}
Footlamberts	$\frac{1}{\pi}$	$\frac{10.764}{\pi}$	1	10.764	10.764x10^{-4}
Apostilbs	$\frac{0.0929}{\pi}$	$\frac{1}{\pi}$	0.0929	1	10^{-4}
Lamberts (lumens/cm^2)	$\frac{929}{\pi}$	$\frac{10^4}{\pi}$	929	10^4	1

1 nit = 1 candela/m^2
1 stilb = 1 candela/cm^2
1 apostilb (international) = 0.1 millilambert = 1 blondel
1 apostilb (German Hefner) = 0.09 millilambert
1 lambert = 1000 millilamberts = 929 footlamberts
1 candela/sq. in. = 452 footlamberts

3.5 Lighting calculations.

3.5.1 Distribution curves. Each type of lighting fixture that consists of more than a pendant socket alters the distribution and intensity of the light produced by the lamp used in it. A clear glass globe absorbs a small percentage of the light without appreciably changing its distribution. A diffusing lens or a glass globe absorbs more light and tends to smooth out variations in the spherical distribution of the light produced by the lamp. Colored glass also absorbs a percentage of the light emitted by the lamp. A reflector intercepts light that is traveling in a direction in which it is not needed and redirects it to where it will be useful, thus building up the candle-power in certain directions and increasing the illumination over a limited area. In making lighting calculations, therefore, it is necessary to know the light distribution of the particular lamp and lighting fixture combination that is to be used. This distribution of light can be represented either graphically or numerically (see appendix A) by several methods, the most common of which are explained as follows:

3.5.1.1 Candlepower distribution curve. A candlepower distribution curve is developed by taking candlepower measurements at various angles around a lighting fixture and plotting them, in graph form, on the polar coordinates. The distance of any point on the curve from the center indicates the candlepower of the lighting fixture in that direction. The illumination received from a single lighting fixture on any given surface can be calculated from candlepower distribution data of the lighting fixture. A candlepower distribution curve of a typical Navy-type lighting fixture (symbol 77.4) is shown on figure 12. The candlepower in any direction is given by the length of the line drawn in that direction from the light source to the curve. For example, figure 12 shows that this fixture delivers approximately 350 candlepower directly beneath the light (O degrees) and about 329 candlepower at an angle of 20 degrees from the vertical.



SH 964-12

FIGURE 12. Candlepower distribution for symbol 77.4.

3.5.1.1.1 Calculation of illumination. Using the inverse square law and given a mounting height of 4 feet from the lighting fixture to the working plane, the illumination at the working plane can be calculated as follows:

(a) Directly beneath the light using equation 9:

$$E = \frac{I}{D^2} = \frac{350}{4^2} = \frac{350}{16} = 22 \text{ footcandles}$$

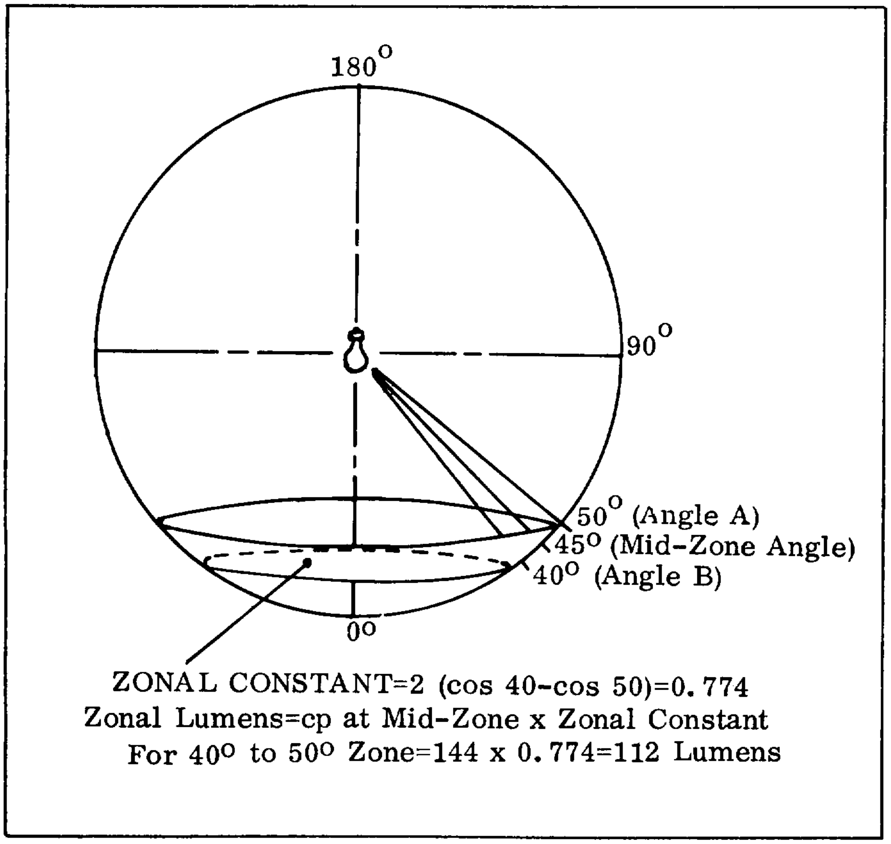
(b) At an angle of 20 degrees using equation 11:

$$E = \frac{I \cos}{D^2} = \frac{(329)\ (\cos 20°)}{4^2} = \frac{(329)\ (.939)}{16} = 19.3 \text{ footcandleg}$$

3.5.1.1.2 Lumen output calculation. Where the candlepower distribution is symmetrical about an axis, the light output of the source in terms of lumen can be obtained from an average candlepower distribution curve. Determination of the total lumen output of a lighting fixture is essential in calculating such factors as efficiency of the lighting fixture, percent of light in various zones, and coefficients of utilization. To make lumen calculations from candlepower data, it is convenient to work by zones on the inside of a spherical surface. The lighting source is considered to be at the center of an imaginary sphere whose inner surface will be illuminated by the light flux given off by the source.

3.5.1.1.2.1 The area of a sphere of l-foot radius is 4 square feet. Therefore, the numerical value of the zonal constant is equal to the area of the zone on such a unit sphere. This permits calculating the constants without considering any particular radius for the imaginary sphere enclosing the light source.

3.5.1.1.2.2 The area of a zone can be determined from the formula: Area of zone - 2 R^2 (COS A - cos B), where R disappears for a sphere of unit radius. A and B are the angular limits of the zone as shown on figure 13. This area, or subdivision of the entire sphere, is the zonal constant for the zone between angles A and B.



SH 964-13

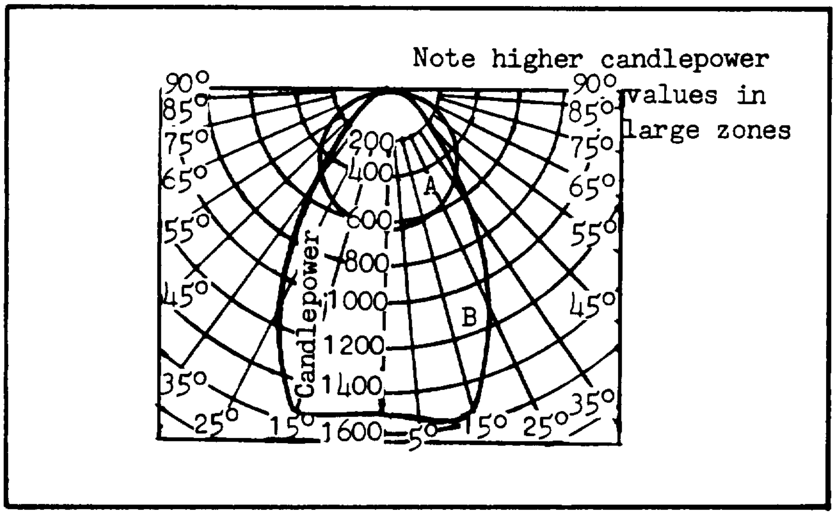
FIGURE 13. Sphere divided into 10-degree zones.

3.5.1.1.2.3 The total lumen output of the source is determined by adding the zonal lumens from O to 180 degrees. The candlepower curve is divided into equal zones, usually of 10 degrees each, and the average candlepower for each zone (ordinarily the value at the center of the zone) is multiplied by a factor which converts it directly to the number of lumens in the zone. Table III lists zonal constants for lo-degree zones and also shows how total lumens are calculated for symbol 77.4. The candlepower for symbol 77.4 is shown on figure 12.

TABLE III. Computation of lumens from candlepower values for symbol 77.4.

Angle	Candlepower	Zone	Zonal constant	Zonal lumens
0	350			
5	348	0-10	.10	34.8
15	338	10-20	.28	94.6
25	320	20-30	.46	147.2
35	292	30-40	.63	183.9
45	254	40-50	.77	195.7
55	213	50-60	.90	191.7
65	162	60-70	.99	160.4
75	137	70-80	1.06	145.2
85	73	80-90	1.09	76.6
90	58			
95	46	90-100	1.09	50.1
105	35	100-110	1.06	37.1
115	27	110-120	.99	26.7
125	21	120-130	.90	18.9
135	12	130-140	.77	9.2
145	4	140-150	.63	2.5
155	3	150-160	.46	1.9
165	2	160-170	.28	.6
175	1	170-180	.10	.1
Total lumens output				1380
Total lumens input (2 lamps 1030 lumens each)				2060
Efficiency = $\frac{\text{Lumens output}}{\text{Lumens input}} \times 100$				67 percent

Because equal angular zones on the surface of an imaginary sphere surrounding the source are much greater in area near the equator than near poles, a given candlepower produces many more lumens at an angle near the center of the curve than at an angle near the top or the bottom. Because of these angular relationships, the area (see figure 14) within a distribution curve is by no means a measure of the total light output of the source. Two units which produce exactly the same number of lumens may distribute the light quite differently, and have a candlepower curve of entirely different shapes and areas.



SH 964-14

FIGURE 14. Curves showing units emitting the same total lumens.

3.5.1.1.2.4 Most of the Navy standard lighting fixtures have symmetrical candlepower distribution. This distribution is represented by a single curve in the military specifications for lighting fixtures. The output of a non-symmetric (asymmetric) lighting fixture is determined by computing the weighted average of candlepower readings taken in a number of planes. For these lighting fixtures, candlepower readings are taken in three planes: O degrees, 45 degrees, and 90 degrees. The average candlepower is computed by adding the candlepower values in planes O degrees and 90 degrees plus twice the value in plane 45 degrees and dividing this sum by 4.

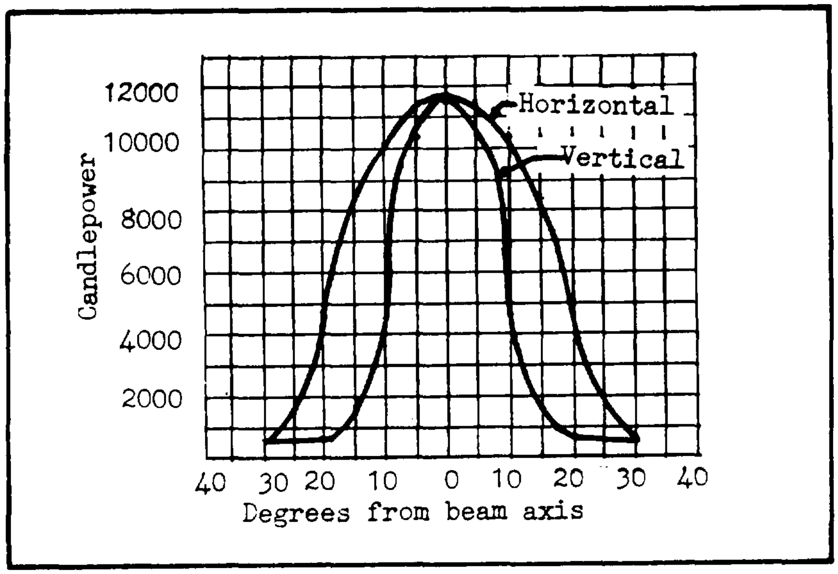
3.5.1.1.3 Lighting fixture efficiency. Lighting fixture efficiency is the ratio, expressed in percent, of the total lumens emitted by the lighting fixture to the total lumens generated by the bare lamps.

$$\text{Efficiency} = \frac{\text{Lumens of lighting fixture (output)}}{\text{Lumens of bare lamps input}} \qquad \text{Equation 12}$$

From table III the total lumens for symbol 77.4 are 1380. Since symbol 77.4 consists of two 20-watt cool white fluorescent lamps each producing 1030 lumens, the efficiency at symbol 77.4 then equals:

$$\text{Efficiency} = \frac{1380}{(2)\ (1030)}\ 100 = 67 \text{ percent}$$

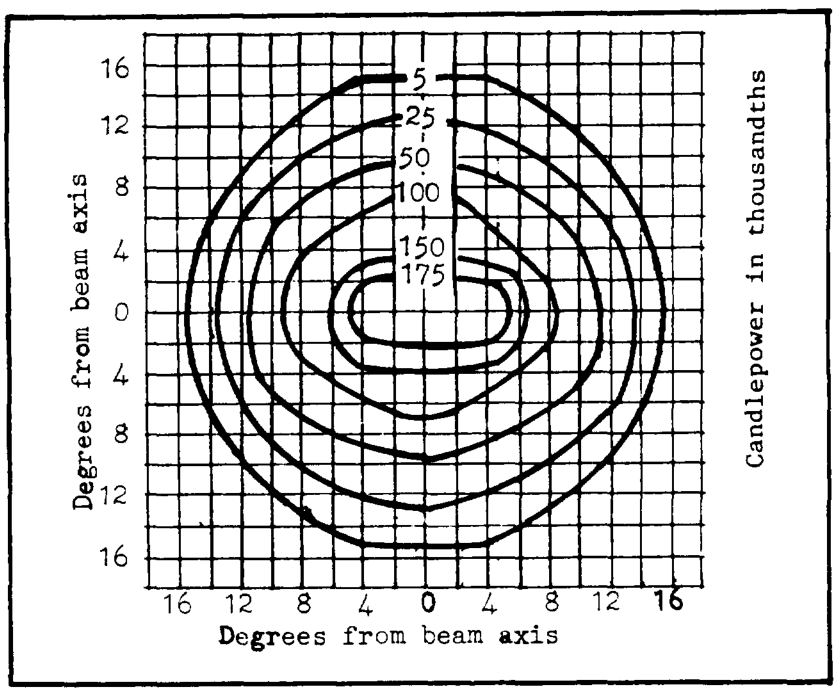
3.5.1.1.4 Candlepower of beam producing lights. Candlepower distribution data on beam-producing lights such as spotlights and floodlights are commonly plotted on rectilinear rather than polar coordinates, angular distance from the center of the beam indicated along the base line and candlepower by the ordinates (see figure 15). When the distribution is symmetrical about the central axis, one curve represents the beam. An asymmetric beam requires a minimum of one vertical and one horizontal traverse for a complete description.



SH 964-15

FIGURE 15. Candlepower distribution of typical floodlight.

3.5.1.2 Isocandela diagram. An irregular beam pattern is often best represented by means of an isocandela diagram (see figure 16). As shown, a large number of candlepower readings are plotted against degrees from the beam axis, both horizontal and vertical, and lines are drawn connecting equal candlepower values. Usually, isocandela diagrams are used in floodlight illumination.



SH 964-16

FIGURE 16. Typical isocandela diagram of a spotlight.

3.5.1.3 Isofootcandle diagram. An isofootcandle diagram is a group of curves drawn through points receiving the same amount of illumination on the working surface. Each different mounting height, or distance between lighting fixture and the working plane, produces a different isofootcandle diagram. Figure 17 shows an isofootcandle diagram for symbol 77.4 for a mounting height of 5 feet from the working plane. The same information is also presented in a footcandle curve on figure 18.

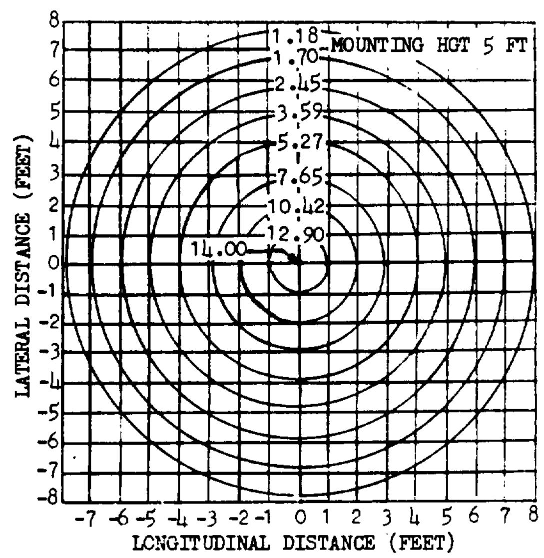


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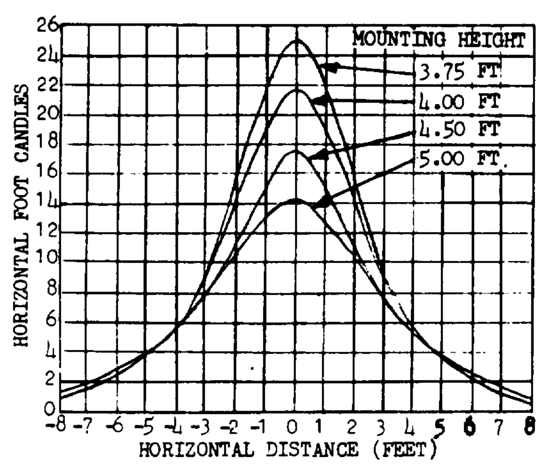
FIGURE 17. Isofootcandle diagram for symbol 77.4 for a mounting height of 5 feet.



SH 964-18

FIGURE 18. Footcandle distribution curves for symbol 77.4 for different mounting heights.

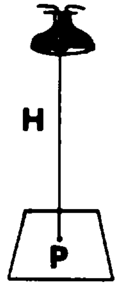
3.5.1.3.1 In order to make the information readily applicable for more than one mounting height, distances on the work plane can also be expressed in multiples of the mounting height. Footcandles for other mounting heights are obtained by multiplying the values given on the curves by the ratio of the square of the present mounting height to the square of the new mounting height. The isofootcandle diagram shown on figure 17 is for a single lighting unit; similar curves for installations can be readily computed by summing the footcandles received at any given point from each lighting fixture contributing illumination to that location.

3.5.1.4 Footcandle distribution. The distribution of illumination may also be represented by footcandle curves plotted for various source-to-working-plane distances. The footcandle distribution curves are used primarily for equipments that produce symmetrical outputs. The isofootcandle curves are generally used where the candlepower distribution is irregular or asymmetric. Typical footcandle distribution curves for symbol 77.4 are shown on figure 18.

3.5.2 Methods of illumination calculations. Illumination levels may be calculated in two ways: the point-by-point method and the lumen method. Using the point-by-point method, the illumination at any point on a surface can be calculated. The actual illumination at any point on a surface will be the sum of the footcandles contributed by all fixtures, regardless of size and type, plus light reflected from surrounding surfaces. Since inter-reflections are not taken into account, point-by-point calculations may be lower (usually 15 to 20 percent) than actually realized. The lumen method makes use of a relatively simple formula to provide average footcandle values. This method, however, applies only to those installations where only one type of lighting fixture is used. When using the lumen method, the illumination computed is an average value that is representative only if the lighting fixtures are spaced to obtain reasonably uniform illumination. The coefficients of utilization are based on empty interiors, and all calculations assume that installation conditions (voltage, temperature, and so forth) are such that lighting fixtures will provide their rated output. Although the lumen method is less complex, the point-by-point method must be used whenever more than one type of lighting fixture is to be installed in the same compartment.

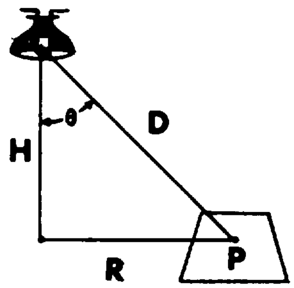
3.5.2.1 Point-by-point method. The point-by-point method is based on the actual amount of light which will be produced at specific points in a given area. This requires a knowledge of the way in which light is distributed from sources of various shapes and sizes. The inverse square law is based on a point light source radiating uniformly in all directions. Thus, where the light source is an extended one, either a line of light or a large surface area, the point-by-point method cannot ordinarily be used to calculate the illumination for normal working distances.

3.5.2.1.1 Point source. Illumination is inversely proportional to the square of the distance (inverse square law, see 3.4.2.1). Because of the relatively compact sizes of most Navy standard fluorescent lighting fixtures, the fluorescent lamp, like an incandescent lamp, alone or in an enclosing globe, can usually be treated as a point source. By applying the variations in the formula involving the inverse-square law in conjunction with the candle power distribution curve for the lighting fixture used, the illumination at any point on a surface can be calculated (see 3.5.1.1.1). When several fixtures contribute illumination to a given point , calculations must be carried out for each fixture. The actual illumination at any point on a surface will be the sum of the footcandles contributed by all of the fixtures plus whatever light is reflected to the point in question by surrounding surfaces. The concepts and formulas shown on figure 19 are used to determine the illumination at definite points in installations where there is little reflection of light from the surroundings, and where the distance from the source is at least five times the maximum dimension of the source. The specific formula to be applied is dependent upon the point location. To facilitate calculations, tables IV, V, and VI have been set up to calculate footcandle intensities. Table VI has been prepared to facilitate the computation of illumination on a horizontal surface. In this table, the footcandles on a horizontal plane have been calculated from the formula $E = (I/D^2) \cos \theta$ (see equation 11) and tabulated for a lighting fixture of 100 candlepower at varied vertical and horizontal distances from the fixture. To compute the footcandles for any given distance using the table, the angle for that distance must be located. Then, the angle at each distance is also given. The candlepower at that angle is divided by 100 and the quotient applied as a multiplying factor to the footcandles (per 100 candlepower) given in the table; the product of this multiplication is the footcandle value at the selected point. For example, table VI shows that 6 feet below and at a horizontal distance of 9 feet from the fixture, the illumination on a horizontal plane is 0.474 footcandles for 100 candlepower, and the angle given is 56 degrees. Figure 12 shows the candlepower for symbol 77.4 in this direction iS 213. Consequently, the illumination is 0.474 x 213/100 or approximately 1.0 footcandle.



a. When the point is on a plane normal to the beam, the formula is:

$$\text{Footcandles} = \frac{\text{Candlepower}}{\text{Distance squared}} = \frac{I}{H^2}$$

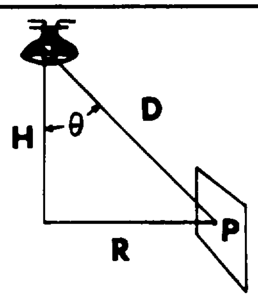


b. When the point is on a horizontal plane at a distance R, the formula is:

$$\text{Footcandles} = \frac{\text{Candlepower x cos } \theta}{\text{Distance Squared}} = \frac{I \times \cos \theta}{D^2}$$

Since sine $\theta = \frac{R}{D}$ and cosine $\theta = \frac{H}{D}$ the formula may then be written in the following form:

$$\text{Footcandles} = \frac{I \times H}{D^3} = \frac{I \times \cos^3\theta}{H^2} = \frac{I \times H \times R^3}{\sin^3\theta}$$



c. When the point is on a vertical plane, the formula is:

$$\text{Footcandles} = \frac{\text{Candlepower x sin } \theta}{\text{Distance Squared}} = \frac{I \times \sin \theta}{D^2}$$

Since sine $\theta = \frac{R}{D}$ the formula may then be written in the following form:

$$\text{Footcandles} = \frac{I \times R}{D^3} \text{ or } \frac{I \times \cos^2\theta \times \sin\theta}{H^2}$$

Note that: $D^2 = H^2 + R^2$

Sines and cosines of angles are given in Table IV

Squares and cubes of numbers are given in Table V

SH 964-19

FIGURE 19. Concepts and formulas for the inverse-square law.

TABLE IV. Trigonometric functions and formulas.

θ°	sin θ	cos θ	$\cos^2 θ$	$\cos^3 θ$	tan θ	θ°	sin θ	cos θ	$\cos^2 θ$	$\cos^3 θ$	tan θ
0	0.0	1.000	1.000	1.000	0.0	46	0.719	0.695	0.483	0.335	1.035
1	.0175	1.000	1.000	1.000	.0174	47	.731	.682	.465	.317	1.072
2	.0349	0.999	0.999	0.998	.0349	48	.743	.669	.448	.300	1.110
3	.0523	.999	.997	.996	.0524	49	.755	.656	.430	.282	1.150
4	.0698	.998	.995	.993	.0699	50	.766	.643	.413	.266	1.191
5	.0872	.996	.992	.989	.0874	51	.777	,629	.396	.249	1,234
6	.105	.995	.989	.984	.1051	52	.788	.616	.379	.233	1.279
7	.122	.993	.985	.978	.1227	53	.799	.602	.362	.218	1.327
8	.139	.990	.981	.971	.1405	54	,809	.588	.345	.203	1.376
9	.156	.988	.976	.964	.1583	55	.819	.574	.329	.189	1.428
10	.174	.985	.970	.955	.1763	56	.829	.559	.313	.175	1.482
11	.191	.982	.964	.946	.1943	57	.839	.545	.297	.162	1.539
12	.208	.978	.957	.936	.2125	58	.848	.530	.281	.149	1.600
13	.225	.974	.949	.925	.2308	59	.857	.515	.265	.137	1.664
14	.242	.970	.941	.913	.2493	60	.866	.500	.250	.125	1,732
15	.259	.966	.933	.901	.2679	61	.875	.485	.235	.114	1.804
16	.276	.961	.924	.888	.2867	62	.883	.470	.220	.103	1.880
17	.292	.956	.915	.875	.3057	63	.891	.454	.206	.0936	1.962
18	.309	.951	.905	.860	.3249	64	.899	.438	.192	.0842	2.050
19	.326	.946	.894	.845	.3443	65	.906	.423	.179	.0755	2.144
20	.342	.940	.883	.830	.3639	66	.914	.407	.165	.0673	2.246
21	.358	.934	.872	.814	.3838	67	.921	.391	.153	.0597	2.355
22	.375	.927	.860	.797	.4040	68	.927	.375	.140	,0526	2.475
23	.391	.921	.847	.780	.4244	69	.934	.358	.128	.0460	2.605
24	.407	.914	.835	.762	.4452	70	.940	.342	.117	.0400	2.747
25	.423	.906	.821	.744	.4663	71	.946	.326	.106	.0347	2.904
26	.438	.899	.808	.726	.4877	72	.951	.309	.0955	.0295	3.077
27	.454	.891	.794	.707	.5095	73	.956	.292	.0855	.0250	3.270
28	.470	.883	.780	.688	.5317	74	.961	.276	.0762	.0211	3.487
29	.485	.875	.765	.669	.5543	75	.966	.259	.0670	,0173	3.732
30	.500	.866	.750	.650	.5773	76	.970	.242	.0585	,0142	4,010
31	.515	.857	.735	.630	.6008	77	.974	.225	.0506	,0114	4.331
32	.530	.848	.719	.610	.6248	78	.978	.208	.0432	,0090	4.704
33	.545	.839	.703	.590	.6494	79	.982	.191	.0364	.0070	5.144
34	.559	.829	.687	.570	.6745	80	.985	.174	.0302	.0052	5.671
35	.574	.819	.671	.550	.7002	81	.988	.156	.0245	.0038	6.313
36	.588	.809	.655	.530	.7265	82	.990	.139	.0194	.0027	7,115
37	.602	.799	.638	.509	.7535	83	.993	.122	.0149	,0018	8.144
38	.616	.788	.621	.489	.7812	84	.995	.105	.0109	.0011	9.514
39	.629	.777	.604	.469	.8097	85	.996	.0872	.0076	.0007	11.430
40	.643	.766	.567	.450	.8391	86	.9976	.0698	.0048	.0003	14.300
41	.656	.755	.570	.430	.8892	87	.9986	.0523	.0027	.0001	19.080
42	.669	.743	.552	.410	.9004	88	.9993	.0349	.0012	.0000	28.630
43	.682	.731	.535	.391	.9325	89	.9998	.0175	.0003	.0000	57.280
44	.695	.719	.517	.372	.9658	90	1.0000	0.0000	.0000	.0000	infinite
45	.707	.707	.500	.354	1.0000						

TRIGONOMETRIC FORMULAS

SINE $θ = \frac{A}{C}$

COSINE $θ = \frac{B}{C}$

TANGENT $θ = \frac{A}{B}$

CONTANGENT $θ = \frac{B}{A}$

SECANT $θ = \frac{C}{B}$

COSECANT $θ = \frac{C}{A}$

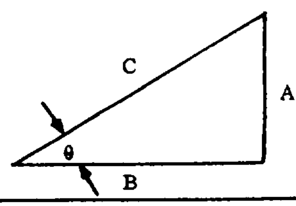


TABLE V. Squares and cubes of numbers.

n	n^2	n^3	n	n^2	n^3	n	n^2	n^3	n	n^2	n^3	n	n^2	n^3	n	n^2	n^3
1	1	1	50	2 500	125 000	100	10 000	1 000 000	150	22 500	3 375 000	200	40 000	8 000 000	250	62 500	15 625 000
2	4	8	51	2 601	132 651	101	10 201	1 030 301	151	22 801	3 442 951	201	40 401	8 120 601	251	63 001	15 813 251
3	9	27	52	2 704	140 608	102	10 404	1 061 208	152	23 104	3 511 808	202	40 804	8 242 408	252	63 504	16 003 008
4	16	64	53	2 916	148 877	103	10 609	1 092 727	153	23 409	3 581 577	203	41 209	8 365 427	253	64 009	16 194 277
5	25	125	54	2 916	157 464	104	10 816	1 124 864	154	23 716	3 652 264	204	41 616	8 489 664	254	64 516	16 387 064
6	36	216	55	3 025	166 375	105	11 025	1 157 625	155	24 025	3 723 875	205	42 025	8 615 125	255	65 025	16 581 375
7	49	343	56	3 136	175 616	106	11 236	1 191 016	156	24 336	3 796 416	206	42 436	8 741 816	256	65 536	16 777 216
8	64	512	57	3 249	185 193	107	11 449	1 225 043	157	24 649	3 869 893	207	42 849	8 869 743	257	66 049	16 974 593
9	81	729	58	3 364	195 112	108	11 664	1 259 712	158	24 964	3 944 312	208	43 264	8 998 912	258	66 564	17 173 512
10	100	1 000	59	3 481	205 379	109	11 881	1 295 029	159	25 281	4 019 679	209	43 681	9 129 329	259	67 081	17 373 979
11	121	1 331	60	3 600	216 000	110	12 100	1 331 000	160	25 600	4 096 000	210	44 100	9 261 000	260	67 600	17 576 000
12	144	1 728	61	3 721	226 981	111	12 321	1 367 631	161	25 921	4 173 281	211	44 521	9 393 931	261	68 121	17 779 581
13	169	2 197	62	3 844	238 328	112	12 544	1 404 928	162	26 244	4 251 528	212	44 944	9 528 128	262	68 644	17 984 728
14	196	2 744	63	3 969	250 047	113	12 769	1 442 897	163	26 569	4 330 747	213	45 369	9 663 597	263	69 169	18 191 447
15	225	3 375	64	4 096	262 144	114	12 996	1 481 544	164	26 896	4 410 944	214	45 796	9 800 344	264	69 696	18 399 744
16	256	4 096	65	4 225	274 625	115	13 225	1 520 875	165	27 225	4 492 125	215	46 225	9 938 375	265	70 225	18 609 625
17	289	4 913	66	4 356	287 496	116	13 456	1 560 896	166	27 556	4 574 296	216	46 656	10 077 696	266	70 756	18 821 096
18	324	5 832	67	4 489	300 763	117	13 689	1 601 613	167	27 889	4 657 463	217	47 089	10 218 313	267	71 289	19 034 163
19	361	6 859	68	4 624	314 432	118	13 924	1 643 032	168	28 224	4 741 632	218	47 524	10 360 232	268	71 824	19 248 832
20	400	8 000	69	4 761	328 509	119	14 161	1 685 159	169	28 561	4 826 809	219	47 961	10 503 459	269	72 361	19 465 109
21	441	9 261	70	4 900	343 000	120	14 400	1 728 000	170	28 900	4 913 000	220	48 400	10 648 000	270	72 900	19 683 000
22	484	10 648	71	5 041	357 911	121	14 641	1 771 561	171	29 241	5 000 211	221	48 841	10 793 861	271	73 441	19 902 511
23	529	12 167	72	5 184	373 248	122	14 884	1 815 848	172	29 584	5 088 448	222	49 284	10 941 048	272	73 984	20 123 648
24	576	13 824	73	5 329	389 017	123	15 129	1 860 867	173	29 929	5 177 717	223	49 729	11 089 567	273	74 529	20 346 417
25	625	15 625	74	5 476	405 224	124	15 376	1 906 624	174	30 276	5 268 024	224	50 176	11 239 424	274	75 076	20 570 824
26	676	17 576	75	5 625	421 875	125	15 625	1 953 125	175	30 625	5 359 375	225	50 625	11 390 625	275	75 625	20 796 875
27	729	19 683	76	5 776	438 976	126	15 876	2 000 376	176	30 976	5 451 776	226	51 076	11 543 176	276	76 176	21 024 576
28	784	21 952	77	5 929	456 533	127	16 129	2 048 383	177	31 329	5 545 233	227	51 529	11 697 083	277	76 729	21 253 933
29	841	24 389	78	6 084	474 552	128	16 384	2 097 152	178	31 684	5 639 752	228	51 984	11 852 352	278	77 284	21 484 952
30	900	27 000	79	6 241	493 039	129	16 641	2 146 689	179	32 041	5 735 339	229	52 441	12 008 989	279	77 841	21 717 639
31	961	29 791	80	6 400	512 000	130	16 900	2 197 000	180	32 400	5 832 000	230	52 900	12 167 000	280	78 400	21 952 000
32	1 024	32 768	81	6 561	531 441	131	17 161	2 248 091	181	32 761	5 929 741	231	53 361	12 326 391	281	78 961	22 188 041
33	1 089	35 937	82	6 724	551 368	132	17 424	2 299 968	182	33 124	6 028 568	232	53 824	12 487 168	282	79 524	22 425 768
34	1 156	39 304	83	6 889	571 787	133	17 689	2 352 637	183	33 489	6 128 487	233	54 289	12 649 337	283	80 089	22 665 187
35	1 225	42 875	84	7 056	592 704	134	17 956	2 406 104	184	33 856	6 229 504	234	54 756	12 812 904	284	80 656	22 906 304
36	1 296	46 656	85	7 225	614 125	135	18 225	2 460 375	185	34 225	6 331 625	235	55 225	12 977 875	285	81 225	23 149 125
37	1 369	50 653	86	7 396	636 056	136	18 496	2 515 456	186	34 596	6 434 856	236	55 696	13 144 256	286	81 796	23 393 656
38	1 444	54 872	87	7 569	658 503	137	18 769	2 571 353	187	34 969	6 539 203	237	56 169	13 312 053	287	82 369	23 639 903
39	1 521	59 319	88	7 744	681 472	138	19 044	2 628 072	188	35 344	6 644 672	238	56 644	13 481 272	288	82 944	23 887 872
40	1 600	64 000	89	7 921	704 969	139	19 321	2 685 619	189	35 721	6 751 269	239	57 121	13 651 919	289	83 521	24 137 569
41	1 681	68 921	90	8 100	729 000	140	19 600	2 744 000	190	36 100	6 859 000	240	57 600	13 824 000	290	84 100	24 389 000
42	1 764	74 088	91	8 281	753 571	141	19 881	2 803 221	191	36 481	6 967 871	241	58 081	13 997 521	291	84 681	24 642 171
43	1 849	79 507	92	8 464	778 688	142	20 164	2 863 288	192	36 864	7 077 888	242	58 564	14 172 488	292	85 264	24 897 088
44	1 936	85 184	93	8 649	804 357	143	20 449	2 924 207	193	37 249	7 189 057	243	59 049	14 348 907	293	85 849	25 153 757
45	2 025	91 125	94	8 836	830 584	144	20 736	2 985 984	194	37 636	7 301 384	244	59 536	14 526 784	294	86 436	25 412 184
46	2 116	97 336	95	9 025	857 375	145	21 025	3 048 625	195	38 025	7 414 875	245	60 025	14 706 125	295	87 025	25 672 375
47	2 209	103 823	96	9 216	884 736	146	21 316	3 112 136	196	38 416	7 529 536	246	60 516	14 886 936	296	87 616	25 934 336
48	2 304	110 592	97	9 409	912 673	147	21 609	3 176 523	197	38 809	7 645 373	247	61 009	15 069 223	297	88 209	26 198 073
49	2 401	117 649	98	9 604	941 192	148	21 904	3 241 792	198	39 204	7 762 392	248	61 504	15 252 992	298	88 804	26 463 592
			99	9 801	970 299	149	22 201	3 307 949	199	39 601	7 880 599	249	62 001	15 438 249	299	89 401	26 730 899

TABLE VI. Point-by-point footcandle calculation table for a 100-candlepower light source.

HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE - FEET

HEIGHT OF LIGHT SOURCE ABOVE WORKING PLANE- FEET	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20	40	50
2	0° 25.00	27° 17.45	45° 8.850	56° 4.275	63° 2.245	68° 1.298	71° .802	74° .528	76° .355	78° .255	79° .190	80° .112	81° .113	81° .090	82° .070	82° .058	84° .048	84° .038	84° .025	87° .000	87° .000
3	0° 11.11	18° 9.500	34° 6.100	45° 3.933	53° 2.400	59° 1.522	63° 1.000	67° .680	69° .477	72° .356	73° .264	75° .205	76° .161	77° .126	78° .100	79° .084	80° .070	81° .050	81° .036	86° .004	87° .002
3.50	0° 8.163	16° 7.257	30° 5.343	41° 3.573	49° 2.331	55° 1.539	60° 1.044	63° .730	66° .526	69° .389	71° .294	73° .227	74° .179	75° .143	76° .116	77° .096	79° .080	79° .057	80° .042	85° .005	85° .005
3.75	0° 7.111	15° 6.415	28° 4.885	39° 3.386	48° 2.275	53° 1.536	58° 1.059	62° .749	65° .544	68° .405	69° .308	71° .239	73° .189	74° .151	75° .123	76° .101	78° .084	78° .060	79° .045	85° .006	85° .006
4	0° 6.250	14° 5.707	27° 4.472	35° 3.200	43° 2.210	51° 1.524	56° 1.066	60° .764	63° .559	66° .419	68° .320	70° .249	72° .198	73° .159	74° .130	75° .107	76° .090	78° .064	79° .047	84° .006	84° .006
4.25	0° 5.536	13° 5.106	25° 4.101	35° 3.019	43° 2.138	50° 1.504	55° 1.069	59° .774	62° .572	65° .431	67° .332	69° .259	71° .206	72° .166	73° .136	74° .112	75° .094	77° .064	78° .050	84° .007	84° .007
4.30	0° 4.938	13° 4.594	24° 3.768	35° 2.844	42° 2.062	48° 1.478	53° 1.067	57° .781	61° .582	63° .442	66° .341	68° .268	69° .214	71° .173	72° .141	73° .117	74° .098	76° .070	77° .061	84° .007	84° .007
4.75	0° 4.432	12° 4.153	23° 3.470	32° 2.679	40° 1.984	46° 1.448	52° 1.060	56° .785	60° .590	62° .451	65° .350	67° .276	68° .221	70° .179	71° .147	72° .122	73° .102	75° .074	76° .055	83° .007	83° .007
5	0° 4.000	11° 3.771	22° 3.202	31° 2.522	39° 1.904	45° 1.414	50° 1.050	54° .785	58° .595	61° .458	63° .358	66° .283	67° .228	69° .185	70° .152	72° .126	73° .106	74° .077	76° .056	83° .080	83° .080
5.25	0° 3.628	11° 3.439	21° 2.691	30° 2.375	37° 1.826	44° 1.378	49° 1.036	53° .784	57° .599	60° .464	62° .365	64° .290	66° .234	68° .190	69° .157	71° .131	72° .110	74° .080	75° .059	83° .008	83° .008
5.50	0° 3.306	10° 3.149	20° 2.744	29° 2.237	36° 1.749	42° 1.339	47° 1.020	52° .780	55° .601	59° .469	61° .370	63° .296	65° .239	67° .196	68° .162	70° .135	71° .114	73° .082	75° .062	82° .008	82° .008
5.75	0° 3.025	10° 2.893	19° 2.549	28° 2.108	35° 1.673	41° 1.300	46° 1.002	51° .774	54° .601	58° .472	60° .374	62° .300	64° .244	66° .200	68° .166	69° .139	71° .117	72° .085	74° .064	82° .009	82° .009
6	0° 2.778	9° 2.666	18° 2.372	27° 1.987	34° 1.600	40° 1.260	45° .982	49° .766	53° .600	56° .474	59° .378	61° .305	63° .249	66° .205	67° .170	68° .142	69° .120	71° .088	73° .066	81° .009	83° .005
6.25	0° 2.560	9° 2.465	18° 2.212	27° 1.876	32° 1.530	39° 1.219	44° .961	48° .756	52° .597	55° .475	58° .381	60° .309	62° .252	64° .208	66° .173	67° .146	69° .120	71° .090	73° .068	81° .009	83° .005
6.50	0° 2.367	9° 2.285	17° 2.067	25° 1.772	32° 1.462	38° 1.179	43° .939	47° .746	51° .594	54° .475	57° .384	59° .312	61° .256	63° .212	65° .177	67° .149	68° .126	70° .093	72° .070	81° .010	83° .005
6.75	0° 2.195	8° 2.125	16° 1.935	25° 1.675	31° 1.398	37° 1.139	42° .916	46° .734	50° .589	53° .474	56° .394	58° .313	60° .259	63° .215	64° .180	66° .152	67° .129	69° .095	71° .072	80° .010	82° .005
7	0° 2.041	8° 1.980	16° 1.814	23° 1.585	30° 1.336	36° 1.100	41° .893	45° .722	49° .583	52° .473	55° .385	58° .316	60° .261	62° .218	63° .183	65° .154	66° .131	69° .097	71° .074	80° .010	82° .006
7.25	0° 1.902	8° 1.852	15° 1.704	23° 1.501	29° 1.277	35° 1.061	40° .870	44° .708	48° .576	51° .470	54° .384	57° .317	59° .263	61° .220	63° .185	64° .157	66° .134	68° .099	70° .075	80° .011	82° .006
7.50	0° 1.778	8° 1.732	15° 1.604	22° 1.423	28° 1.221	34° 1.024	39° .847	43° .695	47° .569	50° .467	53° .384	56° .318	58° .265	60° .222	62° .187	63° .159	65° .136	67° .101	69° .577	79° .011	81° .006
8	0° 1.563	7° 1.527	14° 1.427	21° 1.283	27° 1.118	32° .953	37° .800	41° .672	45° .552	48° .458	51° .381	54° .318	56° .267	58° .255	60° .191	62° .163	63° .140	66° .105	68° .080	79° .012	81° .007
9	0° 1.235	6° 1.212	13° 1.148	18° 1.054	24° .943	29° .825	34° .711	38° .607	42° .515	45° .437	48° .370	51° .314	53° .267	55° .228	57° .196	59° .168	61° .146	63° .110	66° .085	77° .013	80° .008
10	0° 1.000	5°43' .985	11° .943	17° .879	22° .801	27° .716	31° .631	35° .550	39° .476	42° .411	45° .354	48° .305	50° .263	52° .227	54° .196	56° .171	58° .149	61° .115	63° .089	76° .014	79° .008
11	0° .826	5°12' .916	10° .797	15° .742	20° .686	24° .623	29° .559	32° .496	36° .437	39° .383	42° .335	45° .292	48° .255	59° .223	52° .195	54° .171	56° .150	59° .117	61° .092	75° .015	78° .009
12	0° .694	4°46' .687	9° .668	14° .634	18° .593	23° .546	27° .497	30° .448	34° .400	37° .356	40° .315	43° .278	45° .246	47° .217	49° .191	51° .169	53° .150	56° .119	59° .094	73° .017	77° .009
13	0° .592	4°24' .587	9° .571	13° .547	17° .517	21° .481	25° .447	29° .404	32° .366	35° .329	38° .295	40° .263	43° .235	45° .209	47° .187	49° .166	51° .148	54° .119	57° .096	72° .017	76° .010
14	0° .510	4°5' .506	8° .495	12° .477	16° .454	20° .426	23° .396	27° .365	30° .334	33° .304	36° .275	38° .248	41° .223	43° .201	45° .180	47° .162	49° .146	52° .118	55° .096	71° .018	75° .011
15	0° .444	3°49' .442	8° .433	11° .419	15° .401	18° .380	22° .356	25° .331	28° .305	31° .280	34° .256	36° .233	39° .212	41° .192	43° .174	45° .157	47° .142	50° .117	53° .096	69° .019	73° .011
16	0° .391	3°35' .388	7° .382	11° .371	14° .357	17° .339	21° .321	24° .300	27° .280	29° .259	32° .238	35° .219	37° .200	39° .183	41° .167	43° .152	45° .138	48° .115	51° .095	68° .020	72° .012
17	0° .346	3°22' .344	7° .339	10° .331	13° .319	16° .306	19° .290	22° .274	25° .256	28° .239	30° .222	33° .205	35° .189	37° .174	39° .159	41° .146	43° .134	47° .112	50° .094	67° .021	71° .012
18	0° .309	3°11' .307	6° .303	9° .297	13° .287	16° .276	18° .264	21° .250	24° .236	27° .221	29° .206	31° .192	34° .178	36° .165	38° .152	40° .140	42° .129	45° .109	48° .092	66° .021	70° .012
19	0° .277	3°1' .276	6° .273	9° .267	12° .260	15° .251	18° .240	20° .229	23° .217	25° .205	28° .192	30° .180	32° .167	34° .156	36° .145	38° .134	40° .124	43° .106	46° .090	65° .022	69° .013
20	0° .250	2°51' .249	5°43' .246	9° .242	11° .238	14° .228	17° .219	19° .210	22° .200	24° .190	27° .179	29° .168	31° .158	33° .147	35° .137	37° .128	39° .119	42° .103	45° .088	63° .022	68° .013
21	0° .227	2°44' .226	5°26' .224	8° .220	11° .215	13° .210	16° .201	18° .194	21° .185	23° .176	25° .167	28° .158	30° .144	32° .139	34° .131	36° .122	37° .114	41° .099	44° .086	62° .023	67° .014
22	0° .207	2°36' .206	5°10' .205	8° .201	10° .196	13° .192	15° .185	18° .179	20° .171	22° .164	25° .155	27° .148	29° .140	31° .125	33° .124	34° .114	36° .109	39° .096	42° .084	61° .023	66° .014
23	0° .189	2°29' .189	4°58' .187	7° .184	10° .181	12° .176	15° .171	17° .165	19° 1.59	21° .153	24° .146	26° .139	28° .132	29° .125	31° .118	33° .111	35° .105	38° .092	41° .081	60° .023	65° .014
24	0° .174	2°23' .173	4°45' .172	7° .170	10° .166	12° .163	14° .158	16° .154	18° .148	21° .143	23° .137	25° .130	27° .124	28° .118	30° .112	32° .106	34° .100	37° .089	40° .079	59° .024	64° .014
25	0° .160	2°17' .160	4°34' .158	7° .157	9° .154	11° .151	14° .147	16° .143	18° .138	20° .133	22° .128	24° .123	26° .117	27° .112	29° .106	31° .101	33° .096	36° .086	39° .076	58° .024	63° .015
27	0° .137	2°7' .137	4°14' .136	6° .135	8° .133	10° .130	12° .128	15° .124	17° .121	18° .117	20° .113	22° .109	24° .105	26° .100	27° .096	29° .092	31° .087	34° .079	37° .071	56° .024	62° .015
30	0° .111	1°54' .111	3°50' .111	5°43' .109	8° .108	9° .107	11° .105	13° .103	15° .100	17° .098	18° .095	20° .092	22° .089	23° .086	25° .083	27° .080	28° .077	31° .070	34° .064	53° .024	59° .015
33	0° .092	1°44' .092	3°28' .091	5°12' .091	7° .090	9° .089	10° .087	12° .086	14° .084	15° .082	17° .080	18° .078	20° .076	22° .074	23° .072	24° .069	26° .067	29° .062	31° .058	50° .024	57° .015
36	0° .077	1°36' .077	3°11' .077	4°46' .076	6° .076	8° .075	9° .074	11° .073	13° .072	14° .070	16° .069	17° .067	18° .066	20° .064	21° .062	23° .061	24° .059	27° .055	29° .052	48° .023	54° .015
40	0° .063	1°26' .062	2°52' .062	4°17' .062	5°43' .062	7° .061	9° .060	10° .060	11° .059	13° .058	14° .057	15° .056	17° .055	18° .054	19° .053	21° .051	22° .050	24° .047	27° .045	45° .022	51° .015
45	0° .049	1°16' .049	2°33' .049	3°49' .049	5°5' .049	6° .049	8° .048	9° .048	10° .047	13° .046	14° .045	15° .045	16° .044	17° .043	17° .043	18° .042	20° .041	22° .040	24° .038	42° .021	48° .013
50	0° .040	1°9' .040	2°17' .040	3°26' .040	4°34' .040	5°43' .039	7° .039	8° .039	9° .039	10° .038	11° .038	12° .037	14° .037	15° .036	16° .036	16° .035	18° .035	20° .033	22° .032	39° .019	45° .013

*Upper figures-angle between light ray and vertical. Lower figures-footcandles on a horizontal plane produced by a 100 candlepower light source. Footcandles on a vertical surface at a point that lies in a vertical plane which also includes the light source, may be determined by using the multiplying factor found when the table headings are reversed, i.e., the height of the light source is read on the horizontal distance scale, etc.

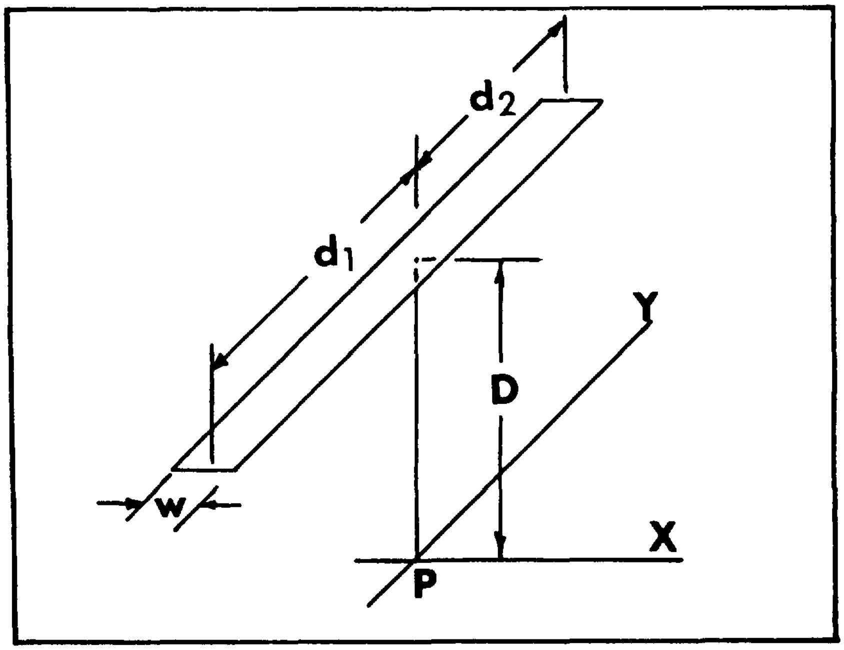
3.5.2 .1.2 Line sources of infinite length. Illumination from a line source of infinite length varies inversely as the distance to the source, not inversely as the square of the distance as is the case with point sources. The following simplified expression may be used for determining the illumination at point P lying on line XY or its extension (see figure 20).

$$E_P = \frac{B \times W}{2D} \qquad \text{Equation 13}$$

where:

E_p = illumination at P in footcandles
B = brightness of source in footlamberts
w = width of source in feet
D = distance from source to point P in feet

This expression is exact only for an infinitely long source, but is accurate to within 10 percent if both d_1 and d_2 are greater than 1.5D, and accurate to within 5 percent if both d_1 and d_2 are greater than 2D. For more exact formulas for the illumination from line sources, refer to Illuminating Engineering Society Lighting Handbook.



SH 964-20

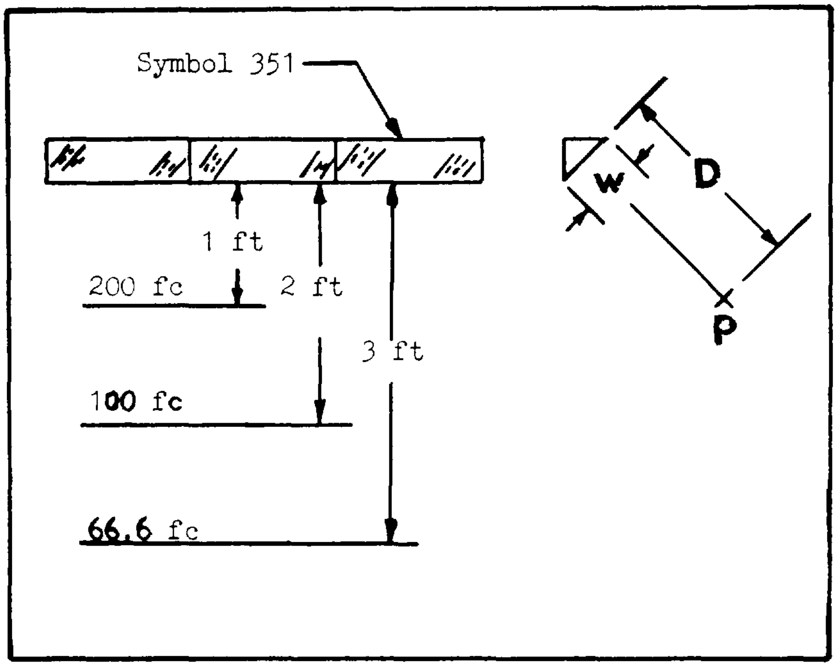
FIGURE 20. Illumination of a line source of infinite length.

A continuous row of fluorescent fixtures, or even one fluorescent lamp at a short distance, approaches the conditions set forth for a line source of infinite length. At sufficiently short distances from any linear source, the footcandle values will be found to vary more nearly inversely with the first power than with the square of the distance. For example: Determine the illumination 2 feet away from the mirror light symbol 351. From the dimensions and light output of symbol 351 (see figure 21), the following are given:

B = 600 footlamberts
W = 8 inches (0.666 feet)

Thus, employing equation 13:

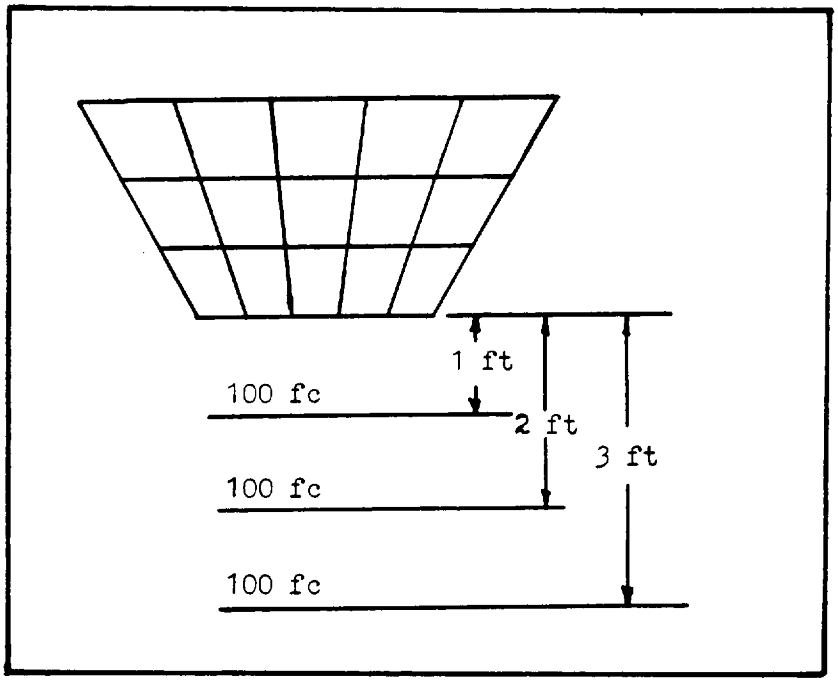
$$E_P = \frac{B \times W}{2\ D} = \frac{(600)\ (0.666)}{(2)\ (2)} = 100'' \text{ footcandles}$$



SH 964-21

FIGURE 21. Illumination of a continuous row of mirror lights, symbol 351.

3.5.2.1.3 Surface source of infinite area. Illumination does not change appreciably with distance. A large luminous panel or a ceiling lighted by totally indirect means may be considered an infinite area. As shown on figure 22, the illumination within a certain range will not change greatly with distance. For more exact formulas, refer to Illuminating Engineering Society Lighting Handbook.



SH 964-22

FIGURE 22. Illumination of an infinite diffusing area.

3.5.2.2 Lumen method. The zonal cavity inter-reflectance method used is based on the relationship between the candlepower distribution characteristics of lighting fixtures, their mounting heights and the room proportions. The basic concept of the lumen method is expressed by the definition of the foot-candle as 1 lumen per square foot; that is,

$$\text{Footcandles} = \frac{\text{Lumens on a surface}}{\text{Area of surface in square feet}} \qquad \text{Equation 14}$$

Since all of the lamp lumens will not reach the work plane due to losses in the lighting fixture and at the room surfaces, the lamp lumens must be multiplied by a coefficient of utilization (CU) which represents the proportion that reaches the work plane. Thus,

$$\text{Footcandles (average initial)} = \frac{\text{Lamp lumens x CU}}{\text{Area in square feet}} \qquad \text{Equation 15}$$

If the design objective is the minimum maintained illumination, factors must be applied to account for the estimated depreciation in lamp lumens and the estimated losses from dirt collection on the lighting fixture surfaces (including lamps).

The formula thus becomes:

Maintained footcandles =

$$\frac{\text{Lamp lumens} \times \text{CU} \times \text{LLD} \times \text{LDD}}{\text{Area in square feet}} \qquad \text{Equation 16}$$

Where:
LLD = lamp lumen depreciation factor
LDD = lighting fixture dirt depreciation factor

For shipboard installation, however, initial footcandles are required and equation 16 is not used since LLD and LDD are equal to unity, thus reducing this equation to equation 15. The lamp lumens in equation 15 are most conveniently taken as the total rated lamp lumens in the lighting fixture, and the area then becomes the area per lighting fixture. Thus,

$$\text{Initial footcandles} = \frac{\text{Lamp lumens per fixture} \times \text{CU}}{\text{Area per fixture}} \qquad \text{Equation 17}$$

or, if the desired footcandles are known, the area per fixture (and hence the spacing between fixtures) to produce this illumination may be obtained by:

$$\text{Area per fixture} = \frac{\text{Lamp lumens per fixture} \times \text{CU}}{\text{Initial footcandles}} \qquad \text{Equation 17a}$$

A lighting system can be designed with spacings between units to approximate this area, but if the total number of fixtures is also desired, then:

$$\text{Total number of fixtures} = \frac{\text{Total room area}}{\text{Area per fixture}} \qquad \text{Equation 18}$$

By combining equations 17a and 18:

$$\text{IFC} = \frac{(\text{LPF})\ (\text{RLPL})\ (\text{TNF})\ (\text{CU})}{(\text{L})\ (\text{W})} \qquad \text{Equation 19}$$

or

$$\text{TNF} = \frac{(\text{IFC})\ (\text{L})\ (\text{W})}{(\text{LPF})\ (\text{RLPL})\ (\text{CU})} \qquad \text{Equation 20}$$

Where:
IFC = initial footcandles
LPF = lamps per fixture
RLPL = rated lumens per lamp
TNF = total number of fixtures
L = room length
w = room width

All of the above parameters, except CU, can be obtained from the Military Specifications for lighting fixtures and the design requirements of the particular room or space. The CU can be determined as outlined in 3.5.2.2.1.

3.5.2.2.1 CU. Absorption of light in a fixture is accounted for in the computation of CU for that particular fixture. Appendix A provides a tabulation of CU calculated by the zonal-cavity method for the more widely used Navy general lighting fixtures. These coefficients are for an effective floor cavity reflectance (efc) of 20 percent, but any CU obtained from the table may be corrected for a different value of efc by applying the appropriate multiplier from table IX. To obtain a CU:

(a) Determine cavity ratios for the room, ceiling and floor from table VII or the formulas in 3.5.2.2.1.1.
(b) Determine the effective ceiling and floor cavity reflectance from table VIII.
(c) Obtain CU for 20 percent efc from appendix A for the lighting fixture to be used. Interpolate, when necessary, to obtain CU for exact room cavity ratio for nearest effective ceiling cavity reflectance above and below reflectance obtained in step (b); interpolate between these CUs to obtain CU for step (b) ceiling cavity reflectance.
(d) If efc differs significantly from 20 percent, obtain multiplier from table IX and apply this to the CU obtained in step (c).

TABLE VII. Cavity ratios.

(For cavity dimensions other than those shown below, the cavity ratio can be calculated by the formulas of 3.5.2.2.1.1.)

DIMENSIONS		CAVITY DEPTH																			
Width	Length	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0	7.0	8.0	9.0	10	11	12	14	16	20	25	30
8	8	1.2	1.9	2.5	3.1	3.7	4.4	5.0	6.2	7.5	8.8	10.0	11.2	12.5							
	10	1.1	1.7	2.2	2.8	3.4	3.9	4.5	5.6	6.7	7.9	9.0	10.1	11.3	12.4						
	14	1.0	1.5	2.0	2.5	3.0	3.4	3.9	4.9	5.9	6.9	7.8	8.8	9.7	10.7	11.7					
	20	0.9	1.3	1.7	2.2	2.6	3.1	3.5	4.4	5.2	6.1	7.0	7.9	8.8	9.6	10.5	12.2				
	30	0.8	1.2	1.6	2.0	2.4	2.8	3.2	4.0	4.7	5.5	6.3	7.1	7.9	8.7	9.5	11.0				
	40	0.7	1.1	1.5	1.9	2.3	2.6	3.0	3.7	4.5	5.3	5.9	6.5	7.4	8.1	8.8	10.3	11.8			
10	10	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0					
	14	0.9	1.3	1.7	2.1	2.6	3.0	3.4	4.3	5.1	6.0	6.9	7.8	8.6	9.5	10.4	12.0				
	20	0.7	1.1	1.5	1.9	2.3	2.6	3.0	3.7	4.5	5.3	6.0	6.8	7.5	8.3	9.0	10.5	12.0			
	30	0.7	1.0	1.3	1.7	2.0	2.3	2.7	3.3	4.0	4.7	5.3	6.0	6.6	7.3	8.0	9.4	10.6			
	40	0.6	0.9	1.2	1.6	1.9	2.2	2.5	3.1	3.7	4.4	5.0	5.6	6.2	6.9	7.5	8.7	10.0	12.5		
	60	0.6	0.9	1.2	1.5	1.7	2.0	2.3	2.9	3.5	4.1	4.7	5.3	5.9	6.5	7.1	8.2	9.4	11.7		
12	12	0.8	1.2	1.7	2.1	2.5	2.9	3.3	4.2	5.0	5.8	6.7	7.5	8.4	9.2	10.0	11.7				
	16	0.7	1.1	1.5	1.8	2.2	2.5	2.9	3.6	4.4	5.1	5.8	6.5	7.2	8.0	8.7	10.2	11.6			
	24	0.6	0.9	1.2	1.6	1.9	2.2	2.5	3.1	3.7	4.4	5.0	5.6	6.2	6.9	7.5	8.7	10.0	12.5		
	36	0.6	0.8	1.1	1.4	1.7	1.9	2.2	2.8	3.3	3.9	4.4	5.0	5.5	6.0	6.6	7.8	8.8	11.0		
	50	0.5	0.8	1.0	1.3	1.5	1.8	2.1	2.6	3.1	3.6	4.1	4.6	5.1	5.6	6.2	7.2	8.2	10.2		
	70	0.5	0.7	1.0	1.2	1.5	1.7	2.0	2.4	2.8	3.4	3.9	4.4	4.9	5.4	5.8	6.8	7.8	9.7	12.2	
14	14	0.7	1.1	1.4	1.8	2.1	2.5	2.9	3.6	4.3	5.0	5.7	6.4	7.1	7.8	8.5	10.0	11.4			
	20	0.6	0.9	1.2	1.5	1.8	2.1	2.4	3.0	3.6	4.2	4.9	5.5	6.1	6.7	7.3	8.6	9.8	12.3		
	30	0.5	0.8	1.0	1.3	1.6	1.8	2.1	2.6	3.1	3.7	4.2	4.7	5.2	5.8	6.3	7.3	8.4	10.5		
	42	0.5	0.7	1.0	1.2	1.4	1.7	1.9	2.4	2.9	3.3	3.8	4.3	4.7	5.2	5.7	6.7	7.6	9.5	11.9	
	60	0.4	0.7	0.9	1.1	1.3	1.5	1.8	2.2	2.6	3.1	3.5	3.9	4.4	4.8	5.2	6.1	7.0	8.8	10.9	
	90	0.4	0.6	0.8	1.0	1.2	1.4	1.6	2.0	2.5	2.9	3.3	3.7	4.1	4.5	5.0	5.8	6.6	8.3	10.3	12.4
17	17	0.6	0.9	1.2	1.5	1.8	2.1	2.3	2.9	3.5	4.1	4.7	5.3	5.9	6.5	7.0	8.2	9.4	11.7		
	25	0.5	0.7	1.0	1.2	1.5	1.7	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0	8.0	10.0	12.5	
	35	0.4	0.7	0.9	1.1	1.3	1.5	1.7	2.2	2.6	3.1	3.5	3.9	4.4	4.8	5.2	6.1	7.0	8.7	10.9	
	50	0.4	0.6	0.8	1.0	1.2	1.4	1.6	2.0	2.4	2.8	3.1	3.5	3.9	4.3	4.5	5.4	6.2	7.7	9.7	11.6
	80	0.4	0.5	0.7	0.9	1.1	1.2	1.4	1.8	2.1	2.5	2.9	3.3	3.6	4.0	4.3	5.1	5.8	7.2	9.0	10.9
	120	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.7	2.0	2.3	2.7	3.0	3.4	3.7	4.0	4.7	5.4	6.7	8.4	10.1
20	20	0.5	0.7	1.0	1.2	1.5	1.7	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0	8.0	10.0	12.5	
	30	0.4	0.6	0.8	1.0	1.2	1.5	1.7	2.1	2.5	2.9	3.3	3.7	4.1	4.5	4.9	5.8	6.6	8.2	10.3	12.4
	45	0.4	0.5	0.7	0.9	1.1	1.3	1.4	1.8	2.2	2.5	2.9	3.3	3.6	4.0	4.3	5.1	5.8	7.2	9.1	10.9
	60	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.7	2.0	2.3	2.7	3.0	3.4	3.7	4.0	4.7	5.4	6.7	8.4	10.1
	90	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.6	4.2	4.8	6.0	7.5	9.0
	150	0.3	0.4	0.6	0.7	0.8	1.0	1.1	1.4	1.7	2.0	2.3	2.6	2.9	3.2	3.4	4.0	4.6	5.7	7.2	8.6
24	24	0.4	0.6	0.8	1.0	1.2	1.5	1.7	2.1	2.5	2.9	3.3	3.7	4.1	4.5	5.0	5.8	6.7	8.2	10.3	12.4
	32	0.4	0.5	0.7	0.9	1.1	1.3	1.5	1.8	2.2	2.6	2.9	3.3	3.6	4.0	4.3	5.1	5.8	7.2	9.0	11.0
	50	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.5	1.8	2.2	2.5	2.8	3.1	3.4	3.7	4.4	5.0	6.2	7.8	9.4
	70	0.3	0.4	0.6	0.7	0.8	1.0	1.1	1.4	1.7	2.0	2.2	2.5	2.8	3.0	3.3	3.8	4.4	5.5	6.9	8.2
	100	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.3	1.6	1.8	2.1	2.4	2.6	2.9	3.1	3.7	4.2	5.2	6.5	7.9
	160	0.2	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.7	1.9	2.1	2.4	2.6	2.8	3.3	3.8	4.7	5.9	7.1
30	30	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0	4.7	5.4	6.7	8.4	10.0
	45	0.3	0.4	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.9	2.2	2.5	2.7	3.0	3.3	3.8	4.4	5.5	6.9	8.2
	60	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.2	1.5	1.7	2.0	2.2	2.5	2.7	3.0	3.5	4.0	5.0	6.2	7.4
	90	0.2	0.3	0.4	0.6	0.7	0.8	0.9	1.1	1.3	1.6	1.8	2.0	2.2	2.5	2.7	3.1	3.6	4.5	5.6	6.7
	150	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.8	3.2	4.0	5.0	5.9
	200	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.1	1.3	1.5	1.7	1.9	2.0	2.2	2.6	3.0	3.7	4.7	5.6
36	36	0.3	0.4	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.9	2.2	2.5	2.8	3.0	3.3	3.9	4.4	5.5	6.9	8.3
	50	0.2	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.7	1.9	2.1	2.5	2.6	2.9	3.3	3.8	4.8	5.9	7.2
	75	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.3	2.5	2.9	3.3	4.1	5.1	6.1
	100	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.6	3.0	3.8	4.7	5.7
	150	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.4	2.8	3.5	4.3	5.2
	200	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.1	1.3	1.5	1.6	1.8	2.0	2.3	2.6	3.3	4.1	4.9
42	42	0.2	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.6	1.9	2.1	2.4	2.6	2.8	3.3	3.8	4.7	5.9	7.1
	60	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.8	3.2	4.0	5.0	6.0
	90	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.4	2.8	3.5	4.4	5.2
	140	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.9	2.2	2.5	3.1	3.9	4.6
	200	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.3	1.4	1.6	1.7	2.0	2.3	2.9	3.6	4.3
	300	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.7	0.8	0.9	1.1	1.3	1.4	1.5	1.7	1.9	2.2	2.8	3.5	4.2
50	50	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.8	3.2	4.0	5.0	6.0
	70	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.2	1.4	1.5	1.7	1.9	2.0	2.4	2.7	3.4	4.3	5.1
	100	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.9	1.0	1.2	1.3	1.5	1.6	1.8	2.1	2.4	3.0	3.7	4.5
	150	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.9	2.1	2.7	3.3	4.0
	300	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.4	1.6	1.9	2.3	2.9	3.5
60	60	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.3	1.5	1.7	1.8	2.0	2.3	2.7	3.3	4.2	5.0
	100	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.9	2.1	2.7	3.3	4.0
	150	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.6	1.9	2.3	2.9	3.5
	300	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.6	2.0	2.5	3.0
75	75	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.9	2.1	2.7	3.3	4.0
	120	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.7	2.2	2.7	3.3
	200	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.5	1.8	2.3	2.7
	300	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.3	1.7	2.1	2.5
100	100	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.6	2.0	2.5	3.0
	200	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.5	1.9	2.2
	300	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.9	1.1	1.3	1.7	2.0

TABLE VIII. Percent effective ceiling or floor cavity reflectance for various reflectance combinations.

Per Cent Ceiling or Floor Reflectance	90				80				70			50			30				10		
Per Cent Wall Reflectance	90	70	50	30	80	70	50	30	70	50	30	70	50	30	65	50	30	10	50	30	10
Ceiling or Floor Cavity Ratio																					
0	90	90	90	90	80	80	80	80	70	70	70	50	50	50	30	30	30	30	10	10	10
0.1	90	89	88	87	79	79	78	78	69	69	68	59	49	48	30	30	29	29	10	10	10
0.2	89	88	86	85	79	78	77	76	68	67	66	49	48	47	30	29	29	28	10	10	9
0.3	89	87	85	83	78	77	75	74	68	66	64	49	47	46	30	29	28	27	10	10	9
0.4	88	86	83	81	78	76	74	72	67	65	63	48	46	45	30	29	27	26	11	10	9
0.5	88	85	81	78	77	75	73	70	66	64	61	48	46	44	29	28	27	25	11	10	9
0.6	88	84	80	76	77	75	71	68	65	62	59	47	45	43	28	28	26	25	11	10	9
0.7	88	83	78	74	76	74	70	66	65	61	58	47	44	42	29	28	26	24	11	10	8
0.8	87	82	77	73	75	73	69	65	64	60	56	47	43	41	29	27	25	23	11	10	8
0.9	87	81	76	71	75	72	68	63	63	59	55	46	43	40	29	27	25	22	11	9	8
1.0	86	80	74	69	74	71	66	61	63	58	53	46	42	39	29	27	24	22	11	9	8
1.1	86	79	73	67	74	71	65	60	62	57	52	46	41	38	29	26	24	21	11	9	8
1.2	86	78	72	65	73	70	64	58	61	56	50	45	41	37	29	26	23	20	12	9	7
1.3	85	78	70	64	73	69	63	57	61	55	49	45	40	36	29	26	23	20	12	9	7
1.4	85	77	69	62	72	68	62	55	60	54	48	45	40	35	28	26	22	19	12	9	7
1.5	85	76	68	61	72	68	61	54	59	53	47	44	39	34	28	25	22	18	12	9	7
1.6	85	75	66	59	71	67	60	53	59	52	45	44	39	33	28	25	21	18	12	9	7
1.7	84	74	65	58	71	66	59	52	58	51	44	44	38	32	28	25	21	17	12	9	7
1.8	84	73	64	56	70	65	58	50	57	50	43	43	37	32	28	25	21	17	12	9	6
1.9	84	73	63	55	70	65	57	49	57	49	42	43	37	31	28	25	20	16	12	9	6
2.0	83	72	62	53	69	64	56	48	56	48	41	43	37	30	28	24	20	16	12	9	6
2.1	83	71	61	52	69	63	55	47	56	47	40	43	36	29	28	24	20	16	13	9	6
2.2	83	70	60	51	68	63	54	45	55	46	39	42	36	29	28	24	19	15	13	9	6
2.3	83	69	59	50	68	62	53	44	54	46	38	42	35	28	28	24	19	15	13	9	6
2.4	82	68	58	48	67	61	52	43	54	45	37	42	35	27	28	24	19	14	13	9	6
2.5	82	68	57	47	67	61	51	42	53	44	36	41	34	27	27	23	18	14	13	9	6
2.6	82	67	56	46	66	60	50	41	53	43	35	41	34	26	27	23	18	13	13	9	5
2.7	82	66	55	45	66	60	49	40	52	43	34	41	33	26	27	23	18	13	13	9	5
2.8	81	66	54	44	66	59	48	39	52	42	33	41	33	25	27	23	18	13	13	9	5
2.9	81	65	53	43	65	58	48	38	51	41	33	40	33	25	27	23	17	12	13	9	5
3.0	81	64	52	42	65	58	47	38	51	40	32	40	32	24	27	22	17	12	13	8	5
3.1	80	64	51	41	64	57	46	37	50	40	31	40	32	24	27	22	17	12	13	8	5
3.2	80	63	50	40	64	57	45	36	50	39	30	40	31	23	27	22	16	11	13	8	5
3.3	80	62	49	39	64	56	44	35	49	39	30	39	31	23	27	22	16	11	13	8	5
3.4	80	62	48	38	63	56	44	34	49	38	29	39	31	22	27	22	16	11	18	8	5
3.5	79	61	48	37	63	55	43	33	48	38	29	39	30	22	26	22	16	11	13	8	5
3.6	79	60	47	36	62	54	42	33	48	37	28	39	30	21	26	21	15	10	13	8	5
3.7	79	60	46	35	62	54	42	32	48	37	27	38	30	21	26	21	15	10	13	8	4
3.8	79	59	45	35	62	53	41	31	47	36	27	38	29	21	26	21	15	10	13	8	4
3.9	78	59	45	34	61	53	40	30	47	36	26	38	29	20	26	21	15	10	13	8	4
4.0	78	58	44	33	61	52	40	30	46	35	26	38	29	20	26	21	15	9	13	8	4
4.1	78	57	43	32	60	52	39	29	46	35	25	37	28	20	26	21	14	9	13	8	4
4.2	78	57	43	32	60	51	39	29	46	34	25	37	28	19	26	20	14	9	13	8	4
4.3	78	56	42	31	60	51	38	28	45	34	25	37	28	19	26	20	14	9	13	8	4
4.4	77	56	41	30	59	51	38	28	45	34	24	37	27	19	26	20	14	8	13	8	4
4.5	77	55	41	30	59	50	37	27	45	33	24	37	27	19	25	20	14	8	14	8	4
4.6	77	55	40	29	59	50	37	26	44	33	24	36	27	18	25	20	14	8	14	8	4
4.7	77	54	40	29	58	49	36	26	44	33	23	36	26	18	25	20	13	8	14	8	4
4.8	76	54	39	28	58	49	36	25	44	32	23	36	26	18	25	19	13	8	14	8	4
4.9	76	53	38	28	58	49	35	25	44	32	23	36	26	18	25	19	13	7	14	8	4
5.0	76	53	38	27	67	48	35	25	43	32	22	36	26	17	25	19	13	7	14	8	4

TABLE IX. Multiplying factors for other than 20 percent efc.

% Effective Ceiling Cavity Reflectance	80				70				50			30			10		
% Wall Reflectance	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10
For 30 Per Cent Effective Floor Cavity Reflectance (20 Per Cent = 1.00)																	
Room Cavity Ratio																	
1	1.092	1.082	1.075	1.068	1.077	1.070	1.064	1.059	1.049	1.044	1.040	1.028	1.026	1.023	1.012	1.010	1.008
2	1.079	1.066	1.055	1.047	1.068	1.057	1.048	1.039	1.041	1.033	1.027	1.026	1.021	1.017	1.013	1.010	1.006
3	1.070	1.054	1.042	1.033	1.061	1.048	1.037	1.028	1.034	1.027	1.020	1.024	1.017	1.012	1.014	1.009	1.005
4	1.062	1.045	1.033	1.024	1.055	1.040	1.029	1.021	1.030	1.022	1.015	1.022	1.015	1.010	1.014	1.009	1.004
5	1.056	1.038	1.026	1.018	1.050	1.034	1.024	1.015	1.027	1.018	1.012	1.020	1.013	1.008	1.014	1.009	1.004
6	1.052	1.033	1.021	1.014	1.047	1.030	1.020	1.012	1.024	1.015	1.009	1.019	1.012	1.006	1.014	1.008	1.003
7	1.047	1.029	1.018	1.011	1.043	1.026	1.017	1.009	1.022	1.013	1.007	1.018	1.010	1.005	1.014	1.008	1.003
8	1.044	1.026	1.015	1.009	1.040	1.024	1.015	1.007	1.020	1.012	1.006	1.017	1.009	1.004	1.013	1.007	1.003
9	1.040	1.024	1.014	1.007	1.037	1.022	1.014	1.006	1.019	1.011	1.005	1.016	1.009	1.004	1.013	1.007	1.002
10	1.037	1.022	1.012	1.006	1.034	1.020	1.012	1.005	1.017	1.010	1.004	1.015	1.009	1.003	1.013	1.007	1.002
For 10 Per Cent Effective Floor Cavity Reflectance (20) Per Cent = 1.00)																	
Room Cavity Ratio																	
1	.923	.929	.935	.940	.933	.939	.943	.948	.956	.960	.963	.973	.976	.979	.989	.991	.993
2	.931	.942	.950	.958	.940	.949	.957	.963	.962	.968	.974	.976	.980	.985	.988	.991	.995
3	.939	.951	.961	.969	.945	.067	.966	.973	.967	.975	.981	.978	.983	.988	.988	.992	.996
4	.944	.958	.969	.978	.950	.963	.973	.980	.972	.980	.986	.980	.986	.991	.987	.992	.996
5	.949	.964	.976	.983	.954	.968	.978	.985	.975	.983	.989	.981	.988	.993	.987	.992	.997
6	.953	.969	.980	.986	.958	.972	.982	.989	.977	.985	.992	.982	.989	.995	.987	.993	.997
7	.957	.973	.983	.991	.961	.975	.985	.991	.979	.987	.994	.983	.990	.996	.987	.993	.998
8	.960	.976	.986	.993	.963	.977	.987	.993	.981	.988	.995	.984	.991	.997	.987	.994	.998
9	.963	.978	.987	.994	.965	.979	.989	.994	.983	.990	.996	.985	.992	.998	.988	.994	.999
10	.965	.980	.989	.995	.967	.981	.990	.995	.984	.991	.997	.986	.993	.998	.988	.994	.999
For 0 Per Cent Effective Floor Cavity Reflectance (20 Per Cent = 1.00)																	
Room Cavity Ratio																	
1	.859	.870	.879	.886	.873	.884	.893	.901	.916	.923	.929	.948	.954	.960	.979	.983	.987
2	.871	.887	.903	.919	.886	.902	.916	.928	.926	.938	.949	.954	.963	.971	.978	.983	.991
3	.882	.904	.915	.942	.898	.918	.934	.947	.936	.950	.964	.958	.969	.979	.976	.984	.993
4	.893	.919	.941	.958	.908	.930	.948	.961	.945	.961	.974	.961	.974	.984	.975	.985	.994
5	.903	.931	.953	.969	.914	.939	.958	.970	.951	.967	.980	.964	.977	.988	.975	.985	.995
6	.911	.940	.961	.976	.920	.945	.965	.977	.955	.972	.985	.966	.979	.991	.975	.986	.996
7	.917	.947	.967	.981	.924	.950	.970	.982	.959	.975	.988	.968	.981	.993	.975	.987	.997
8	.922	.953	.971	.985	.929	.955	.975	.986	.963	.978	.991	.970	.983	.995	.976	.988	.998
9	.928	.958	.975	.988	.933	.959	.980	.989	.966	.980	.993	.971	.985	.996	.976	.988	.998
10	.933	.962	.979	.991	.937	.963	.983	.992	.969	.982	.995	.973	.987	.997	.977	.989	.999

3.5.2.2.1.1 Cavity ratios. The room or compartment is classified according to the proportions and the fixture mounting height above the floor or deck. In the zonal-cavity method, the effects of room proportions, fixture suspension length and work plane height upon the CU are respectively accounted for by the room cavity ratio, ceiling cavity ratio, and floor cavity ratio. These ratios are determined by dividing the room into three cavities as shown on figure 23, and substituting dimensions (in feet) in the following formulas:

Room cavity ratio, $$RCR = \frac{5HRC\ (L + W)}{LW}$$ Equation 21

Ceiling cavity ratio, $$CCR = \frac{5HCC\ (L + W)}{LW} = RCR\ \frac{HCC}{HRC}$$ Equation 22

Floor cavity ratio, $$FCR = \frac{5HFC\ (L + W)}{LW} = RCR\ \frac{HFC}{HRC}$$ Equation 23

Where:
- HRC = height of room between fixture plane and work plane
- HCC = distance from fixture plane to ceiling
- HFC = height of work plane above floor
- L = room length
- w = room width

The cavity ratio of irregular compartments can be calculated using the following formula:

$$\text{Cavity ratio} = \frac{2.5 \times \text{cavity height} \times \text{cavity perimeter}}{\text{Area of cavity base}}$$ Equation 24

Cavity ratios may also be obtained from table VII.

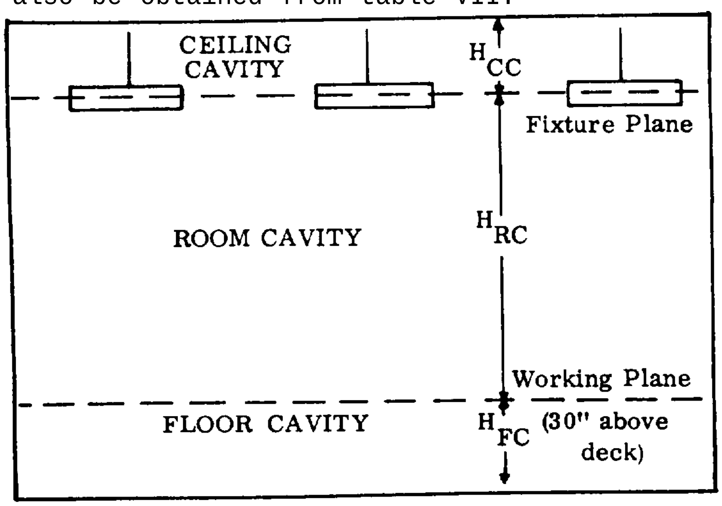


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FIGURE 23. The three cavities used in the zonal-cavity method.

3.5.2 .2.1.2 Effective cavity reflectances. Table V III provides a means of converting the combination of wall and ceiling or wall and floor reflectances into a single effective ceiling cavity reflectance and a single efc.

Note that for recessed lighting fixtures , ceiling cavity ratio equals O and the ceiling reflectance may be used as effective ceiling cavity reflectance.

3.5.2.2.2 Examples of using the lumen method. A typical example of using the lumen method is shown on figure 27 (see 3.5.3.3.1), using equation 20. Table X has been prepared to minimize the mathematical-calculations necessary to determine in-service footcandles. Table X lists the initial footcandles produced by each 1000 lamp lumens for the various coefficients of utilization. For example, consider 12 symbol 77.4 fixtures installed in a 30- by 14-foot spacing with a CU of 0.53. Table X does not show areas per fixture as large as 420 square feet, but the figure for 42 square feet, divided by 10, will give the correct answer. Reference to table X shows that for these conditions and by interpolation (first interpolate for CU of 0.53 between CUs 0.52 and 0.54 and then for area of 42 between areas of 40 and 45), 1.26 footcandles will be delivered to the work plane for each 1000 lamp lumens. Since 12 symbol 77.4 fixtures emit 24,720 lumens, 1.26 multiplied by 24.72 equals 31.1 footcandles on the working plane. Table X can be used for all types of lamps, and by using appropriate constants, for any area.

TABLE X. Precalculated footcandle table.

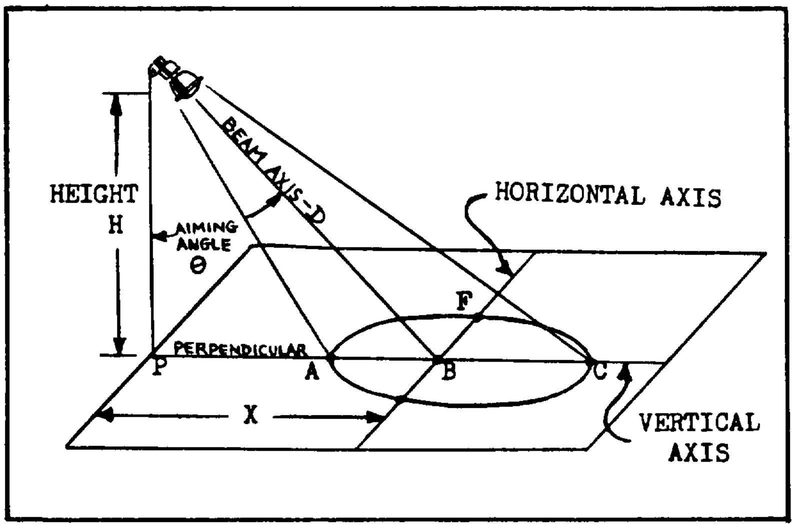
(Footcandles for each 1000 lamp lumens (see 3.5.2.2.2))

*Area (Square feet)	Coefficients of Utilization																								
	.30	.32	.34	.36	.38	.40	.42	.44	.46	.48	.50	.52	.54	.56	.58	.60	.62	.64	.66	.68	.70	.72	.74	.76	.78	.80
10	30.0	32.0	34.0	36.0	38.0	40.0	42.0	44.0	46.0	48.0	50.0	52.0	54.0	56.0	58.0	60.0	62.0	64.0	66.0	68.0	70.0	72.0	74.0	76.0	78.0	80.0
11	27.2	29.0	30.4	32.4	34.6	38.2	39.2	40.0	41.8	43.6	43.4	47.2	49.0	51.0	52.8	54.6	57.4	58.2	60.0	61.8	63.6	65.4	67.4	69.2	71.0	72.8
12	23.0	26.6	28.4	30.0	31.6	33.2	35.0	36.6	38.4	40.0	41.6	43.2	45.0	46.6	48.2	50.0	51.6	53.2	55.0	56.6	58.4	60.0	61.6	63.4	65.0	66.8
13	23.0	24.6	26.2	27.6	29.2	30.8	32.4	33.8	35.4	37.0	38.4	40.0	41.6	43.0	44.6	46.2	49.2	52.4	50.8	52.4	53.8	55.4	57.0	58.4	60.0	61.6
14	21.4	22.8	24.2	25.6	27.0	28.2	30.0	31.4	32.8	34.2	35.6	37.0	38.4	40.0	41.4	42.8	44.2	45.6	47.0	43.4	50.0	51.4	52.8	54.4	55.6	57.2
16	18.7	20.0	21.2	22.4	23.6	25.0	26.2	27.4	28.6	30.0	31.2	32.4	33.6	35.0	36.2	37.4	38.6	40.0	41.2	42.4	43.6	45.0	46.2	47.6	48.8	50.0
18	16.7	17.8	18.9	20.0	21.0	22.2	23.2	24.4	25.4	26.6	27.6	28.8	30.0	31.0	32.2	33.2	34.4	35.4	36.6	37.6	38.8	40.0	41.2	42.2	43.4	44.4
20	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0	39.0	40.0
22	13.6	14.5	15.4	16.4	17.3	18.2	19.1	20.0	20.8	21.8	22.6	23.6	24.4	25.4	26.2	27.2	28.0	29.0	30.0	30.8	31.8	32.8	33.6	34.6	35.4	36.4
24	12.5	13.3	14.2	15.0	15.8	16.7	17.5	18.3	19.1	20.0	20.8	21.6	22.4	23.2	24.0	25.0	25.8	26.6	27.6	28.4	29.2	30.0	30.8	31.6	32.6	33.4
26	11.5	12.3	13.1	13.8	14.6	15.4	16.1	16.9	16.7	18.5	19.2	20.0	20.6	21.4	22.2	23.0	23.8	24.6	25.4	26.2	27.0	27.8	28.4	29.2	30.0	30.8
28	10.7	11.4	12.1	12.8	13.6	14.5	15.0	15.7	16.4	17.1	17.8	18.6	19.3	20.0	20.6	21.4	22.0	22.8	23.6	24.2	25.0	25.8	26.4	27.2	27.8	28.6
30	10.0	10.7	11.4	12.0	12.7	13.4	14.0	14.7	15.4	16.0	16.7	17.4	18.0	18.7	19.4	20.0	20.7	21.4	22.0	22.7	23.4	24.0	24.7	25.4	26.0	26.6
35	8.6	9.2	9.7	10.3	10.9	11.4	12.0	12.6	13.1	13.7	14.3	14.8	15.4	16.0	16.6	17.2	17.7	18.3	18.9	19.4	20.0	20.6	21.2	21.8	22.2	22.8
40	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0
45	6.66	7.1	7.54	8.0	8.44	8.88	9.32	9.76	10.2	10.7	11.1	11.5	12.0	12.4	12.9	13.3	13.8	14.2	14.7	15.1	15.5	16.0	16.4	16.9	17.3	17.7
50	6.0	6.4	6.8	7.2	7.6	8.0	8.4	8.8	9.2	9.6	10.0	10.4	10.8	11.2	11.6	12.0	12.4	12.8	13.2	13.6	14.0	14.4	14.8	15.2	15.6	16.0
55	5.44	3.88	6.18	6.54	6.9	7.26	7.64	8.0	8.36	8.72	9.08	9.44	9.8	10.2	10.4	10.5	11.3	11.6	12.0	12.4	12.7	13.1	13.5	13.8	14.2	14.5
60	5.0	5.32	5.66	6.0	6.32	6.66	7.0	7.32	7.66	8.0	8.32	8.66	9.0	9.32	8.66	10.0	10.3	10.7	11.0	11.3	11.7	12.0	12.3	12.7	13.0	13.3
65	4.61	4.92	5.24	5.54	5.84	6.16	6.46	6.76	7.08	7.38	7.90	8.00	8.30	8.62	8.92	9.24	9.54	9.84	10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.3
70	4.28	4.56	4.86	5.14	5.42	5.7	6.0	6.28	6.56	6.86	7.14	7.42	7.7	8.0	8.28	8.56	8.86	9.14	9.42	9.70	10.0	10.28	10.56	10.86	11.14	11.42
80	3.74	4.00	4.24	4.50	4.74	5.0	5.24	5.5	5.74	6.00	6.24	6.5	6.75	7.0	7.24	7.5	7.75	8.0	8.24	8.50	8.75	9.0	9.24	9.5	9.75	10.0
90	3.32	3.54	3.76	4.0	4.22	4.42	4.66	4.88	5.10	5.32	5.54	5.76	6.00	6.22	6.42	6.66	6.88	7.1	7.32	7.54	7.76	8.0	8.22	8.42	8.66	8.88

*Area may represent floor area in square feet per lamp fixture or room. If the area is multiplied by 10^n, divide footcandles by 10^n.

3.5.3 Floodlighting calculations.

3.5.3.1 General. In many locations where floodlighting is necessary there are some basic dimensions that can be assumed to be already fixed. For example, in the usual deck floodlighting, the engineer is usually able to locate points where the floodlights should logically be placed, such as nearby kingposts or along high points of ship's superstructure. These locations establish the height (H) from the floodlight to the surface to be lighted, distance X, lighting pattern, and the aiming angle (see figure 24). They also guide the choice of floodlight type: narrow, medium, or broad beam. The aiming angle is the angle between the perpendicular and the axis of a floodlight aimed toward the center-line.



SH 964-24

FIGURE 24. Floodlighting geometry.

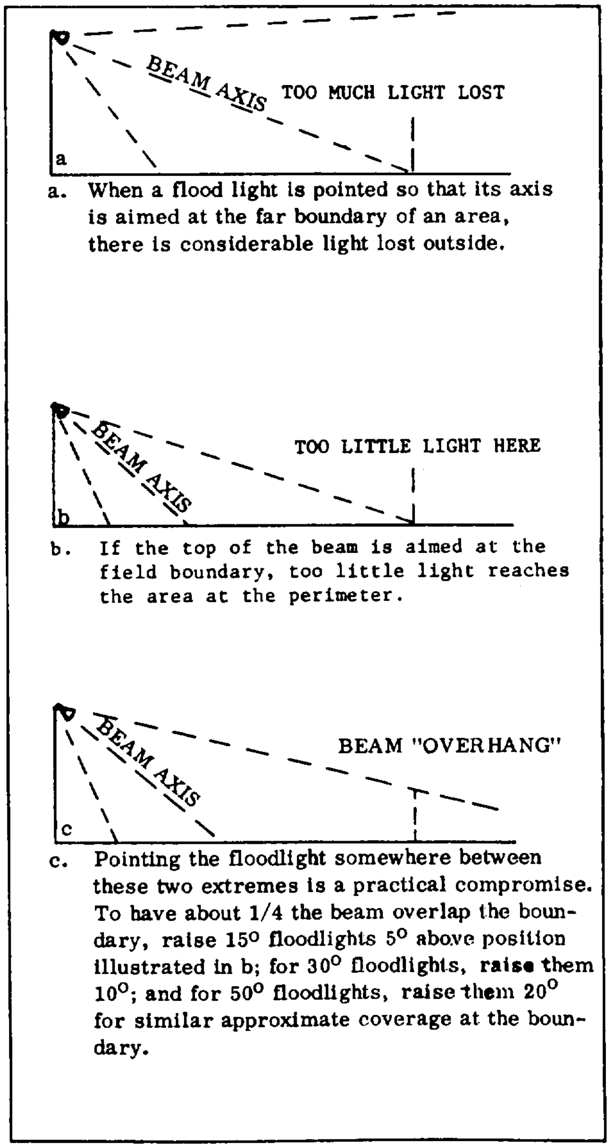
3.5.3.2 Candlepower and aiming of floodlights. The light output of a particular floodlight can be obtained from its specifications or can be determined from published data by lamp manufacturers and configuration of floodlight design. Navy floodlights are either of the open (lamp not covered by a lens) or enclosed type. In the open type, utilizing the sealed beam lamp as in symbol 303.1, the light output of the floodlight is the same as published by industry. In the enclosed type, however, the light output must be adjusted since both clear and colored lenses absorb light. The following approximate transmission values are found in typical Navy lenses:

Clear:	75 – 85 percent
Amber:	40 - 60 percent
Red:	5 - 10 percent
Green:	5 - 20 percent
Blue:	3 - 6 percent

Light output data for lamps used in Navy floodlights are given in appendix A.

3.5.3.2.1 Although the choice of beam spread for a particular application depends upon individual circumstances, the following general principles apply:

(a) The greater the distance from the floodlight, the narrower the beam spread desired.
(b) Since by definition the candlepower at the edge of a floodlight beam is 10 percent of the candlepower near the center of the beam, the illumination level at the edge of the beam is one-tenth or less than that at the center. To obtain reasonable uniformity of illumination, the beams of individual floodlights must overlap each other as well as the edge of the surface to be lighted.
(c) The percentage of beam lumens falling outside the area to be lighted is usually lower with narrow-beam than with wide-beam units. Thus, narrow-beam floodlights are preferable where they will provide the necessary degree of uniformity of illumination at the proper footcandle level. Correct aiming of floodlights is shown on figure 25.



SH 964-25

FIGURE 25. Aiming of floodlight.

3.5.3.3 The point-by-point method for floodlights. The point-by-point method (see also 3.5.2.1) permits the determination of footcandles at any point and orientation on a surface. This method is valuable since it permits a visualization of the degree of lighting uniformity realized for any given set of conditions. Figures 26 and 28 have been prepared to facilitate the calculation of footcandle intensities of the elliptical patterns encountered in floodlighting. Figure 26 shows vertically and horizontally distributed illumination of an elliptical light pattern. Figure 28 depicts graphically the length of distances X and Ds and axes ABC and EBF of figure 26 for a given height, aiming angle, and floodlight beam spread. This use is illustrated in the following example:

3.5.3.3.1 Example. Determine the length of AB, BC, EB, and BF and the illumination at points A, B, C, E, and F of figure 26 for a floodlight with a 30-degree vertical and 60-degree horizontal candlepower distribution as shown on figure 15 mounted 50 feet above deck at an aiming angle of 30 degrees. From the data given:

H = 50 feet $\qquad \theta_1 = \theta_2 = 15$ degrees
θ = 30 degrees $\qquad \theta_3 = \theta_4 = 30$ degrees

Constructing a template as shown on figure 28 with H = 50 and aiming angle of 30 degrees, the following can be obtained:

x = 28.8 feet $\qquad D_1$ = 52.0 feet
PA = 13.4 feet $\qquad D$ = 57.5 feet
PC = 50 feet $\qquad D_2$ = 63.5 feet

Thus: AB = X-pA = 28.8-13.4 = 15.4 feet
BC = PC-x = 50.0-28.8 = 21.2 feet

Constructing a template as shown on figure 27 with H = D = 57.5 feet, O degrees aiming angle and beam spread of 30 degrees, the following can be obtained:

EB = BF = 33.5 feet
$D_3 = D_4$ = 66.2 feet

From figure 15, the candlepower at points A, B, C, E, and F is as follows:

A = C = 1,600 candlepower
E = F . 500 candlepower
B = 11,600 candlepower

Thus the illumination at points A, B, C, E, and F can be calculated using equations 25 through 28 and tables IV and V as follows:

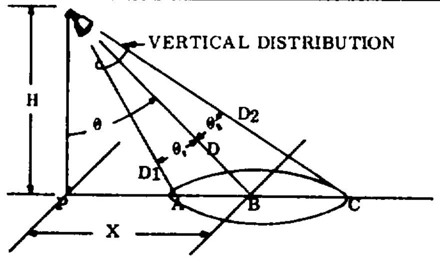
$$E_A = \frac{1600 \cos 30 \cos^2 (30-15)}{(50)2} = 0.46 \text{ footcandles} \qquad \text{Equation 25}$$

$$E_B = \frac{11{,}600 \cos^3 30}{(50)2} = 3.0 \text{ footcandles} \qquad \text{Equation 26}$$

$$E_C = \frac{1600\cos 30\cos^2(30+15)}{(50)2} = 0.27 \text{ feet}$$ Equation 27

$$E_E = E_F = \frac{500\cos^3 30\cos 30}{(50)2} = 0.11 \text{ feet}$$ Equation 28

By similar calculations and smaller beam spreads, the illumination at any point on the axis of the ellipse can be calculated.



a. Illumination along line ABC:

From geometry:

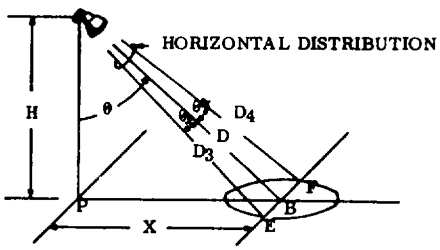
$$D = \frac{H}{\cos\theta}\ ;\ D_1 = \frac{H}{\cos(\theta-\theta_1)}\ ;\ D_2 = \frac{H}{\cos(\theta+\theta_2)}$$

Using Eq. 11, the illumination along line ABC can be calculated as follows:

At point B; $E_B = \frac{I_B \cos\theta}{D_2} = \frac{I_B \cos^3\theta}{H_2}$ Eq. 25

Along line AB; $E_{AB} = \frac{I_{\theta 1}\cos\theta}{D_1^2} = \frac{I_{\theta 1}\cos\theta\cos^2(\theta-\theta_1)}{H^2}$ Eq. 26

Along line BC; $E_{BC} = \frac{I_{\theta 2}\cos\theta}{D_2^2} = \frac{I_{\theta 2}\cos\theta\cos^2(\theta+\theta)}{H^2}$ Eq. 27



b. Illumination along line EBF:

From geometry:

$$D = \frac{H}{\cos\theta}\ ,\ D_1 = \frac{D}{\cos\theta_3} = \frac{H}{\cos\theta_3\cos\theta}\ ,\ \theta_3 = \theta_4$$

Using Eq. 11, the illumination along line EBF can be calculated as follows:

At point B; Same as Eq. 24

Along line BE or BF;

$E_E = \frac{I_E\cos\theta}{D_1^2} = \frac{I_E\cos^3\theta\cos\theta_3}{H^2}$ Eq. 28

Note that line EBF can move forward and aft to cover the whole ellipse.

SH 964-26

FIGURE 26. Illumination of an elliptical light pattern.

TYPICAL PROBLEM

Determine the number of lighting fixtures required to provide 28 footcandles in a room 30 feet long by 14 feet wide by 8 feet high using the 40 watt fluorescent fixtures, *Symbol* 77.4. The reflectance of the overhead (ceiling) is 70 percent, the bulkhead (wall) 50 Percent and the deck (floor) 30 percent. The lighting fixtures are to be mounted 7 feet from the deck. A working plane 30 inches above the deck is required.

GENERAL INFORMATION

fill in the following date:

Average initial footcandles required: 28 footcandles

Lighting Fixture Data:

Specification: MIL-F-16377/11 Symbol Number: 77. 4

Lamps (type end color): F20T12/CW Number per flxture: 2

Rated lumens per lamp: 1030 Total lumens per fixture: 2060

SELECTION OF COEFFICIENT OF UTILIZATION

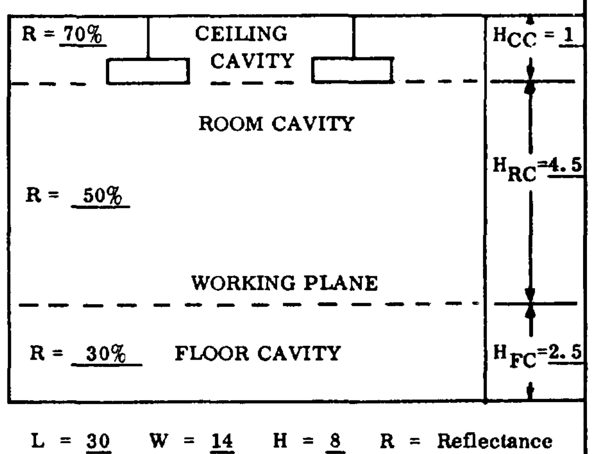
Step 1: Fill in sketch at right.

Step 2: Determine Cavity Ratios from Table VII or by formulas (see 3.5 .2.2 .1.1)

Room Cavity Ratio, RCR = 2.35

Ceiling Cavity Ratio, CCR = 0.5

Floor Cavity Ratio, FCR = 1.3



Step 3: Obtain Effective Ceiling Cavity Reflectance (ccc) from Table VIII. ecc = 64%

Step 4: Obtain Effective Floor Cavity Reflectance (efc) from Table VIII. efc = 26%

Step 5: Obtain Coefficient of Utilization (CU) from Appendix A. CU = 0.53

CALCULATIONS

Using Equation 6-9

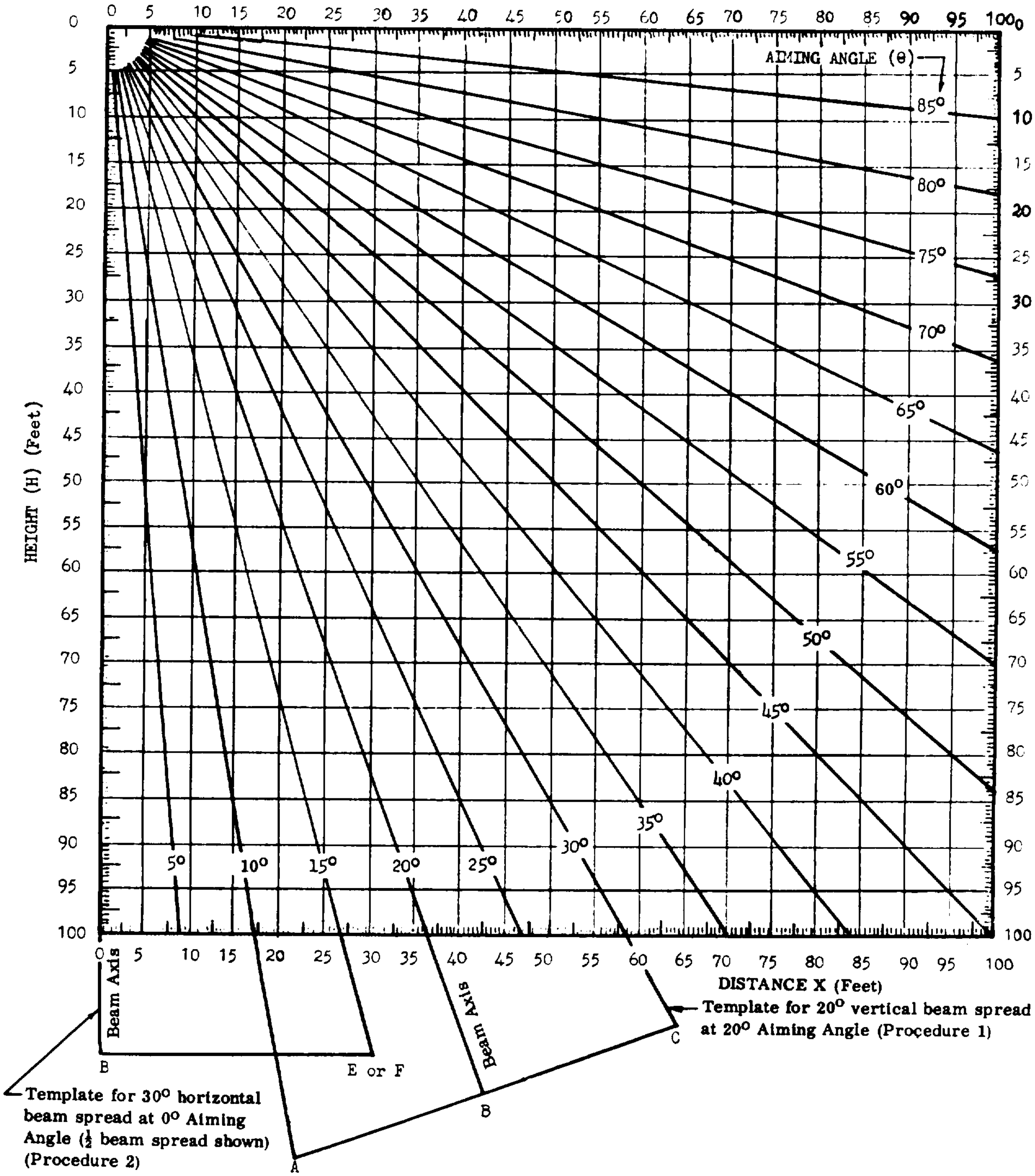
$$\text{No. of lighting fixtures required} = \frac{\text{Average initial footcandles x room length x room width}}{\text{Lamps per fixture x lumens per lamp x coefficient of utilization}}$$

$$= \frac{(28)\ (30)\ (14)}{(2)\ (1030)\ (o.\ 53)} = 10.8 \text{ or 12 fixtures for symmetry}$$

NOTE: 10 fixtures till provide 24.0 f. c. while 12 fixtures will provide 31.1 f. c. (see 3.5.2.2.2)

SH 964-27

FIGURE 27. Example of using the lumen method.



PROCEDURE:

1. To find X, AB, and BC:
   a. Place Beam Azis at the desired Aiming Angle and draw lines for vertical beam spread.
   b. Obtain X, AB, and BC for the desired height from chart.
2. To find BE or BF (Note BE=BF):
   a. Determine distance D and substitute for Height (H) in chart. Note: $D = \sqrt{H^2 + X^2}$
   b. Place Beam Axis at 0° Aiming Angle and draw line for ½ horizontal beam spread.
   c. Obtain BE or BF along the "DISTANCE X" axis for the desired distance D.
3. To find D mark its magnitude on a piece of paper and place along "DISTANCE X" axis.

SH 964-28

FIGURE 28. Floodlight beam spread.

3.5.3.4 The beam-lumen method for floodlights. The beam-lumen method for floodlights is quite similar to the beam-lumen method for interior lighting. The major difference is the fact that, unlike interior lighting, floodlights are aimed from various angles other than directly above the surface to be illuminated.

The basic formula is:

$$\text{Number of floodlights} = \frac{\text{Area x footcandles}}{\text{Beam lumens x CBU x MF}}$$

Where:

Area = surface area to be lighted

Footcandles = as desired.

Beam lumens = the quantity of light that is contained within the floodlight beam. Beam lumens also equal the lamp lumens multiplied by the beam efficiency of the floodlight (see 3.5.3.2).

CBU = coefficient of beam utilization, which expresses the following ratio:

$$\text{CBU} = \frac{\text{Lumen effectively lighting an area directly from the floodlight}}{\text{Total beam lumens}}$$

Where an area is uniformly lighted, the average CBU of the floodlights in the installation is always less than 1.0. The CBU for any individual floodlight depends on its location, the point at which it is aimed, and the distribution of light within its beam. In general, it may be said that the average CBU of all the floodlights in an installation should fall within the range of 0.60 to 0.90. If less than 60 percent of the beam lumens are utilized, it is a definite indication that a more economical lighting plan could be designed by using different locations or narrower beam floodlights. On the other hand, if the CBU is over 0.90, it is most probable that the beam spread selected is too narrow and the resultant illumination will be spotty. Accurate determination of the CBU is possible only after the aiming points have been selected.

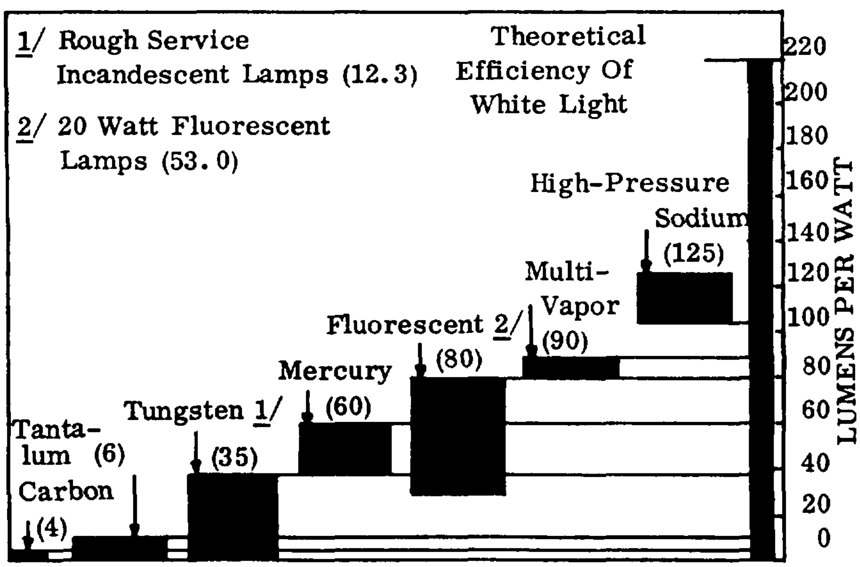
MF = Maintenance factor which is an allowance for depreciation of lamp output with life and depreciation of floodlight efficiency due to the collection of dirt on lamp, reflector, and cover glass. Depreciation of lamp output with life is dependent upon the type of lamp used. Dirt factors will differ between open and enclosed floodlights. The total factor, then, may vary from 0.65 to 0.85. After a tentative installation layout has been made, the uniformity may be checked by calculating the intensity of illumination at a few points on the floodlighted surface, using the point-by-point method. If the uniformity is found to be unsatisfactory, a larger number of units may have to be used.

3.6 Light sources.

3.6.1 General. The most common sources of electric light used in naval ships are the incandescent, fluorescent, and glow lamps. A complete list of the lamps used by the Navy is contained in federal item identification number sequence in the Illustrated Shipboard Shopping Guide (ISSG) FSC 6240 carried aboard all ships. This list includes the electrical characteristics, physical dimensions, and an outline of each Navy type lamp.

3.6.1.1 The primary purpose of a light source is the production of light, and the efficiency with which a lamp fulfills this purpose is expressed in terms of lumens emitted per watt of power consumed. If a source could be developed that would radiate all the energy it received as monochromatic yellow-green light in the region of maximum sensitivity of the eye (555 nm) it would produce approximately 680 lumens for each watt of power consumed. A theoretical source of white light of maximum efficiency, emitting only visible energy without any infrared or ultraviolet, would produce about 220 lumens per watt. Since all practical light sources do produce considerable quantities of infrared, and since there is some inevitable energy loss by conduction and convection, no present lamp closely approaches the theoretical maximum efficiency.

3.6.1.2 The incandescent filament lamp has certain characteristics which make it inherently inefficient as a source of light. Since the maximum possible efficiency values have already been approached, refinements in manufacturing processes can add little toward increasing the light output. The electric discharge lamp produces light by an entirely different process and is capable of achieving much higher efficiencies. Present clear mercury lamps have efficiencies up to 60 lumens per watt, mercury-fluorescent lamps up to 62 lumens per watt. A number of types of fluorescent lamps now provide over 70 lumens per watt, and some over 80 lumens. Multi-vapor and high pressure sodium lamps produce up to 90 and 125 lumens, respectively. Continued development work will undoubtedly lead to further improvements and still higher outputs. Figure 29 lists the efficiency of various light sources.



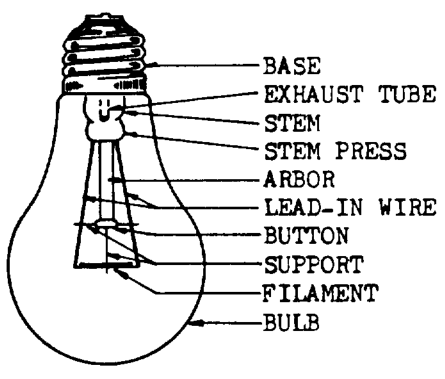
SH 964-29

FIGURE 29. Light source efficiency in lumens per watt.

3.6.1.3 Although, when viewed alone, the color of an incandescent light source may appear white, when compared with a “white” or “daylight” fluorescent source it appears to be orange. This difference in light source color is referred to as color temperature (measured in degrees Kelvin) and is directly related to the wavelength of light emitted. The lower the color temperature, the more orange or red a light source is and, conversely, the higher the temperature, the more blue the light. Thus, each color is assigned a number according to that color’s relative position in the visible portion of the electromagnetic spectrum. Beginning with red, the colors include orange, yellow, green, blue and violet.

3.6.2 Incandescent lamps. Incandescent lamps are commonly used light sources of naval ships. They produce light by means of a tungsten or carbon filament which is heated to incandescence by an electric current. Oxidation and consequent failure of the filament, which would occur in air, are prevented by surrounding the filament with an inert gas or by operating it in a vacuum. The 115- or 120-volt Navy-type lamps, up to and including the 50-watt size, are vacuum lamps; those of higher wattage are gas-filled. The use of gas in a lamp prevents rapid evaporation of the filament and permits higher temperatures which result in higher efficiencies. The effectiveness of gas in increasing luminous output is less pronounced in the lower wattage lamps; therefore, those under 50 watts continue to be of the vacuum type. The incandescent lamps most used for general lighting on shipboard are 115- or 120-volt; 50-, 100- and 200-watt rough service (RS) lamps. These RS lamps have specially constructed filaments supported at several points to increase their ability to withstand vibration and shock.

3.6.2.1 Construction. The incandescent lamp consists of a tungsten or carbon filament supported by a glass stem. The glass stem is mounted in a suitable base that provides the necessary electrical connections to the filament. The filament is enclosed in a transparent or translucent glass bulb. The passage of an electric current through the filament causes it to become incandescent and to emit light. Figure 30 shows the components of a typical incandescent lamp.

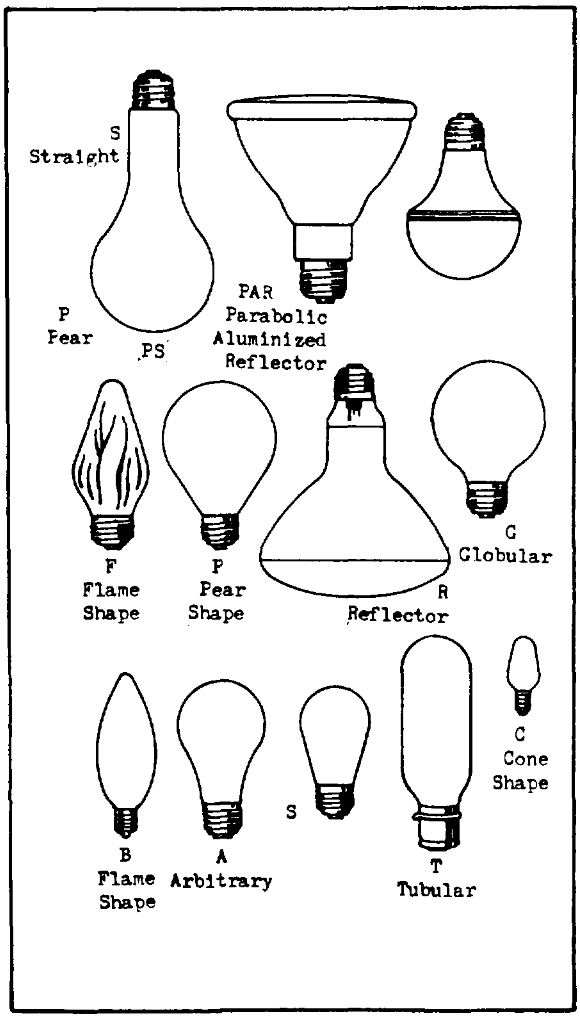


SH 964-30

FIGURE 30. Components of an incandescent lamp.

3.6.2.2 Rating. Depending on their type, incandescent lamps are rated in watts, amperes, volts, candlepower or lumens. Generally, large lamps are rated in volts, watts, and lumens. Miniature lamps are rated in amperes for a given single voltage and in candlepower for a voltage-range rating.

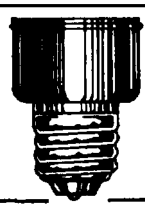
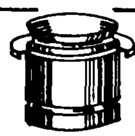
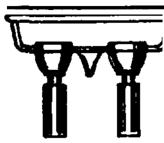
3.6.2.3 Designation. Standard incandescent lamps are designated according to the shape of bulb, the finish of bulb, and the type of base. The designating of lamps according to the shape of bulb with the corresponding letter designation is shown on figure 31. The designation letter, which denotes the shape of the bulb, is followed by a numeral (not shown) that denotes the diameter of the bulb in eighths of an inch. For example, if the lamp shown on figure 31 is designated PS-52, it is a lamp with a pear-shaped bulb and straight sides having a diameter of 52/8 or 6-1/2 inches. The clear lamp consists of a bulb made of unclouded or luminous glass, that exposes the filament to view. These lamps are used with reflecting equipments that completely conceal the lamps to avoid glare. The most commonly used lamp on shipboard is the inside frosted lamp consisting of a glass bulb whose entire inside surface is coated with a frosting. The frosting conceals the filament and diffuses the light emitted from the lamp. These lamps can be used with or without reflecting equipment.



SH 964-31

FIGURE 31. Designation of lamps according to bulk and shape.

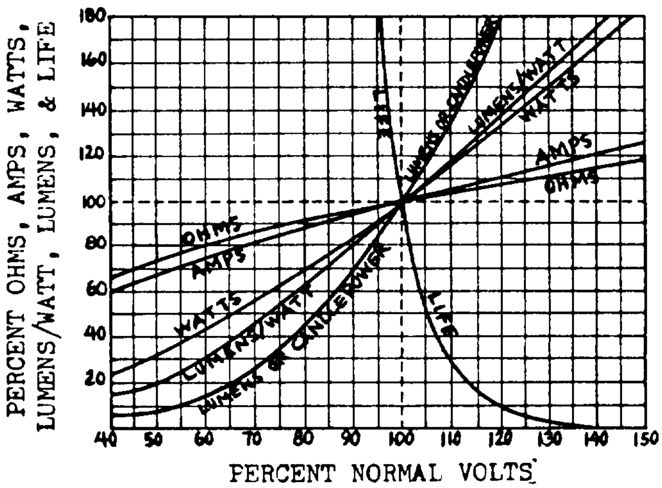
3.6.2.3.1 The designation of lamps according to the type of base is shown on figure 32. The size of the base is indicated by name (mogul, candelabra, intermediate, and so forth); the type of base provided with the different sizes is also denoted by name (bayonet, prefocus, bipost, and so forth).

	CANDELABRA. Uses include showcase, optical, appllance, Indicator, sign, and decorative lamps. This is the smallest base for 120-volt lamps.
	INTERMEDIATE. Applications include appliance, Indicator, sign, and decorative lamps.
	MEDIUM. This base is standard on general service lamps of 300 watts and under. A high degree o-f interchangeability in lamp applications Is possible because the medium base is so widely used.
	MOGUL. Normally used on 300-watt lamps and up. Also applied on special lower wattage lamps, particularly where low voltage design means a high current.
	SKIRTED. Used on lamp where the neck is too large to fit into the desired size base, or where additional space between the filament and lamp terminals is desired.
	BAYONET. Applied on specialty lamps, such as, for vacuum cleaners, sewing machines, etc. Also used on low-voltage lamps.
	PREFCCUS. Used where accurage positioning of the filament Is necessary such as in spotlights, optical lights, etc.
	MEDIUM BIPOST. Used for higher current lamps.

SH 964-32

FIGURE 32. Lamp bases.

3.6.2.4 Effect of voltage on lamp performance. Lights and lighting fixtures installed on naval ships are designed to be operated at a certain specified voltage. When operated by voltages other than those specified, the light output, life, and electrical characteristics are materially affected. A small percentage increase in voltage results in a greater percentage increase in light output and a much greater percentage decrease in life. Conversely, a small percentage decrease in voltage results in a greater percentage decrease in light output and a much greater percentage increase in life. The characteristic curves (see figure 33) for large gas-filled incandescent lamps give an approximate indication of how the performance of the lamps is affected when they are operated continually at other than design voltage. The curves for vacuum lamps, while not exactly the same, are closly related, thus the curves shown can also be applied to vacuum lamp performance. The important conclusion to be drawn from the curves is that the lighting system should be operated close to its rated voltage. Low voltage seriously decreases illumination; high voltage increases illumination, but an excess voltage of even 5 percent cuts the lamp life to about one-half and makes more frequent replacement necessary.



RELATIONSHIPS:

$$\frac{\text{life}}{\text{LIFE}} = \left(\frac{\text{VOLTS}}{\text{volts}}\right)^{a} \qquad \frac{\text{watts}}{\text{WATTS}} = \left(\frac{\text{volts}}{\text{VOLTS}}\right)^{d}$$

$$\frac{\text{lumens}}{\text{LUMENS}} = \left(\frac{\text{volts}}{\text{VOLTS}}\right)^{b} \qquad \frac{\text{amperes}}{\text{AMPERES}} = \left(\frac{\text{volts}}{\text{VOLTS}}\right)^{e}$$

$$\frac{\text{LUMENS/WATT}}{\text{lumens/watt}} = \left(\frac{\text{VOLTS}}{\text{volts}}\right)^{c} \qquad \frac{\text{ohms}}{\text{OHMS}} = \left(\frac{\text{volts}}{\text{VOLTS}}\right)^{f}$$

CAPITALS REPRESENT NORMAL RATED VALUES.

THE EXPONENTS IN THE ABOVE EQUATIONS ARE AS FOLLOWS:

	a	b	c	d	e	f
GAS-FILLED LAMPS	13.1	3.38	1.84	1.54	0.541	0.46
VACUUM LAMPS	13.5	3.51	1.93	1.58	0.580	0.42

SH 964-33

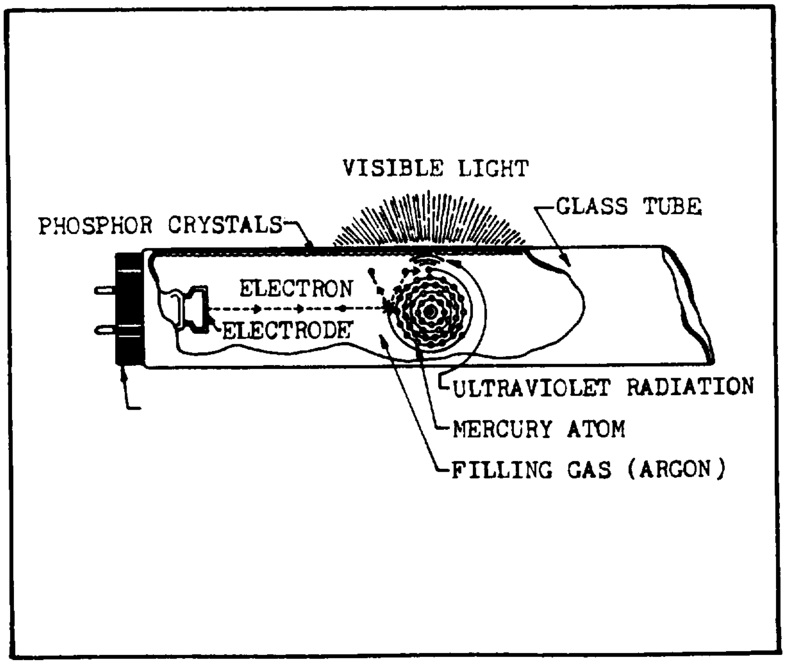
FIGURE 33. Characteristic curves for large gas-filled filament lamps.

3.6.2.5 Energy distribution. The incandescent lamp was conceived as a light source and is used principally for this purpose. However, the hot tungsten filament radiates energy in the infrared and ultraviolet as well as in the visible part of the electromagnetic spectrum. All of the input energy is not absorbed by the bulb and other lamp parts, other losses are encountered as heat is conducted or convected away from the filament and out of the lamp. The distribution of input energy for a typical 100-watt rough service lamp is as follows (the radiation and losses are shown as percentages of lamp wattage):

Light - 7.5	Gas loss - 13.5
Infrared - 73.3	Base loss - 5.7

3.6.3 Fluorescent lamps. Fluorescent lamps are now used for the majority of both red and white lighting on naval ships. The Navy has standardized on three lamp sizes, 8-watt, 15-watt and 20-watt cool white lamps of a preheat type; some other types of lamps are still used for special purposes. The use of fluorescent lamps over 20 watts has been limited to special installations because of their fragility, length, and their inability to withstand shock and vibration without an exorbitant design of a lighting fixture. Generally, red lighting is accomplished by enclosing a fluorescent lamp in a red plastic tube within a lighting fixture. The lamp enclosed is usually the center lamp of a three-lamp fixture.

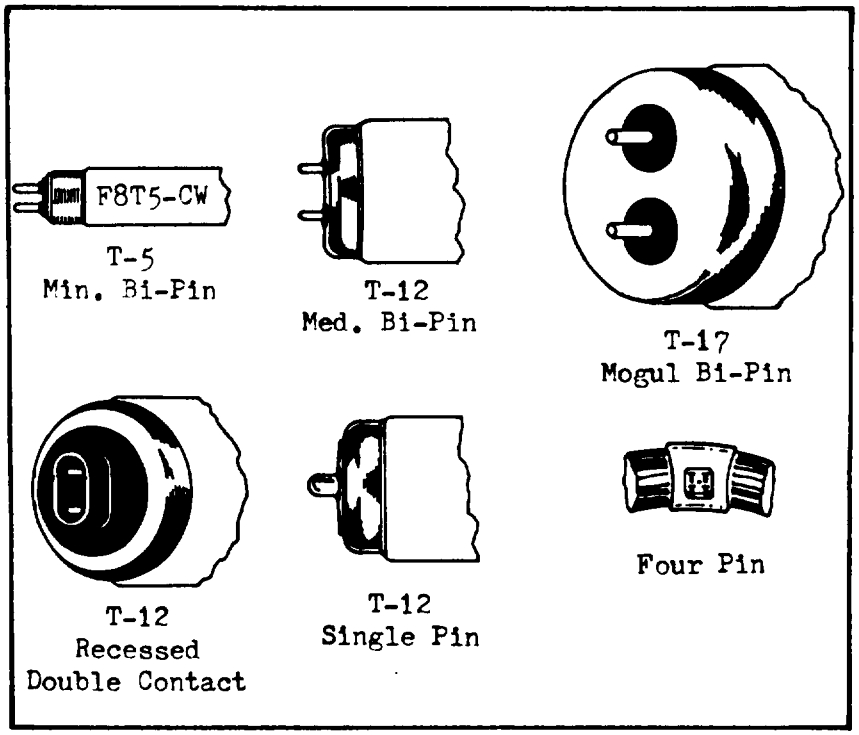
3.6.3.1 Construction. These elongated light sources are electric discharge lamps, each consisting of a glass tube (see figure 34) coated on the inside with a fluorescent phosphor and enclosing two electrodes (one at each end), a drop of mercury, and a small amount of argon gas. A fluorescent lamp produces invisible, shortwave (ultraviolet) radiation by the discharge through the mercury vapor in the tube. The phosphor absorbs the invisible radiant energy and reradiates it over a band of longer wavelengths to which the eye is sensitive.



SH 964-34

FIGURE 34. Components of a fluorescent lamp.

3.6.3.1.1 Lamps incorporating preheat or rapid-start cathodes require four electrical contacts, which in the standard line of lamps take the form of a bi-pin base at each end. There are three standard types of bipin bases: miniature bipin, medium bipin, and mogul bipin. In circline lamps, the contacts at the ends of the lamps adjoin. The high output lamps have recessed double contact type bases because of the higher ballast voltage required with lamps longer than 4 feet. Instant start lamps require only one electrical contact on each end of the lamp; thus, the single-pin base is most commonly used. Typical bases for fluorescent lamps are shown on figure 35.



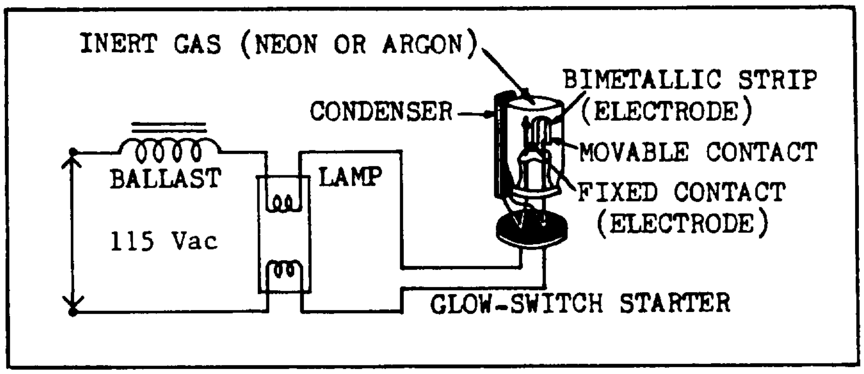
SH 964-35

FIGURE 35. Bases for fluorescent lamps.

3.6.3.2 Designation. Preheat lamps are usually identified by wattage, bulb diameter (in eighths of an inch), and color. Thus a lamp marked F20T8/cw is a 20 watt, l-inch diameter, cool white fluorescent lamp. In the case of high output (HO) lamps, the number following the F in the designation is the nominal lamp length in inches, rather than the lamp wattage as with most pre-heat lamps. For instance, a lamp marked F48T12/cw/HO/HT is a 48-inch long, 1-1/2 inch diameter, cool white, high output, high temperature fluorescent lamp.

3.6.3.3 Lamp types and control equipment. All lamps are designed for one of three general types of operating circuits: preheat, rapid-start, or instant-start. As in all discharge light sources, fluorescent lamps require special auxiliary control equipment, such as ballast, to limit the current and provide the necessary starting voltage. Since the ballast consumes some power, it must be added to the wattage of the lamp when estimating circuit requirements. Each lamp requires a ballast specifically designed for its electrical characteristics, the type of circuit in which it is to be operated and the voltage and frequency of the power supply. Generally, ballasts are incorporated as an integral part of a lighting fixture. However, certain detail lights, such as those on the secretary bureau, radio operator's desk and berth lockers, require the use of an external ballast housed in a separate box.

3.6.3.3.1 Preheat lamps. The auxiliary components of a preheat fluorescent lamp system include a ballast and a starter (see figure 36).



SH 964-36

FIGURE 36. Basic ac circuit of a preheat fluorescent lamp.

Preheat lamps are started by means of a starter which completes the circuit that permits a heating current to flow through the electrode at each end of the lamp. When the switch is opened, a high-voltage pulse is impressed across the lamp and strikes the arc.

3 .6.3.3.1.1 Starters. Automatic starting switches (see table XI) may be of the thermal or the glow-suit ch type with the latter in more common use today. The glow switch starter contains two electrodes, one of which is a bimetallic strip, enclosed in a small glass bulb filled with an inert gas such as neon or argon. When voltage is applied , a small current flows through the circuit as a result of a glow discharge between the two electrodes of the suit ch. The heating effect of the current expands the bimetallic element and causes the electrodes to touch. The closing of the switch stops the glow discharge, but allows a substantial f low of current to preheat the lamp electrodes during the short period of time when there is enough residual heat in the switch to keep it closed. As the bimetal cools, the switch opens and the resultant high-voltage pulse starts normal lamp operation. If the lamp arc fails to strike, the cycle is repeated. The condenser suppresses radio interference. The switch

does not glow after the lamp arc is established because the remaining available electrical potential is insufficient to cause a breakdown between its electrodes. Thus, the switch consumes no power , and when the lamp is turned off, it is available for immediate restarting. Thermal starters must be used in operating conditions involving low temperature, direct current (de), or widely varying line voltage. This type starter has a heating coil in series with the ballast and lamp. Since the thermal switch is closed, preheating occurs immediately upon application of voltage. The heating coil actuates the bimetallic strip in the starter switch and after sufficient preheat time elapses, the thermal switch opens and the lamp starts. During lamp operation a small amount of energy is consumed by thermal starters.

TABLE XI. Starters.

Voltage	Description	Fluorescent lamp 6-8 watts	Fluorescent lamp 15-20 watts
Ac	Item name	Simple glow switch, without lockout	Simple glow switch, without lockout
	Specification	Type III of W-S-755	Type 111 of W-S-755
	Commercial designation	FS-5	FS-2
	National stock number	6250-00-299-5962	6250-00-299-2884
Dc	Item name	Thermal switch, without lockout	Thermal switch, without lockout
	Specification	Type IV of W-S-755	Type IV of W-S-755
	Commercial designation	AT-58	AT-2
	National stock number	6250-00-283-9904	6250-00-884-2103
	Condenser type	Ceramic	Ceramic

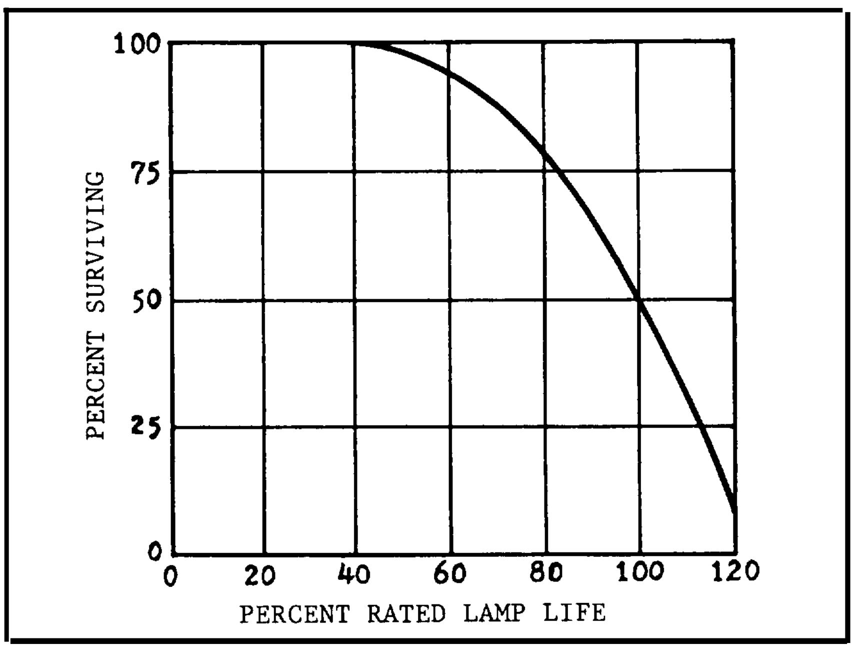
3.6.3.3.1.2 Ballasts. The principal function of a ballast is to limit current to a fluorescent lamp. A ballast also supplies sufficient voltage to start and operate the lamp. In case of rapid-start circuits, a ballast supplies voltage to continuously heat the lamp cathodes. A fluorescent lamp is an arc discharge device and the more current in the arc, the lower the resistance becomes. Without a ballast to limit current, the lamp would draw so much current that it would destroy itself. An inductive ballast constitutes the most practical solution to limiting lamp current. The simplest. inductive ballast is a coil, inserted into the circuit to limit current. Single-lamp preheat ballasts of the low power factor type (55 percent) are used in the standard Navy lighting fixtures because of the space and weight limitations and the peculiar application of lighting fixtures in split circuits for red and white illumination.

3.6.3.3.2 Rapid-start lamps. As in the preheat lamps, the electrodes in a rapid-start lamp are preheated to start the arc. However, unlike the preheat lamps, the heating circuit contains two electrical contacts at each end. A rapid-start circuit differs from a preheat circuit in that heating voltage is provided by special windings in the ballast, and there is no switch to terminate the heating circuit when the arc strikes. A small heating current flows through the electrodes continuously while the lamp is burning. Starting is quicker within 1 second under normal conditions than for preheat lamps.

3.6.3.3.3 Instant-start lamps. These lamps are started by direct application of a voltage great enough to strike the arc without any preheating of the electrodes. Because there is no preheat circuit, instant-start lamps need only one electrical contact at each end.

3.6.3.4 Operating conditions.

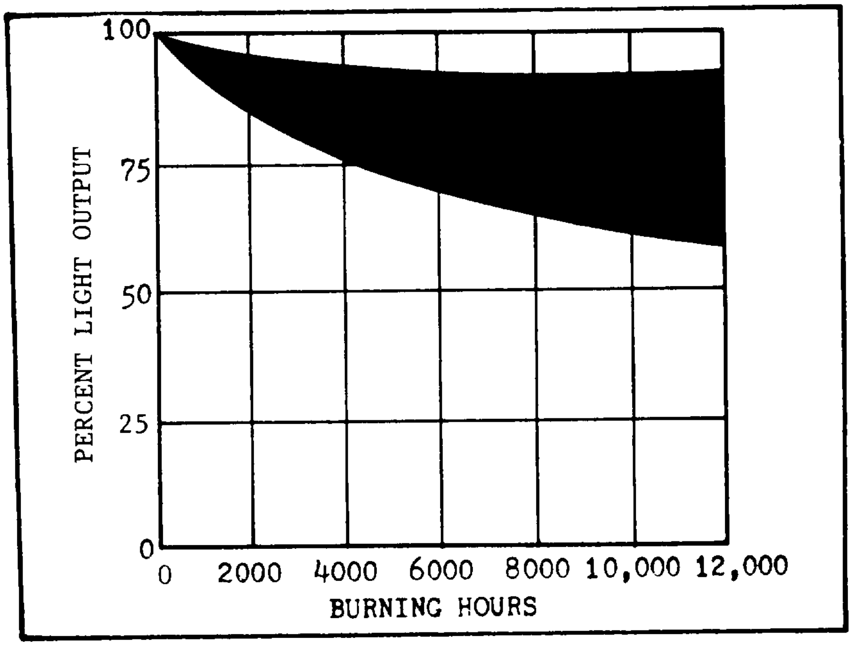
3.6.3.4.1 Lamp mortality. Fluorescent lamp life is influenced to a great degree by operating conditions. For example, operation with frequent starts shortens life appreciably. On the other hand, operation with many burning hours per start lengthens lamp life. For this reason, lamps have several different life ratings, based on the number of hours per start. When a large group of lamps is tested it will be found that failures occur very nearly in accordance with the mortality curve shown on figure 37, the average life being the point at which approximately 50 percent burn out.



SH 964-37

FIGURE 37. Lamp mortality.

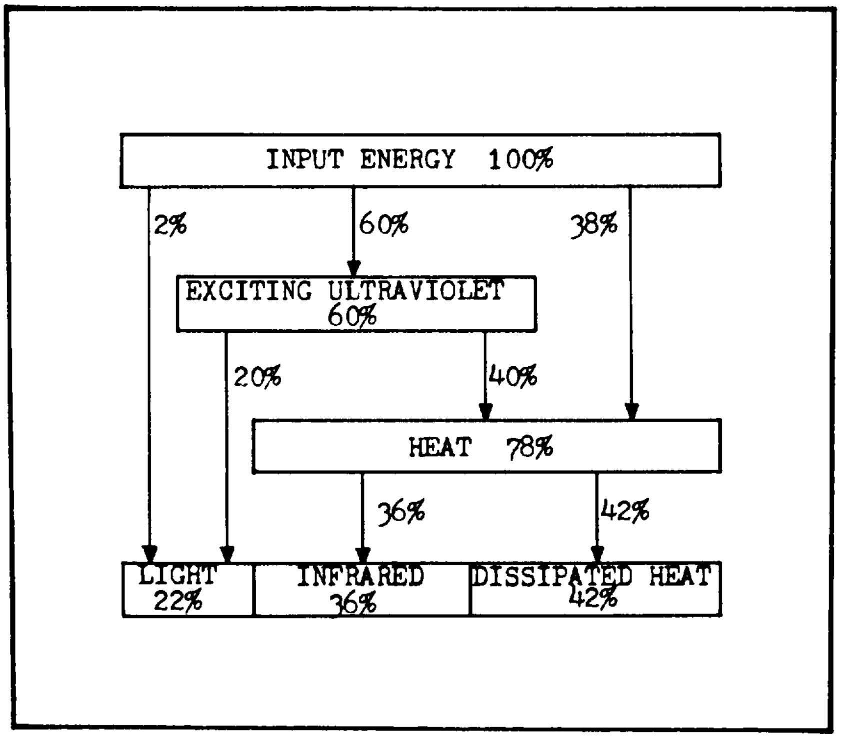
3.6.3.4.2 A fluorescent lamp decreases in lumen output most rapidly during the first 100 hours of its life cycle; therefore, the published "initial lumens" is the value obtained after 100 hours of burning. The curve shown on figure 38 shows the typical range of lamp depreciation in light output versus time. The vast majority of lamp types depreciate along a line near the upper limit of the curve. Depreciation in light output is due chiefly to a gradual deterioration of the phosphor powders and a blackening of the inside of the tube.



SH 964-38

FIGURE 38. Lumen maintenance.

3.6.3.4.3 Energy distribution. Figure 39 shows the distribution of energy in a typical cool white fluorescent lamp. For air conditioning purposes, note that l-watt-hour of power consumed produces 3.414 British thermal units (Btu) of heat.



SH 964-39

FIGURE 39. Energy distribution in a typical cool white fluorescent lamp.

3.6.3.4.4 Effect of temperature. The light output of any fluorescent lamp depends on the mercury vapor pressure inside the lamp. Optimum pressure for maximum light output for most fluorescent lamps occurs when the coolest spot on the bulb is about 100 degrees Fahrenheit (°F). Bulb wall temperature is affected by lamp wattage and bulb diameter, by the design of the lighting fixtures, and by the ambient temperature and draft conditions. As the bulb wall temperature is raised above 100°F, the mercury vapor pressure within the tube Increases causing the light output and lamp wattage to slowly drop. At lower bulb wall temperatures the mercury condenses on the tube, pressure drops, the light output falls sharply, and the wattage drops slowly. This characteristic is common to all fluorescent lamp designs.

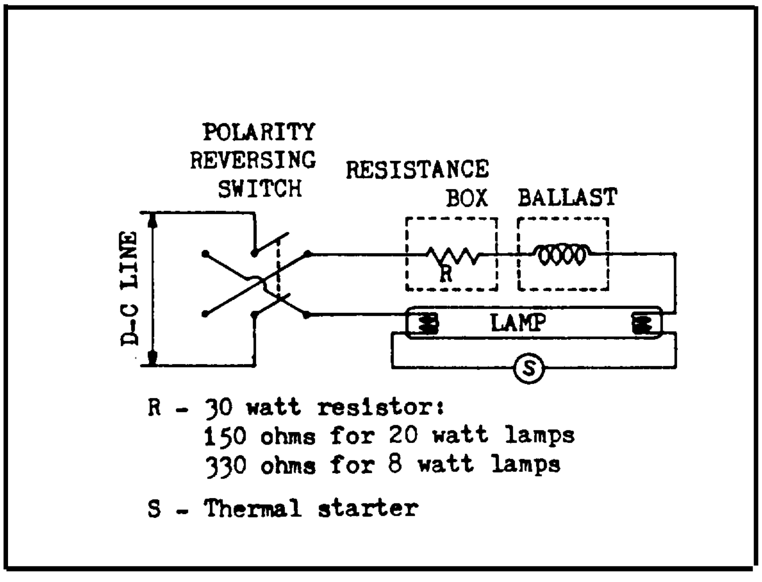
3.6.3.4.4.1 For maximum efficiency, the bulb wall temperatures should be within a range of 100 to 120°F. Light output decreases about 1 percent for each 1 degree drop in bulb temperature below 100°F, and a like amount for each 3-degree rise between 120 and 200°F.

3.6.3.4.4.2 Low temperatures may also cause starting difficulty. Preheat and rapid-start type lamps will give reliable starting at ambient temperatures of 50°F and above. Preheat lamps can be started at lower temperatures by the use of thermal rather than glow-switch starters.

3.6.3.4.5 Effect of voltage. The voltage of the fixture should be kept well within the normal operating range for the ballast. Low voltage as well as high voltage reduces efficiency and shortens life. This is in contrast with filament lamps where low voltage reduces efficiency but prolongs life. Low voltage on fluorescent lamps may also produce instability in the arc and cause starting difficulty. On voltages above the specified range, the operating current becomes excessive and may not only overheat the ballast but cause premature end-blackening and early lamp failure. Voltages below the specified range may lower the preheat current to a point where the electrodes fail to emit their proper quota of electrons. Such a condition may cause the lamps to flash on and off without starting. Under these conditions, if the lamps do start, the emission material may waste away too rapidly, with consequent shortening of lamp life.

3.6.3.4.6 Effect of frequency. The current-limiting characteristics of a ballast depend directly on the frequency of the power supply, and for this reason ballasts must be used only at the frequency for which they were designed. When operated at a frequency lower than the design frequency (for example, a 60-Hz ballast on a 50-Hz supply), the inductive reactance of a lag ballast is reduced, and higher current flows through the lamp resulting in shorter lamp life and an overheated ballast. At a frequency higher than the design frequency, the lamp current is reduced resulting in shorter lamp life and lowered light output. Operation of fluorescent lamps at higher frequencies (such as 400 Hz) increases lamp efficiency and makes possible reduced ballast size, weight, and wattage loss. Practical utilization of these advantages is dependent upon the development of efficient and economical equipment to produce these frequencies.

3.6.3.5 Dc operation. Although the fluorescent lamp is basically an ac lamp, it can be operated on dc with proper auxiliary equipment. The current is controlled by an external resistance in series with the lamp (see figure 40). Since there is no voltage peak, starting is more difficult and thermal switch starters are required.



SH 964-40

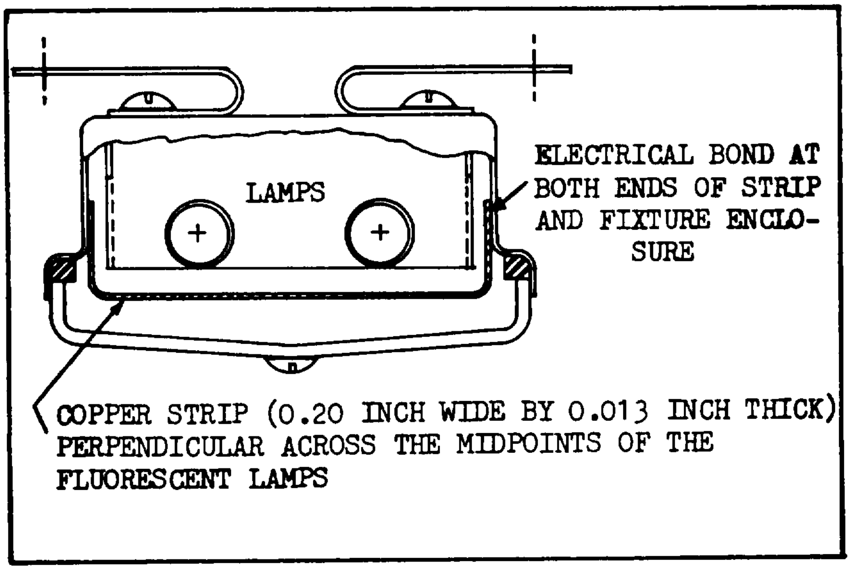
FIGURE 40. Typical circuit for dc operation of fluorescent lamps.

3.6.3.5.1 When a fluorescent lamp is operated in an ac circuit, an inductive ballast limits current to the lamp without consuming an appreciable amount of power. This is possible because of characteristics exhibited by inductance in an ac circuit. However, the resistance ballast used for dc operation consumes about the same amount of power as the lamp. Because of the greater voltage loss in resistance, the overall lumens-per-watt efficiency of dc systems is about 60 percent of the ac system. Fluorescent lamps operated on dc have a tendency to become dim at one end after several hours of operation. The dimming is a result of continuous current flow in one direction, which eventually causes the mercury to accumulate at the negative (cathode) end of the lamp. A line-reversing switch is often used to reverse the electrode functions periodically (every few hours of operation), thus overcoming the tendency to dim more at one end. Lamps operated on dc may function for only 80 percent of their rated life. Because of these limitations, dc operation of fluorescent lamps should be limited only to detail illumination of berths, desks and offices.

3.6.3.6 Radio interference. The mercury arc in a fluorescent lamp emits electro-magnetic radiation. This radiation may be picked up by nearby radios causing an audible sound. Because of the frequencies generated by the fluorescent lamp, interference is ordinarily limited to the AM broadcast band and nearby amateur and communication bands. The FM, television, and higher frequency bands are very rarely affected.

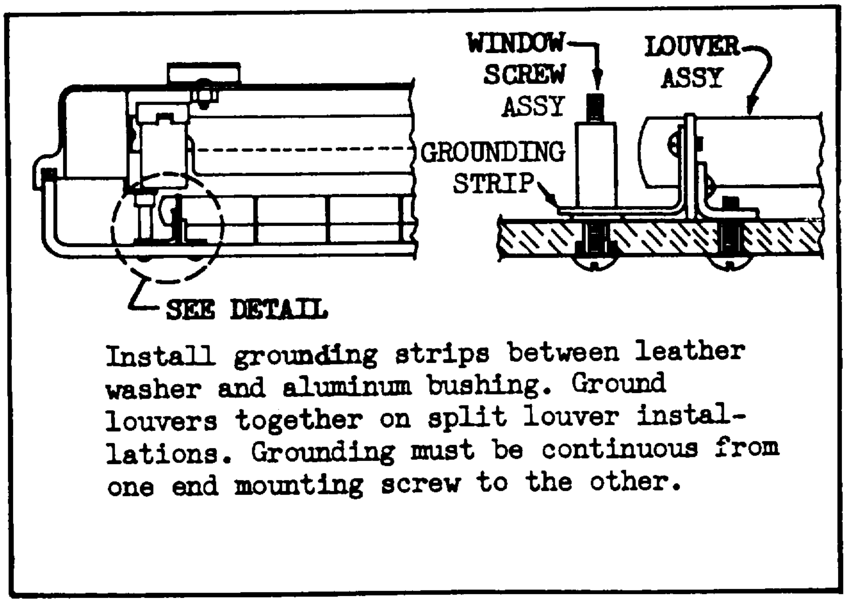
3.6.3.6.1 Interference from fluorescent lamps can readily be identified by tuning the set to a point where the interference is most pronounced, and then turning off the lamps. If the noise persists, it is from some source other than the lamps. Radiation from fluorescent lamps may reach the radio in three ways: by direct radiation from the lamp to the radio aerial circuit, by line radiation from the electric supply to the aerial circuit, and by line feedback from the lamp through the power line to the radio. Most radio interference from preheat lamps is eliminated by the small condenser ordinarily mounted in the starter-switch container. With rapid-start and instant-start systems the condenser is mounted in the ballast.

3.6.3.6.2 Radiated interference may be eliminated by moving the radio antenna farther from the lamp, 5 feet is usually sufficient. Where this is not practical, shielding media, such as the installation of a copper strip across the lamps as shown on figure 41, and grounding of metal louvers in the clear white shielded fluorescent lighting fixtures will suppress the noise below the interference level, as shown on figure 42. Conducted interference may be suppressed by radio-interference filters which are commercially available. The simplest of these is a three-section delta-connected capacitor which is grounded to the fixture and connected across the supply lines as they enter the fixture, as close to the lamps as possible. A larger capacitor type filter is also available for installations in laboratories, radio repair shops, and other places where conditions are not favorable for good radio reception. Figure 43 shows a typical filter circuit.



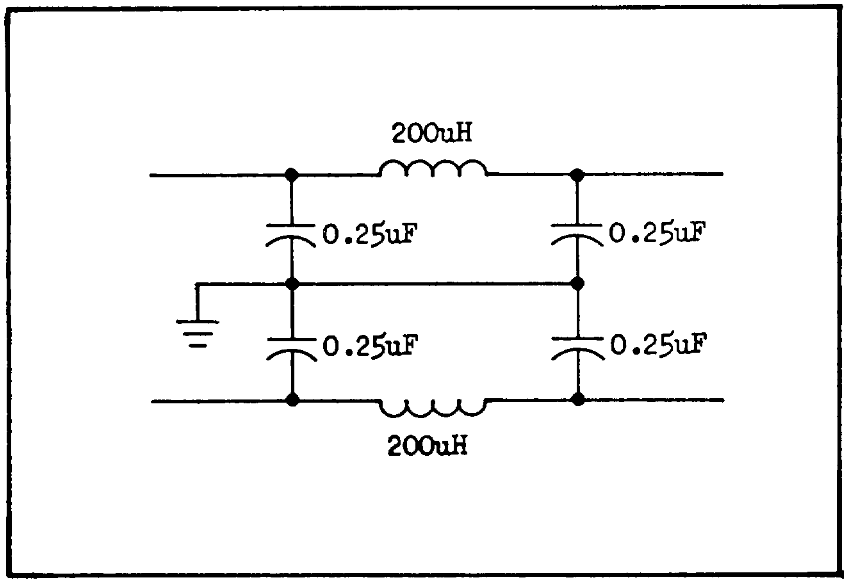
SH 964-41

FIGURE 41. Reduction of electromagnetic interference of fluorescent lamps.



SH 964-42

FIGURE 42. Grounding metal louvers of fluorescent lamps.



SH 964-43

FIGURE 43. Typical radio interferencefilter used in critical applications.

3.6.3.7 Dimming. The light output of some fluorescent lamps (rapid-start) may be adjusted or dimmed by a number of special circuits. All of these circuits incorporate one essential principle: the ballast must keep the cathodes of the lamp energized at the proper voltage regardless of the amount the lamp may be dimmed. Current passing through the lamp or lamps in the dimming system may be controlled by a number of methods. The methods used include thyrations, silicon-controlled rectifiers and other solid-state devices; also, variable inductors, autotransformers, saturable core reactors, magnetic amplifiers, and so forth.

3.6.3.7.1 Dimming of the Navy standard lighting fixtures can be accomplished by replacing the standard ballast with a dimmable type and by employing a rheostat to control the voltage. The dimmable ballasts are considered special equipments, weigh more and, because of their dimensions, must be separately mounted from the lighting fixtures. This sytem was tried in the past and was proven unreliable, therefore, it is no longer used.

3.6.3.7.2 Reduced illumination aboard ships is obtained by energizing a selective number of lighting fixtures or lamps within a fixture. This is very easily accomplished by proper wiring and switching arrangements.

3.6.3.8 Stroboscopic effect. When a fluorescent lamp is operated on ac, the voltage passes through zero and reverses in direction twice for each cycle. On 60-Hz power, this occurs 120 times per second. The light from the lamp decreases momentarily each time the voltage reverses, but no telltale flicker is visible since the eye does not respond to a frequency this high. However, an interesting phenomenon called stroboscopic effect (the tendency to see moving objects in repetitive flashes at successive positions) may sometimes be observed on rapidly moving or rotating objects. With the increased carry-over of light of the phosphorescent qualities of the present coatings used in fluorescent lamps and the increased levels of illumination, there is no danger of mistaking a rotating object as a stationary one. In an unusual combination of circumstances where the stroboscopic effect might be a problem, the following actions (listed in order of preference) can be taken:

(a) Use two or more adjacent lighting fixtures and connect them to different phases of the lighting power supply.
(b) Use a two-lamp fixture and connect each lamp to a different phase of the lighting power supply.
(c) Use a three-lamp fixture and connect each lamp to a different phase of the lighting power supply.

3.6.4 High-intensity discharge (HID) lamps. HID lamps include the groups of lamps commonly known as mercury, metal halide, and high pressure sodium lamps. Their common characteristic is that they consist of gaseous discharge arc tubes which, in the versions designed for lighting, operate at pressures and current densities sufficient to generate desired quantities of radiation within their arcs alone. While many variations occur in sizes, physical configurations and arc materials, the high intensity arc is common to all types.

3.6.4.1 Mercury lamps. In mercury lamps, light is produced by the passage of an electric current through mercury vapor. Mercury has a low vapor pressure at room temperature and becomes even lower at cold temperatures; therefore, a small amount of the more readily ionized argon gas is introduced to facilitate starting. The original arc is struck through the ionization of this argon gas. After the arc strikes, the heat slowly vaporizes the mercury until it is completely evaporated. The amount of mercury in the lamp essentially determines the final operating pressure, which is usually 2 to 4 atmospheres in the majority of lamps.

3.6.4.2 Metal halide lamps. Metal halide lamps (also called multi-vapor lamps) are very similar in construction to the mercury lamps, the major difference being that the metal halide arc tube contains various metal halides (thallium, iridium, scandium and dysprosium) in addition to mercury. When the lamp has attained full operating temperature, the metal halides in the arc tubes are partially vaporized. When the halide vapor approaches the high temperature central core of the discharge, it is dissociated into the halogen and the metal, with the metal radiating its appropriate spectrum. As the halogen and metal move near the cooler arc tube wall, they recombine by diffusion and convection and the cycle starts over again.

3.6.4.3 High pressure sodium lamps. In the high pressure sodium lamp, light is produced by electricity passing through sodium vapor. This lamp is constructed with two envelopes, the inner being of polycrystalline alumina which has the properties of resistance to sodium attack at high temperatures as well as a high melting point, and good light transmission (more than 90 percent) even though this material is translucent. Presently, this lamp has the highest light producing efficiency of any commercial source of white light.

3.6.5 Short-arc lamps. High pressure gas discharge lamps having an arc length which is small compared with the size of the electrodes are called short-arc or compact-arc lamps. Depending on rated wattage and intended application, the arc length of short-arc lamps may vary approximately 1/3 millimeter to approximately 1 centimeter. These arcs have the highest brightness and radiance of any continuously operating light source and they are primarily used in search lights. Today, most short-arc lamp types are designed for dc operation. Better arc stability and substantial longer life of the dc lamps have limited the use of the ac compact-arc lamps to a few special applications. Short-arc mercury, mercury-xenon, and xenon lamps are, during operation, under considerable pressure (up to 50 atmospheres for small lamps and approximately 10 atmospheres for large units) and therefore, must be operated in an enclosure at all times. Further, precaution must be taken to insure protection from the powerful ultraviolet radiation emitted from these lamps. In order to eliminate a possible hazard during shipment, storage, or handling of xenon or mercury-xenon lamps, special protective cases are provided. These cases are made of metal or plastic and are so arranged around the bulb that the lamp can be electrically connected without removing the case. The case should not be removed until immediately before the lamp is put into operation.

3.6.5.1 Mercury and mercury-xenon lamps. To facilitate lamp starting, short-arc mercury lamps contain argon or another rare gas at a pressure. In a mercury lamp, the voltage becomes stable only after all the mercury is vaporized. The vaporizing process is directly related to lamp warm-up time which starts when the initial arc is struck. Mercury lamps generally require several minutes to warm up to full operating pressure and light output. However, this warm-up time can be reduced by approximately 50 percent if xenon at a pressure exceeding 1 atmosphere is added to the mercury. Lamps with this type of filling are known as mercury-xenon short-arc or compact-arc lamps.

3.6.5.2 Xenon lamps. Xenon short-arc lamps are filled with several atmospheres of xenon gas. They reach some 80 percent of their final output immediately after start. The arc color approximates daylight very closely (color temperature approximately 6000 kelvins) with the spectrum continuous in the visible.

3.6.6 Glow lamps. Glow lamps are electric-discharge light sources which are used as indicator or pilot lights for various instruments, fuseholders and on control panels. Since glow lamps have a relatively low light output, they are used to indicate the energizing of circuits or the operation of electrical gear in remote locations rather than for illumination. They are also useful in identifying dc and ac. For these services the lamps offer the advantages of small size, ruggedness, long life, negligible power consumption, and operation in standard voltage circuits. The following are glow lamp operational characteristics:

(a) Every glow lamp has two electrodes sealed in a glass bulb which contains an inert gas. The color of the light produced depends upon the gas used. Neon gas produces an orange-red light, and argon produces a blue light.
(b) Aglow lamp must be operated in series with a current-limiting device. This consists of a high resistance which in some glow lamps is built into the base.

(c) When a glow lamp is operated on dc, the glow surrounds only the negative electrode; on ac, the glow surrounds both electrodes. This characteristic makes it possible to use a glow lamp as an indicator of dc and ac.

3.6.7 Low pressure sodium lamps. In low pressure sodium discharge lamps, the arc is carried through vaporized sodium. The starting gas is neon with small additions of argon, xenon, or helium. The starting time to full light output is 7 to 15 minutes. When first started, the light output is the characteristic red of the neon discharge and this gradually gives way to yellow as the sodium is vaporized. The lamp is constructed with two envelopes, the inner being the arc tube. The arc tube must be enclosed in a vacuum flask or in an outer bulb at high vacuum in order to maintain an arc bulb wall temperature of approximately 500°F which will provide efficiencies in excess of 170 lumens per watt.

3.6.8 Luminous tape. Luminous tape is used on shipboard for darkened ship conditions to mark passageways, ladders, hatchways, and so forth. The material used is one which will emit visible light for an appreciable period of time after it has been activated by exposure to white light. The light emitted is faint, hence luminous tape is suitable only for applications where low luminosity is sufficient and where the observer is dark-adapted to some extent.

4. DETAIL DESIGN CONSIDERATIONS

4.1 Illumination levels. The quantitative requirement for good illumination varies greatly with the nature of the activity, and is primarily a function of the difficulty of the visual task in terms of size of detail, brightness or color contrast, and speed demanded. Other factors such as the length of time for which the task is to be performed, the surrounding conditions, and the physiological state of the eyes that have to do the work are also involved. Without sufficient footcandles that give adequate illumination, no visual task can be performed correctly, rapidly, safely or easily.

4.1.1 Evidence providing a sound basis for definite footcandle recommendations is not easy to obtain. Much work in this field has been carried on over a period of many years, using various methods and various criteria of visual performance.

4.1.2 The study of lighting practices and seeing methods is a study of variables: people do not all have the same ability to see, they have different tolerances to discomfort and they perform seeing tasks that differ. Another highly significant variable is the relation between the cost of light and its value to the user. Because of variables such as these, many factors must be weighed in arriving at specific footcandle levels of illumination.

4.1.3 Average initial minimum footcandle values for compartments are given in table XII. The table is divided into two parts, general lighting and detail lighting. The illumination specified is to be provided on the work surface, whether this is horizontal, vertical, or oblique. Where there is no definite work area, it is assumed that the illumination is measured on a horizontal plane 30 inches above the deck. The values given are average initial footcandles provided by the illumination produced by a lighting installation at its peak, when lamps and fixtures are new. As lamps darken with use and fixtures and reflectors become dirty, the footcandles decline and stabilize at approximately 70 percent of the initial value. (This footcandle is referred to as the maintenance level, see 6.1.) The term "initial" refers to the initial condition when lamps and fixtures are new and clean.

TABLE XII. Compartment illumination requirements - average initial (minimum).

Functional group no.	General lighting requirements		Detail lighting requirements	
	Function group	Footcandles (note 1)	Equipment or furniture	Footcandles (note 1)
1	Hangar and air control and associated spaces, except:	14.0		
	Flight deck crew shelter	7.0		
	Flight crew ready room	Note 2	Status board	Note 2
2	Living, and recreation spaces, except:	14.0	Berths	Note 3
			Mirror, flat	Note 3
	Staterooms	7.0	Mirror, toilet cases	Note 3
	Berthing areas	7.0	Mirror, washrooms	Note 3
	Recreation areas	28.0	Reading and writing areas	42.0
	Library	28.0	Secretary-bureau	Note 3
3	Food service and messing spaces	28.0	Food preparation counter	42.0
			Range tops	42.0
			Serving lines	42.0
4	Damage control spaces except:	14.0	Diagram boards	28.0
	Repair stations	7.0		
	Unit patrol stations	7.0		
	Foam injection stations	7.0		
5	Communications, control and electronic equipment spaces	14.0	Desk, radio operators	28.0
			Workbench, electronic	42.0

See notes at end of table.

TABLE XII. Compartment illumination requirements - average initial (minimum). - Continued

Functional group no.	General lighting requirements: Function group	General lighting requirements: Footcandles (note 1)	Detail lighting requirements: Equipment or furniture	Detail lighting requirements: Footcandles (note 1)
6	Machinery spaces except:	14.0	Gauge and control boards	21.0
			Switchboards (except weapons control)	21.0
	Shaft alley	7.0		
	Bilges	7.0	Log desk	28.0
	Machinery control and operation station	21.0	Switchboards, weapons control	28.0
			Machine tools	Note 7
			Water columns and sight glasses	Note 3
7	Ordnance spaces (enclosed) and weapons control spaces except:	14.0	Control rooms - operated light:	
			Panels and instruments (bulkhead mounted)	28.0
	Spaces fitted with BBB lighting	(See 5.5)	Computers (requiring illumination)	28.0
	Gunnery spaces, ammunition handling spaces, and magazines, except:	7.0	Range keepers	28.0
			Stable elements	28.0
	Armory	14.0	Control rooms - operated darkened	(See 5.5)
	Ready service magazinc	3.0		
	Ready service lockers	0.0		
8	Flag spaces (except galley)	14.0		
9	Medical and dental spaces, except:	28.0		
	Laboratories	42.0	Dental bracket table	Note 4
	Medical treatment room	42.0	Dental operating chair (dental vision)	Note 3
	Surgical dressing room	42.0		
	Pharmacy	42.0	Dental prosthetic laboratory unit	Note 3
	X-ray viewing and examination room (dental)	42.0	Dental instrument cabinet	35.0
			Medical training room and technical professional library (reading position)	28.0
	Battle dressing stations	Note 6		
			Operating table	Note 3

See notes at end of table.

TABLE XII. Compartment illumination requirements - average initial (minimum). - Continued

Functional group no.	General lighting requirements: Function group	General lighting requirements: Footcandles (note 1)	Detail lighting requirements: Equipment or furniture	Detail lighting requirements: Footcandles (note 1)
10	Offices	28.0	Desks Tables Desk, typewriter Teletypewriters	42.0 42.0 42.0 42.0
11	Control spaces not included in other functional groups (for example: enclosed look-out stations, secondary-conning station, pilot house)	7.0	Chart table (not in pilot house) Chart table (in pilot house)	42.0 Note 8
	Command and control spaces operated darkened	(See 5.5)	CIC	(See 5.5)
12	Workshops	28.0	Workbench, general Workbench, fine work, such as instrument calibration and typewriter repair, and so forth Machine tools Workbench, avionic shop	42.0 143.0 Note 9 Note 7 100.0
13	Storerooms Dental storerooms Issue rooms Ship store	3.0 21.0 14.0 28.0	Issue counters Bins and drawer areas	14.0 14.0
14	Utility spaces, except: Brig	14.0 Note 5	Sewing machines Barber shop chair Barber shop mirror and shelf Laundry press areas	28.0 42.0 Note 3 28.0
15	Sanitary spaces, except: Shower areas	14.0 3.0	Mirrors	Note 3

See notes at end of table.

TABLE XII. Compartment illumination requirement - average initial (minimum). - Continued

Functional group no.	General lighting requirements		Detail lighting requirements	
	Function group	Footcandles (note 1)	Equipment or furniture	Footcandles (note 1)
Misc.	Moving stairways, passageways, companionways, ladders, and vestibules.	7.0	Bulletin boards Elevator controls	14.0 7.0
	Scuttles, hoists, unattended equipment spaces, unassigned spaces, escape trunks, and cargo spaces.	7.0		
	Passageways (used as medical waiting rooms).	21.0		
	Photographic spaces except:	7.0	Sink (photographic)	14.0
	Print shop	28.0		

NOTES:

1. Illumination requirements apply to minimum average initial footcandles of white lighting except as specifically indicated. Conversion of illumination values into metric system (SI - System International) is as follows (1 Footcandle = 10.76 Lux = 10.76 Metercandle (see 3.4)):

Footcandles	Lux	Footcandles	Lux
2	21.5	21	226.0
3	32.3	28	301.3
4	43.0	35	376.6
7	75.3	42	451.9
14	150.6	143	1538.2

2. See method H-l-A of appendix B for illumination of flight crew ready room and status board.
3. Footcandle requirements for detail lighting are not specified. Amount of illumination shall be that achieved by proper installation of the specified detail fixtures shown on Drawing 803-5184170 (see appendix B) or by the fixture furnished with the equipment.
4. Two fixtures, symbol 350, shall be installed side-by-side over the dental bracket table.
5. Lighting shall be provided in brig spaces, as follows: in each solitary cell - one psychiatric ward fixture, symbol 137; in detention cell, sentry vestibule, and cell lobby - sufficient number of psychiatric ward fixtures, symbol 137, to achieve 14.0 footcandles.
6. As specified for the area in which battle dressing station is located.

NOTES: (Continued)

7. Illumination of machine tools shall be that achieved by the fixture furnished with the machine or by proper installation of symbol 266.2.
8. Illumination of the chart table in the pilot house shall be by use of symbols 141.2 or 150.2 with red filters symbol 121.1.
9. Detail illumination over the instrument calibration workbenches shall be provided with lighting fixtures installed on the overhead.

4.1.4 Compared with the levels ordinarily encountered in nature (see table XIII) and with those of shore installations, the footcandle values listed in table XII are low. They are not low because low levels are satisfactory for critical seeing, but because of the following limitations: space, weight, cost and the constraints of shock and vibration requirements on the design of lighting fixtures. These footcandle levels, however, are considered good present-day practice and they closely agree with the levels recommended for marine applications by the Illuminating Engineering Society.

TABLE XIII. Representative levels of illumination of natural sources.

Source	Footcandles
Starlight	0.0001
Moonlight	0.01
Daylight	
At north window	50-200
In shade (outdoors)	100-1000
Direct sunlight	5000-10,000

4.2 Light and interior finishes.

4.2.1 General. Light is an element of design which should be used not only for visual comfort but also to achieve predetermined emotional responses within the lighted environment. Light has certain characteristics that affect the mood and atmosphere of the space, influencing the emotional responses of the people who occupy the space.

4.2.1.1 People are emotionally responsive to their surroundings and color is one of the chief characteristics of those surroundings. The colors at the red end of the spectrum (reds, oranges, and yellows) are psychologically warm and stimulating, while those at the blue end (blues, greens, and purples) create impressions of coolness and repose.

4.2.1.2 Warm-colored surfaces appear to approach the observer; hence, a room finished in warm tones seems smaller than it really is and conveys an impression of coziness and intimacy. Conversely, cool colors appear to recede; they can be used to create an impersonal atmosphere.

4.2.1.3 In planning a lighting system, the lighting system engineer must concern himself not only with light sources but also with colors and reflectance of interior finishes. The correct combination of colors and the ability of overheads, bulkheads, and decks to reflect a part of the incident light plays a vital role in the function of a well designed lighting system.

4.2.1.4 Cooperation between the interior designer and the lighting system engineer becomes increasingly important as the design of lighting and interiors gains in sophistication.

4.2.2 Lighting efficiency. In addition to light sources and lighting fixtures commonly used in compartment lighting, a large portion of the illumination on work planes is provided by light which has been reflected one or more times from overheads, bulkheads, and decks. As a result, the reflectance of the compartment surfaces greatly affects the overall efficiency of the compartment in delivering light to the work. In general, the higher the reflectance, the higher the utilization of light. In fact, a compartment in which all surfaces are flat white would produce the highest possible light utilization. But judged from a practical and psychological standpoint, this type of environment is seldom desirable.

4.2.3 Studies of visual comfort point out clearly that extreme brightness contrasts between the specific task and its immediate surroundings, and between the task and the more remote parts of the environment can cause discomfort and fatigue. The primary use of color in work spaces should be to improve conditions for visual comfort by reducing sharp contrasts in the area immediately surrounding the task. This may be carried further into the general surroundings by making sure, for instance, that overheads and bulkheads adjacent to ports and windows have a reflectance of at least 60 percent. This may well mean that paint used in such areas be of a lighter shade than that of the primary room color. Distracting contrasting features should also be of a light color; but vertical pillars which are liable to be a hazard may well be painted a color which will call attention to them. Just as low contrasts may obscure unwanted detail, vivid contrast may be used to call attention to items such as gears, moving parts, dangerous cutting edges and levers and control buttons. For rooms in which prolonged work is usually performed, the brightness pattern should be well balanced. Control of the brightness pattern depends on the directional distribution of light and on the reflectance of room surfaces.

4.2.4 Reflectance of interior surfaces. The reflectance of overheads, bulkheads, decks, and furnishings or machinery contribute significantly to the general illumination level. For any specified level of illumination, a workplace with highly reflecting surface requires a less intense light source than one with low reflecting surfaces. A study to obtain a comfortable brightness ratio (see 4.3.2.5) should include both the lighting fixtures (and their outputs) and the reflecting characteristics of overheads, bulkheads, decks and furnishings. The reflection factors shown on figure 44 are representative reflection factors which will provide desirable brightness ratios with the footcandle levels specified in 4.1.

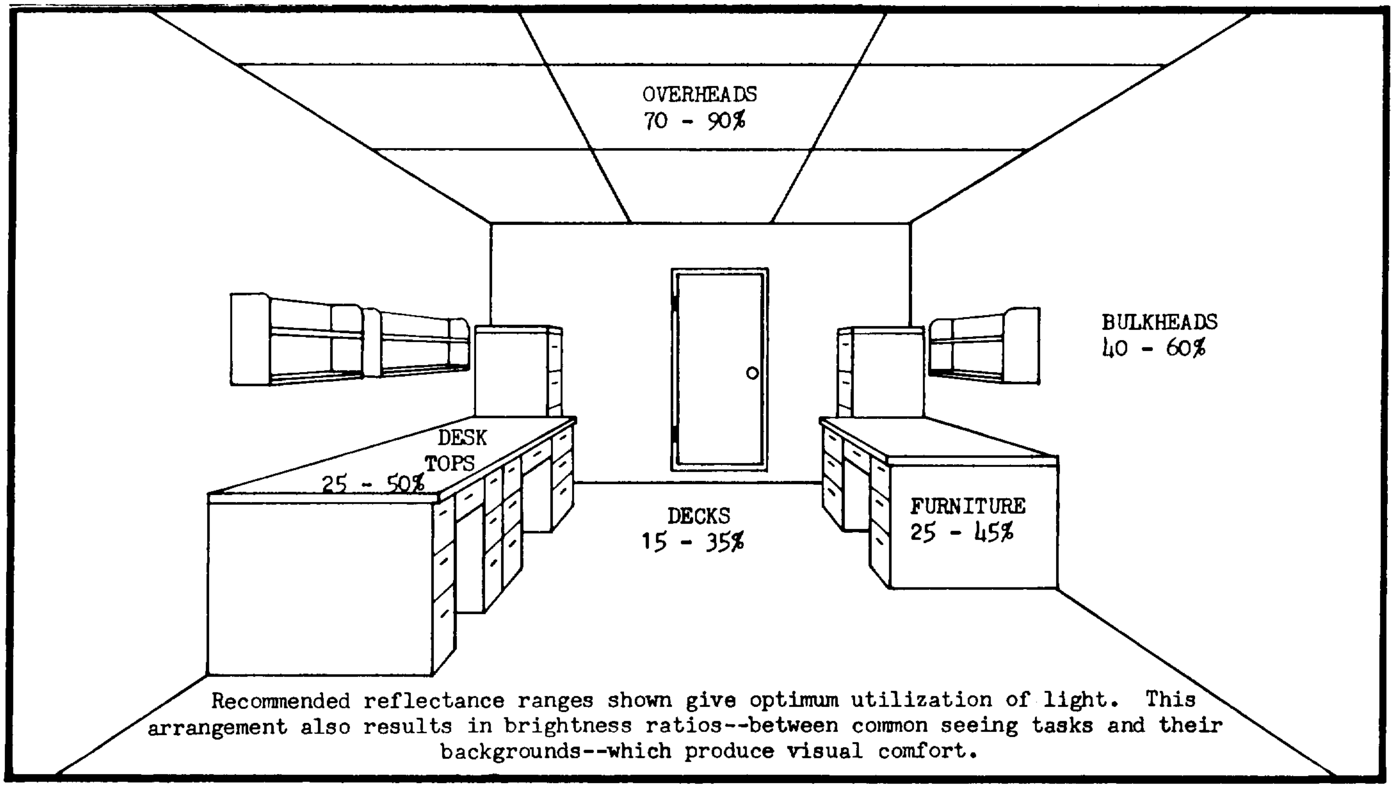


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FIGURE 44. Recommended reflectance for interior finishes.

4.2.4.1 Undesirable glare (see 3.3.4) can be avoided by using diffuse or matte surfaces (in other words, surfaces that scatter incident light without glossy reflections) wherever possible and by using light hues on all surfaces where interreflections from these surfaces will increase the amount of light in obscured areas. Finishes that generally have low reflectance factors such as wood, dark shades of gray, green, blue, red, and brown should not be used on large surfaces; instead, pastels and light gray are recommended. some representative reflection factors for matte surfaces are listed in table XIV.

For diffuse or matte surfaces:

$$\text{Reflectance} = \frac{\text{Reflected light}}{\text{Incident light}} = \frac{\text{Brightness (footlamberts)}}{\text{Illumination (footcandles)}}$$

TABLE XIV. Representative reflection factors for matte surfaces.

Color or paint (matte)	Reflected light (percent)
White	85
Yellow - light to medium	75 - 65
Buff	70 - 63
Gray - light to dark	75 - 30
Green - light to dark	65- 7
Blue - light to dark	55 - 8
Red - dark	13
Brown - dark	10

4.2.4.2 Polished surfaces (see figures 45 and 46) exhibit specular reflection, in other words, act as a mirror to reflect any source brightness. A plate glass desk top, for example, will reflect the image of high brightness objects such as overhead lighting fixtures. Specular reflectance can be a problem when large areas, such as bulkheads and desk-as–bulkheads and desk tops, have polished surfaces.

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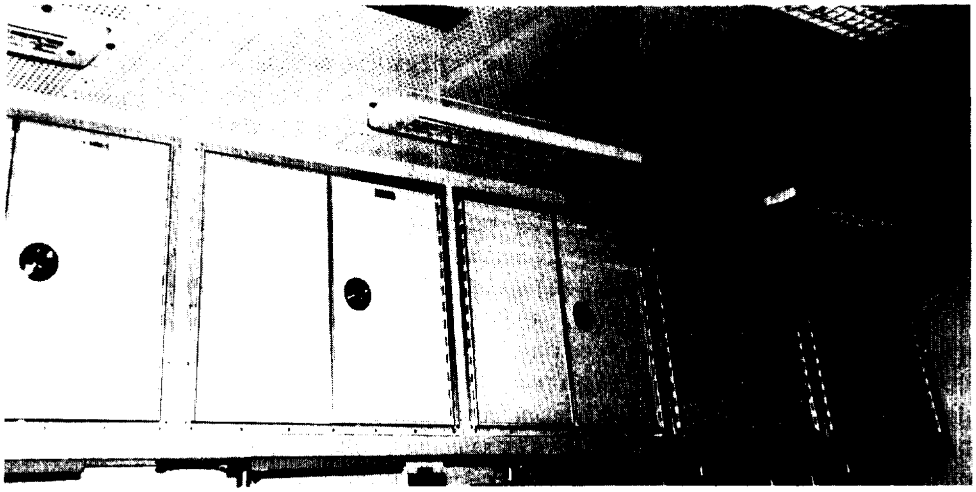
FIGURE 45. Polished cabinet surfaces exhibiting specular reflection.



SH 964-46

FIGURE 46. Light diffusing cabinet surfaces (light gray) preventing glare.

4.2.5 Effect of light on color. The color of the light source also influences the reflectance of the surfaces it lights. Since a colored surface does not reflect all wavelengths of light energy equally, and because natural and electric light sources have many different distributions of spectral energy, it follows that colored surfaces will reflect more of the light emitted from some sources than from others. The appearance of colored surfaces will change as a result of the illumination level and spectral (color) quality of the light source. Dissatisfaction with color schemes often stems from the fact that colors are selected under high levels of daylight and later, when viewed under the much lower levels of electric light, they appear dull and may even seem to be of a different color. Low illumination levels cause a surface to take on a grayish, less colorful appearance. Color variations may be caused by the differences in color composition or quality of light of daylight and electric light sources. The color of both light sources vary over a wide range; from reddish or warm white to bluish or cool white. Both daylight and light from fluorescent lamps contain higher proportions of blues and greens than are present in the light from incandescent filament lamps. In the latter, the proportion of yellow-red is greater. Where possible, the lighting conditions in the area where the colors are selected should closely approximate those of the area where the colors will be used.

4.2.5.1 In most examples of interior ship lighting, the differences between light sources (fluorescent lamps, incandescent lamps and different colored fluorescent lamps) are minimized by the type of interior finishes used on the larger surfaces. These finishes are usually neutral in color, muted in shade, or pastels, none of which produce sharp variations in reflectance. As a result, the reflectance of a typical finished surface varies only slightly with a change in the light source.

4.2.6 Spaciousness. The pattern of brightness in a space, which is determined by the light distribution and room reflectance, also influences the atmosphere or mood of the space. Generally, dark vertical and dark overhead surfaces tend to create a sense of intimacy at low illumination levels. This same pattern may look unduly enclosing and cheerless at a higher level of illumination. Long narrow rooms may be made to look wide by using cool colors at the ends. Horizontal breaks, especially in cool colors, will tend to reduce the apparent height of a room. Conversely, if the upper part of the bulkhead and the overhead are the same color, a feeling of spaciousness will be produced in a room with a relatively low overhead. A room with a low overhead will appear higher if it is brightly lighted; a high overhead will appear lower if the major pattern of lighting is thrown downward leaving the overhead fairly dark. Most of these effects are subjective but they have become accepted as common practice and do provide good “rules of thumb”.

4.3 Design of lighting installations.

4.3.1 Essential elements in design. A marksman in a rifle match must know what his target is, must have a rifle to shoot with, must know how to use his rifle, and must be able to check his score. Similarly, the designer of a lighting installation must:

(a) Know the requirements that must be met by the lighting system he is to design.
(b) Know the equipment that he can use to provide the desired result.
(c) Know the design procedures he must use to select and arrange the equipment to produce the desired result.
(d) Be able to check the actual performance of the lighting installation against the required performance. (This subject is covered in section 6.)

4.3.2 Requirements. To determine the design requirements of a lighting system, refer to the ship specifications for the following:

(a) Distribution system.
(b) Type of illumination required.
(c) Illumination levels.
(d) Uniformity of illumination.
(e) Brightness ratio.
(f) Glare.

4.3.2.1 Distribution system. The distribution system includes normal and emergency (or alternate) lighting.

4.3.2.1.1 Ship service lighting systems (surface ships). The ship service lighting system must provide a distribution system for the ship service lighting and 120-volt auxiliaries. This distribution system should be the most economical one that provides maximum continuity of service and minimum vulnerability to mechanical and battle damage.

4.3.2.1.1.1 The ship service lighting system distribution is by radial feeders from the ship service switchboards or load centers to local lighting load center points. The load center points are determined through the use of general requirements for "cube" distribution as outlined in section 331 of NAVSEA S9AAO-AA-SPN-010/GEN-SPEC. The data in section 331 is used to determine the number, size and configuration of the lighting cubes, number and size of transformer banks, feeder circuit breaker sizes, and total lighting load for power analysis purposes.

4.3.2.1.1.2 In order to determine the most economical method of distribution, a study should be made of each feeder to determine whether a 450-volt feeder with local transformers or a 120-volt feeder fed directly from the 120-volt bus established by transformers at the switchboards will result in less weight, space and cost. This is a function of electrical load and length of feeder. In addition to the power required for supplying illumination, a sizable amount of power from these same feeders is required to supply the 120-volt auxiliaries. These auxiliaries include hotel loads, such as coffee makers, drinking fountains, toasters, small tools, photographic auxiliaries, and so forth.

4.3.2.1.2 Emergency (or alternate) lihting systems (surface ships}. An emergency lighting system is installed on ships having an emergency power system. If an emergency system is not installed , alternate supplies from another ship service power source will be provided for service selected in accordance with the basic principles applying to an emergency lighting system. In the following discussion, the term 'alternate" can be substituted for "emergency". The emergency lighting system must provide a suitable distribution system which, upon failure of the ship service lighting system, will assure continuity of service of the lighting system in vital spaces and of certain selected 120-volt vital services. Vital spaces and services are defined in section 331b of NAVSEA s9AA0-AA-SPN-0l0/GEN-sPEC.

4.3.2.1.2.1 The emergency lighting system consists of a selected group of fixtures or a service that is fed from the emergency switchboard and fed through an automatic bus transfer equipment. Normally the supply is from the ship service distribution system with automatic transfer to the emergency system only when the ship service supply is interrupted. Where generator capacity permits, all the fixtures in a space requiring the emergency supply are fed from this system, thereby obviating the need to duplicate control equipment. However, if the additional load involved in energizing all fixtures in the compartment or space causes serious complications in the emergency power and lighting system, only the essential fixtures need be connected to the emergency circuit. The emergency feeders are either 450-volt or 120-volt, based on the same design principles as the ship service system.

4.3.2.1.2.2 In addition to the installed emergency power supply, all ships are fitted with several sources of temporary, portable illumination for use in extreme conditions of damage or during temporary power interruption. These include: portable hand lanterns, relay lanterns which automatically turn on when all power fails, storage battery powered lanterns (primarily for use by damage control parties), and battery powered flashlights. The relay lantern consists of a sealed beam lamp, two type BA-200/U batteries, and a relay enclosed in a molded yellow plastic housing. The relay for the lantern is connected to the lighting power supply in the area where the lantern is installed so that, when power fails, the lantern will automatically light from its batteries. The portable hand lantern is similar in construction to the relay lantern except it does not contain relay and must be manually operated. The damage control floodlantern consists of an adjustable sealed beam lamp mounted on a carrying case that contains four type BB-254/U rechargeable storage cells.

4.3.2.1.3 Lighting systems (submarines). Submarines will normally be supplied with an ac and a dc ship service lighting system. The ac system provides for the normal illumination, which consists primarily of fluorescent lighting fixtures, and the 120-volt auxiliaries. The dc system provides for a limited number of 50-watt, 120-volt incandescent lighting fixtures installed to produce a minimum of illumination in operating areas, manned spaces, and access routes during periods when ac power is not available for the normal lighting system.

4.3.2.1.3.1 The ac system is supplied through 450/120-volt, 3-phase 60-Hz transformer banks energized from the primary 450-volt power systems. To insure continuity of illumination in all major compartments and operating stations, the fixtures will be divided between feeders deriving power from each of the two 450-volt systems. This will be accomplished by either providing port and starboard feeders supplied from their respective primary power systems or by an automatic bus transfer capable of transferring the lighting transformer to either of the two 450-volt systems.

4.3.2.1.3.2 The number and location of load centers and transformer banks are chosen to keep the amount of cable to a minimum. The feeder and mains will be 3-phase, with single-phase loads divided as evenly as practical between the three phases.

4.3.2.1.3.3 The dc lighting system is supplied from the ship's battery, connected to the battery side of quick opening disconnects and protected by a fused switch, symbol 2470. Feeders usually have relays that will automatically energize the dc lighting when ac power is not available for the normal lighting. The relay contacts shall be in the circuit of one conductor of the dc feeder. The relay coil shall be energized from the associated 120-volt, 60-Hz bus. The relay contacts shall have ample ampere rating at 500 volts and the coil shall operate at 120-volt 60-Hz. A means of deenergizing the relay coil shall be provided for test purposes. Lighting circuits shall consist of three 50-watt incandescent lighting fixtures, symbol 92.2, 64.1 or 65, connected in series and shall be supplied from fused distribution panels in each major compartment. The number of such circuits to be installed in each section shall be determined by the minimum illumination required for continuous safe operation of the ship. However, special attention shall be given to all control and operating stations, and especially the maneuvering area. Watertight fixtures shall be installed in the battery, machinery, and reactor spaces. A submersible fixture, symbol 174.2 (with a 50-watt, 120-volt lamp, MS15586-2), shall be provided in the access and escape trunks. Nonwatertight fixtures are satisfactory for other spaces. The dc lighting fixtures located in areas having red illumination shall be red or provided with red filters. Portable lanterns are installed in areas not served by the dc lighting system.

4.3.2.2 Type of illumination required. Types of illumination that would be required for different occasions are defined as follows:

(a) General illumination. The white illumination provided from all lighting fixtures on the overhead and bulkheads except detail-lighting fixtures.
(b) Detail illumination. The illumination provided for specific seeing tasks, such as provided by lights on desks, log desks, berths, and machine tools.
(c) Special illumination. The illumination provided by miscellaneous fixtures for purposes other than covered by general and detail illumination.
(d) Red illumination. The low intensity red illumination provided for standing lights in berthing areas, minimum interference with dark-adapted vision, and certain special applications involving darkened ship operation.
(e) Broad band blue (BBB) illumination. The illumination provided in spaces normally operated darkened, such as in the Combat Information Center and similar command and control spaces containing cathode ray tube display consoles.
(f) Emergency illumination. The illumination provided from "emergency illumination" designated lighting systems. Many lighting fixtures are provided with power only from the ships service lighting systems. Others are normally provided with power from the ships service system and are automatically connected to the emergency power supply when the ships service power supply fails. Emergency lighting is provided for all spaces and inboard watch stations where, because of functional requirements, continuous illumination is essential and where personnel are expected to remain on duty.

4.3.2.3 Illumination levels. Illumination levels for lighting systems are generally specified in the ship specifications. If they are not specified, 4.1 shall be used as a guide. The following criteria apply:

(a) Average. Since the illumination produced by a lighting installation is not uniform, illumination requirements are specified in terms of an average value. The procedure for determining the average illumination from photometric measurements on a completed installation is described in section 5. The designer should choose the number of fixtures and locate them such that the average value measured in the photometric survey (after the installation is complete) meets the specified illumination requirements.
(b) Initial. The illumination produced by a lighting installation is at its peak when lamps and fixtures are new. Thereafter, the illumination declines gradually as lamps darken with use and fixtures and reflectors become dirty. The term "initial" refers to peak illumination which occurs when lamps and fixtures are new and clean.

(c) Average initial footcandles. Illumination requirements are given in terms of average initial footcandles.

(d) Where located. The average initial footcandles for general illumination specify the required average initial footcandles on a horizontal plane 30 inches above the deck.

(e) Tolerance. The average initial footcandle illumination specified shall be considered the minimum acceptable illumination. A minus tolerance in these values will not be permitted except in special cases, as approved by the supervisor.

(f) Use of compartment. Where a compartment serves two or more functions, the level of illumination provided shall be for the primary function of the compartment. Higher levels of illumination, when required by a secondary function, shall be provided only in those specific areas requiring the higher level of illumination.

4.3.2.4 Uniformity of illumination. In fulfilling illumination requirements, the ratio of maximum footcandles under a lighting fixture to the minimum footcandles between it and the nearest adjacent fixture shall be not greater than two to one. For the best results, the ratio should be close to unity, thus providing level of illumination at the working level that will be substantially uniform. If the number of fixtures provide a ratio greater than two to one, additional lighting fixtures shall be installed, or the installed fixtures shall be rearranged, subject to specific approval of the supervisor, to obtain this ratio. Uniformity of illumination is particularly desired in offices, shops, and electronic spaces. In arranging fixtures to provide a uniform level of illumination, they shall be spaced to provide maximum illumination on working surfaces. Spacing between lighting fixtures and bulkheads shall provide substantially uniform illumination without spotty light distribution, dark areas, or dark corners on shelves, racks or vertical surfaces. In general, spacing between lighting fixture and bulkhead shall be one-half or less the spacing between fixtures. Figure 47 illustrates the variation of illumination uniformity as a function of fixture mounting height and fixture separation.

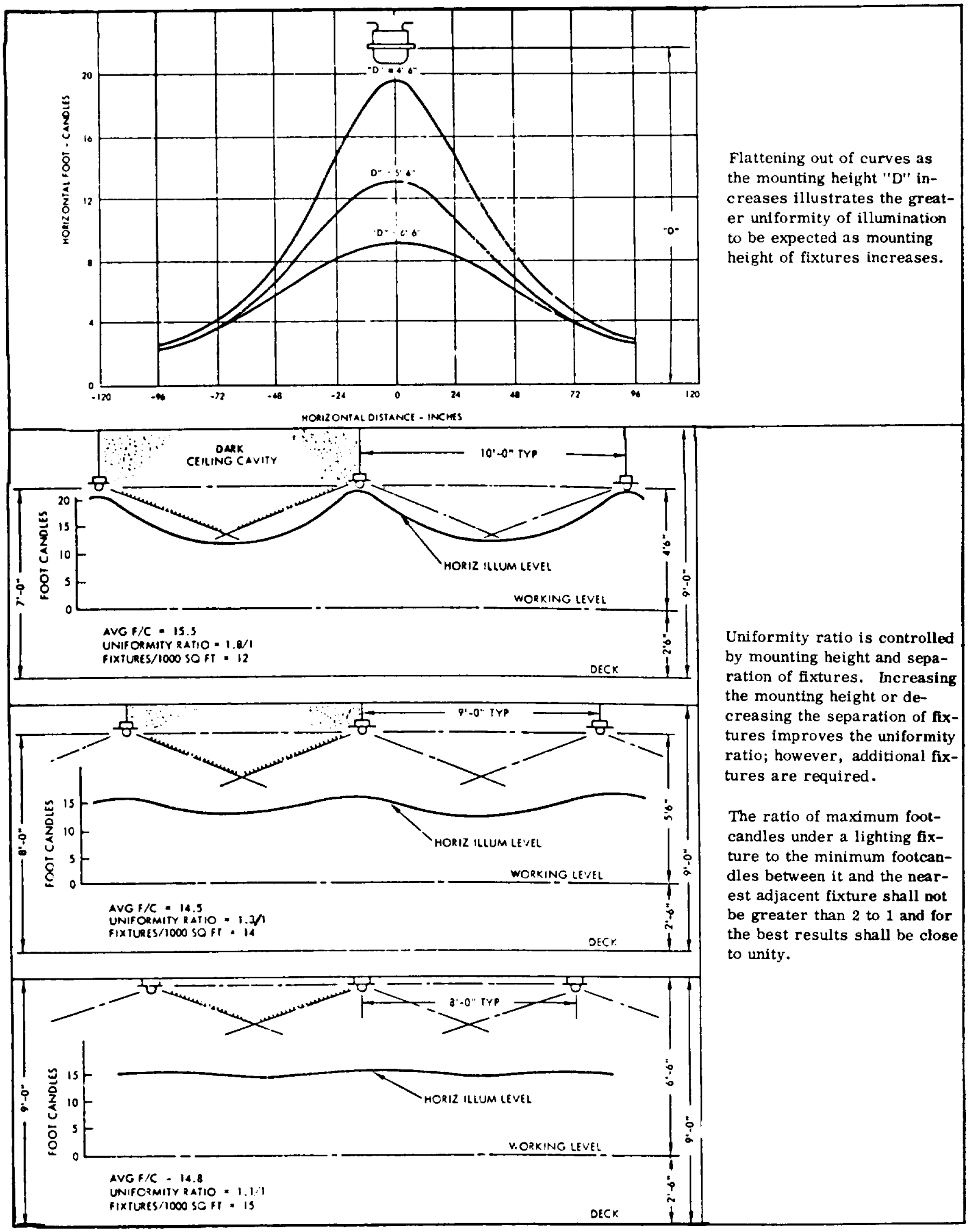


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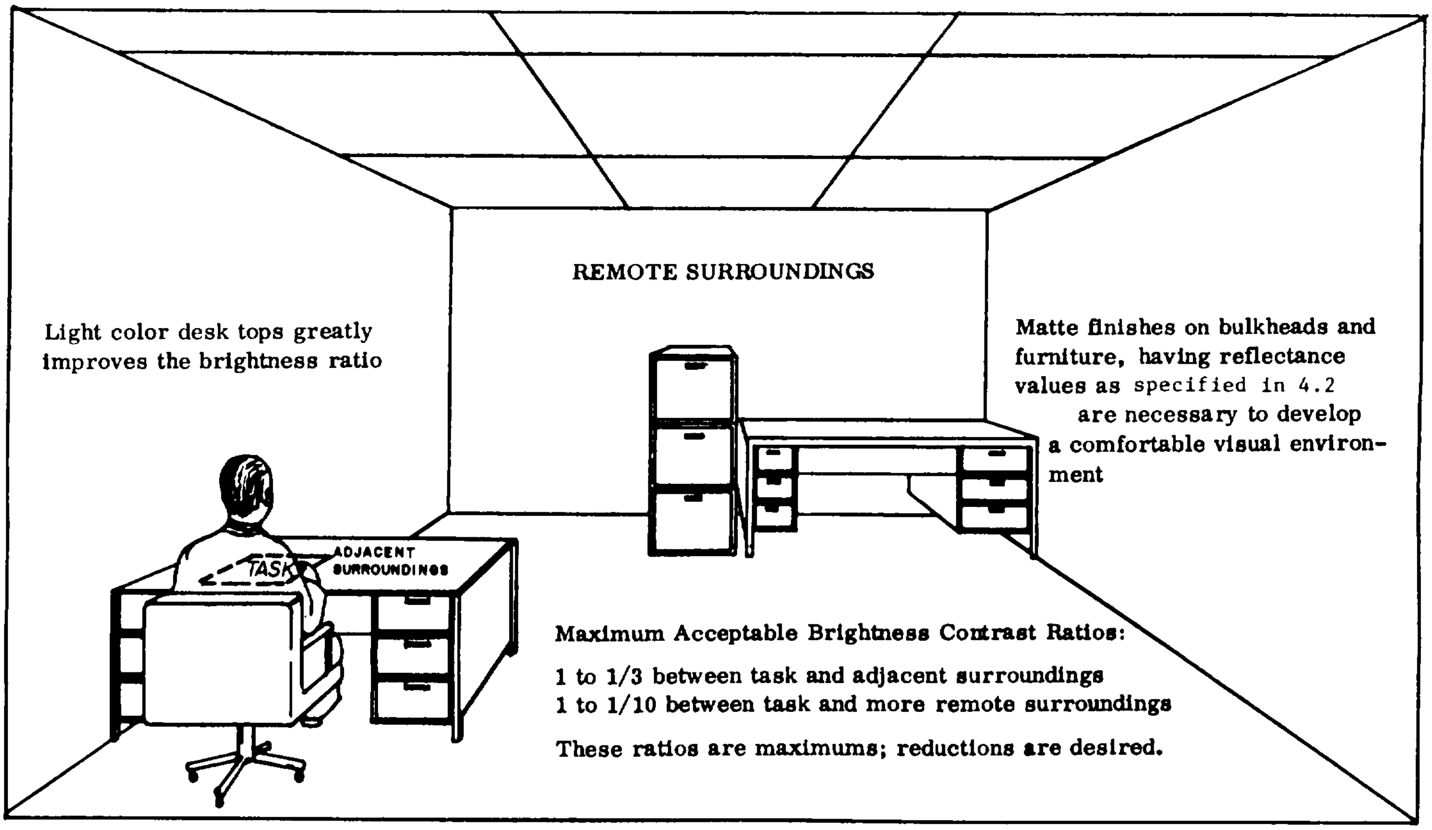
FIGURE 47. Illumination uniformity as a function of fixture mounting height and separation.

4.3.2.5 Brightness ratio. To minimize eye fatigue, excessive brightness contrasts between seeing tasks and the background immediately surrounding such tasks shall be avoided, particularly in compartments such as in offices, chart-room, or control spaces where continuous visual tasks are performed. A brightness contrast ratio of unity is desirable and a ratio of three to one is good between a task and adjacent surroundings such as a written paper and a desk top. The brightness contrast shall be not greater than ten to one (or be less than one to ten) between a task and remote surroundings (written paper and opposite bulkhead) (see figure 48). Fixtures shall be selected and installed accordingly. Additional information pertaining to brightness ratios is provided in 3.3.5. A study to determine a comfortable brightness ratio should consider more than just the lighting fixtures. Other items to be included are reflecting characteristics of overheads, bulkheads, decks and furnishings and the illumination on them. Representative reflection factors specified in 4.2 will provide desirable brightness ratios with the footcandle levels specified in 4.1.



SH 964-48

FIGURE 48. Brightness contrast ratios.

4.3.2.6 Glare. Excessive glare conditions in the normal field of view, as shown on figure 49, shall be avoided. In compartments where close visual tasks are performed, or where visual tasks are performed for long periods, the lighting fixtures shall be of the clear prismatic lens or the clear white shielded type. It should be noted that the installation of blue lights is not considered a glare reduction technique. See 4.5 for an explanation of the use of blue lights. The lighting fixtures shall be located to eliminate glare sources from the normal field of vision. Additional information is provided in 3.3.4, and sheets G-3 and G-4 of Drawing 803-5184170 (see appendix B).

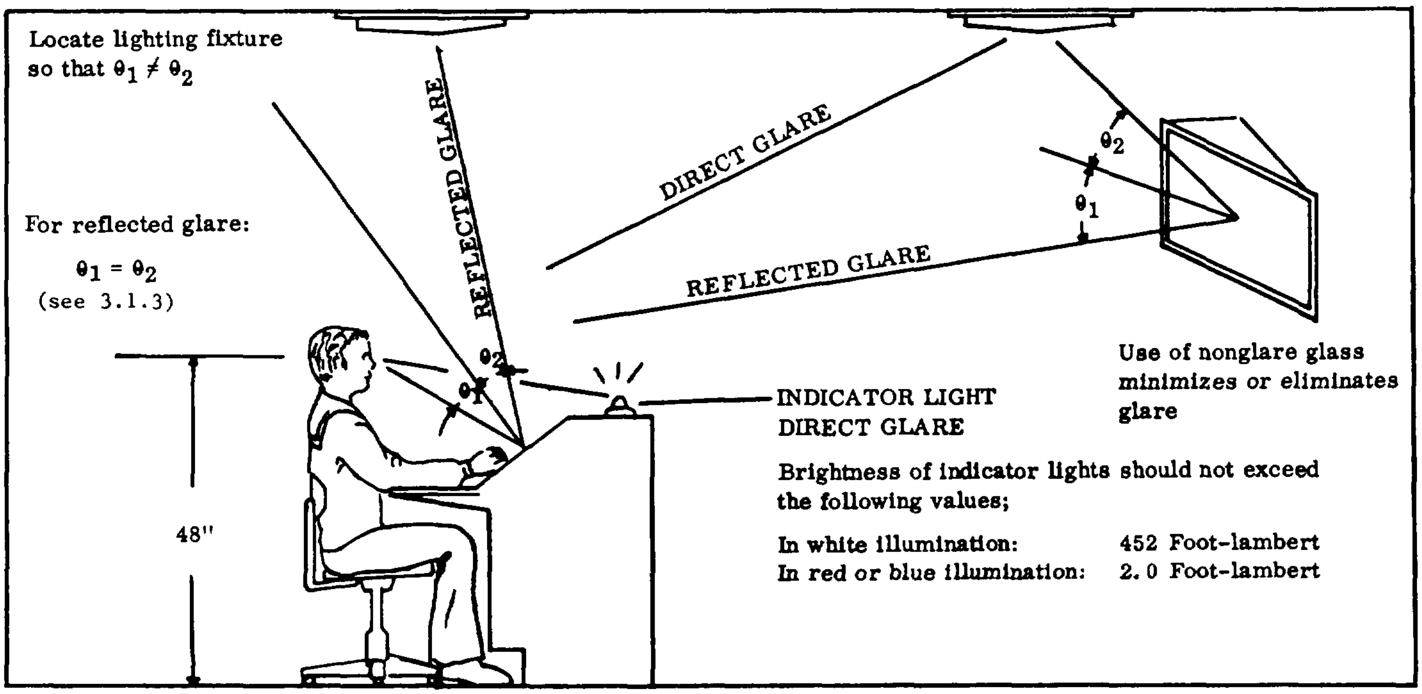


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FIGURE 49. Glare conditions.

4.3.3 Selection of equipment.

4.3.3.1 Distribution and control. Distribution and control equipment of Navy standard types listed in NAVSEA S0300-AT-GTP–010/ESL shall be selected unless considerations justify development of special types. A partial equipment list is provided on Drawing 803-5184170, sheet J-6 (see appendix B).

4.3.3.2 Lighting fixtures. Navy lighting fixtures are designed to provide satisfactory illumination, optimum operational economy, maximum continuity of service, and minimum vulnerability to mechanical and battle damage. They are identified by symbol numbers in NAVSEA S0300-AT-GTP-010/ESL. Symbol numbers are a shorthand means of identifying electrical equipment on lighting deck drawings. Photometric data are provided in appendix A.

4.3.3.2.1 Lighting fixtures installed in compartments and spaces shall be of sufficient number and located such to provide the initial average foot-candle values of general illumination specified in the ships specifications. Lighting fixtures shall be installed in accordance with the following (see notes 1 through 6):

(a) Fluorescent fixtures shall be installed throughout the ship except where incandescent fixtures are required.
(b) Incandescent fixtures shall be installed in refrigerated spaces, in spaces where the ambient temperature exceeds 75 degrees Celsius (°C), in weather deck areas and in confined spaces where fluorescent fixtures cannot be installed because of their physical size.

NOTES:
1. In submarines, fluorescent fixtures with clear and white prismatic windows shall be installed in offices, living, messing and recreational spaces.
2. Fluorescent fixtures, symbols 74 and 75, shall be used in high bay spaces (such as hangar space or tank spaces on landing ships).
3. General overhead lighting fixtures shall have lenses or globes in all spaces having pressurized oil systems, with valves, flanges, or couplings, and also in storerooms where adjustable metal battens are used.
4. Standard Navy fluorescent lighting fixtures for overhead general illumination in spaces provided with suspended ceilings shall be symbols 348, 349 or 350.
5. In areas where the general lighting fixtures cause specular reflections on the glass faces of meters, gauges or dials, shielding shall be provided. Suggested methods are provided in Drawing 803-5184170, sheets G-3 and G-4 (see appendix B).
6. Where minimum electromagnetic interference is required, fluorescent lighting fixtures may be modified as specified in 3.6.4.6. Symbol 75, modified by providing a clear window in lieu of red, and white louvers in lieu of black may be used.
7. Explosion proof lighting fixtures shall be installed in potentially explosive atmospheres as specified in section 300 of NAVSEA S9AAO-AA-SPN-010/GEN-SPEC.

4.3.4 Design procedures.

4.3.4.1 Distribution system.

4.3.4.1.1 Distribution and control. The design of the lighting distribution system is covered in the detail specifications for each ship and on the elementary diagrams included in the contract guidance drawings. These specifications and diagrams provide the guidance for the shipbuilder in the development of his working drawings, thus insuring the design to be in accordance with NAVSEA requirements. The lighting distribution system consists of feeders from ships service emergency switchboards, or load centers to distribution panels or feeder distribution fuse boxes located at central distribution points. From these central distribution points, power is distributed to local lighting circuits. The following design procedures are recommended:

(a) Obtain a complete set of the general arrangement drawings for the ship in order to become familiar with the layout and compartmentation of the ship.
(b) Determine the type of distribution system required.
(c) Determine what spaces and services should receive ships service or emergency power.
(d) Determine the requirements for general and detail switching and control.
(e) Divide the ship into cubes or zones and centrally locate the distribution panels to provide the distribution system desired.

4.3.4.1.2 Installation of equipment. Methods of supporting cables, panels, switches and appliances shall be as shown on Drawing 803-5001027.

4.3.4.1.3 Load balance. Single phase circuits on 3-phase systems shall be connected to approach a balance of the 3-phase circuits for each compartment (where the load is large enough to warrant) or a group of compartments (such as staterooms) requiring the same type of service. Such a balance shall be made on the basis of the expected normal use of the lighting fixtures and appliances serving such spaces. An unbalance between phases at the load side of 3-phase transformer banks shall be minimized.

4.3.4.1.4 Ground detector lamps. Ground detector lamps shall be installed on all electrically isolated 120-volt lighting distribution points; except that the lamps are not required on the secondary side of transformers for the isolated receptacle circuits. The ground detectors shall be installed at the initial point of distribution.

4.3.4.1.5 Circuit wiring. In determining the number of lighting fixtures to be installed on each circuit, the saving of weight or cost of cable or wiring equipment will be considered together with the following factors:

(a) Allowable voltage drop.
(b) Control features required.
(c) Current capacity of cable.
(d) Rating of local switches.
(e) Rating of fuses or circuit breakers in branch circuits.

4.3.4.1.5.1 At least two single phase circuits separately protected and supplied from branches emanating from each of the two (port and starboard) lighting feeders, or two separately protected 3–phase circuits shall be provided to supply fixtures in the following locations:

(a) Any compartment which is manned for the purpose of operation or navigation, or during military functioning of the ship (general quarters).
(b) Any large space in which personnel may be grouped for an extended period of time (living space, messing spaces, library, shops, and so forth).

A branch circuit for emergency or detail lighting fixtures shall be considered one of the two required circuits. Fixtures in spaces not falling into the categories listed may be grouped on a circuit that serves an adjacent space, provided the following conditions exist:

(a) The space does not contain unattended machinery with exposed moving parts.
(b) The spaces are on the same level and in the same watertight subdivision.
(c) An adjacent space on the same lighting circuit need not be traversed for exit to a passageway or an area having two sources of power to lighting fixtures.

4.3.4.1.5.2 Small appliances, refrigerators, drinking fountains, coffee makers, permanently mounted detail lighting fixtures, and bracket fans shall be permanently connected to the ship's lighting system.

4.3.4.1.5.3 Vital spaces and services shall be connected to the emergency system as required by section 331b of NAVSEA S9AAO-AA-SPN-010/GEN-SPEC.

4.3.4.1.6 Spare capacity. Distribution wiring boxes shall be the nearest standard size box suitable; no provision shall be made for spare circuits in such boxes. Distribution panels shall be provided with spare circuit breakers as required by section 320 of NAVSEA S9AAO-AA-SPN-010/GEN-SPEC.

4.3.4.1.7 System protection. DDS 311-3 shall be used as guidance in selecting and determining the ratings of protective devices. The protection requirement of table V of section 303 of NAVSEA S9AA0-AA-SPN-010/GEN-SPEC shall apply to the system.

4.3.4.1.8 Equipment enclosures and protection. Equipment enclosures and protection shall be in accordance with section 320 of NAVSEA S9AA0-AA-SPN-010/GEN-SPEC.

4.3.4.1.9 Cable marking. Cable tags and nameplates shall be identified in accordance with section 305 of NAVSEA S9AAO-AA-SPN-010/GEN-SPEC.

4.3.4.1.10 Power analysis.

4.3.4.1.10.1 Load approximation. At the early stage of ship design, the lighting system engineer will be required to provide approximate lighting loads for a preliminary power analysis to demonstrate adequacy of the generator installation. The system loads can be divided into four categories as follows:

(a) Lighting fixture load. Obtained by summarizing requirements for lighting fixtures to be used to provide the initial foot-candle values of general illumination.
(b) Receptacle circuit load. Obtained by summarizing requirements for workshops, electronic test equipment, office machines, sanitary and living spaces, and general purpose.
(c) Small appliance load. Obtained by summarizing requirements for commissary, living, workshop, sanitary and utility spaces.
(d) Miscellaneous system loads. Obtained by summarizing requirements for isolated interior communication 120-volt loads and loads for other systems.

Data for load calculation for categories (b), (c), and (d) shall be those of the connected loads. Calculations of the general illumination load may be accomplished by using a simplified method referred to as “watts-per-square-foot”. This method is explained as follows:

(a) The first step is to correlate the total power (watts) required to operate a lighting fixture to its light output (lumens). Illumination in footcandles, by definition, is lumens per square foot of an illuminated area. The term lumens per square foot can then be substituted by watts per square foot since they are directly related (in other words, it takes a certain amount of power for a given light output of a particular lighting fixture). Thus, a graph of watts per square foot versus footcandles of illumination can be plotted, as shown on figure 50, to provide an indication of the expected load for a specific illumination level. The data are only approximate and are based on the typical problem of figure 27. For more accurate results, data for specific lighting fixtures and for specific sized compartments and reflectance should be used and should be verified by photometric surveys. A prediction of this nature is only a very rough approximation, useful only in estimating early load requirements and should never be substituted for actual load calculations.

4.3.4.1.10.2 Load calculations. In determining the power to operate a lighting fixture, the total power, including component and power factor losses, shall be considered. Table XV provides the power requirements for the most common fluorescent lamps used apparent power is also stated as volt amperes).

TABLE XV. Fluorescent lamp power requirements.

(Quantity) Lamp description	Line voltage	Line current amperes	Power factor (percent)	Watts			Volt-ampere
				Lamp	Ballast	Active	Apparent
(1) F8T5	115	0.170	55	8.0	3.0	11.0	20.0
(1) F15T8	115	0.400	55	19.0	7.0	26.0	47.3
(1) F20T12	115	0.380	55	20.0	5.0	25.0	45.0
(3) F48T12/CW/HO/HT	115	1.700	97	180.0	15.0	195.0	200.0
(3) F48T2/SR/HO/HT	115	1.700	97	180.0	15.0	195.0	200.0

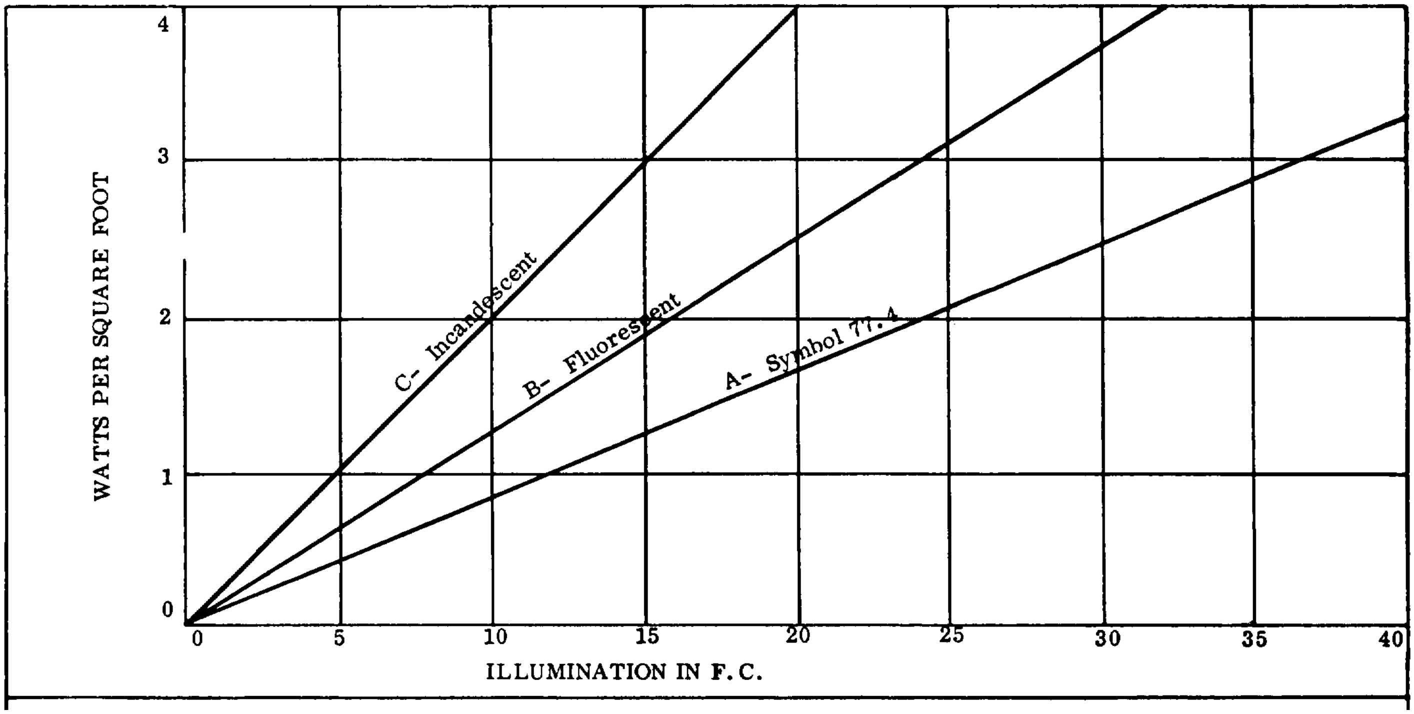
The total power in a circuit with only resistive loads, such as filament lamps, may be expressed by the fundamental equation:

Total watts (rated wattage of lamp) = volts x amperes

In such circuits the total watts are active in doing useful work; that is, in heating the filament to incandescence. Electric discharge lamps such as fluorescent lamps require ballasts to limit the current and to provide the necessary starting voltage. Since these ballasts are not pure resistive loads, some of the current flowing in the circuit is not effective in the operation of the ballast or in the production of light. In these circuits the total watts as seen by the generator may be expressed as:

$$\text{Volt-ampere (apparent power)} = \frac{\text{Total watts (active power)}}{\text{Power factor}}$$

Thus, the total power in a circuit is equal to the total number of lamps multiplied by their apparent power.



From the typical example of Figure 27, it can be seen that 12 lighting fixtures, Symbol 77.4, provide 31.1 f. c. of illumination for a room 30 feet long and 14 feet wide.

Converting into watts/ft^2:

$$\frac{12 \text{ Fixtures X 2 Lamps per Fixture X 45.0 Watts per Lamp}}{30 \text{ Feet X 14 Feet}} = 2.57 \ \frac{\text{Watts}}{\text{ft}^2}$$

Thus, 2.57 watts/ft^2 provide 31.1 f. c. of illumination for the conditions of figure 27. Curve A can thus be plolted. It should be noted that curve A applies only to Symbol 77.4 Installed at a mounting height of 7 feet in an empty room having overhead, bulkhead, and deck reflectance of 70, 50, and 30 percent, respectively.

Actual shipboard installations, however, differ from the ideal installation of figure 27 and higher watts/ft^2 must be used to account for illumination losses due to obstructions, lower reflectance, asymmetrical location of lighting fixtures, higher mounting heights, etc. Curves B and C are average curves representing typical shipboard installations and are recommended for preliminary load approximations.

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FIGURE 50. Watts per square foot versus footcandles of illumination.

4.3.4.1.10.3 Voltage drop calculations.

4.3.4.1.10.3.1 General. Application, selection, and installation of electric cables should be in accordance with section 304 of NAVSEA S9AA0-AA-SPN-010/GEN-SPEC. Voltage drop calculations should be in accordance with DDS 304-1. In support of the above documents, information presented hereafter is in an analytical form to aid the lighting system engineer in making voltage drop calculations for selection of cables.

4.3.4.1.10.3.2 Definitions. The following definitions are applicable:

(a) Demand factor. The ratio of the maximum load, averaged for a period of 15 minutes, to the total connected load on the cable.
(b) Percent voltage drop. The difference in voltage between any two points in a circuit expressed as percentage of the rated voltage at the power source (switchboard bus or transformer secondary).
(c) Total connected load current. The sum of the identification plate of rated currents of all connected loads and the specified spare current allowance.
(d) Resultant load current. The product of the total connected load current and an approved demand factor application to the total connected load.

4.3.4.1.10.3.3 Resultant load current. The resultant load current shall be determined by the following:

(a) Branches. Vector sum of rated connected loads.
(b) Submains. Highest line current obtained from the vector sum of all branch circuit connected loads.
(c) Mains. Vector sum of connected load currents of all connected submains.
(d) Feeders. Product of feeder demand factor and vector sum of the 3-phase resultant load currents of all connected mains. The demand factor shall be not less than that obtained from figure 52 (see 4.3.4.1.10.3.6).

4.3.4.1.10.3.4 Allowable voltage drop. The size of cables shall be such that the voltage drop at loads in the most remote branch, when calculated using a copper resistivity of 12 ohms per circular-roil-foot, will not exceed the following:

Ship service lighting circuits	Emergency lighting circuits
ac - 6 percent	ac - 12 percent
dc - 8 percent	dc – 15 percent

The foregoing maximum values of the voltage drop for ac lighting circuits shall be exclusive of transformer regulation. The voltage drop for a cable feeding a distribution point supplying two or more high intensity searchlights, and possibly other loads, shall be based on the requirements of one searchlight having a starting current of 45 amperes at a power factor of 0.15 and a steady state current of 18 amperes at a power factor of 0.85 for the other searchlights. The size of the cable supplying each individual high intensity searchlight from the distribution point shall be such that the voltage drop at the input to the ballast will not exceed 5 percent during starting. Voltage drop, rather than current carrying capacity, shall be the basis for determining cable size. Voltage drop calculations shall be based on the total connected load.

4.3.4.1.10.3.5 Acceptable method. The following acceptable methods for calculating voltage drops take into consideration the power factors and the unbalance in loading; thus, they embrace all possible situations which may arise on ac circuits of the lighting system. DDS 304-2 contains the derivation of the formulas used. The following is a definition of the symbols used:

E Magnitude of source voltage, nominal transformer secondary voltage.
v Terminal voltage or load voltage.
L Length of cable in feet.
z Cable impedance in ohms per thousand feet.
e Load power factor angle.
I (x) Resultant load current in one leg of the circuit, in amperes.
D% Total voltage drop, expressed as a percent of the rated voltage, E.
a Angle between current vector and its applied voltage vector.

(a) Single phase branch voltage drop calculations. The total connected load current, used in calculating the voltage drops on the single phase lighting branch circuits is the scalar magnitude of the current and is obtained by adding, vectorially, the load currents of the equipments on the branch.

(1) First, obtain the magnitude of the full connected load current and its angle (power factor angle, θ) with respect to the assumed applied voltage. This is done by adding, vectorially, the load currents of equipments on the branch and converting the answer to polar form. The final answer is the magnitude of current and its angle with respect to an assumed applied voltage of 115 volts at zero degrees. Applying this information, the voltage drop can be obtained from the following:

$$D\% = 2 L I \frac{Z}{E} \cos a \qquad \text{Equation 29}$$

(2) To simplify the equation, the expression $100 \frac{Z}{E} \cos \alpha$ has already been calculated for the various cable sizes and power factor angles (θ). This expression is called the drop factor and can be obtained from table 5 of DDS 304-1 once the proper cable size and power factor angle are known. Once the drop factor magnitude of current and conductor length are known, the following equation can be used to determine the voltage drop:

$$D\% = 2 \times L \times I \times \text{drop factor} \qquad \text{Equation 30}$$

(b) 3-phase cable voltage drop calculations (see figure 51) graphically portray the notations used hereafter.

(1) Voltage drop for a 3-phase cable that joins with single phase cables.

Step 1. Obtain the tOtal phase currents I_{AB}, I_{BC} and I_{CA}, by vectorially summing the load currents of each branch, connected across their respective phases, at the point of junction with the 3-phase cable. Refer these currents to their respective assumed applied voltages as follows:

$V_{AB} = 115 \angle 0°$ volts	Equation 31
$V_{BC} = 115 \angle -120°$ volts	Equation 32
$V_{CA} = 115 \angle +120$ VOltS	Equation 33

Step 2. Taking the phase currents in rectangular form, obtain the line currents by subtracting the phase currents vectorially in the following order:

$I_A = I_{AB} - I_{CA}$	Equation 34
$I_B = I_{BC} - I_{AB}$	Equation 35
$I_C = I_{CA} - I_{BC}$	Equation 36

It should be noted that 1_A, I_B and I_C are the actual currents flowing in the conductors; and thus, the current carrying capacity of the cable used (see DDS 304-2) should be checked against those currents to insure that it is of adequate size to carry the current of the largest magnitude.

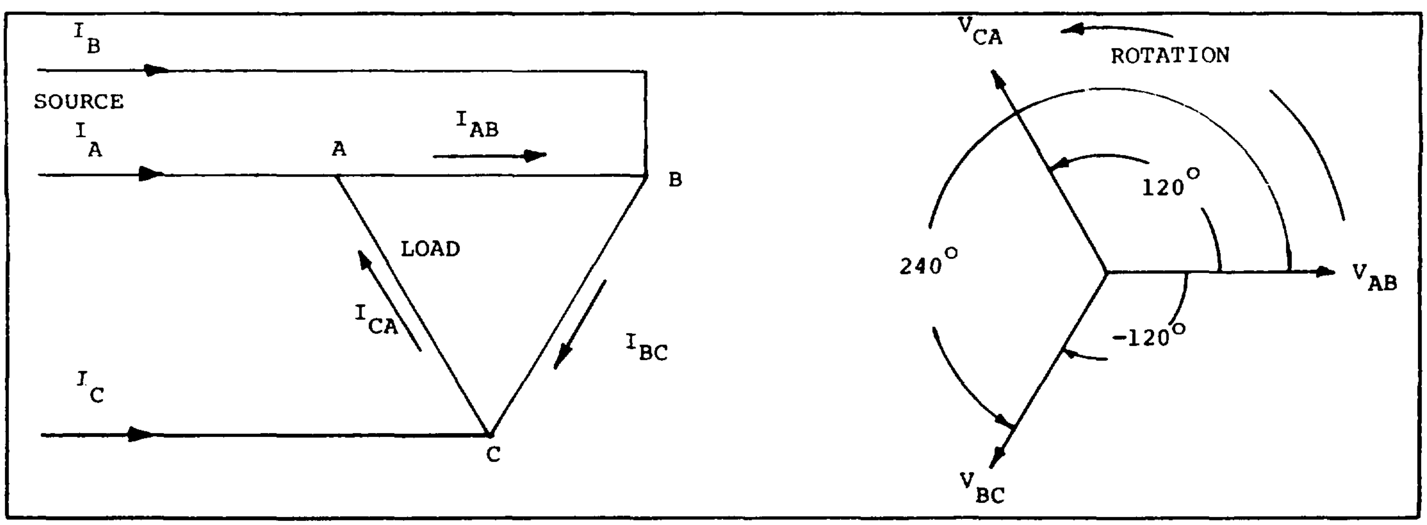

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FIGURE 51. Voltage and current relationships in a 3-phase ac circuit.

Step 3. Taking the line currents in rectangular form, subtract them vectorially, in the proper sequence, to obtain the values for the 3-phase voltage drop calculation. The magnitudes of these currents will be designated in the voltage drop equation as "$I_{(X)}$" and will represent the following, depending on which voltage drop (V_{AB}, V_{BC}, or V_{CA}) is desired:

$$I_{(X)AB} = I_A - I_B \quad \text{Equation 37}$$
$$I_{(X)BC} = I_B - I_C \quad \text{Equation 38}$$
$$I_{(X)CA} = I_C - 1_A \quad \text{Equation 39}$$

Step 4. After the current "$I_{(x)}$" has been found, its angle with respect to the associated applied voltage (angle *a)* must be found. This angle is measured between the current vector and its applied voltage vector. The angle “a” is assigned a negative sign when the current vector angle is smaller than the voltage vector angle (which is measured in a counter-clockwise direction from the voltage reference vector angle (V_{AB}) at zero degrees). The angle "a" is assigned a positive sign when it is larger than the voltage vector angle (measured as previously described).

Step 5. Given the magnitude of I(x) and the angle “a”, the drop factor can be obtained from table 5 of DDS 304-1 and the voltage drop, in percent, can be computed from the following equation:

$$D\% = I_{(x)} \text{ x L x drop factor} \quad \text{Equation 40}$$

(2) Voltage drop for a 3-phase cable that joins with other 3-phase cables.

Step 1. Taking the line currents for each individual section of a 3-phase cable, add them vectorially to obtain the total line current.

Step 2. After obtaining the total line currents, follow the step-by-step procedures for a 3-phase cable that joins with single phase cables to obtain the voltage drop for a 3-phase cable.

(c) Total voltage drop. The total voltage drop is obtained by summing the voltage drops in the phase of the feeder that has the greatest overall drop.

4.3.4.1.10.3.6 Example of voltage drop calculations.

(a) Problem: Find the voltage drops for the various sections of the feeder, 1 SB-1L-(3-57-2), shown on Drawing 803-5184170, sheet J-5 (see appendix B). The actual voltage drop from the switchboard to the lighting load center is approximately 0.35 percent for all phases.

(b) Solution of problem:

Step 1. Obtain the total current in each phase by summing all loads using the same or similar procedures shown for branch circuit B_3, phase AB on Drawing 803-5184170, sheet J-5 (see appendix B). Thus, to find the current in main B:

Branch	Phase	Magnitude of current
B3	AB	5.83
B1	BC	6.2
B2	CA	4.66
B4	CA	5.11
Total for phase	CA	9.77

The power factor angle for all branches is the angle whose cosine is 0.55 (trigonometrically, $\cos^{-1} 0.55 = 56.60$). To obtain the magnitude of current and power factor angle of the total connected load when there is a mixture of incandescent and fluorescent lamps or fluorescent lamps of different power factors, find the total current of each group of lamps, add vectorially, and convert the answer to polar form.

Step 2. Refer the phase currents to their respective voltages:

$$I_{AB} = 5.83\angle 0-56.6° = 5.83\angle -56.6°$$

$$I_{BC} = 6.2\angle -120-56.6° = 6.2\angle -176.6°$$

$$I_{CA} = 9.77\angle 120-56.6° = 9.77\angle 63.4°$$

(Note that all loads are inductive; therefore, the currents lag the voltages by the power factor angle).

Step 3. Change the phase currents from polar to rectangular form:

$$I_{AB} = 5.83 \cos(-56.6°) + j5.83 \sin(-56.6°) = 3.21 - j4.87$$
$$I_{BC} = 6.2 \cos(-176.6°) + j6.2 \sin(-176.6°) = -6.18 - j0.367$$
$$I_{CA} = 9.77 \cos(+63.4°) + j9.77 \sin(+63.4) = 4.37 + j8.73$$

Step 4. Subtract the phase currents to obtain the line currents of the mains:

$$I_A = I_{AB} - I_{CA} = (3.21-j4.87) - (4.37 + j8.73) = 1.16-j13.6$$
$$I_B = I_{BC} - I_{AB} = (-6.18-j0.37) - (3.21-j4.87) = -9.39+j4.5$$
$$I_C = I_{CA} - I_{BC} = (4.37 +j8.73) - (-6.18 -j0.37) = 10.55+j9.1$$

Step 5. Obtain the magnitude of the maximum line current of the mains (used as a check to insure the cable installed is of adequate current carrying capacity; the original determination of cable size was based on voltage drop). From observation of the line currents in rectangular form, current I_C will have the largest magnitude. Its magnitude will be:

$$I_R = \sqrt{10.6^2 + 9.1^2} = 13.9 \text{ amperes}$$

The cable size shall carry at least 13.9 amperes in accordance with DDS 304-2.

Step 6. Obtain the line currents in the feeder by summing the line currents to the mains vectorially, thus:

Main No.	I_A	I_B	I_C
1	1.6-j 10.6	-10.7+j4.5	9.1+j6.1
2	-1.2-j 13.6	-9.4+j4.5	10.6+j9.l
3	13.5-j 13.8	-18.0-j3.4	4.5+j17.2
4	15.0-j0.0	-15.0-j0.0	0.0+j0.0
Total feeder currents	28.9-j38.0	-53.l+j5.6	24.2+j32.4

Step 7. Obtain the magnitude of maximum line current of the feeder. The maximum line current is in phase B; its magnitude is:

$$I_B = \sqrt{53.1^2 + 5.6^2} = 53.4 \text{ amperes}$$

The resultant current for the feeder cable is the magnitude of maximum line current times the demand factor. The demand factor, taken from figure 52, is 0.89 for this magnitude of current. Hence, the resultant current for this cable is 53.4 x 0.89 = 47.6 amperes. The resultant current establishes the minimum current carrying capacity of the feeder cable in accordance with DDS 304-2. (As explained in step 5, this is used as a check since the cable size is usually determined by the voltage drop.)

Step 8. Subtract, vectorially, the feeder line currents to obtain the currents "I(X)" for the voltage drop equations:

$I_{(x)AB} = I_A - I_B = (28.9-j38) - (-53.l+j5.6) = 82-j43.6 = 92.9 \underline{/-28°}$

$I_{(X)BC} = I_B - I_c = (-53.l+j5.6) - (24.2+j32.4) = -77.3-j26.8 = 81.8 \underline{/199.1°}$

$I_{(x)cA} = I_c - I_A = (24.2+J32.4) = (28.9-j38) - -4.7+j70.4 = 70.5 \underline{/93.8''}$

Step 9. Find the angles "a" for the voltage drop equations:

$\alpha_{AB} = \angle$ of V_{AB} - $\angle$ of $I_{(X)AB}$ = $\underline{/360°-3320}$ = -28°

α_{BC} = $\angle$ of V_{BC} - $\angle$ of $I_{(X)BC}$ = $\underline{/240°-199.10}$ = -40.9°

α_{CA} = $\angle$ of V_{CA} - $\angle$ of $I_{(X)CA}$ = $\underline{/120°-93.8}°$. 26.2°

(Note: All angles (a) were assigned negative signs since the current angles were smaller than their corresponding voltage angles when measured in a counter-clockwise direction.)

Step 10. Calculate the voltage drops for the feeder cable. The allowable voltage drop for the feeder is: 100 feet (cable length)/250 feet (average overall cable length) x (6.0 percent allowable voltage drop - 0.35 percent switchboard drop to lighting load center) = 2.26 percent. Note that the average overall length (AOL) of any section of a circuit is computed as the arithmetical average of the length, in feet, from the beginning of the section to the end of the branch circuits connected to the section. For more information see Drawing 803-5184170, sheet J-5 (see appendix B). Given the length of the feeder, the currents "I(X)" and the angles *"a",* the drop factors can be obtained from table 5 of DDS 304-1 and the voltage drops computed using equation 40. (Note: For feeder cables, the current, I(x), must be multiplied by the demand factor before using it in the voltage drop equation 40. Interpolate for angle a if not given in table 5 of DDS 304-1.) Thus, D% = I(x) X L X D. F. and:

$D\%_{AB}$ = (92.9 x 0.89) X 100 X 29 X 10^{-5} = 2.4%
$D\%_{BC}$ = (8108 x 0.89) X 100 X 25.4 X 10^{-5} = 1.85%
$D\%_{CA}$ = (70.5 X 0.89) X 100 X 29.3 X 10^{-5} = 1.85%

A size TSGU-30 cable was selected because it would provide a voltage drop that is approximately equal to the allowable voltage drop calculated for this section of cable.

Step 11. Calculate the voltage drop for No. "B" main section of cable. The currents "$I_{(x)}$" and the angles " α" are found in the same manner described in step 8 and step 9, respectively and equation 40 is used for the voltage drop calculation; thus:

(a) Currents I(X) :

$I_{(x)AB} = I_A - I_B = (-1.16-j\,13.6) - (-9.39+j4.5) = (8.23-j18.1) = 19.9\ \underline{/-65.2°}$

$I_{(X)BC} = I_B - I_C = (-9.59+j4.5) - (10.55+j9.1) = (19.9-j4.6) = 20.5\ \underline{/193°}$

$I_{(x)CA} = I_C - I_A = (10.55+j9.1) - (-1.16-j\,13.6) = (11.7+j\,22.7) = 25.5\ \underline{/62.7°}$

(b) Angle "a":

$\alpha_{AB} = \underline{/360° - 294.8°} = -65.2°$

$\alpha_{BC} = \underline{240° - 193°} = -47.0°$

$\alpha_{CA} = \underline{120° - 62.7°} = -57.3°$

(c) Percentage voltage drops. The allowable voltage drop for this section of cable is 105/155 (6.0 - 0.35 - 2.4) = 2.2 percent for phase AB and 105/155 (6.0 - 0.35 - 1.85) = 2.53 percent for phases BC and CA. The cable size which most nearly provides these voltage drops is TSGU-9.

$D\%_{AB} = 19.9 \times 105 \times (47.5 \times 10^{-5}) = 1.0\%$
$D\%_{BC} = 20.5 \times 105 \times (76.2 \times 10^{-5}) = 1.65\%$
$D\%_{CA} = 25.5 \times 105 \times (60.8 \times 10^{-5}) = 1.63\%$

Step 12. Calculate the single phase branch voltage drops. Only the branch with the greatest overall voltage drop from the switchboard need be shown on feeder and main drawings. By summing the voltage drops to this point, and noting the lengths of the branch cables and the magnitudes and angles of the branch currents, it is readily apparent that the branch which is supplied by phase BC will have the greatest overall voltage drop. The summed voltage drops also show that an additional voltage drop of 2.25 percent in phase AB, 2.15 percent in phase BC and 2.13 percent in phase CA may be used without exceeding the 6 percent overall voltage drop limitation. Thus, calculating the voltage drop in branch Bl:

Single phase D% = $2 L \times I \times D.F. = 2 \times 50 \times 6.2 \times 200 = 1.24\%$

(The allowable voltage drop remaining will permit the use of a DSGU-3 cable.)

Step 13. Maximum total voltage drop from the switchboard to the end of the branch. Thus, the voltage drop:

From switchboard to feeder	= 0.35%
In phase BC of feeder cable	= 1.85%
In phase BC of main cable	= 1.65%
In branch B1	= 1.24%
Maximum total voltage drop	= 5.09%

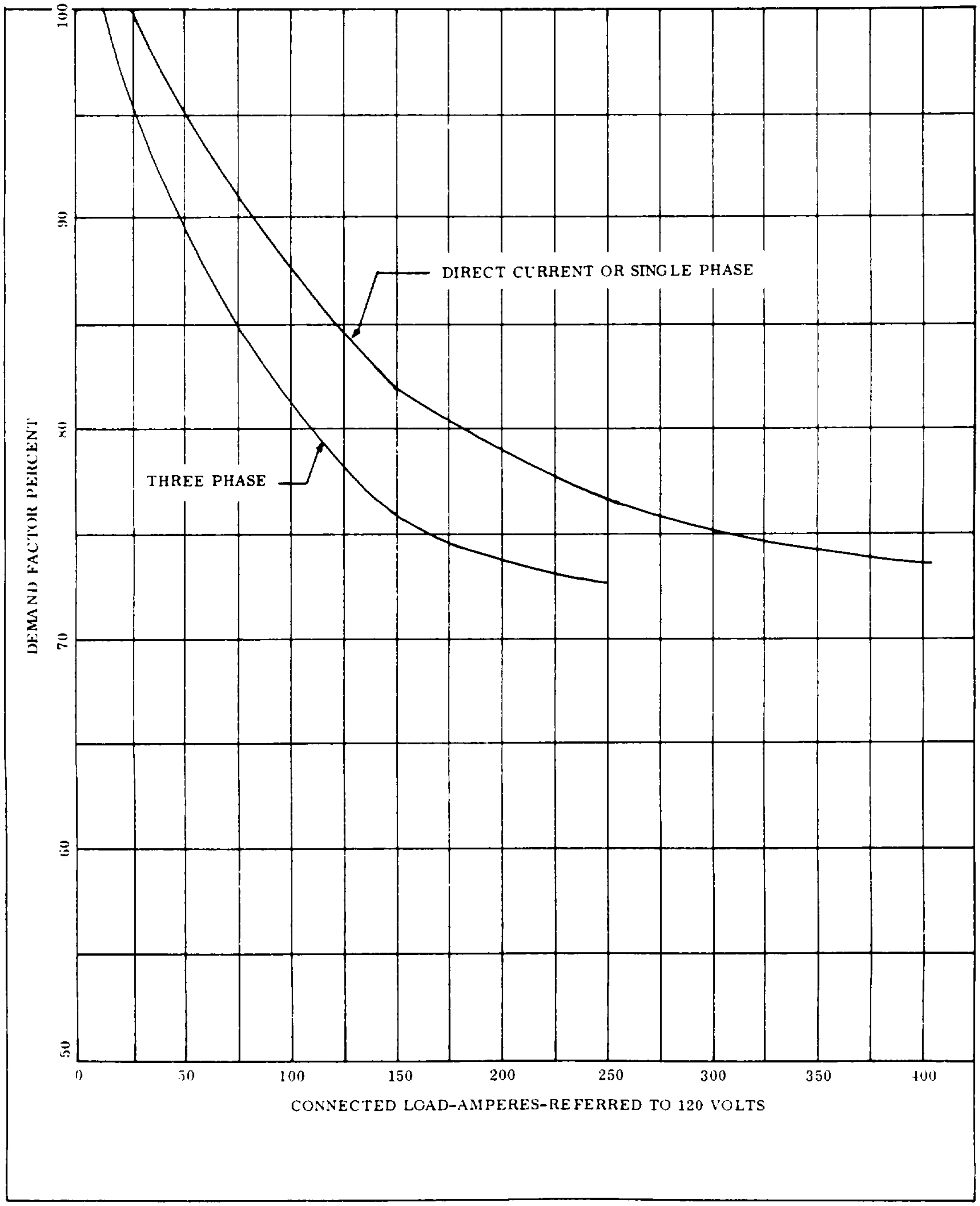

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FIGURE 52. Demand factors feeders for shipboard lighting system.

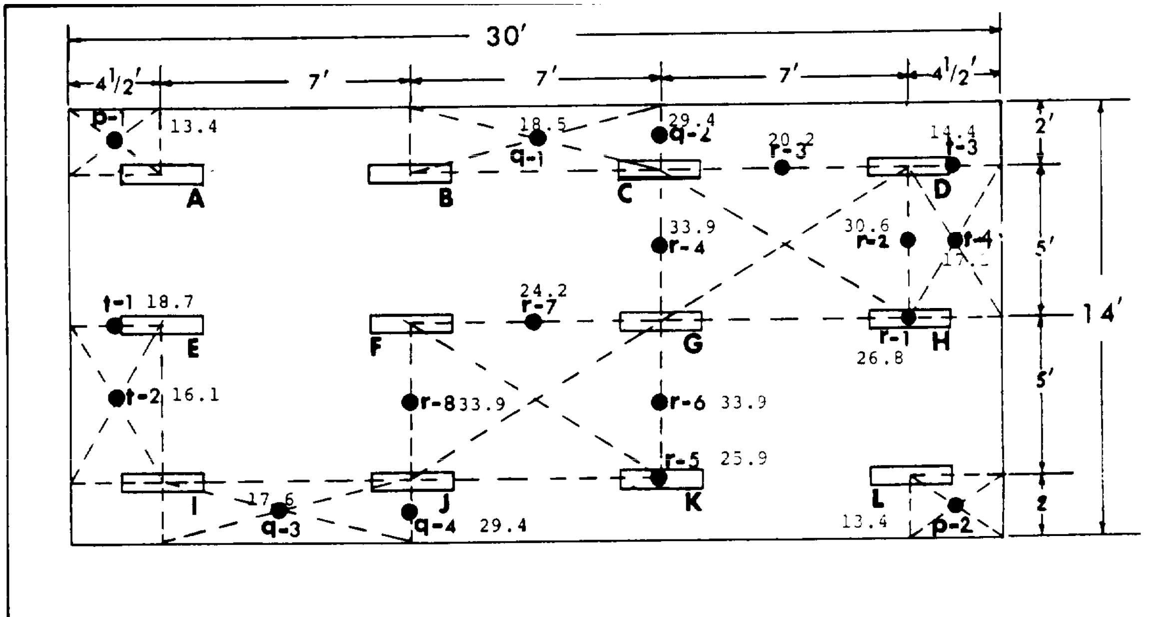
4.3.4.2 General illumination.

4.3.4.2.1 Steps in design. The recommended steps in the design of a compartment lighting installation are:

(a) Determine, from the specifications for the ship, the required illumination levels for general and detail illumination in the compartment.
(b) Determine the appropriate lighting fixtures to use in the compartment. Check to make sure that the choice is not in conflict with any requirements of the ship specifications.
(c) Using the lumen method described in 3.5, determine the total number of fixtures required to provide the specified illumination.
(d) Arrange the lighting fixtures for uniform illumination. It is not always practical to provide uniform illumination throughout the areas below decks on Naval ships. Where the size and configuration of the space and lack of obstructions make it practicable, substantially uniform illumination is achieved if the lighting fixtures are spaced at approximately the same distance apart as their mounting height above the deck. The outer rows of fixtures should be about half this distance from the sides and ends of the compartment.
(e) Using the point-by-point method described in 3.5, check the preliminary arrangement by calculating the illumination it produces at a sufficient number of points to make sure that the requirements for uniformity are met. If the requirements for uniformity are not met, rearrange the fixtures accordingly. When making these check calculations, it is advisable to refer to the plans in section 6 herein and calculate illumination at points where measurements will be made during the survey. Footcandle distribution curves such as shown in appendix A are convenient for this purpose.

4.3.4.2.2 Fixture layout. In the design of any lighting system in a compartment, an analysis should first be made of the seeing tasks involved. The planned fixture layout provides the required footcandles with optimum uniformity and with minimum glare and brightness ratios. Usually, there is one layout which comes closest to meeting these requirements, and every effort should be made to install this layout. However, in many cases, the lighting fixtures are not located until after other systems such as ventilation and piping have already been laid out and, in some instances, lighting fixtures are moved to make room for a change in some other system without regard to the effect of illumination. This approach to lighting system layouts is one of the most important factors contributing to poor shipboard lighting today. New fixtures can be designed, colors can be improved and more light can be provided, but all of these benefits can be largely nullified by a poor arrangement of the fixtures. This problem can be solved if each group, in planning its layout, gives consideration to the needs of the other groups involved and , when necessary, compromises on a combined layout which will serve the needs of all groups to the best extent practicable.

4.3.4.2.3 Example of design. A typical example of using the lumen method to determine the number of fixtures required to provide a specified illumination is shown on figure 27, and a check for uniformity requirements is shown on figure 53.



Location	A Dist fc	B Dist fc	C Dist fc	D Dist fc	E Dist fc	F Dist fc	G Dist fc	H Dist fc	I Dist fc	J Dist fc	K Dist fc	L Dist fc	Total Footcandles
r-1			8.6 0.9	5.0 3.6			7.0 7.6	0.0 17.0			8.6 0.8	5.0 3.0	26.8
r-2			7.4 1.4	2.5 10.0			7.4 1.4	2.5 10.0			10.3 0.5	7.5 7.3	30.6
r-3		10.5 0.5	3.5 6.9	3.5 6.8		11.5 0.3	6.0 2.4	6.0 2.4			10.6 0.5	10.6 0.5	20.2
r-4		7.4 1.4	2.5 10.0	7.4 1.4		7.4 1.4	2.5 10.0	7.4 1.4	10 3 0.5		7.5 7.3	10.3 0.5	33.9
r-5			10.0 6.5			9.6 0.8	5.0 3.6	9.6 9.9		7.0 1.6	0.0 17.0	7.0 1.6	25.9
r-6		10.6 0.5	7.5 7.3	10.6 0.5		7.4 1.4	2.5 10.0	7.4 1.4		7.4 1.4	2.5 10.0	7.4 1.4	33.9
r-7		6.0 2.4	6.0 2.4		10.5 0.5	3.5 6.8	3.5 6.8	10.5 0.5		6.0 2.4	6.0 2.4		24.2
r-8	10.3 0.5	7.5 7.3	10.3 0.5		7.4 1.4	2 5 10.0	7.4 1.4		7.4 1.4	2.5 10.0	7.4 1.4		33.9
q-1	10.6 0.5	3.6 6.5	3.6 6.5	10.6 0.5	12.0 0.3	7.0 1.6	7.6 1.6	12.0 0.3	11.5 0.4		11.5 0.3		18.5
q-2		7.2 1.5	1.0 15.6	7.2 1.5		7.0 1.6	7.5 1.3	7.0 1.6			11.0 0.4		29.4
q-3	13.0 0.2	13.0 0.3			7.0 1.6	7.0 1.6	12.3 0.4		3.6 6.5	3.6 6.5	10.6 0.5		17.6
q-4		11.0 0.4			7.0 1.6	7.5 7.3	7.0 1.6		7.2 1.5	1.0 15.6	7.2 1.4		29.4
t-1	5.5 2.9	10.5 0.5			2.2 11.2	9.2 0.7			5.5 2.9	10.5 0.5			18.7
t-2	7.9	12.0 0.3			3.3 7.3	9.6 0.6			3.3 7.3	9.6 0.6			16.1
t-3			9.2 0.7	2.2 11.2			10.5 0.5	7.2 1.5				10.3 0.5	14.4
t-4			9.6 0.6	3.3 9.3			9.6 0.6	3.3 7.3			12.0 0.3	7.5 1.1	17.2
p-1	2.5 10.0	9.3 0.7			6.5 1.9	11.0 0.4			11.3 0.4				13.4
p-2				11.3 0.4			11.0 0.4	6.5 1.9			9.3 0.7	2.5 10.0	13.4

Step 1. Obtain a scale drawing which shows the general arrangement (furniture, equipment, etc.) of the compartment.

Step 2. Arrange the number of lighting fixtures obtained by the lumen method to satisfy the illumination requirements for the compartment. An obvious arrangement for the example of figure 27 is as shown above.

Step 3. Calculate the illumination at those locations where measurements will be made during the photometric survey (section 4) as follows: (a) Make a table of locations and fixtures as shown above; (b) from the scale drawing, obtain the distances for each location from each fixture, noting that after some distance (usually 10 feet) from the location very little illumination is provided by some fixtures, so that these fixtures can be omitted without a significant error; (c) from the footcandle distribution curves of Appendix A, determine the footcandles for each location from each fixture and total them for the illumination of each location. Footcandle values for the example of figure 27 are given above.

Step 4. Examine the footcandle values obtained in Step 3 for uniformity and rearrange fixtures, if necessary.

Step 5. Calculate the average illumination in accordance with section 4 For the example of figure 27, the average illumination is 24.2f.c. section 4. This value is somewhat low from the theoretical 31.1f.c. value because the footcandle distribution curve used does not take into account that there will be an additional buildup of footcandles (a factor of 15-20 percent is usually used depending on the compartment reflectance) caused by reflections from overheads, bulkheads, and decks; particularly near the bulkheads where the illumination is somewhat low, thereby lowering the overall average.

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FIGURE 53. Example of illumination calculation using the point-by-point method.

4.3.4.2.4 Typical installation methods. Typical installation methods for lighting fixtures are provided in appendix B.

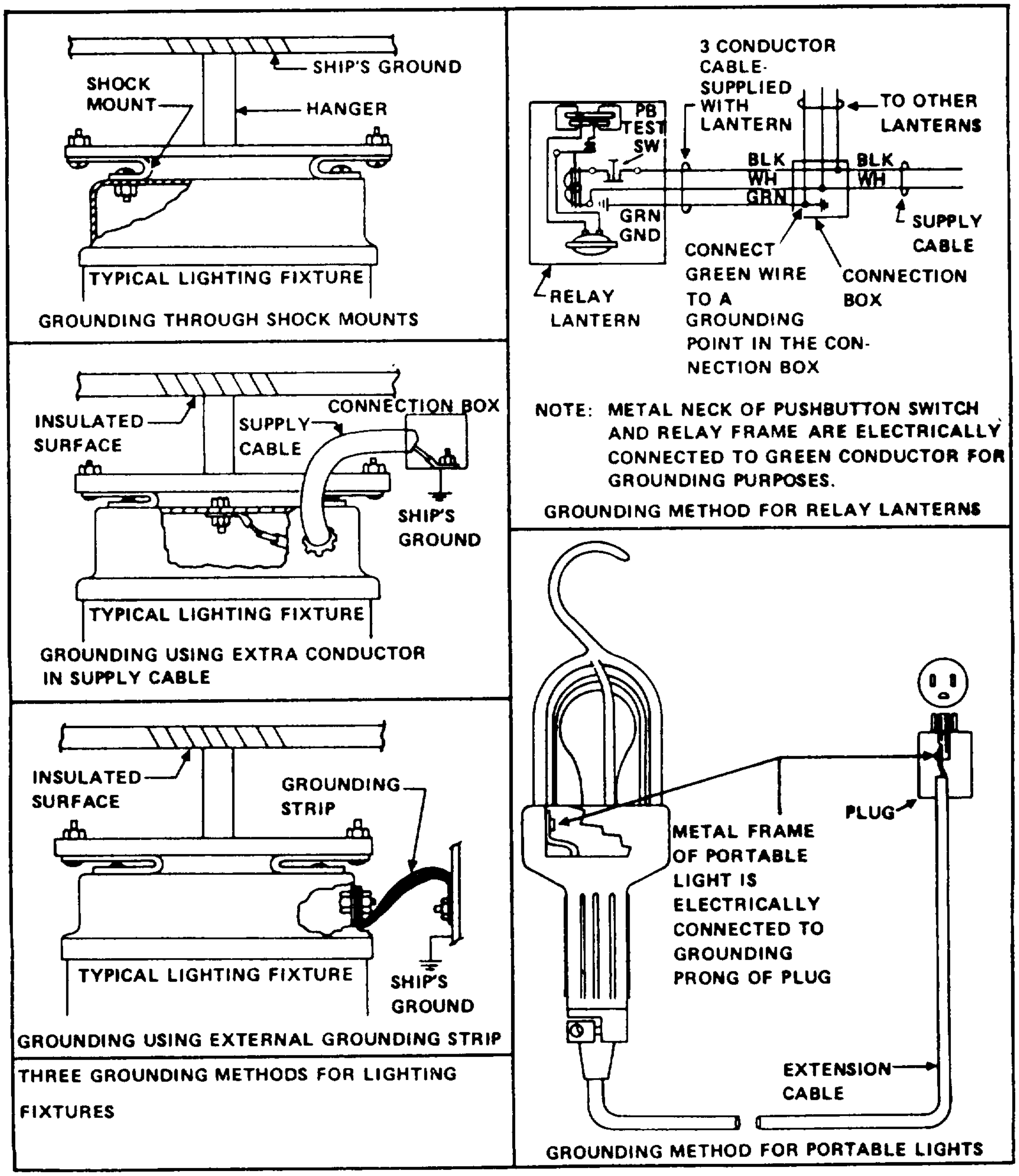
4.3.4.2.5 Mounting heights. Where practicable, fixtures shall be installed close to the overhead to achieve a desirable uniformity of illumination. If the overhead arrangement is such that one or more of the fixtures must be lowered considerably to avoid obstructions such as ducts, pipes, or wireways, or to achieve satisfactory illumination, the remaining fixtures shall not be lowered. Where an overhead fixture is used to furnish illumination for a detail lighting task, the fixture mounting height shall be selected to meet the detail illumination requirements.

4.3.4.2.6 Fixture location. Where practicable, specific fixtures shall be located as follows:

(a) Overhead lighting fixtures in living spaces shall be located above passages between berths.
(b) Lighting fixtures in messing spaces shall be located to illuminate mess tables and mess counters properly.
(c) Lighting fixtures in storerooms, issue rooms and commissary spaces shall be located above the center of passages and not at top of bins, fittings, or equipage.
(d) Overhead and directional type fixtures shall be arranged to minimize interference by specular reflection from the seeing tasks when the operator is in the normal operating position. Where necessary, shielded windows shall be used.
(e) Fixtures shall be located to suit the contemplated arrangement of machinery, structure, fittings, or furniture. If such arrangement is changed during installation, the location of fixtures shall be changed accordingly.

4.3.4.2.7 Fixture clearance. Clearance between lighting fixtures installed using the shock mounts furnished with the fixtures and adjacent equipment or structure shall be not less than 1-1/2 inches for incandescent fixtures and 3/4 inch for fluorescent fixtures, except where fixtures are installed flush in suspended ceilings in order to provide the “spring” action necessary for shockproofing.

4.3.4.2.8 Grounding of lighting fixtures. The seriousness of the hazard of electric shock cannot be overemphasized. Ashore, particularly in homes, lighting and power systems are treated with considerable contempt. This has lead to the mistaken impression that 115-volt circuits are not lethal. The facts are simple. More personnel in the Navy have been killed by 115-volt circuits than by circuits of all other voltages combined. Conditions aboard ships affecting the hazard of electric shock are vastly different from those generally found ashore. These conditions and the subject of electric shock hazard are presented in detail in NAVSEA 0283-236-0000. Lighting fixtures shall be installed such that all exposed metal parts are at ground (ships hull) potential at all times to ensure the safety of operating and maintenance personnel. Figure 54 provides acceptable methods for grounding lighting fixtures. Grounding techniques shall be in accordance with the requirements of MIL-STD-1310.



NOTE: Refer to MIL-STD-1310 for wooden construction.

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FIGURE 54. Acceptable methods of grounding lighting fixtures - metal ships.

4.3.4.2.9 Switching. Lighting in large spaces (machinery spaces and cargo holds) should be controlled by switches or ALB-1 circuit breaker panels directly from the lighting distribution fused boxes. Lighting in staterooms, officers' recreation rooms and other smaller spaces shall be controlled by switches at the doors. Where practicable, these switches shall be located so that opening of the door will not obstruct access to them. Switches shall break both sides of the circuit. Switches shall be watertight or non-watertight as required by the location. Where watertight fixtures are required the switches should also be watertight. Switches controlling fixtures in spaces in which explosive gases or flammable mixtures may normally be expected to accumulate shall be located outside such spaces.

4.3.4.3 Detail illumination. Whenever general illumination is inadequate for efficient performance of specific tasks, detail illumination shall be provided using standard Navy detail fixtures, designed for the specific function, listed in NAVSEA S0300-AT-GTP-010/ESL. Detail lighting fixtures shall not be provided where judicious location of general lighting fixtures will provide the required levels of detail illumination. Additional general lighting fixtures may be installed in lieu of detail fixtures in these cases. This does not apply to berth lights or furniture with built-in illumination. The detail illumination values shall be calculated for the task working plane. Drawing 803-5184170 (see appendix B) provides typical installation methods for the following detail illumination tasks:

(a) Berth lights - appendix B, section B.
(b) Mirror lights - appendix B, section C.
(c) Desk lights - appendix B, section D.

4.3.4.4 Special illumination. Special illumination shall be provided in accordance with section 332f of NAVSEA S9AA0-AA-SPN-010/GEN-SPEC.

4.3.4.5 Red illumination. Low level red illumination shall be provided in accordance with section 332g of NAVSEA S9AA0-AA-SPN-010/GEN-SPEC. Further details are provided in 4.4.

4.3.4.6 BBB illumination. BBB illumination shall be provided in accordance with section 332h of NAVSEA S9AA0-AA-SPN-010/GEN-SPEC. Further details are provided in 4.5.

4.4 Red illumination.

4.4.1 General. Despite the development of such sensing devices as radar and sonar, the best detection mechanism for locating small objects at sea (boats and ships, downed fliers, buoys, obstructions and the like) remains the human eye. For this reason, and to serve as backup to electronic sensors for collision avoidance and aircraft spotting, shipboard lookouts are still posted topside as they have been since the days of sail. At night the role of the lookout is a particularly vital one, and unfortunately, it is in the low-level lighting situation that the human eye is least effective. Although the ability to see well in the dark varies with the individual, night vision capabilities can be significantly improved with training, practice and an understanding of how the eye functions in low-level lighting. Dark adaptation and how the eye functions in low–level lighting are discussed in 3.2.

4.4.2 Purpose. Red illumination (also referred to as low-level or standing lights) is installed in Naval ships for the following primary purposes.

(a) To provide low-level illumination in berthing spaces for safety and sleeping comfort.
(b) To provide illumination that will afford the least practicable interference with dark-adapted vision in access routes to topside battle and watch stations and in special compartments and stations.
(c) To provide illumination for special applications involving darkened-ship operation.
(d) To provide illumination for replenishment-at-sea operations (see 4.6).

4.4.3 Lighting fixtures. Red illumination shall be furnished by standard lighting fixtures selected from NAVSEA S0300-AT-GTP-O10/ESL.

4.4.3.1 For fluorescent lighting installations, red illumination shall be accomplished by standard red lighting fixtures or by use of red filter tubes over selected lamps of white lighting fixtures, as necessary to accomplish the desired illumination.

4.4.3.2 For incandescent lighting installations, red illumination shall be furnished by standard red lighting fixtures. Red glass lamps, or globes and lamps with surfaces painted or dyed red, shall not be employed in place of standard red globes.

4.4.4 Details of red light installations.

4.4.4.1 Location and quantity of red lights. The red lighting fixtures shall be located and spaced to provide sufficient illumination of the area, with particular attention being given to the illumination of door sills, hatch coamings, ladders, and obstacles. Symbol 93.2, installed on bulkheads to illuminate door sills and hatch coamings, shall be a minimum of 2 feet above the deck (to the bottom of the globe) and shall be installed as close to the minimum as practicable. Red lighting fixtures, including those at replenishment stations, shall be installed so that no direct light is exposed to view outside the ship and any indirect light reflected from weather-deck structures or passing through such openings as scuttles, cargo hatches and hangar doors is kept to a practical minimum. This shall be accomplished by judicious location and shielding fixtures and by the application of black paint. Indicator lights on equipment located in areas having low-level red illumination shall be red.

4.4.4.1.1 Red lighting fixtures, which are installed for the purpose of preserving dark-adapted vision of personnel using optical instruments, shall be located outside the field of vision of operators occupying their normal working positions. The fixtures shall be shielded to reduce light in the working area to a minimum. Installation of the required red lighting fixtures in compartments and passages shall not affect the number of white lights required.

4.4.4.1.2 When necessary to adjust the degree of illumination and direction characteristics of a red lighting fixture, the globe or windows shall be shielded. For example, a fixture located adjacent to the head of a berth or near the top of a ladder shall be shielded so that the light does not shine directly into the eyes.

4.4.4.1.3 Lights installed in the pilot house, including indicator lights, shall be located or shielded so that no light is reflected in any of the windows or windshield glass. This is particularly important when lights are installed on the after bulkhead of the pilot house.

4.4.4.1.4 Due to the diversity of red illumination, average illumination levels are not specified. However, red illumination of approximately 0.4 foot-candle is satisfactory for crude work such as moving aircraft in the hangar bay.

4.4.4.2 Red lighting control. Double throw switches shall be used to energize either the red light circuits or the white light circuits. In addition, where operating conditions or personnel comfort make it desirable to reduce the amount of low-level illumination, such reduction shall be accomplished through the use of integral or individual local switches. In large cargo spaces, where practicable, control shall be provided to permit the number of lights turned on to be limited to the area in use.

4.4.4.2.1 Red lighting fixtures shall be supplied from the local ship service lighting circuits and will be connected to permit their control when the regular illumination is extinguished. In surface ships having an emergency lighting system, the red light fixtures shall be connected to the emergency system in all compartments designated to receive emergency lighting supply.

4.4.4.3 Surface ship requirements.

4.4.4.3.1 Living spaces. Red lighting fixtures shall be installed as standing lights for living compartments that accommodate four or more persons and for washroom and water closet spaces that are within or near living spaces. A sufficient number of fixtures shall be provided to permit personnel to move from berths to access routes. In troop living spaces, additional red standing lights shall be installed to provide sufficient illumination for assembling troops gear. Deck level red illumination in berthing areas shall be provided by recessed step lights, symbol 353.1.

4.4.4.3.2 Access routes. Red lighting fixtures shall be installed along routes leading from stateroom and berthing areas to weather deck stations involved in navigation, weapons control, signaling, gunnery, flight operations, and other similar essential activities. In general, the routes selected shall lead along main passageways and terminate at each main access to the weather decks. These routes shall permit personnel traffic within the ship, rather than on weather decks, insofar as practicable. This will result in most large ships having a continuous fore-and-aft red lighted passageway, both port and starboard, under shelter. Where such routes lead through large spaces such as shops or messing spaces, red lights shall be installed to illuminate only these routes. Companionways, ladders, and moving stairways in access channels shall be provided with red illumination.

4.4.4.3.2.1 Red-lighted access routes shall have a minimum exposure to white light; but total exclusion of white light is not mandatory (for example, door switches shall not be installed solely to keep white light out of these routes). Washrooms and water closet spaces opening into such routes shall have red lights.

4.4.4.3.2.2 The number of red lighting fixtures shall be limited to the minimum number required to insure safe, rapid movement of personnel under low-level illumination conditions. In long, unobstructed passageways, one fixture shall be provided for each watertight subdivision or approximately 40 feet apart when a subdivision is greater than 40 feet in length. However, where the passageway changes direction, a sufficient number of fixtures shall be provided to illuminate the passage from either direction.

4.4.4.3.3 Special compartments and stations. Red light fixtures shall be installed in compartments used by personnel preparatory to performing duties outside at night or compartments entered periodically in the course of carrying out such duties, and in stations in which optical instruments (such as range finders) are used. Each of these compartments having an inboard access shall be made accessible from living areas via red-lighted access routes utilizing, where practicable, the main red-lighted routes previously specified. Red-lighted routes shall also be provided between these spaces and the weather decks where direct access outboard does not exist. Specific red light installations follow:

(a) Squadron ready rooms. Red light fixtures shall be installed in accordance with Drawing 803-5184170, method H-l-A (see appendix B).
(b) Chart room. Red illumination of the chart table shall be provialed by attaching red filter assembly, symbol 121.1, to desk lights provided for white illumination.
(c) Flight deck control station, Pri-Fly control, and air group line operations room. Red light fixtures shall be installed to illuminate the flight deck control board.
(d) Conflagration and hangar deck lighting control station. Red light fixtures shall be installed for illumination of indicator panels where not internally illuminated.
(e) Aircraft engine shop. One red hangar fixture, symbol 75, shall be installed over each workstand and over each workbench.

4.4.4.3.4 Special applications involving darkened-ship operations. Red light fixtures shall be installed in spaces, subject to use during darkened-ship operation, having light-exposing openings such as high bay spaces, enclosed gun mounts and upper handling rooms. Door switches shall be provided for the control of these lights. Occasional by-passing of door switches may be necessary in such spaces in order to meet operational exigencies such as handling planes in hangar spaces during darkened-ship. Therefore, the installation of red lights in these spaces shall be such that no direct light is exposed to view outside the ship and any indirect light passing through hatches or other openings is subdued to a minimum. This shall be generally accomplished by judicious location and shielding of fixtures and by application of black paint to the reflecting surfaces of fixtures and the ship’s structure, as necessary. The following typical spaces shall have a red light installation in accordance with the aforementioned general provisions.

(a) Replenishment ships. Cargo store rooms, cargo weapons spaces, cargo and cargo weapon handling equipment storage areas and cargo handling areas - fluorescent fixtures, symbols 333.1 or 333.2 with a red center lamp, shall be installed in sufficient quantities to provide the required white illumination. The red illumination obtained from the center lamp of the fixtures will be sufficient. Additional fixtures for red illumination are not required. One incandescent fixture, symbol 93.2, shall be installed to each 100 square feet of deck space in cargo refrigerated spaces.

(b) High bay spaces. The number of red lighting fixtures, symbol 75, to be installed in high bay spaces (such as hangar space or tank spaces on landing ships) shall be the same as the number of white fixtures, symbol 74, required to produce the white illumination level specified for that space.

(c) Gun mounts. Red light fixtures shall be installed in manned enclosed gun mounts that have openings for visual sightings to exterior of the ship and in control and handling rooms that are directly below such mounts.

4.4.4.4 Submarine requirements. In addition to the requirements of 4.4.4.1 and 4.4.4.2, low-level illumination shall be provided in readiness areas (defined as areas used by personnel to attain dark–adapted vision prior to assuming duties in an operational area) and in additional areas (defined as the periscope station area and those areas visible from that station):

(a) The amount of low-level illumination in readiness areas shall be:

(1) General illumination (at working level) - 0.25 to 2.0 footcandles.

(2) Brightness of any area in the field of vision shall not exceed 2.0 foot-lamberts.

(b) The amount of low level illumination in operational areas shall be:

(1) General illumination (at working level) - 0.01 to 0.40 footcandles.

(2) Illumination on black and white dials and nameplates - 0.03 to 0.10 footcandles.

(3) Brightness of instrument faces - 0.02 to 0.08 foot-lamberts.

(4) Brightness of indicator lights shall not exceed 2.0 foot-lamberts.

In determining the areas to receive red lighting, officers country and the associated passage to the periscope station area are normally considered to be readiness areas. Crew messing and berthing spaces are not considered readiness areas unless they are adjacent to operational areas, or part of an access channel between two or more operational areas. Electronic spaces do not require red illumination unless they are integrated with the periscope station, are in an access channel, or there is a need for the periscope operator to enter these spaces in performing his duties. Changing from white to red illumination in the operational areas shall be accomplished by the minimum number of switches. The fixtures in the immediate vicinity of the periscope station shall have individual switches in the red light circuit. The readiness areas shall be wired to allow as much flexibility as possible, by means of switching, to permit the commanding officer to establish red-lighted readiness areas in accordance with the ship's operating procedure. In order to protect the periscope operator from direct light from fixtures in his field of vision, additional external baffles may be installed. Deck level red illumination berthing areas shall be provided by recessed step lights, symbol 353.1.

4.5 Blue illumination.

4.5.1 Background.

4.5.1.1 The problem. Illumination is a longstanding problem which has plagued those associated with lighting design and operational requirements in spaces such as combat information centers (CIC) and similar command and control spaces containing radar system display consoles. The display console incorporates a cathode ray tube (CRT) which provides visual displays of surface or aerial targets as they are illuminated by the radar equipment. The targets are projected as lighted traces on the CRT screen. Ambient illumination excites the phosphor coating on the inside of the CRT causing a significant decrease in the signal-to-noise or contrast ratio. This results in a dimming of the target trace, thereby affecting the operator's ability to see the target. In time of war, the target may be an enemy vessel or aircraft; therefore, it is vital that the trace be of an intensity to be easily noticed when it appears. The conventional solution for improving the visibility of targets on the CRT is the darkened room. The darkened room does improve the CRT presentation; however, it reduces operator efficiency by requiring the work be done in the dark and adversely affects target visibility whenever light is required to perform maintenance.

4.5.1.2 Other considerations. In addition to operating the display consoles, other operating functions, most of which require some type of local illumination, must be carried on. These include reading charts and messages, plotting on status boards and operating electrical and electronic equipments. Another extremely important function, which is often performed simultaneously with operations, is maintenance of equipment. Since preventive maintenance aids in eliminating major breakdowns, it must be scheduled and rigidly enforced. During operating conditions, this maintenance is normally accomplished with the aid of a flashlight or extension light. This type of light usually provides adequate illumination for the task at hand but, added to the overall reflections from other light sources, it may affect the phosphor of nearby CRTs. Safe movement of personnel into, through and out of the space is an important requirement since watches must be changed, messages or other documents carried into or out of the space and equipment checked or repaired.

4.5.1.3 one solution. BBB illumination for shipboard utilization adequately satisfies normal requirements. It provides improved scope visibility, permits the use of an illuminated working environment, and makes possible 24-hour continuous operations.

4.5.2 BBB illumination.

4.5.2.1 General. The BBB illumination system is based on the use of only a small portion of the light output of a light source, or blue light. The basic principle of this lighting system is frequency sharing. Abroad band of blue light (the shorter wavelengths of the visible spectrum (see 3.1)) are allocated for ambient room illumination and the remaining portion of the visible spectrum is used for CRT viewing and for other special purposes. The system is referred to as "Broad Band Blue" because the light utilized covers a wide band of frequencies and correspondingly extends from blue light of a longer wavelength to blue light of a shorter wavelength.

4.5.2.2 Light source. "White" light sources emit all colors. The "whiter" the source, the higher the color temperature (see 3.6.1.3) and consequently, the more blue emitted. Thus, a light source having a relatively high blue content is preferred. A "daylight" fluorescent lamp has a color temperature of 6500 degrees Kelvin (°K), whereas a "white" fluorescent lamp of the same wattage has a color temperature of 3500°K. Blue light is obtained by utilizing the daylight type lamp with a blue filter which permits only the desired wavelengths to pass and thereby provides low-level general illumination. The smaller bell-shaped curve of figure 55 indicates the percent transmittance of the blue filter at various wavelengths. Note that these limits are within the larger bell-shaped curve of figure 55 which indicates the relative sensitivity of the human eye at various wavelengths.

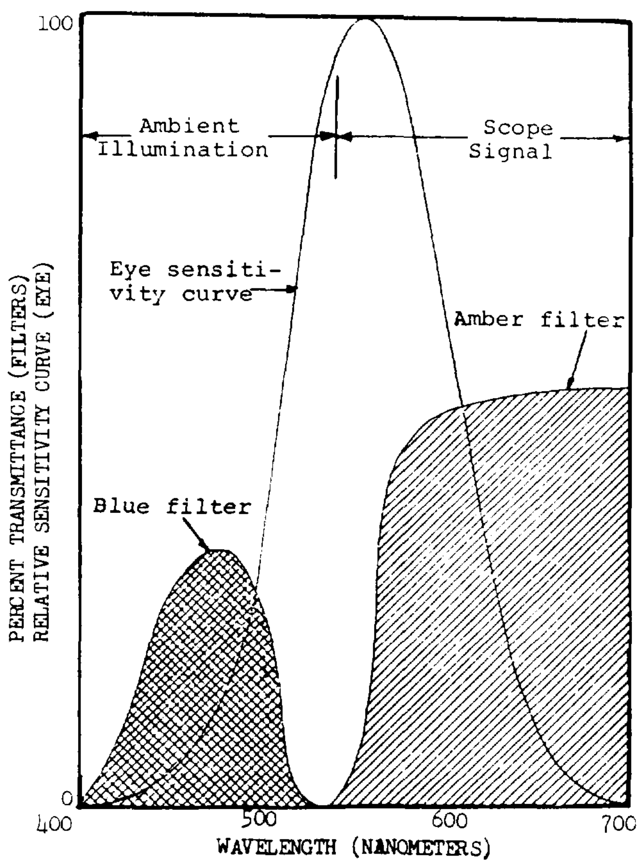

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FIGURE 55. BBB lighting system filter coverage.

4.5.2.3 Effect on CRT. Since white light excites the phosphor of the CRT, blue light will do likewise because white light contains blue. To prevent the blue light from reaching the phosphor of the-CRT, an amber filter is placed over the face of the CRT. Because the amber filter transmits wavelengths other than those of the blue light, only a very small portion of blue light reaches the phosphor. The scope signal consists primarily of wavelengths within the range of the amber filter. Therefore, it follows that the amber filter will pass the scope signal but will reject practically all blue illumination. This rejection also includes the initial blue flash which occurs when the scan picks up an object. The elimination of this flash is desirable because the flash is detrimental to the final level of eye adaptation. The right hand curve of figure 55 indicates the percent transmittance of the amber filter at various wavelengths. Again note that this coverage extends beyond the upper limit of the sensitivity curve. Although the intensity of the trace is reduced somewhat by the amber filter, the effect is offset by a slightly greater contrast between the trace and the background. The overall compatibility of the BBB system with the viewing of a scope is shown on figure 56.

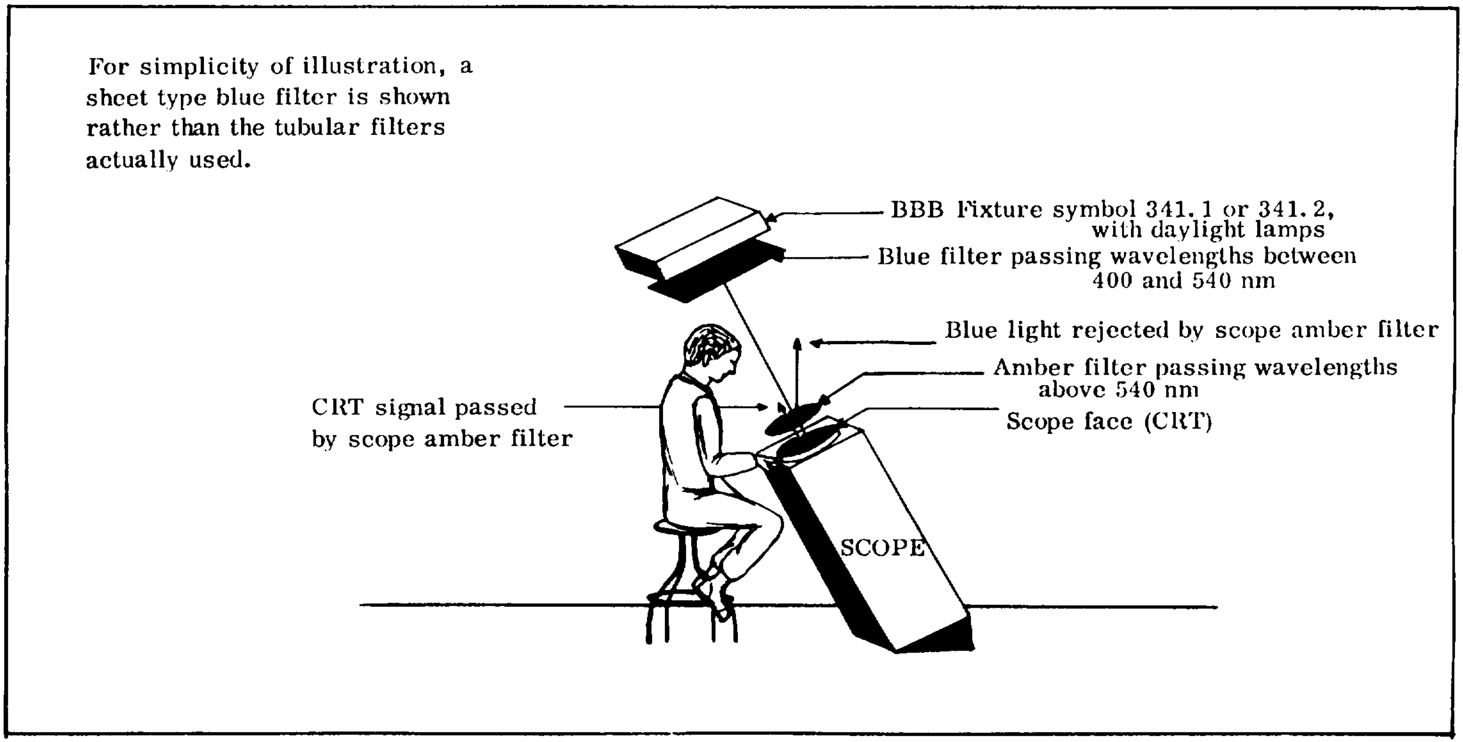

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FIGURE 56. Compatibility of BBB lighting system with use of scope.

4.5.2.4 Other related effects. Like any other lighting installation, undesirable reflections can be introduced if the wrong combination of lighting fixtures and interior finish is used. These reflections will generally be observed only in scope faces and status or plotting boards. Reflections can almost wholly be eliminated by use of a dark overhead, preferably blue-black, and by the most efficient fixture location and the proper use of shields. Reflections may be further eliminated by the operator's use of amber goggles which act in the same manner as the scope filter previously described. Like any monochromatic light, blue light has an effect on printed colors found on charts, especially blue. This problem can be solved by the use of local spot lights which provide the necessary additional white light to permit discernq ent of colors.

4.5.3 Installation.

4.5.3.1 General. On surface ships, command and control spaces containing CRT display consoles, except spaces where the function of the space requires visibility exterior to the ship, shall be provided with BBB operational illumination, highly directional supplementary illumination, and white maintenance lighting to provide:

(a) Maximum CRT visibility.
(b) Adequate legibility of secondary displays.
(c) Sufficient illumination for maintenance and supporting personnel for a 24-hour-a-day operation.
(d) Sufficient illumination for reading, writing, and free movement of personnel.

4.5.3.2 Lighting fixtures. Symbol 341.1 (surface mounting) or symbol 341.2 (flush mounting) shall be used for BBB illumination. These fixtures are provided with two lamps covered with blue filters for blue illumination and one white lamp for white maintenance lighting. The fixtures are provided with integral switches for each blue lamp and with a black painted louver for shielding. The lamps in the fixtures are so wired that either one or both blue lamps or the white maintenance lamp can be energized separately.

4.5.3.3 Lighting fixture location. Fixtures shall be judiciously located so that, when operators are in their normal operating positions, fixture images will not degrade scope displays and will not be objectionable in plotting and status boards. In order to obtain illumination levels required to provide illumination as uniform as possible and to eliminate glare sources, additional shielding may be provided.

4.5.3.4 Illumination levels. The number of fixtures installed shall provide an optimum ambient illumination throughout the space. The illumination levels of BBB light given in table XVI shall be used as a guide and shall be achieved, providing all other requirements herein are satisfied.

TABLE XVI. BBB footcandle levels.

Area	Footcandle levels
In walking areas (30 inches above deck)	0.6 minimum (BBB)
On scope faces	0.16 maximum (BBB)
On DRT's (with supplementary white light)	2.0 minimum
On other equipment, such as clocks and communication consoles (with supplementary white light)	1.0 minimum
On desks and tables (with supplementary white light)	4.0 minimum
White maintenance light	3.0 minimum

4.5.3.5 Maintenance white lighting. Maintenance lighting shall be provided by the center tube of the BBB fixtures. No additional fixtures shall be provided for this purpose unless the initial installation produces an average initial illumination level, in the module, of less than three footcandles of white light. When additional fixtures are required to obtain the white maintenance level specified, fluorescent type shall be selected.

4.5.3.6 Supplementary illumination. Highly directional supplementary illumination shall be provided for chart tables, communication consoles, radio operators positions, DRTs and items which do not have adequate internal illumination, such as clocks, information plates and position markers of manually operated switches. Supplementary illumination may be provided by Navy standard desk lights fitted with filter symbol 121.2 or spotlights, symbol 147.2. The shield insert of the spotlight may be reversed to provide a broader distribution pattern, if required.

4.5.3.7 Control switching. Control switching for lighting in each module shall be located in that module and shall be arranged so that one switch will energize all blue lights. This control may be combined in one selector switch with an off position. It should be noted that each lighting fixture is provided with integral switches for each blue lamp so that the intensity of the blue illumination can be adjusted by energizing both lamps (bright level) or one lamp only (dim level) as desired (see Drawing 803-5184170, method J-2-A in appendix B).

4.5.3.8 Amber filters for CRTs. If CRTs are not so covered, they should be covered with a 3/16-inch thick, amber, heat-resistant, acrylic plastic having a light transmission of not less than 80 percent and CIE chromaticity coordinates of x = 0.452 and y = 0.504 when measured using CIE, source C. Readjustment for parallax elimination should be made as necessary after filter installation.

4.5.3.9 Auxiliary equipment and displays. Brightness of internally illuminated dials and indicator lights of auxiliary equipment and displays shall not exceed 2.0 foot-lamberts.

4.5.3.10 Compartment finish. Compartments with BBB lighting should be painted as follows:

(a) Bulkheads - light pastel blue, color no. 25526 of FED-STD-595.
(b) Overhead - insignia blue, color no. 35044 of FED-STD-595.
(c) Decks - light colored tiles.

Painting the overhead and decks blue increases the reflectance of these surfaces, thereby producing a perceptually brighter compartment. Care should be exercised to make sure the blue paint does not convert the blue light to longer wavelengths that would pass through the scope amber filter. For a quick test, view the bulkheads through an amber filter. If the bulkheads appear black, little to no conversion is taking place.

4.5.3.11 Yellow-orange goggles. Under certain conditions, the wearing of goggles with yellow-orange lenses will permit scope observers to see much longer trails, or to see fainter targets more clearly. Reflections of the blue light are eliminated by the goggles, which also exclude nearly all of the room light, thus increasing the operator's visual sensitivity. Initially, the goggles will prevent the operator from seeing other personnel and non-fluorescent surfaces for about 15 minutes. Because of this 15 minute "blindness" and the discomfort of wearing additional gear along with the headsets, goggles are not used with BBB illumination.

4.6 Replenishment-at-sea (RAS) red lighting.

4.6.1 General. In order to carry out the Navy's mission, the fleet must be capable of remaining at sea for prolonged periods, fully ready to carry out assigned tasks. To enable extended periods of operations at sea, units of the fleet receive the logistic support they require by means of RAS operations. Prescribed procedures for those mobile logistic support operations are contained in Naval Warfare Publications 14 (series). As stated in that publication, "The primary goal of RAS is the safe delivery of the maximum amount of cargo in a minimum of time". In that regard, normal RAS evolutions such as rigging, load transfer and load receipt, together with other weather deck cargo handling operations, are included in the general requirements for RAS red lighting.

4.6.2 Visual landing aids (VLA). VLA equipment, lighting arrangement, and flight deck marking for vertical replenishment (VERTREP) shall be in accordance with the applicable NAVAIR Visual Landing Aids, General Service Bulletin.

4.6.3 Purpose. Visually cued operations, such as those common in RAS, are normally more hazardous at night than during the day because of the greatly reduced levels of ambient illumination at night and because of the ineffectiveness of the human eye in low level lighting situations as discussed in 4.4. Thus, considerable care must be exercised in the design of low-level, red lighting systems. Visual ship detection avoidance and the maintenance of night vision impose the upper limit on illumination levels. The lower limit is governed by the minimum levels required for satisfactory performance of specific tasks.

4.6.4 Illumination levels. The number of fixtures installed in an area shall be sufficient to provide an optimum ambient illumination throughout the space or area. The levels of red illumination for RAS operations given in table XVII are minimum values and shall be achieved, providing all other requirements herein are satisfied. These illumination levels are based on the need to maintain night vision and also on the visual requirements for the tasks being performed. In areas where it may be impractical to attempt to obtain uniform levels of illumination, it is important that the fixtures be aimed at the centers of specific task areas. Consideration should also be given to the use of various aids to low-level vision, such as application of reflective markers or paints in peripheral areas.

TABLE XVII. RAS illumination levels.

Space	Footcandles (minimum)
Secondary deck handling routes.	0.2
Primary deck handling routes; fueling-at-sea stations; solid cargo transfer stations; connected replenishment rigging assembly and drop zone; vertical replenishment areas for handling cargo, ammunition and stores; strike-up and strike-down interfaces; general handling areas; cargo; staging areas; winch control stations; winches and winch platforms; cargo holds.	0.5
Missile strike-down interfaces at critical alignment points.	2.0

4.6.5 Lighting fixtures. Red lighting fixtures specified in NAVSEA S0300-AT-GTP-010/ESL shall be installed for general lighting of RAS stations during night replenishment operations on ships fitted for delivering or receiving supplies such as fuel, water, or stores. Typical red lighting fixtures for weather deck installation are symbols 68.2, 69, 93.2 and 113. Floodlighting shall be accomplished by employing primarily symbols 263 and 317.

4.6.6 Lighting fixture location. The red lighting fixtures for illumination of RAS transfer stations shall be located so they do not obstruct or will not be subjected to damage by booms, rigging, hatch covers or other cargo handling gear. Red lighting fixtures shall be installed so that no direct light is exposed to the view of bridge personnel or outside the ship and any indirect light reflected from weatherdeck structures is kept to a practical minimum. This shall be accomplished by judicious location and shielding of fixtures and by the application of black paint. A floodlight mounted at an angle of greater than 45 degrees creates an undesirable glare situation.

4.6.7 Control switching. Red lighting fixtures shall be supplied from the local ship service lighting circuits and connected to permit their control when the regular illumination is extinguished. In surface ships having an emergency lighting system, the red lighting fixtures shall be connected to the emergency system. Switches and variable power transformer dimmers (symbol 960) shall be installed to control the red illumination at each station. The switching arrangement shall isolate port and starboard RAS red light circuits.

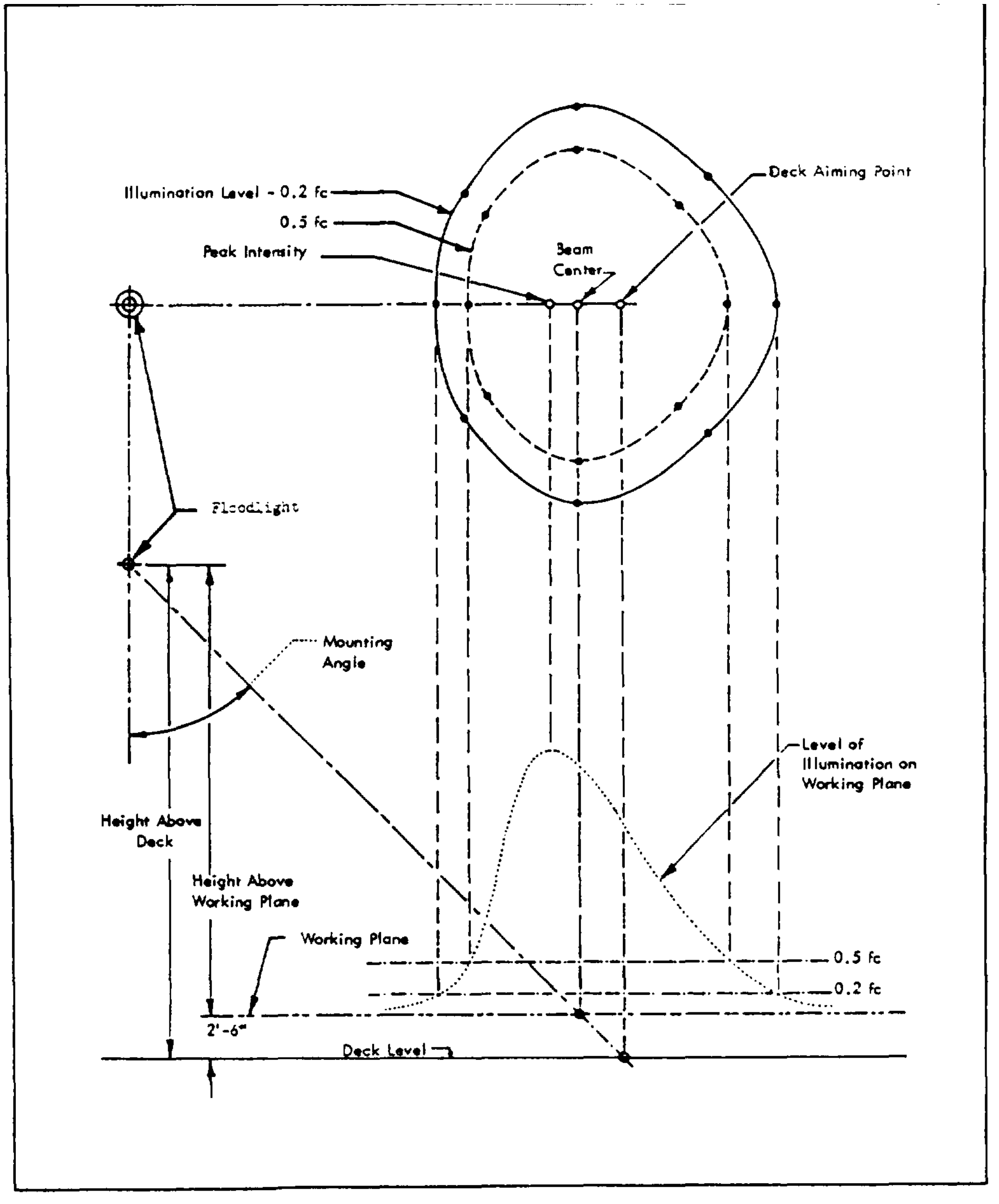
4.6.8 Floodlighting calculations by template.

4.6.8.1 General. As indicated in 3.5, the locating and aiming of floodlights for maximum illumination effectiveness is accomplished through the use of mathematical or graphical techniques. During the design of a lighting system, the lumen method is usually used to determine the average illumination level and degree of uniformity required throughout the area to be lighted. However, when minimum values are required for defined tasks at specific locations, the point–by–point method, or some variation thereof, should be used. The point-by-point method does not consider inter-reflections (an assumption which may be accepted as generally valid when considering bulkheads and deck surfaces), and therefore, provides illumination levels which are conservative in proportion to the reflectivity of the surfaces. In order to avoid some of the practical difficulties encountered when using the point-by–point method, an adaptation designated the template method has been developed.

4.6.8.1.1 The template method is a simplified technique which employs specially prepared templates (scaled patterns of illumination intensity) to determine proper placement and mounting angles of light fixtures. A more detailed description of the method, including assumptions and limitations, preparation of templates, lighting of the computer program, printout of results, and so forth, may be found in Naval Ship Research and Development Laboratory (NSRDL), Annapolis, report no. 3562, “The Template Method of Illumination Design”.

4.6.8.1.2 Based on point-source theory and calculation, and assuming little or no reflection of light from surroundings, the template method accuracy is 1/2 degree. This accuracy is generally acceptable providing the distance from the light source to the surface to be illuminated is at least five times that of the maximum dimension of the light emitting source. The template method is applicable to the design of any lighting system for which the necessary data are available; but it is outlined here specifically for low-level red lighting systems intended for use in RAS operations.

4.6.8.1.3 Figure 57 shows the indicated parameters which define the template. Lines representing equal illumination levels on the template may be thought of in the same sense as lines of equal elevation on a contour map. It should be kept in mind that these lines represent specific illumination levels, such as 0.2 and 0.5 footcandles, and not the limit of illumination of the lamp. The 0.2 footcandle has been established as the minimum requirement for "secondary deck handling routes". Areas inside the template increase in intensity as the beam center is approached. The beam center is a point of reference. Its projection through the working plane onto the deck locates the deck aiming point which is used to establish the correct direction and angle of the fixture. It should be noted that peak illumination is at the beam center only when the mounting angle is zero. As the mounting angle increases, the point of peak illumination moves off center, toward the lamp.

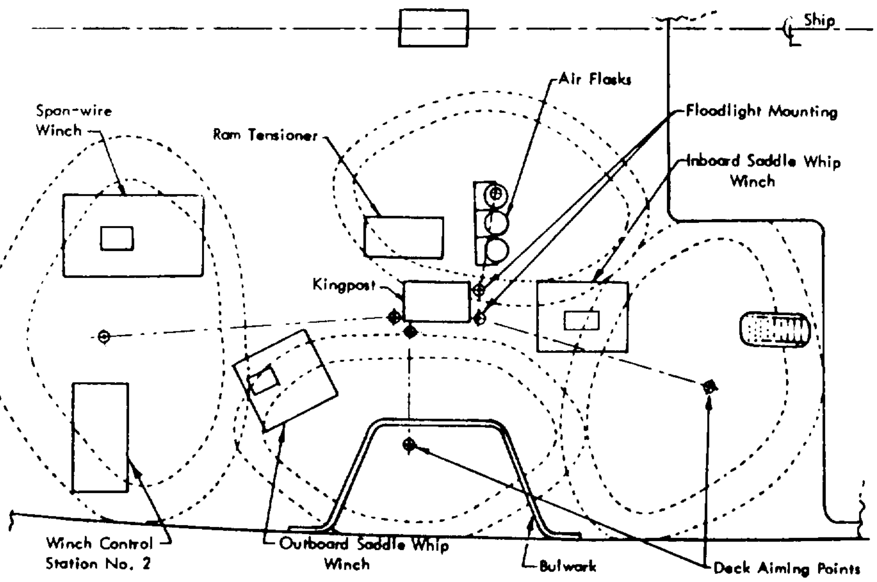


SH 964-57

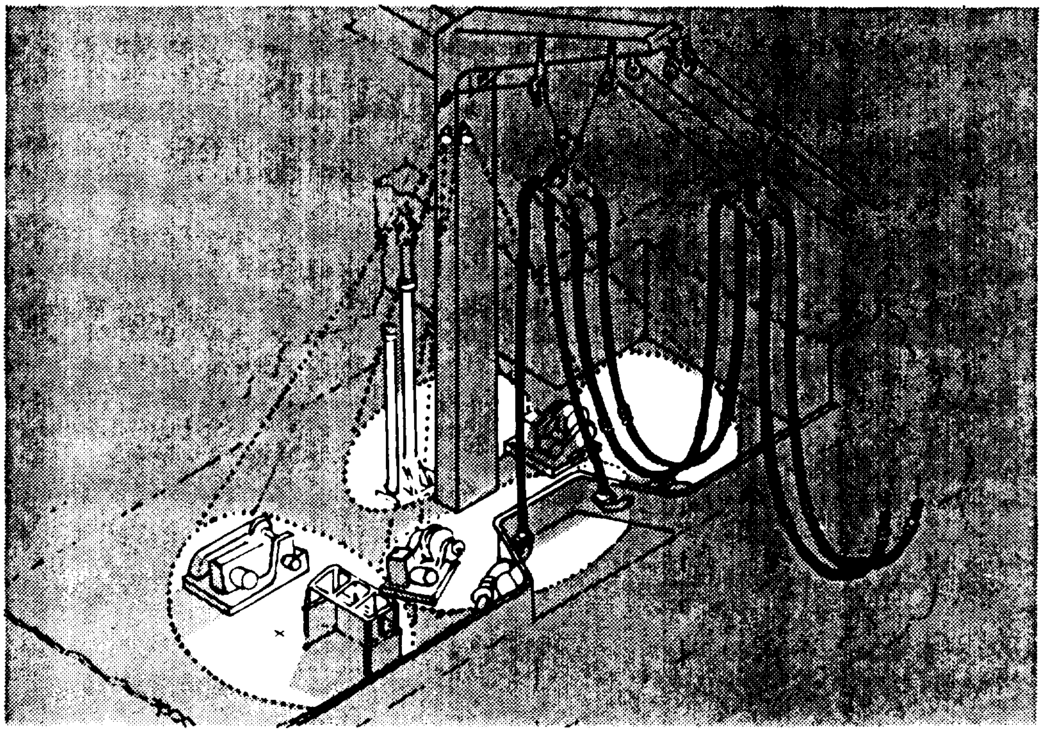
FIGURE 57. Template usage (typical).

4.6.8.2 Procedure. The first step in the design procedure is to obtain a set of general arrangement drawings and from these, develop a properly scaled RAS lighting drawing. A scale of 1/4 inch to 1 foot is recommended since templates furnished in appendix D are drawn to this scale. The templates provided are for illumination patterns of varying mounting heights at angular increments of 5 degrees. Make sure that the ships drawing and the template set are to the same scale. Establish the critical areas, in other words, those areas used by the transfer station crew which must be adequately illuminated. These areas should be afforded priority lighting considerations. Mark possible floodlight locations, giving preference to high points such as kingposts and masts. Starting with the areas most distant from the mounting points, select a template with a pattern that will cover the area being illuminated. A narrow spot lamp with a high mounting height and a large aiming angle will generally provide the illumination required at the more distant areas. Areas close to the mounting point can usually be satisfactorily lighted by a lower mounted floodlamp. Position the template over the area to be illuminated and lightly trace the outline of the pattern onto the drawing. Cover all other areas in a similar manner. For best utilization of the lighting pattern, make sure that the illumination patterns are tangent to one another or overlapping slightly. At this point, the advantages of the template method can be readily appreciated. Any benefits to be derived by changing mounting height or location, or advantages to be gained by using one lamp type in preference to another, can be determined quickly by shifting or changing templates. Upon completion, the initial plan should be carefully reviewed to determine if floodlight placement will be adversely affected by the operation of equipment or deck machinery. If the ship, or another of her class, is available for inspection, verify that the floodlight placement is physically possible, and that there are no undocumented obstructions present which will interfere with satisfactory illumination. If shadows exist in any of the critical areas, reposition or add floodlights and make appropriate changes in the lighting system layout.

4.6.8.3 Example. In order to demonstrate the use of the templates, the lighting design requirements of a fueling station will be studied in some detail. Figure 58 illustrates the general arrangement of major equipments used during typical fueling-at-sea operations in a Fleet oiler. Each fueling station has *one* outboard saddle whip winch, and one hydro-pneumatic device for controlling spanwire tension. Included at various locations are fairlead blocks and sheave assemblies, padeyes, and shackles needed to support the rigging. In general, the winches, ram tensioner, and rigging components for each station are grouped as shown.



A. Typical Illumination Pattern using Template Method (Plan View)



B. Typical Illumination Pattern using Template Method (Isometric View)

SH 964-58

FIGURE 58. Illumination of major equipments used during typical fueling-at-sea operations in a Fleet oiler.

4.6.8.3.1 It is important to become familiar with the details of the operation in order to be sure that adequate lighting will be available at each critical work area. It is assumed that the placement and operation of equipment is satisfactory to perform its intended function, but a reexamination shall be made to determine if limited visibility under low-level red floodlighting conditions will affect operations. Another aspect to be considered when locating the lights is the possibility that the repositioning of some piece of equipment during the operation may obscure or cast shadows on a critical area. Some of the critical work areas are shown on figure 58A. Each winch shall be illuminated so that the winch safety man can observe that wire rope inhaul or payout is being accomplished in a satisfactory manner. The areas around the winches shall be illuminated to insure safety of personnel. Consideration shall be given to the interplay of lighting effects produced by overhead lighting with illuminated gauges and controls. Lights shall be located and positioned at a height and angle to avoid producing glare reflections on gauges or indicators. Sufficient illumination shall fall on the ram tensioner to enable ram position to be determined. Other areas in which personnel handle lines, make tests, and so forth, shall be lighted well enough to accomplish the specific task safely. Practical application of the template method of determining RAS red lighting requirements is based on providing adequate illumination in designated areas by selection of the most applicable template from those included in appendix D. Each template outlines an illumination pattern wherein the solid outside line represents 0.2 footcandle and the inside dotted line represents 0.5 footcandle. The deck aiming point is indicated by a small circle inside the pattern while the mounting surface perpendicular to the deck is indicated by a small circle outside the pattern. The deck aiming and mounting points are separated by a dotted line that represents the horizontal distance between the two points at deck level. After the designer has obtained the plan and profile drawings of the general areas to be illuminated, the plan view should be blocked out in 1/4"=1'-0" scale on a sheet of vellum, or similar material. The appropriate template page or series of templates should then be inserted under the drawing to determine the template most suitable. The profile drawing need only be used as a reference to determine available mounting heights for the floodlight mounting and fixture together with possible elevation obstructions to the illumination pattern. The following major factors (forming the bounding lines of a right angled triangle) are generally decisive in selection of the most applicable template from appendix D:

(a) Installation height. There may be a significant range of mounting heights physically available; however, only a narrow selection of heights will be usable when all other major factors are considered.

(b) Horizontal distance. This is the distance, at deck level, between floodlight installation and deck aiming points. In this regard, it should be noted that the template design provides the pre-determined footcandles required to illuminate the area outlined. Figure 57 illustrates this factor.

(c) Mounting angle. This is the angle between the fixture installation height, the vertical structure for the floodlight, and the deck aiming point. Variance of the mounting angle, within specific installation heights, provides a means of supplying illumination at desired levels in specific areas. The key element in determining correct mounting angle (in conjunction with other factors) is the reduction of shadow obstructions to an acceptable minimum. That is, the illumination beam should be of sufficient height to avoid shadow producing impediments, such as from machinery installations or from people in the critical work areas.

4.6.8.3.3 The various aspects of the template application are demonstrated in the four illumination patterns illustrated on figure 58. The illustration depicts general illumination requirements for major installed equipment at a port-side fuel station. However, because of space limitations, no attempt has been made to present a usable scale drawing. Further, in the interest of simplicity, illumination requirements for the kingpost rigging platforms and outrigger catwalks have not been included.

4.6.8.3.4 Specifically, figure 58 illustrates the effect of locating four red floodlights using appropriate templates to ensure adequate lighting of major installations and deck handling areas. Lighting patterns described by the templates indicate that usage of appropriate mounting heights and predetermined installation angles will provide significantly increased levels of lighting in key operating areas while more diffused light is directed to the periphery. It should be noted that, for sending and receiving ships, the transfer whip (or spanwire) has a working range of 30 degrees forward to 30 degrees aft of a transverse plane perpendicular to the centerline of the ship. Therefore, lighting patterns considered must be adequate to illuminate deck handling areas within the entire 60 degrees transfer range and also provide coverage to include major components of both standing and running rigging within the designated sector. In the four floodlights, hypothetically illustrated on figure 58, initial checks of pertinent elevation and kingpost drawings indicated that the kingpost was clear for installation of floodlights between heights of 26 and 36 feet above the deck.

4.6.8.3.5 In the illumination pattern for the spanwire winch and control station, the horizontal distance of the deck aiming point was established as being 22 feet from the kingpost. After manually checking the templates for this distance, a 300-watt wide floodlight (WFL) was selected for installation at a height of 30 feet 6 inches with a mounting angle of 35 degrees. Selection of the appropriate template for the area to be illuminated around the outboard saddle-whip winch and the bulwark was dictated primarily by the relatively short distance between the kingpost and a deck aiming point within the bulwark. In this case, the template for a 300-watt WFL installed at a height of 30 feet 6 inches with a mounting angle of 15 degrees provided the most adequate area illumination.

4.6.8.3.6 The 300-watt WFL template for the area aft of the inboard saddle-whip winch was selected at an installation height of 30 feet 6 inches and mounting angle of 30 degrees. That template provided a wide area of adequate illumination and installation high enough to allow a mounting angle that avoided shadows caused by the winch.

4.6.8.3.7 The close proximity of the ram tensioner required the use of a template with a short distance between the floodlight mounting point and the aiming point. In this case, the inboard side of the kingpost was not clear for floodlight installation; therefore, a location had to be selected that provided adequate illumination for the areas around the ram tensioner, air flasks and inboard saddle-whip winch. The 300-watt WFL template with an installation height of 26 feet 6 inches above the deck at a mounting angle of 20 degrees was found to provide the most adequate lighting pattern for the designated area.

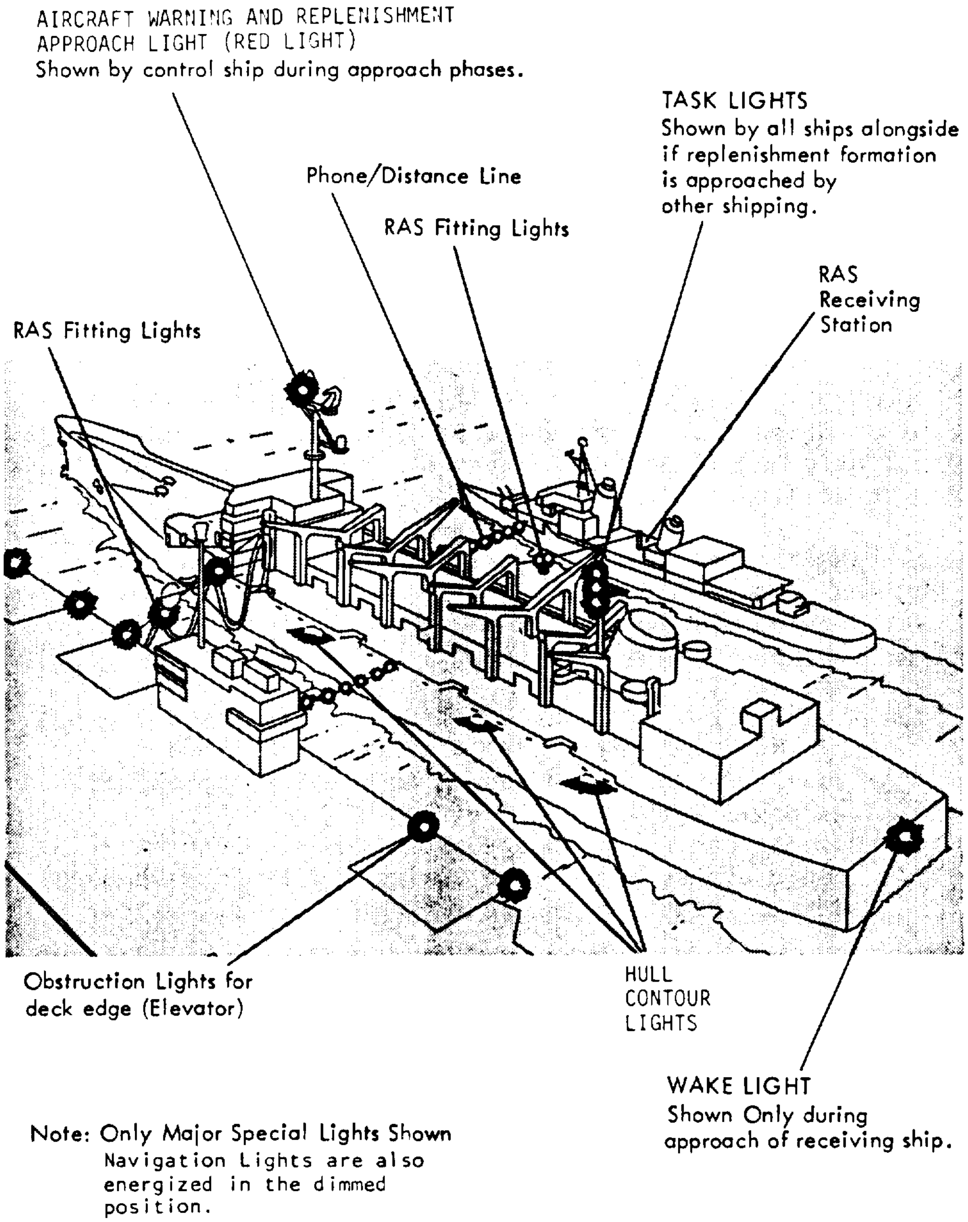
4.6.9 General RAS lights. Other lights used during RAS operations in accordance with the procedures outlined in Naval Warfare Publications 14 (series) are listed below and are further delineated in 4.7 and figures 59 through 63. These lights include:

(a) Task lights
(b) Hull contour lights
(c) Station marking box
(d) Aircraft warning red light
(e) Wake light
(f) Flashlights with wands (MIL-F-3747, type IV, NSN 9G6230-00-926-4331) with red, green and amber filters for standard hand signals outlined in Naval Warfare Publications 14 (series).
(g) Flashlights for marking obstructions, phone distance lines, attachment points, fittings, and so forth. Flashlights are available as follows:

One cell flashlights in accordance with MIL-L-573

Clear lens	9G6230-00-172-5833
Red lens	9G6230-00-172-5822
Amber lens	9G6230-00-172-5823
Blue lens	9G6230-00-172-5824
Green lens	9G6230-00-172-5831
White lens	9G6230-00-172-5832

(h) Chemical lights 9G6260-00-106-7478



SH 964-59

FIGURE 59. General requirements for RAS special lighting.

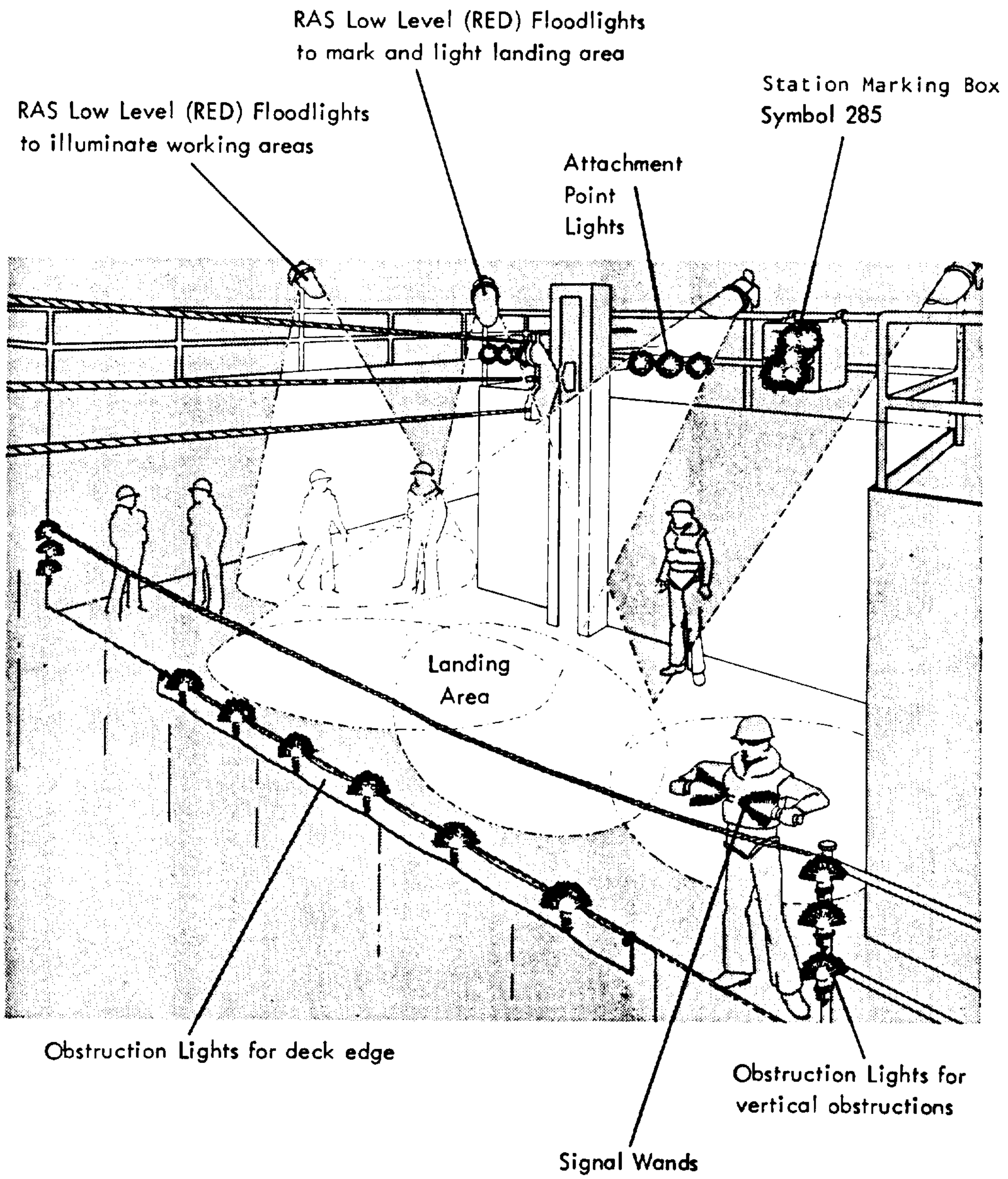


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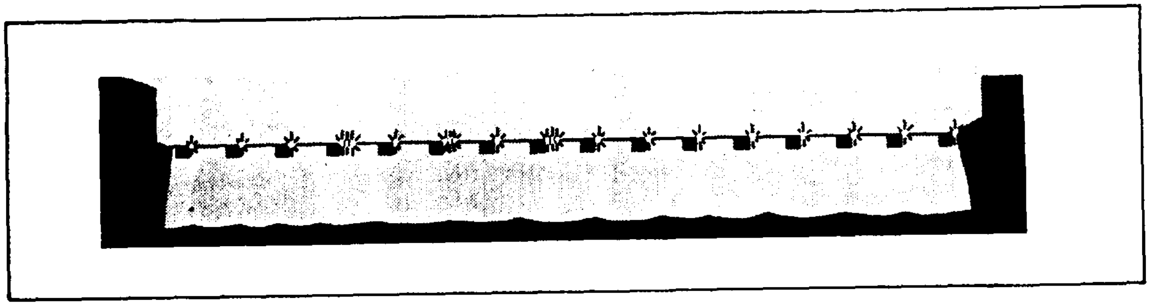
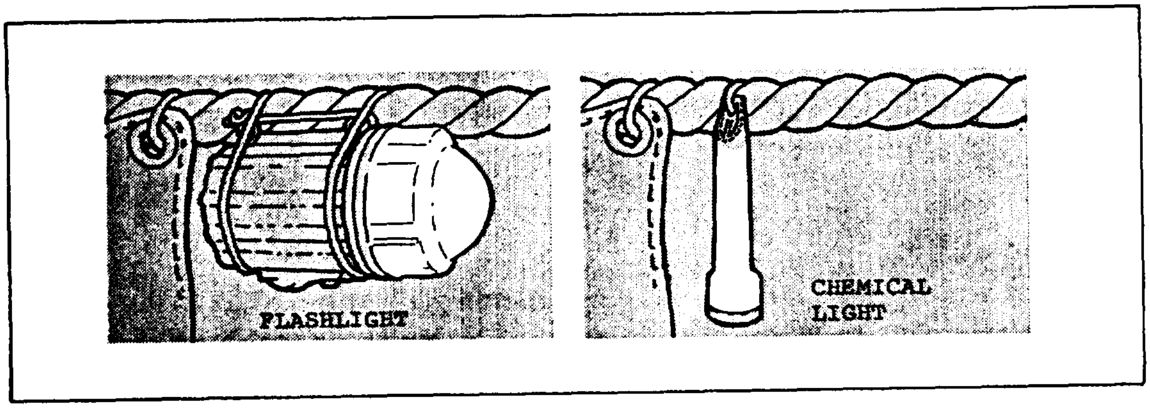
FIGURE 60. General requirements for typical receiving station lighting.



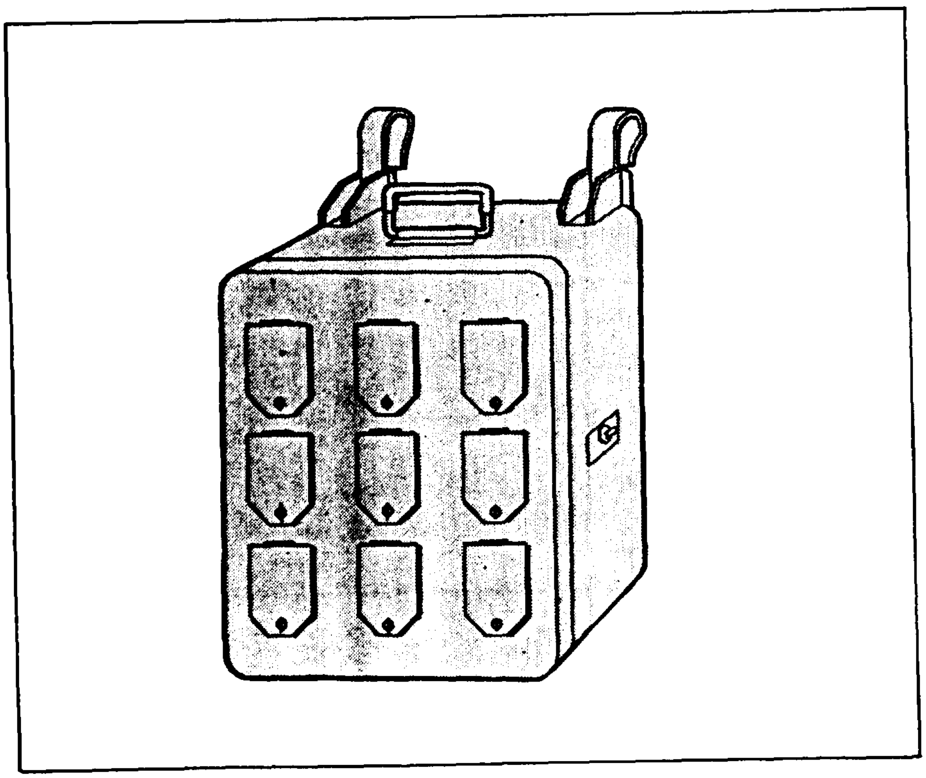
SH 964-61

FIGURE 61. Phone/distance line light markings.



SH 964-62

FIGURE 62. Typical installation of one-cell flashlight and chemical light on phone/distance line.



SH 964-63

FIGURE 63. Station marking box.

4.6.10 Shipboard tests. A photometric survey shall be conducted in accordance with the instructions set forth in section 5. The red lighting associated with RAS operations shall be checked specifically for suitability, adequacy and conformance with the requirements herein. It shall be noted whether or not the red lighting fixtures give proper distribution over the area which they should cover. Annoying glare, either directly from the fixtures or reflected from the working area, shall be noted. Objectionable shadows cast on the work by obstructions or by personnel as they perform their normal activities in that area shall be noted, and notations shall be made if necessary to move existing fixtures or install additional fixtures to overcome these shadows. It shall be noted whether illumination is uniform throughout the space and is free of objectionable contrasting light and dark areas when all fixtures for red illumination are in use. It shall also be noted whether fixtures have been installed so that obstructions and corners are adequately illuminated. Deficiencies shall be corrected as directed by the supervisor.

4.7 Navigation and signal lights.

4.7.1 Governing regulations.

4.7.1.1 Navigational lights.

4.7.1.1.1 International regulations for preventing collisions at sea, 1972 (72 COLREGS). The number, location, arc, and range of visibility of the navigational lights which must be displayed by all ships while navigating upon the high seas are established by the International Regulations for Preventing Collisions at Sea, 1972 (commonly called the 72 COLREGS). The 72 COLREGS are part of the international convention that was developed under the auspices of the United Nations' Inter-Governmental Maritime Consultative Organization (IMCO) in 1972. For additional information refer to Command and Instruction M16672.2A. By Executive order 11964 of January 19, 1977, the 72 COLREGS became effective on July 15, 1977 for all United States ships, both public and private. The 72 COLREGS abrogated and replaced the 60 COLREGS. Public Law 95–75, the "International Navigational Rules Act of 1977," was passed by the Congress and signed into law on July 26, 1977, codifying the Regulations under United States Code of Federal Regulations, Title 33, Sections 1601-1608. This law provides that any requirement as to number, position, and range of visibility of lights required under the rules shall not apply to any ship of the Navy where the Secretary of the Navy shall certify that, by reason of special construction, it is not possible for that ship to comply with the statutory requirements without interfering with the military function of the ship.

4.7.1.1.2 Exemption and waiver for naval vessels. As required by Executive Order 11964, Certifications and Exemptions of existing ships were issued by the Secretary of the Navy and were published in the Federal Register. The statute requires such exempted ships to comply as closely to the requirements of the applicable statutes as the Secretary shall find to be feasible. When it is necessary to obtain a waiver for a new ship or when modification of an existing waiver is required, a report shall be forwarded to NAVSEA. The report shall be in sufficient detail so that NAVSEA can determine that the closest possible compliance with the rules has been obtained, and to serve as a basis for a NAVSEA request to the Chief of Naval Operations and Judge Advocate General for a certificate of waiver or change in existing waiver. The report shall show dimensioned locations of all navigational lights, describe any features of the installation which fail to conform to the rules, and reasons for nonconformance. A note shall be made in the ship's departure report stating what changes, if any, have been made to the navigational light locations. Reference shall be made to drawings indicating the current or modified locations of such lights. If location drawings are not available, actual locations of each navigational light shall be indicated in the ship's departure report. Certificates executed in this connection by the Secretary are published in the Weekly Notice to Mariners and in the Federal Register.

4.7.1.2 Signal lights. Signal lights are not required by statutory law but are in accordance with Navy criteria. Locations for these lights are determined in accordance with tables XXI, XXII, and XXIII (see 4.7.3.1) and the configuration of the ship.

4.7.1.3 Steering lights. Steering lights will not be installed before delivery of new construction ships. They may be installed at the option of Type Commanders by Forces Afloat when desired. Drawing 803-5184170, sheet H-2 (see appendix B) provides installation guidances.

4.7.2 Visibility of external lights.

4.7.2.1 Sea mile candela. A sea mile candela is the illumination produced at a surface all points of which are at a distance of 1 nautical mile from a uniform point source of 1 candela. This unit is used in calculations involving signal lights to determine the candlepower necessary to produce a desired range of visibility. Threshold illumination at the eye (the lowest illumination that can be detected) is different for direct and corner-of-the-eye vision and varies with the color of the light, as shown in table XVIII. The values given in table XVIII are for the dark-adapted eye and are valid only when the background is completely dark. Note that the threshold values for detection of the light by direct vision are much lower than those for positive identification of its color, and that the values for detection by corner-of-the-eye vision are even lower. Color identification for corner-of-the-eye vision is not given because this type vision is relatively insensitive to color.

TABLE XVIII. Approximate thresholds in sea mile candelas for white and colored lights.

Color of light	Direct vision: Detection	Direct vision: Color identification	Corner-of-the-eye vision: Detection
White	0.32	16.0	0.013
Purple		3.3	
Blue	.33	5.0	. 001
Green	l 43	9.8	.005
Orange	.27	20.0	.061
Red	.19	6.7	.17

The threshold visibility of signal lights is affected by the background brightness. As the background brightness increases, so must the intensity of the signal light, although at a somewhat lesser rate. The color identification range is also affected by the number of colors to be seen. For example, a single red light can be identified at a longer range than the same red light in an array with other colors even though the candlepower of the red light is the same in both instances.

4.7.2.2 Atmospheric attenuation of light. The atmosphere was not considered during calculations involving interior and flood lighting because of the short distances involved. However, the atmospheric effect on the transmission of light increases proportionally with the distance over which the light must travel. Atmospheric transmission of light is expressed in terms of percent transmission per mile. For example, if the atmospheric transmission is 70 percent, the total light flux remaining in a given cone of light after penetrating a mile of atmosphere will be only 70 percent of the flux in the cone measured at the light source. At the end of the second mile, the flux in the light cone will be 70 percent of 70 percent, or 49 percent of the original amount of light. Atmospheric transmission varies greatly with weather conditions and somewhat with the color of the light. Unfortunately, it is not easily measured, but table XIX may be used as a basis for approximate calculations:

TABLE XIX. Transmissivities for various weather conditions.

Weather	Transmission per nautical mile (percent)
Exceptionally clear	90
Very clear	80
Average clear	70
Light haze	50
Haze	15
Light fog	0.05
Moderate fog	0.00005

4.7.2.3 Illumination at great distances. The following formula is used in calculating illumination for long ranges:

$$M = It^{d}/d^{2}, \text{ or} \qquad \text{Equation 41}$$

$$I = d^{2}M/t^{d} \qquad \text{Equation 42}$$

Where:

M = the illumination in sea mile candelas.
t = the atmospheric transmission per nautical mile.
I = the candlepower of the light source (candelas).
d = the distance in nautical miles.

The formula shows that the attenuating effect of the atmosphere on a beam of light increases exponentially with the distance. Theoretically, a clear incandescent lamp signal light would have to produce an illumination of approximately 0.32 sea mile candelas to be detected by an observer looking directly at the light source on a completely dark night (see table XVIII). When the distance from the lamp to the observer is 5 miles, this would require a lamp with only 25 candelas if the atmospheric transmission were 80 percent, but about 100 candelas for t = 60 percent, and over 3,200 candelas for t = 30 percent. Since the sky is almost never completely dark, these candlepower values would have to be multiplied by a factor ranging from unity to about 5 to compensate for the reduction in visibility due to background brightness. When the light is used for Morse signaling, an additional factor of about 30 must be applied to raise the visibility high enough above the threshold value so that messages may be consistently read. Thus, for satisfactory Morse signaling at 5 miles, the theoretical candlepower values given might have to be increased to roughly 3750 candelas for t = 80 percent, 15,000 candelas for t = 60 percent, and 480,000 candelas for t = 30 percent.

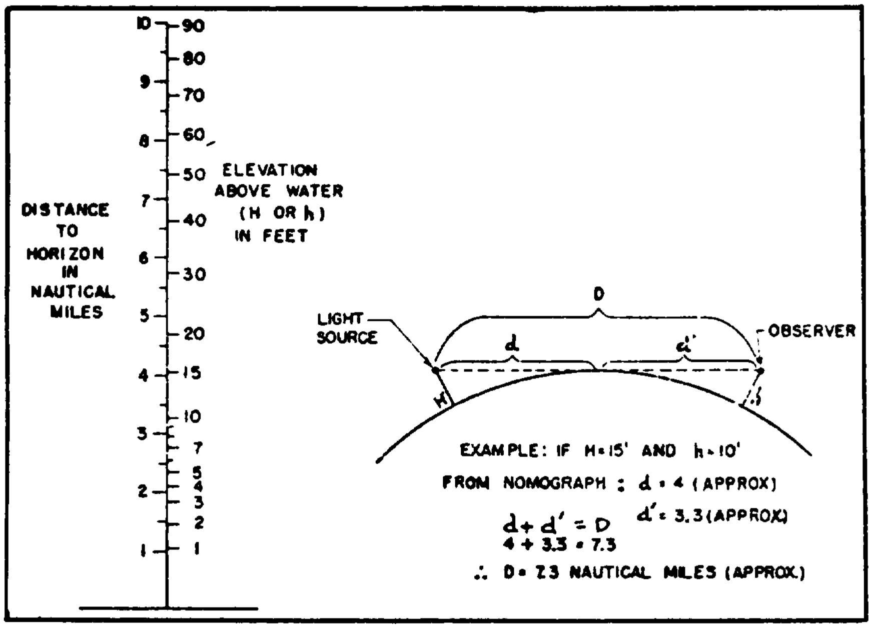
4.7.2.4 Effect of earth's curvature on visibility. When the signal light and the observer are both at low elevations above the water, the visibility of the light may be limited by the curvature of the earth. The following formula permits calculation of the range of unobstructed vision that may be expected when the heights of the light source and observer are known.

$$D = 1.05 (H + h)$$

Where:

D = distance in nautical miles.
H = height of light source in feet.
h = height of observer in feet.

To use the nomograph shown on figure 64, the elevations of the light source and the observer should be known. Opposite the elevation of the light source read the distance to the horizon. Similarly, find the distance from the observer to the horizon. The sum of these two distances is the maximum range for unobstructed vision between two points.



SH 964-64

FIGURE 64. Effect of earth's curvature on visibility.

4.7.2.5 Screening. To maintain a proper lookout, it is essential that neither direct light nor reflected light from the deck or objects on the deck enter the eyes of the lookout. Therefore, the masthead, towing, revolving beam ASW lights, identification light for submarines, and any other light that could interfere with the lookout's vision must be provided with screens. The screen size shall be determined using the following formula (see figure 65):

$$R = \frac{12H + 6V}{2V + 1} \qquad \text{Equation 43}$$

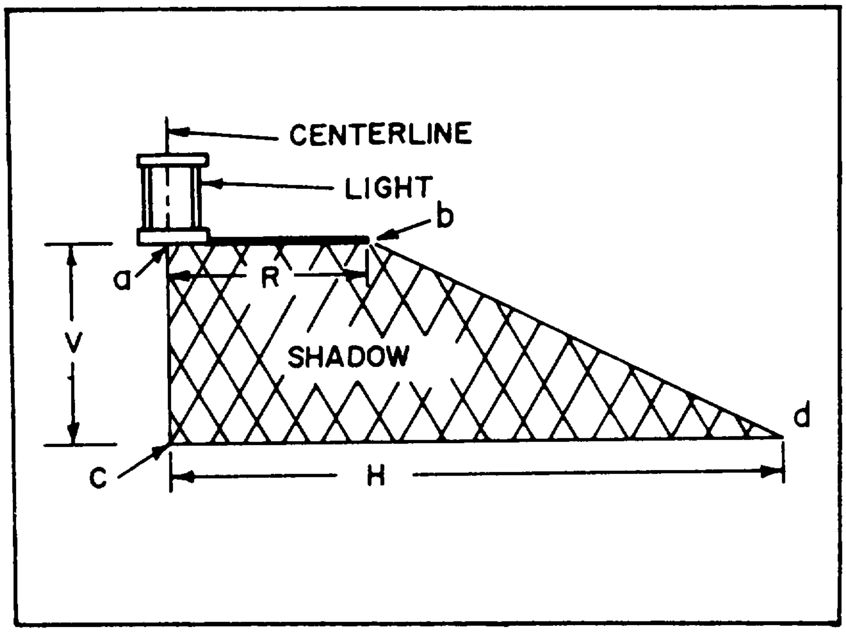
Where:

R = the radius of the screen, measured from the vertical centerline of the light.

V = the vertical distance, measured between two horizontal and parallel lines, "ab" is at the top edge of the screen and intersects the vertical centerline of the light at "a". The line "cd" is parallel to line "ab" and passes through a point "d" which is the highest and most distant point desired to be kept in the shadowed area. This point may be at the lookout's eyes, on the deck, or some object on the deck, or on some other object above the deck that may cause light from the masthead, range, towing, revolving beam ASW lights or identification light for a submarine to be reflected into the eyes of the lookout.

H = the horizontal distance, measured from point "d" to the vertical center line of the light.

The screen shall be so constructed that it will withstand normal shipboard use without changing its shape and that noise or vibration are reduced to a minimum when the ship is underway. Illuminated surfaces of the screen shall be painted with black deck paint, formula 104 in accordance with DOD-P-15146.



SH 964-65

FIGURE 65. Screen size determination.

4.7.3 Navigation and signal lights.

4.7.3.1 General. Navigation and signal lights include all external lights used for navig=n= signaling purposes between ships to reduce the possibility of collision and to transmit intelligence. For design convenience, these lights are divided into three groups:

(a) Navigational lights - International rules of the road.
(b) Signal lights - Visual communication.
(c) Signal lights - Station or operational.

The number, location, arc, range of visibility, and other pertinent information concerning navigation and signal lights are provided in tables XXI, XXII, and XXIII and Drawing 803-518470, sheet I-3 (see appendix B). These lights shall be supplied from a lighting circuit having an emergency source, or alternate source if no emergency system exists, and shall be fed from control equipments and circuits as indicated in table XX. Supply and control panels for navigation and signal lights shall be located in the pilot house (control room or attack center on submarines). Unless otherwise specified in tables XXI and XXIII, these lights shall be exhibited from sunset to sunrise. In restricted visibility and when otherwise deemed necessary, they shall also be exhibited from sunrise to sunset.

TABLE XX. Power supply and control of navigation and signal lights.

Surface ships			Submarines
Supply, control and telltale panel 1/	Supply and control (no telltale panel) 2/	Local lighting circuit	Supply and control panel 3/
Masthead light (forward) Masthead light (aft) Port side light Starboard side light Stern light, white	Aircraft warning lights (or replenishment red truck lights or both) Air cushion craft light Anchor light, aft Anchor light, forward Blinker lights Clearance/obstruction lights (permanent) Not-under-command (breakdown and man overboard lights) Minesweeping lights Task (restricted maneu-verability) lights Station keeping lights (minesweeping) Stern light, blue Towing light Masthead light used when towing, upper Masthead light used when towing, lower Wake lights	Approach lights (replenishment) Polarity signal lights Revolving beam ASW light Station marking box	Anchor light, aft Anchor light, forward Masthead light Port side light Starboard side light Stern light Identification light Searchlight

1/ Supply, control and telltale panels: symbol 969.1-115 Vat; symbol 964.1-120 Vdc.
2/ Supply and control (no telltale panel): symbol 944.2-36 bus, 6 CKTS, ac; symbol 940.1-3Ø bus, 8 CKTS, ac; symbol 945.1-14 bus, 8 CKTS, dc; symbol 942.1-14 bus, 10 CKTS, dc.
3/ Supply and control panel (no telltale): symbol 2550.1.

TABLE XXI. Navigational lights - international rules of the road.

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Air cushion craft light	Indicates operation in the nondisplacement mode. Note: C.G. rules 22, 23(a)(b); Annex I paragraph 9(b), 10(a)	An all round yellow light flashing 120 or more times a minute	3 miles for ships 50 meters (165 feet) or over in length 2 miles for ships under 50 meters (165 feet) in length	Locate where it can best be seen all around the horizon
Anchor light - aft Symbol no. 161.4 (for surface ships) Symbol no. 174.4 (for submarines)	Required to be shown from sunset to sunrise by ship at anchor, aground, or secured to a buoy Notes: 1. May be shown, but not required on ships under 50 meters (165 feet) in length. 2. C.G. rules 21(e), 22, 27(b)(iv), 27(d)(iv), 30; Annex I paragraph 2(k), 9(b), 10(a).	Horizontal: An all round (white) light, visible as far as practicable, all around the horizon Vertical: No special requirements	3 miles for ships 50 meters (165 feet) or over in length 2 miles for ships under 50 meters (165 feet) in length	At or near the stern of the ship, not less than 4.5 meters (14.75 feet) lower than the forward anchor light
Anchor light - forward Symbol no. 161.4 (for surface ships) Symbol no. 174.4 (for submarines)	Required to be shown from sunset to sunrise by ship at anchor, aground, or secured to a buoy Notes: 1. A ship less than 50 meters (165 feet) in length may exhibit an all round light where it can best be seen, instead of the fore and aft anchor light.	Horizontal: An all round (white) light, visible as far as practicable, all around the horizon Vertical: No special requirements	3 miles for ships 50 meters (165 feet) or or over in length 2 miles for ships under 50 meters (165 feet) in length	In the fore part of the ship. On ships 50 meters (165 feet) or more in length the light shall be not less than 6 meters (19.75 feet) above the uppermost continuous deck.

TABLE XXI. Navigational lights - international rules of the road. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Anchor light - forward (Cont'd)	2. A ship at anchor may and a ship 100 meters (330 feet) or more in length shall also use available working or equivalent lights to illuminate decks. The Judge Advocate General Admiralty Division (JAG) has stated that available working or equivalent lights would include any existing white light which illuminates the deck. 3. The new light on the masthead is considered the forward anchor light on aircraft carriers.			
Clearance/ obstruction light Symbol no. 194	Indicates: (a) The side of a ship restricted in its ability to maneuver. (b) The ship is engaged in underwater operations. (c) The side on which an obstruction exists. (d) The side on which another ship may pass.	Four lights, two red and two green, visible all around the horizon.	3 miles for ships 50 meters (165 feet) or over in length 2 miles for ships under 50 meters (165 feet) in length	Two red lights in a vertical line not less than 2 meters (6.6 feet) apart to indicate the side on which an obstruction exists and two green lights in a vertical line not less than 2 meters (6.6 feet) apart to indicate the side on which another ship may pass. The lights shall be placed at the maximum practical horizontal athwartship distance, but in no case less than 2 meters (6.6 feet) from the task lights, nor shall the upper of these lights be at a greater height than the lower task lights. In no case shall the lower lights be less than 4 meters (13 feet) above the uppermost continuous deck.
	Notes: 1. Portable clearance/obstruction lights, when required, may be assembled by ships force in accordance with Drawing 803-5184170, sheet I-13 (see appendix B). 2. C.G. rules 22, 27(d)(g); Annex I paragraph 4(b), 10(a).			

TABLE XXI. Navigational lights - international rules of the road. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Masthead light - aft Symbol no. 172.2	Required to be shown from sunset to sunrise by ship underway and making way to indicate presence and course to other ships except when ship is not under command.	Horizontal: An unbroken (white) light visible from ahead to 22-1/2 degrees abaft the beam on either side (total arc 225 degrees) Vertical: Screens shall be fitted at base if glare or reflection interferes with navigation.	6 miles for ships 50 meters (165 feet) or over in length 5 miles for ships and craft under 50 but 20 meters (66 feet) or over in length 3 miles for craft under 20 but 12 meters (40 feet) or over in length 2 miles for craft under 12 meters (40 feet) in length	Over the fore and aft centerline and the following: (a) The light shall be not less than one-half the ship's length aft of forward light, but it need not be more than 100 meters (330 feet) aft of forward light in the same vertical plane over the keel. (b) Light shall be not less than 4.5 meters (14.75 feet) higher than the forward light. (c) Light shall be seen over and separate from the forward light in all normal conditions of trim at a distance of 1000 meters (3300 feet) from the stem when viewed from sea level.
	Notes: 1. Shall be installed on all ships 50 meters (165 feet) in length and over. 2. Optional on ships under 50 meters (165 feet) in length (see also notes under Masthead light - forward).			
Masthead light - forward Symbol no. 172.2 (for surface ships) Symbol no. 174.4 (for submarines)	Required to be shown from sunset to sunrise by ship under way and making way to indicate presence and course to other ships except when ship is not under command.	Horizontal: An unbroken (white) light visible from right ahead to 22-1/2 degrees abaft the beam on either side (total arc 225 degrees). Vertical: Screens shall be fitted at base if glare or reflection interferes with navigation.	6 miles for ships 50 meters (165 feet) or over in length 5 miles for ships and craft under 50 but 20 meters (66 feet) or over in length 3 miles for craft under 20 but 12 meters (40 feet) or over in length	Over the fore and aft centerline not more than one-quarter the length of the ship from the stem. For ships less than 50 meters (165 feet) in length the light shall be installed in the forward part of the ship.

TABLE XXI. Navigational lights - international rules of the road. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Masthead light - forward (Cont'd)			2 miles for craft under 12 meters (40 feet) in length	Vertical: (a) For a ship 20 or more meters (66 feet) in length - not less than 6 meters (20 feet) above the uppermost continuous deck. If the breadth of the ship exceeds 6 meters (20 feet), then at a height not less than such breadth. However, the light need not be placed at a greater height above the uppermost continuous deck than 12 meters (40 feet). (b) For a craft of 12 meters (40 feet) but less than 20 meters (66 feet) the light shall be placed at a height of not less than 2.5 meters (8.2 feet) above the gunwale. (c) A craft less than 12 meters (40 feet) in length may carry the light at a height less than 2.5 meters (8.2 feet) above the gunwale. However, the light shall be carried at least 1 meter (3.3 feet) higher than the side lights.

Notes:
1. All 225-degree lights (former masthead, range and towing lights) are now called masthead lights.
2. In all circumstances the masthead light or lights shall be placed above all other lights and obstructions. (A waiver will be issued allowing the task and not under command lights to be above masthead lights.)
3. One of the two or three masthead lights used when towing shall be the forward masthead light. The lowest light shall be not less than 4 meters (13 feet) above the uppermost continuous deck.

TABLE XXI. Navigational lights - international rules of the road. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Minesweeping lights Symbol no. 116.1	Required to be shown from sunset to sunrise to indicate that it is dangerous for another ship to approach closer than 1000 meters (3300 feet) astern or 500 meters (1650 feet) on either side of the minesweeper.	Horizontal: An unbroken (green) light visible, as far as possible, all around the horizon Vertical: No special requirements	3 miles for ships 50 meters (165 feet) or over in length 2 miles for ships under 50 meters (165 feet) in length	Three lights in a triangular display. One of the lights shall be exhibited at or near the foremast head and one at each end of the fore yard.
	Notes: 1. A waiver will be required if any of the lights are higher than the masthead light. 2. To insure the threshold visibility of lights to be identified by color, a minimum separation of 1.2 meters (4 feet) between the masthead light and any colored lights shall be maintained.			
Not-under-command (man overboard and breakdown) lights Symbol no. 190.1	Required to be shown on a ship which, through some exceptional circumstances, is unable to maneuver. Also used, on U.S. Navy ships only, to furnish blinking man overboard signal to warn other ships to keep clear.	Horizontal: Unbroken (red) lights, visible all around the horizon Vertical: No special requirements	3 miles for ships 50 meters (165 feet) or over in length 2 miles for ships under 50 meters (165 feet) in length	Two fixtures in a vertical line not less than 2 meters (6.6 feet) apart. Lower light shall not be less than 4 meters (13 feet) above the uppermost continuous deck.

TABLE XXI. Navigational lights - international rules of the road. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Not-under-command (man overboard and breakdown) lights (Cont'd)	Notes: 1. Usually the U.S. Navy uses the upper and lower task lights for the not-under-command lights. 2. To facilitate pulsating these lights as a man overboard signal, the rotary snapswitch which controls them shall be fitted with a crank handle as specified in MIL-S-15743. 3. Facilities shall be provided for pulsating these lights from the ship control console. A pulsating light controller which will flash the lights at a rate of 50 ± 10 times per minute shall be incorporated in the console. 4. When making way through water, side lights and a stern light shall be exhibited.			
Side lights Symbol nos. 182.2 (port) and 183.2 (starboard) (for surface ships) Symbol nos. 188.3 (port) and 189.3 (starboard) (for submarines)	Required to be shown from sunset to sunrise by ship under way and making way to indicate presence and course to other ships.	Portside: Horizontal: An unbroken (red) light visible from right ahead to 22-1/2 degrees abaft the beam on the port side Vertical: No special requirements Starboard side: Horizontal: An unbroken (green) light visible from right ahead to 22-1/2 degrees abaft the beam on the starboard side	3 miles for ships 50 meters (165 feet) or more in length 2 miles for ships and craft 12 meters (40 feet) or more but less than 50 meters (165 feet) in length 1 mile for craft less than 12 meters (40 feet) in length	(a) At or near the sides of a ship 20 meters (66 feet) or more in length. (b) Shall not be in front of the forward masthead light on a ship 20 meters (66 feet) or more in length. (c) Shall be placed at a height above the uppermost continuous deck not greater than three-quarters of that of the forward masthead light. (d) Shall not be so low as to be interfered with by deck lights.

TABLE XXI. Navigational lights - international rules of the road. - Continued

TABLE XXI. Navigational lights - international rules of the road. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Side lights (Cont'd)		Vertical: No special requirements		(e) May be carried on the fore and aft centerline, combined in one fixture not less than 1 meter (3.3 feet) below the masthead light on craft less than 20 meters (66 feet) in length.
	Notes: 1. Shall be fitted with inboard screens painted matte black, and meeting the requirements of section 9 of Annex I to the regulations. 2. With a combined lantern using a single vertical filament and a very narrow division between the red and green sections, external screens need not be fitted.			
Task lights (restricted maneuverability) Symbol no. 190.1 (red) Symbol no. 192.1 (white)	To indicate that the ship is restricted in its ability to maneuver because it is laying, servicing, or picking up a submarine cable or navigation mark; is engaged in replenishment or transferring persons, provisions, or cargo while underway; or is engaged in launching or recovering aircraft and, therefore, is unable to keep out of the way of another ship.	Horizontal: Unbroken red over white over red vertical array visible all around the horizon Vertical: No special requirements	3 miles for ships 50 meters (165 feet) or over in length 2 miles for ships under 50 meters (165 feet) in length	Two sets of lights, three lights to a set, with all the lights in a set in a vertical line, one over the other, so the upper and lower lights shall be the same distance from and not less than, 2 meters (6.6 feet) above or below the middle light. The dual array of lights in the mentioned color sequence shall be installed with the corresponding lights in each set at the same level on the mast. A straight shield, 250 mm (0.820 feet) long and 200 mm (0.666 feet) high, painted a matte black (MIL-P-24441/4, formula 153-R_0=1.8 if over vinyl or epoxy, or formula 104 in accordance with DOD-P-15146) shall be installed between each light and the mast. The shields shall be aligned parallel to the ship fore and

TABLE XXI. Navigational lights - international rules of the road. - Continued

TABLE XXI. Navigational lights - international rules of the road. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Task lights (restricted maneuverability) (Cont'd)	Notes: 1. Six-degree sectors of obscuration to all round visibility are allowed by the rules. However, the U.S. Navy is putting dual array task lights above all lights and obstructions to insure all round visibility. 2. Since the task lights, by SECNAV waiver, will not be shown at the same time as the masthead lights, this is not a violation of the requirement that the masthead lights be above all other lights. 3. The red lights shall be the same fixtures as those used for not-under-command (breakdown) and man overboard lights and the switching shall be arranged accordingly. 4. The dual task light array with its all round unobscured visibility is considered in closer compliance to the regulations than the single array (required by rule 27(b)(i) of the International Regulations) which, when installed below the masthead lights on naval ships, would be obscured through greater arcs than the 6-degree sectors allowed by the regulations.			aft center-line, with the mid-point of each shield located at the athwartship centerline of the mast and corresponding light. The horizontal separation between light arrays shall be kept to a minimum to minimize the distance from the ship at which they will appear as two sets of lights. These arrays shall be installed on a mast with a maximum diameter of 300 mm (1 foot), high enough above the superstructure so there will be no obstruction to the arcs of visibility of the lower lights (such as other masts, radar, or other electronic equipment). The middle lights shall be installed on the mast above, below, or between other equipment that of necessity may be mounted on the mast. The uppermost lights shall be either at the top of the mast or below other equipment on the mast top. Other equipment installed on the mast shall not obstruct the all-round visibility of the lights.

TABLE XXI. Navigational lights - international rules of the road. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Towing lights Symbol no. 196.4 (towing light) Symbol no. 172.2 (masthead light used when towing)	Required on ships normally engaged in towing operations to indicate presence of a tow.	Masthead: Horizontal: An unbroken (white) light visible from right ahead to 22-1/2 degrees abaft the beam on either side (total arc 225 degrees) Vertical: Screens shall be fitted at base if glare or reflection interferes with navigation Stern: Horizontal: An unbroken (yellow) light visible over an arc of the horizon of 135 degrees and so fixed as to show the light 67-1/2 degrees from right aft on each side of the ship Vertical: No special requirements	Masthead: 6 miles for ships 50 meters (165 feet) or over in length 5 miles for ships and craft under 50 but 20 meters (66 feet) or over in length 3 miles for craft under 20 but 12 meters (40 feet) or over in length 2 miles for craft under 12 meters (40 feet) in length Stern: 3 miles for ships 50 meters (165 feet) or over in length 2 miles for ships under 50 meters (165 feet) in length	Masthead lights used when towing: Two additional masthead lights shall be installed vertically in a line with the masthead light. These three lights shall be equally spaced, not less than 2 meters (6.6 feet) apart. The lowest light shall be not less than 4 meters (13 feet) above the uppermost continuous deck and one of the lights shall be the forward masthead light. Stern: The towing light shall be installed in a vertical line with and not less than 2 meters (6.6 feet) above the stern light.

Notes:
1. Masthead towing lights shall be of the same construction and character as the masthead light.

TABLE XXI. Navigational lights - international rules of the road. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Stern light (white) Symbol no. 196.3 (for surface ships) Symbol no. 174.4 (for submarines)	Required to be shown from sunset to sunrise by ship under way to indicate presence and course to other ships	Horizontal: An unbroken (white) light over an arc of the horizon of 135 degrees and fixed to show the light 67.5 degrees from right aft on each side of the ship Vertical: No special requirements	3 miles for ships 50 meters (165 feet) or over in length 2 miles for ships under 50 meters (165 feet) in length	Near the stern, on or near the centerline

Notes:
1. On submarines, the stern light shall be located as far aft as practicable and arranged to permit its being used without attention from outside the hull.

TABLE XXII. Signal lights - visual communication.

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Blinker lights Symbol no. 191.2	For limited range visual communication	Horizontal: An unbroken white light visible all around the horizon (360 degrees using two fixtures) Vertical: Screens shall be fitted at base to prevent glare or reflection from interfering with navigation of the ship		On signal yardarms outboard, one port and one starboard. On ships with more than one mast, lights shall be installed only on the forward signal yardarm.
	Note: Lights shall be operable from signal keys located on each side of the signal bridge. A four-position switch in accordance with MIL-S-15743 shall be installed in such a manner as to provide for energizing the top light, the bottom light, or both lights, and provide an OFF position. Where infrared transmitting set (AN/SAT-2 series) is installed, the blinker lights shall be connected to operate from the signal keys and transfer switch provided for this equipment.			
8-inch searchlights MIL-S-16938 Symbol no. 297 (115-V, 60-Hz) Symbol no. 297.1 (28-V, 60-Hz)	Primarily signaling and deck lighting aboard submarines			Two sockets for the searchlights shall be installed on the bridge, one port and one starboard, to insure coverage from 25 degrees below the horizon to 105 degrees above the horizon throughout 360 degrees of azimuth.
	Note: Searchlights shall be installed in locations which provide a minimum of obstruction to the operating arc of the beam both in train and elevation. One receptacle shall be provided on the bridge such that the searchlight can be moved from one socket to the other without de-energizing the searchlight. They shall be portable and stowage facilities shall be provided within the submarine.			

TABLE XXII. Signal lights - visual communication.

TABLE XXII. Signal lights - visual communication. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
12-inch searchlights MIL-S-19551 Symbol no. 299 (mercury xenon) Symbol no. 299.1 (incandescent)	Primarily signaling			The following conditions shall be met in selecting the location: (a) Searchlights shall be installed in locations which are readily accessible. (b) Signaling searchlights shall be provided port and starboard on the navigating bridge, and port and starboard on each signal station not adjacent to, or on the same level as, the navigating bridge. (c) If fewer than four 12-inch searchlights are specified for a ship, they shall be installed so each can be brought to bear in elevation from 25 degrees below the horizontal to 105 degrees above the horizontal. The number installed shall insure coverage throughout 360 degrees of azimuth. If four or more 12-inch searchlights are specified for a ship, they shall be installed so that at least two of the lights can be brought to bear on an object from dead ahead to dead astern on either port or starboard side and in elevation from 25 degrees below the horizontal to 105 degrees above the horizontal.

Note: The searchlights shall be installed in locations which provide a minimum of obstruction to the operating arc of the beam in train and elevation.

TABLE XXIII. Signal lights - station or operation.

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Aircraft warning light Symbol no. 160.1	To indicate the presence of an obstruction to low flying aircraft when ship is at anchor	Horizontal: An unbroken red light all around the horizon (360 degrees) Vertical: No special requirements	3 miles	One light installed at truck of each mast extending more than 8 meters (26 feet) above highest point on superstructure. Where impossible to locate one light for all around visibility, two lights shall be installed. Where two masts, high enough to require these lights, are located less than 15 meters (50 feet) apart, lights shall be provided on only the highest mast.
	Note: Where a red all around light is already installed at the truck of a mast for another purpose, a separate aircraft warning light is not required.			
Hull contour lights (replenishment) Symbol no. 164.3	Required on ships having RAS delivery ship capabilities to establish the contour of the delivery ship to assist the receiving ship in coming alongside	Horizontal: Red lights visible outboard from right astern through the arc of 135 degrees permitted by design of the fixture Vertical: Fitted with hoods to prevent upward shining of direct light	At least 900 meters (3000 feet), but not more than 7200 meters (24,000 feet)	Two lights shall be installed on each side of the ship rigged at the rail at points which mark the extremes of that portion of the side parallel to the keel and positioned on the coaming at the edge of the deck or on top of the bulwark or catwalk to give the required arc of visiblity. On ships over 180 meters (600 feet) in length, a third light shall be located midway between the two other lights.
	Note: Lights shall be supplied from a convenient lighting distribution box or panel having an emergency source of power. Additional lights, as required, shall be installed to mark obstructions that extend beyond the ship's parallel contour lines during delivery.			

TABLE XXIII. Signal lights - station or operation.

TABLE XXIII. Signal lights - station or operation. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Night flight operation lights Note: Information concerning visual landing aid lighting and night flight operation lighting is covered in NAVAIR technical manuals and bulletins.				
Polarity signal light Symbol no. 215 MS17315	Required on all magnetic minesweepers to indicate polarity or direction of magnetic field	Horizontal: These two lights (one red and one green) to be visible from 20 degrees forward to 20 degrees abaft the beam on either side Vertical: No special requirements	455 meters (1500 feet) full daylight	Lights installed on each side of the ship.
	Note: Polarity signal lights shall be energized from a ship service lighting circuit by pulsation contacts in the minesweeping control panel.			

TABLE XXIII. Signal lights - station or operation. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Revolving beam ASW light Symbol no. 176	For intership signaling ASW operations. Installed on all ships equipped to participate in operations.	Horizontal: A colored light visible, as nearly as practical, all around the horizon Vertical: A screen shall be fitted at the base if glare or reflection interferes with navigation		On either the yardarm or mast platform where it can be seen all around the horizon.
	Note: Two red, two green, and two amber lenses are provided with fixture. Colors to be used are determined by operating forces.			
Station keeping lights (mine sweeping) Symbol no. 225.1 (starboard) Symbol no. 226.1 (port) Symbol no. 227.1 (full aft)	On minesweeping ships required to sweep in formation at night as an aid in maintaining prescribed intervals and bearings	Horizontal: These two white lights shall be visible from right aft to 20 degrees forward of the beam on each side of the ship (total arc 220 degrees). If it is impossible to locate the lower light so that it can be seen on both sides of the ship, two lights shall be used, one on each side Vertical: No special requirements	180 meters (600 feet) minimum	The lights shall be located in a vertical plane perpendicular to the keel 9 meters (30 feet) apart on MSO type ships and 6 meters plus or minus 7 cm (19.5 $\pm$ 0.23 feet) apart on MCS and MSI types. The lights shall be located as close to a vertical line as possible.

TABLE XXIII. Signal lights - station or operation. - Continued

TABLE XXIII. Signal lights - station or operation. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Station keeping lights (mine sweeping) (Cont'd)	Notes: 1. Where it is impossible to locate the lower light so it can be seen on both sides of the ship, two lights shall be used. Each light shall be visible from right aft to 20 degrees forward of the beam on its respective side (total arc, each light, 110 degrees). 2. The two lower station keeping lights shall be in vertical alignment with the upper station keeping light when viewed from the side.			
Station marking box (replenishment) Symbol no. 285	To indicate the commodity being handled Note: One watertight receptacle shall be installed at each RAS station, outboard near or under the rail or lifeline, in a position which will cause the least obstruction. Mechanical protection shall be provided for the receptacles installed in an exposed location.	No special requirements		On delivery ships, one box shall be provided for each replenishment station. For all other ships, one box shall be provided for each replenishment station on one side of the ship, plus one spare.
Stern light (blue) Symbol no. 197.2	Required on ships likely to be engaged in convoy operations, to enable ship astern to keep station in wartime on dark nights when ships are darkened and not showing navigation lights.	Horizontal: An unbroken dim blue light from right aft to 22.5 degrees abaft the beam on each side of the ship (total arc 135 degrees) Vertical: No special requirements		Adjacent to the white stern light.

TABLE XXIII. Signal lights - station or operation. - Continued

Type of light	Function	Arcs of visibility and colors of signals	Range of visibility (min nautical miles)	Position of fixtures
Submarine identification light Symbol no. 233.1	To identify submarines because the normal navigational lights are easily mistaken for those of small ships Note: Mounting shall be permanent.	Horizontal: An amber colored rotating light emitting approximately 90 flashes per minute and visible all around the horizon	3 miles	To be located where it can best be seen not less than 61 cm (0.2 feet) above or below the masthead light.
Wake light Symbol no. 200.2	To illuminate the wake	Horizontal: Spot light, white Vertical: No special requirements		Shall be installed on flagstaff or after part of ship, positioned to illuminate the wake and shall be so mounted that no part of the ship is illuminated.

TABLE XXIII. Signal lights - station or operation. - Continued

4.7.3.2 Supply, control and telltale panel for running lights. The Supply, Control and Telltale Panel (symbol 969.1 or 964.1) for the running lights of surface ships is designed to aid in keeping the ships running lights (masthead, stern, and side lights) lit as prescribed by the rules for preventing collisions at sea. The panel is installed in or near the pilot house and gives an alarm when one of the running lights is out or is operating on its secondary filament.

4.7.3.2.1 Upon failure of the primary filament (or its circuit) in any running light, the power is automatically transferred to the lamp's secondary filament and an indicator lamp on the panel lights. The indicator Lamp of the affected light will remain lit until the repair (restoration of the primary filament) has been completed. Failure of the secondary filament is indicated by a red lamp and audible buzzer. The sequence of operations is shown in table XXIV.

TABLE XXIV. Sequence of operations of running lights.

Operation				
	Operation	Indications	Condition	Action
1	Turn all switches on panel to "ON" (normal)	None	Primary filaments of all running lights energized.	None
2	Push test button	(a) Amber light (b) Amber light, red light and buzzer	Secondary filament OK Secondary filament circuit open	None Replace lamp in running light and retest with new equipment
3		Amber light	Running light operating on secondary filament (primary filament circuit open)	Replace lamp in running light in the morning
4		Amber light, red light and buzzer	Running light "out" (primary and secondary filament circuits open)	Replace lamps in running light at once
5	Turn unit switch to "OFF" to silence buzzer after condition 4.	Red light	Running light "OUT" not energized	Replace lamp at once unless unit switch was turned off for reasons other than to silence buzzer.

4.7.3.2.2 Certain older ships have permanent towing lights installed and connected to control switches on the telltale panel. These towing light switches are manual. The designs of the older panels for ac and dc systems are shown on Drawing 815-1197050.

4.7.3.2.3 Description of circuit operation. The operation of the supply, control and telltale panel are easily seen by following the schematic diagram in appendix B, section I, sheet 11, detail "A". For simplification this schematic shows one of the five running lights; the operation is the same for all five. A circuit analysis of the operations is given as follows and is summarized in table XXV.

(a) When the primary filament of the running light is lighted, relay K1 is energized (contacts open), relay K2 is de-energized (contacts closed), the indicator lamp is dark (out), and the buzzer is off (deenergized).

(b) If the primary filament circuit opens (as when the primary filament burns out), relay K1 deenergizes, closing its contacts. One set of contacts supplies power to the amber lamp and the other set completes the circuit for energizing relay K2. (The other leg of the circuit of K2 is completed through the running light secondary filament.)

(c) If the secondary filament circuit opens (as when both the primary and secondary filaments burn out) relay K2 deenergizes, closing its contacts. When the contacts of both K1 and K2 are closed, the amber and red lamps are lighted, and buzzer sounds. The buzzer may be silenced during repairs (restoration of the primary and secondary filament) by rotating the rotary snap switch to its "off" position; but the lamps will still remain lighted.

(d) When the defective lamps are replaced (or faults in the circuits are corrected), and the rotary snap switch is turned to the "on" position, the primary relay (Kl) coil energizes, the secondary relay (K2) deenergizes, returning the unit to its normal condition.

(e) A test button is built in the circuit. During normal operation, when the test button is pushed in, the primary filament circuit is opened (to simulate a primary filament burnout condition), power is transferred to the secondary filament and an amber lamp is lighted to confirm this condition. On the other hand, if both indicator lamps are lighted and the buzzer sounds, a possible secondary filament failure is indicated.

TABLE XXV. Circuit analysis of running lights.

Circuit analysis									
	Condition	Dimming light		Amber light	Red light	Buzzer	Unit S.W.	Primary delay contacts	Secondary delay contacts
		Prim.	Sec.						
1	Normal, Switch on	On	Out	Out	Out	Off	On	Open	Closed
2	Primary filament fails	Out	On	On	Out	Off	On	Closed	Open
3	Secondary filament fails	Out	Out	On	On	On	On	Closed	Closed
4	Unit switch off (to silence buzzer)	Out	Out	Out	On	Off	Off	Closed (dead)	Closed (dead)
5	Push test Push button								
	Condition 2(a) table XXIV	Out	On	On	Out	Off	On	Closed	Open
	Condition 2(b) table XXIV	Out	Out	On	On	On	On	Closed	Closed

4.7.3.3 Dimmer control panel. On surface ships, a dimmer control panel, symbol 989, is installed adjacent to the supply, control, and telltale panel and is connected as shown in appendix B, section I, sheet 11, detail “A”. This panel is used for dimming the masthead light, port side light, starboard side light, and stern light (white). A 5- by 8-inch plate is also installed adjacent to the dimmer panel with the inscription, “NAVIGATION LIGHTS IN DIM POSITION DO NOT COMPLY WITH THE RULES OF THE ROAD.” This panel provides one position of dimming. In the dim position the visibility of the masthead, side lights, and stern light is reduced to about 4000 yards. The sequence of operation of the telltale panel is the same whether the running lights are in the bright or dimmed condition.

4.7.3.4 Running lights. The running lights include: masthead light, port side light, starboard side light and stern light (white). They indicate the presence and course of one vessel to another. The running lights for submarines are pressure proof fixtures without shields while those of surface ships are spraytight with external shields to show an unbroken light over an arc of the horizon as specified in table XXI. Shields for submarine lights are provided by the shipbuilder. Running lights are provided with a 50-watt, two-filament lamp.

4.7.3.5 Blinker lights. The blinker lights are located, one port and one starboard, outboard on the signal yardarm. They are used for limited range visual communication. The fixtures are spray-tight, each provided with two clusters of six 15-watt, one-filament lamps. Cluster no. 1 may be used singly for normal use. Through switching, cluster no. 2 may be added to no. 1 to increase brilliance for communication at greater distance or cluster no. 2 may be selected alone when no. 1 fails. Blinker lights are fitted with a screen at the base to prevent glare or reflection that may interfere with the navigation of the ship. These lights are operated from signal keys, symbol 978.2, located on each side of the signal bridge. An ON-OFF snapswitch on the supply and control panel - signal and anchor lights is employed to energize or reenergize these lights. The lights are connected to the infrared control transmitter in order that the same signal key employed for the infrared lights is employed for the blinker lights. A selector switch on the infrared control transmitter selects which lights are to receive the pulse. Infrared and blinker lights cannot be employed simultaneously. A four-position switch located near the infrared control transmitter controls which bank is energized. Switch positions are: LOWER, LOWER AND UPPER, UPPER AND OFF.

4.7.3.6 Not-under-command (breakdown and man-overboard) lights. The not-under-command fixtures (red) are spray-tight and are equipped with 15-watt, one-filament lamps. They indicate a ship unable to maneuver or give warning to other ships to stay clear because a man is overboard. When these lights are used as a man-overboard signal, they are pulsed by a rotary snap-switch (fitted with a crank handle) on the signal and anchor light supply and control panel. These lights are mounted and operated in conjunction with the ship’s task lights.

4.7.3.7 Ship's task lights. The upper and lower lights of this three-light array are red, utilizing the presently installed man-overboard and break-down lights, relocated as necessary. The center light is a white light. These lights shall be connected to the supply and control (no telltale) panel in such a way that:

(a) The two red lights may be burned steadily to indicate the ship is "Not Under Command."
(b) The two red lights may be flashed by rotating the switch (crank-type) handle, to Indicate a man-overboard condition exists.
(c) The three lights will burn simultaneously to indicate the ship is either launching or recovering aircraft or engaged in RAS operations, and by the nature of its work, is unable to get out of the way of approaching vessels. The switch for this application shall be labeled "Ship's Task Lights." A dimmer control panel, symbol 989.1, shall be installed for dimming the task lights.

In addition to the tasks cited herein, these lights will be displayed on all vessels engaged in laying, servicing or picking up a navigational mark, sub-marine cable or pipeline; or a vessel engaged in dredging, surveying or under-water operations.

4.7.3.8 Submarine identification light. This light is displayed solely for identifying a craft on the surface as a submarine. Its display does not change any of the rules of the road nor confer any privilege on the ship showing it. The light is an intermittent flashing yellow beacon with a sequence of operation of approximately 90 flashes per minute.

4.7.3.9 Aircraft warning and replenishment approach light. A steady red light is exhibited near the top of masts extending more than 25 feet above the highest point on the superstructure to indicate the presence of obstructions to low flying aircraft. The aircraft warning light is also exhibited by the control ship (a ship capable of delivery) during the approach phases of RAS operations. When used in this way, the aircraft warning light shall be con-nected through a selector switch and a dimmer, symbol 951.1, so that it can be dimmed during RAS operations only. The selector switch shall select between aircraft warning and RAS (see appendix B, sheet 1-12).

4.7.3.10 Multipurpose signaling kit. The multipurpose signaling kit, symbol 106.1, consists of a hand spotlight with a 5-3/4 inch diameter sealed beam, 20-volt, l/2-ampere lamp mounted in an enclosure which has a pistol-grip handle with trigger-type switch. Power is normally supplied by a battery inside the light, which also contains a rheostat to control the intensity of the beam. The lamp can also be energized from ship's service through a transformer located in the carrying case. The multipurpose signaling kit is furnished with red, green, and yellow filters and is intended primarily for visual communication at night.

4.7.3.11 Portable floodlight for search and rescue operations. The portable floodlight, symbol 311, utilizes a powerful 600-watt, 120/28-volt lamp and is designed for use in search and rescue operations (that is, finding a man overboard, mooring to a buoy, disentangling downed flyers from their parachutes or harnesses> junk searches) and anti-swimmer lighting). The floodlight can be operated from either a 115-volt ac or a 28-volt ac/dc power source.

4.7.3.12 Night-flight operation lights. Night-flight operation lights are installed on aircraft carriers to assist pilots during take-off and landing at night. They also provide visual aid to pilots for locating and identifying the parent carrier. Information concerning visual Landing aid lighting is covered in NAVAIR technical manuals and bulletins.

4.7.3.13 Searchlights.

4.7.3.13.1 General. Naval searchlights are used to project a narrow beam of light for the illumination of distant objects and for visual signaling. To accomplish its purposes, the searchlight must have an intense, concentrated source of light, a reflector that collects light from the source (to direct it in a narrow beam), and a signal shutter (to interrupt the beam of light). Searchlights are classified according to size of reflector and light source. The three general classes are: 24-inch, 12-inch, and 8-inch searchlights. The 24-inch searchlight is of the carbon-arc type; the 12-inch light is either of the incandescent or inert-gas type; and the 8-inch light is of the sealed-beam incandescent type. A brief description of searchlights is provided herein. Additional information concerning operation and maintenance of searchlights is covered in chapter 9660 of the Naval Ships Technical Manual, NAVSEA 0901-422-0000.

4.7.3.13.2 Searchlights with carbon-arc lamps. The 24-inch high intensity carbon-arc searchlight is used primarily for signaling, and secondarily for navigational purposes. It consists of a stationary pedestal, turntable with arms, drum with iris and signaling shutters, and carbon-arc lamp. The turntable is supported on a pedestal and can rotate continuously in train; and the drum, which provides a housing for the lamp, is trunnioned on the turntable arms and can be elevated or depressed through angles of 110 and 30 degrees, respectively. The carbon-arc lamp utilizes a high intensity dc arc between special cored carbon electrodes. It is designed for operation with an arc-ballast resistor (located below deck) supplied from the ship’s 120-volt, dc power supply. The arc current is adjusted for 75 to 80 amperes with an arc voltage of 65 to 70 volts. The arc-ballast resistor is connected in series with the arc to limit the starting current, stabilize the arc, and absorb the difference between the line voltage and arc voltage. Due to the improved performance of smaller searchlights (in other words, mercury-xenon, incandescent), carbon-arc searchlights are no longer required for new-construction ships.

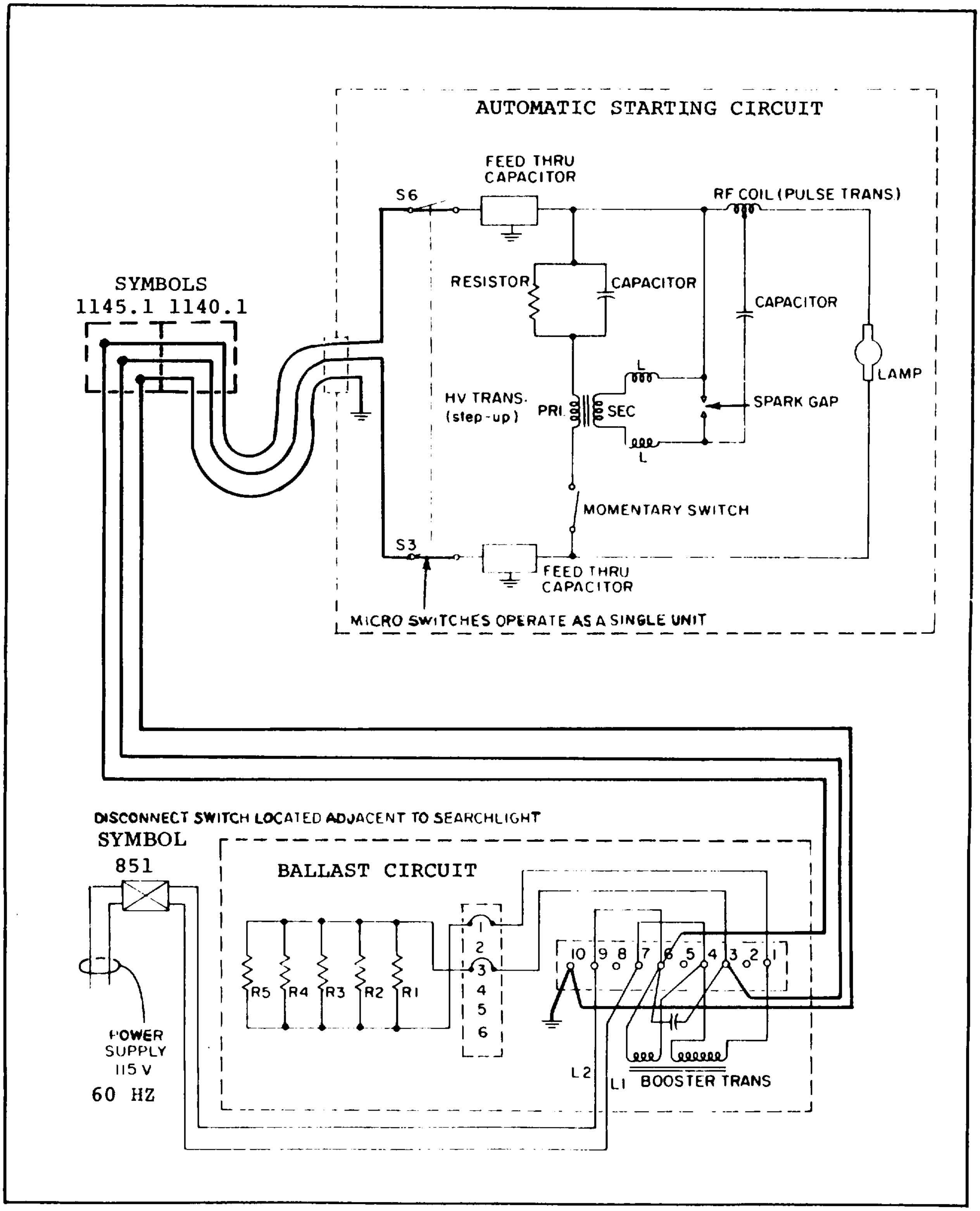
4.7.3.13.3 Searchlights with mercury-xenon arc lamps.

4.7.3.13.3.1 Characteristics and uses. These searchlights are used primarily for signaling, and secondarily for illumination. The mercury-xenon, gas-filled arc Lamps operate at 60 Hz, or with some changes in the starter circuit and ballast resistor, at 400 Hz. They produce a concentrated arc of intense brilliance which permits sharp focusing.

4.7.3.13.3.2 12-inch mercury-xenon arc searchlights. This searchlight, symbol 299, uses a 1000-watt mercury-xenon lamp that requires 45 amperes to start and 18 amperes for operation. It is supplied from the ship 117-volt, 60-Hz, single-phase power source. The lamp consists of two tungsten electrodes spaced about 1/4-inch apart inside a 2-inch diameter quartz bulb. The bulb contains a small quantity of liquid mercury and xenon gas at a pressure of 3 to 5 atmospheres when the lamp is cold (an atmosphere at sea level is equivalent to 14.6 pounds per square inch (lb/in^2). After the arc is started and the lamp attains a stable operating temperature, the internal pressure increases to approximately 20 atmospheres. The lamp does not produce full-light output until this pressure is reached and all of the mercury has been vaporized. This lamp differs from the incandescent lamp in that it requires a high voltage, radio frequency (rf) current for starting and a ballast for continuing operation at its rated output. The searchlight consists of a drum, back dome, signaling shutter, mounting yoke, lamp, focusing device, starter box, and ballast assembly. The automatic starting circuit assembly is attached to the lower part of the drum. A screening hood with various color filters is supplied. The electrical components (see figure 66) include:

(a) Automatic starting circuit. A high voltage pulse-type circuit is used. When the searchlight is turned on, the booster transformer supplies 130 volts to the primary of the transformer which, in turn, provides a series of pulses of approximately 50,000 volts which are generated by high frequency discharges through a spark gap. When the main arc in the lamp is established, the voltage to the primary of the transformer drops to 65 volts. This voltage is not high enough to cause the secondary voltage of the transformer to break down the spark gap. Thus, the high voltage pulses to the lamp automatically cease.

(b) Ballast circuit. Five resistors are connected in parallel and are, in turn, connected in series with the lamp. These resistors limit the current at starting and during operation, and supply the correct electrical values to the lamp. Four capacitors are required to keep the pulse transformer primary circuit resonant during starting. The other capacitors are used to prevent feedback of the high frequency power produced by the pulse transformer.



SH 964-66

FIGURE 66. Wiring diagram of a typical 12-inch mercury-xenon searchlight.

4.7.3.13.4 Searchlights with incandescent lamps.

4.7.3.13.4.1 Characteristics and use. The major units of the searchlights with incandescent lamps are: mounting bracket, yoke, drum, and lamp. The mounting bracket permits the searchlight to be secured to a vertical pipe or to a flat vertical surface. The yoke is swivel mounted on the bracket to allow the searchlight to be rotated continuously in train. The steel drum provides the lamp housing and is trunnion mounted on the yoke to allow it to be elevated and depressed. Clamps are provided for locking the searchlight in any position of train and elevation. The signaling shutter is a venetian blind type shutter. It is held in the closed position by two springs and is manually opened by a lever on either side of the drum. The searchlights in this group are used primarily for signaling purposes, and secondarily for illumination. The incandescent lamps used have special concentrated filaments for reducing the area of the light source and consequently, the spread of the light beam,

4.7.3.13.4.2 12-inch searchlights. The lamp for the 12-inch incandescent searchlight, symbol 299.1, is usually a 1000-watt, 117-volt incandescent lamp having special concentrated filaments that reduce the area of the light beam. The lamp is mounted in a mogul bipost socket. The socket is located in front of the reflector and can be adjusted only slightly. The replacement of the lamp is accomplished through the rear door of the searchlight. The light source must be at the focus of the reflector for minimum beam spread and maximum intensity. Some types of 12-inch incandescent searchlights are provided with focusing adjustment screws. Other types can be adjusted by loosening the screws on the lamp-socket support plate, adjusting the entire socket assembly toward or away from the reflector until the beam has a minimum diameter at a distance of 100 feet or more from the light, and retightening the screws. When checking the diameter of the beam, the rear door must be shut and tightly clamped. A screen hood is provided for attachment to the front door to limit the candlepower of the beam, to reduce its range, and to lessen stray light, which causes secondary illumination around the main beam. The hood also provides for the use of colored filters.

4.7.3.13.4.3 8-inch sealed-beam searchlight. The 8-inch signaling searchlight utilizes an incandescent, PAR 64, 250-watt, 28-volt, screw terminal sealed-beam lamp. It is designed to withstand high vibratory shock and extreme humidity conditions and will operate equally well in hot or cold climates. Searchlight, symbol 297, is designed for operation with 115-volt power systems, while searchlight, symbol 297.1, is designed for use on small craft with a 28-volt power source. Three filter assemblies (red, green, and yellow) that can be readily snapped in place over the face of the searchlight are provided.

4.7.3.13.5 Searchlights for small boats. Searchlights for small boats utilize a PAR 56 incandescent sealed-beam lamp of the type shown in table XXVI. There are two types of searchlights available.

(a) Symbol 301.1. This searchlight is mounted at a convenient point on the boat and requires the operator to be outside for operation.
(b) Symbol 309. This searchlight is mounted on top of the pilot house and is remotely controlled from inside the pilot house.

TABLE XXVI. Lamp schedule for searchlights for small boats.

Industry number	volts	Watts	Beam	National stock number
4543	12.5	100	spot	9G6240-00-193-0941
4548	24-28	250	spot	9G6240-00-274-4013
4549	24-28	250	Flood	9G6240-00-270-4695
4541	24-28	450	spot	9G6240-00-155-7774
300 PAR 56/2SP	120	300	Flood	9G6240-00-270-4689

4.7.3.13.6 Searchlights with xenon arc lamps. These searchlights are used primarily for illumination. They are large (in the 18-inch range), commercial type searchlights and are generally installed on auxiliary ships. The following warning signs shall be installed at the operating station and remote stations:

"WARNING

Xenon lights focused at short
range into the human eye will
cause permanent eye damage."

5* SHIPBOARD TESTS

5.1 General. After the lighting system is complete, the entire installation shall be thoroughly tested to check conformance to applicable ship requirements. As a minimum, the following applicable tests shall be performed:

(a) Photometric survey
(b) Darkened ship survey (surface ships)
(c) Navigation and signal lights check-out
(d) Ship service lighting system check-out
(e) Emergency lighting system check-out (submarines)

5.2 Photometric survey.

5.2.1 Purpose. The purpose of the photometric survey is to measure and record the illumination levels in the various compartments and to compare the results with applicable requirements.

5.2.2 Scope. A photometric survey of illumination values for general, operational, detail, red and blue illumination in the various compartments and spaces shall be made as follows:

(a) When only one ship of a class is being constructed at a yard, the survey shall be made on that ship.
(b) When more than one ship of a class is being constructed at a yard, the survey shall be made on only the first ship completed under each contract.

(c) When a single class of ships is being constructed at more than one yard from the same working drawings, the survey shall be made on only the first ship of the group at that yard under each contract.

When more than two spaces or compartments are of the same functional group (in other words, berthing areas, staterooms, sanitary spaces, and so forth) and are identical with respect to the application of detail lighting fixtures and the areas they illuminate, the detail survey need be made in only two of these spaces or compartments to determine that the detail lighting requirements are met. The supervisor shall select the spaces or compartments to be surveyed.

5.2.3 Power supply. The lighting system may be energized from either the ship service generators or from another source. The voltage at the main switchboard bus shall be maintained at 450 volts plus or minus 1 percent.

5.2.4 Lighting fixtures. All lighting fixtures shall be checked to make sure that they are clean. New lamps of the proper type, voltage and wattage shall be installed in all Lighting fixtures when the photometric survey is made. New incandescent lamps shall be seasoned for 6 hours and new fluorescent lamps for 100 hours at rated voltage prior to the survey. If seasoning of fluorescent lamps is impracticable, the minimum footcandle values obtained for the unseasoned lamps shall be not less than 106 percent of those specified in 4.1. All fluorescent fixtures shall be placed in operation at least 1/2 hour immediately before taking readings except that totally enclosed and gasketed fixtures shall be placed in operation 2 hours before tests.

5.2.5 Light meter.

5.2.5.1 General. Photometry is defined as the science of measuring the intensity of light. The basic instrument employed in the measurement of light is a photometer, commonly known as a light meter. In general, photometers are divided into two types: laboratory photometers of high accuracy and portable photometers of lower accuracy. They are further subdivided into two categories: visual photometers in which the eye is used to compare the brightness of two surfaces and photoelectric photometers in which the circuitry of the instrument is calibrated to read the light intensity directly. These in turn may be grouped according to function, such as photometers that measure illumination (footcandle meter), brightness (brightness meter), and so forth. The light measurements with physical instruments are useful only if the instruments are calibrated to respond to light in the same way as the human eye.

5.2.5.2 Visual photometers. Visual photometers are brightness comparison instruments with which the eye is used to compare the brightness of two surfaces (one known, the other unknown), usually by adjusting them to equality. Visual photometers are primarily used to measure low photometric brightness, such as that encountered in light trap security aboard ship. The selection of the photometer is a matter of personal choice. However, among those which have been found quite satisfactory are the so-called Rochester photometer, the MacBeth illuminometer, the Luckiesh-Taylor luminance meter, the Freund brightness spot meter and the Pritchard photometer. In recent years, visual photometric methods have largely been supplanted commercially by physical methods.

5.2.5.3 Photoelectric photometers. Photoelectric photometers are divided into two classes: those employing photoemissive tubes, and those employing solid state devices such as photovoltaic and photoconductive cells. The most popular photoelectric meters for shipboard tests are the photovoltaic types since they are simple to operate and they do not require additional support equipment. A typical photovoltaic cell footcandle meter consists of a selenium cell, a microammeter, color and cosine-corrected filters, a multiplier switch, and a resistor to shunt the meter for the higher scale. (Less expensive meters do not include color correction or cosine correction.) The selenium cell is a steel plate with a high purity selenium coating.

5.2.5.4 Color correction. Most pocket-size light meters use a selenium photovoltaic cell. Selenium cells do not respond to colors of light in the same manner as the average human eye. For example, selenium cells respond to ultraviolet and infrared energy; the human eye does not. Also, selenium cells are more sensitive to blue and red light than is the human eye. Correction of light meter response is achieved by using special colored filters to modify the response of the cell. Figure 67 illustrates the degree to which a typical, commercially-corrected selenium photovoltaic cell, commonly in footcandle meters, approximates the standard eye sensitivity curve. The color-corrected light meter responds to the color of incident light in much the same manner as the human eye. Accordingly, it need not be calibrated for use with a specific type of white light (that is, incandescent, mercury, or fluorescent), nor are correction factors required for measurements of these sources, as is necessary with meters having no color correction. However, a color-corrected meter for white light measurements is not necessarily color-corrected for measurements of monochromatic lights, such as red and blue. For accurate measurements of monochromatic lights, the light meters must be color-corrected for the specific color involved.

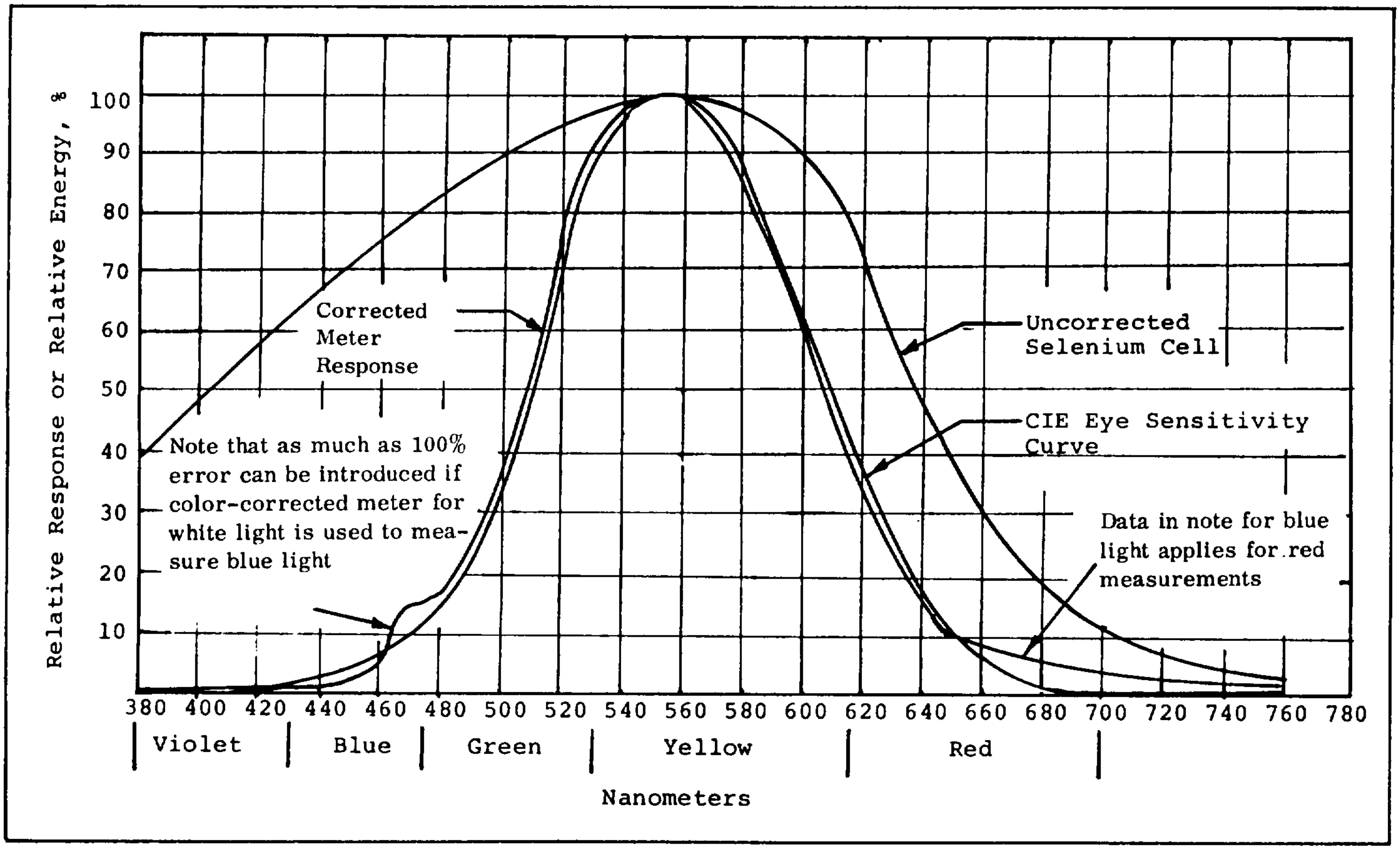


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FIGURE 67. **Color correction for light meter cells.**

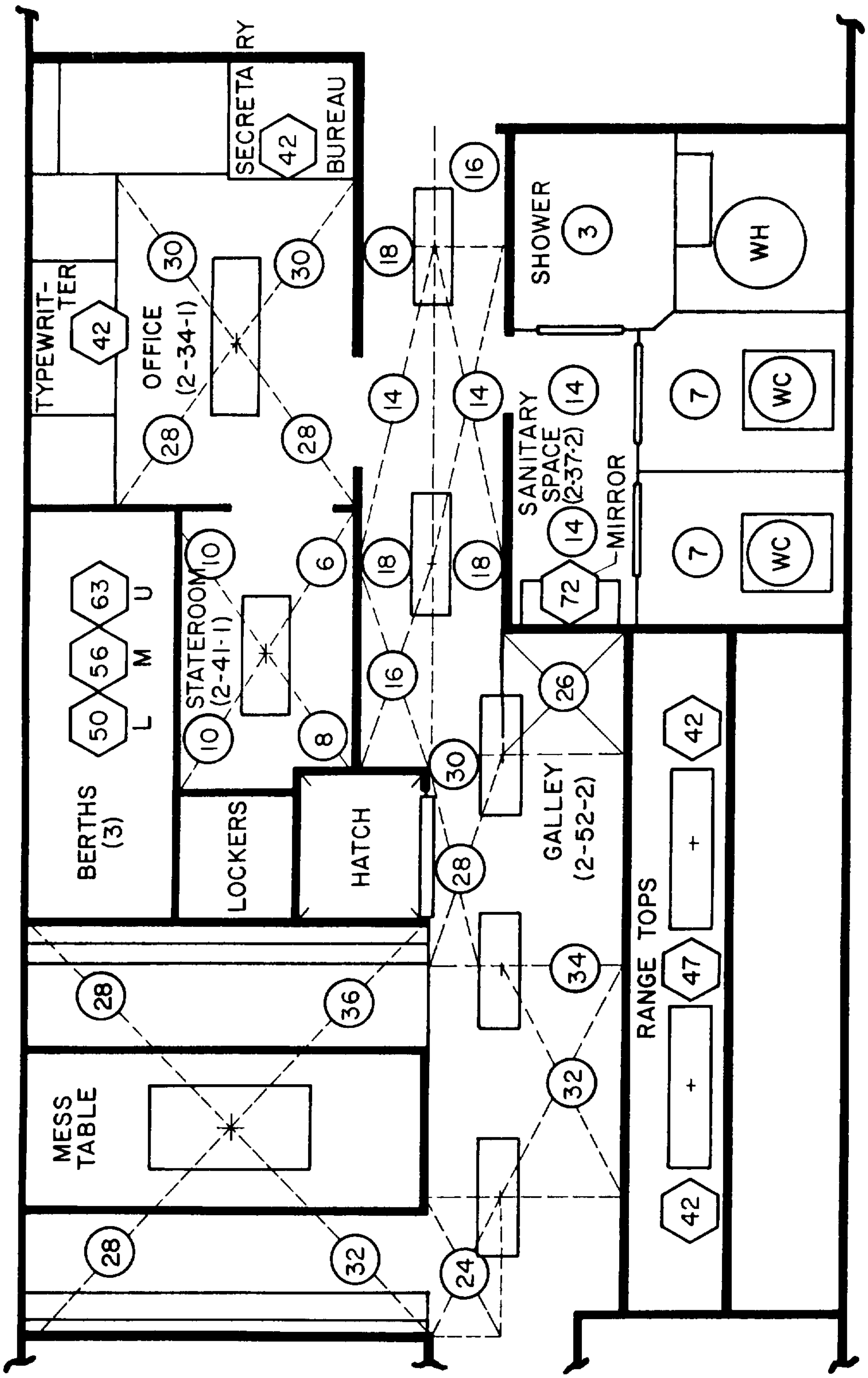
5.2.5.5 Cosine correction. A light meter which is not cosine-corrected generally has a glass plate to cover the selenium cell for mechanical protection. Part of the light which strikes the glass plate at an angle is reflected, and thus is not evaluated by the meter. The resultant error increases with the angle of incidence and, in measuring illumination where an appreciable portion of the flux comes at wide angles, an uncorrected meter may indicate as much as 25 percent below the true value. The cells used in most footcandle meters are now provided with diffusing covers or some other means of correcting the light-sensitive surface to approximate the true cosine response. The meter reading of a fully cosine-corrected light meter represents the true illumination on the light receiver regardless of the angle from which the light approaches. When light strikes a light cell at an angle, the reading on the light meter should equal the reading that would occur if the light meter were held perpendicular to the rays of light, multiplied by the cosine of the angle of incidence on the meter cell.

5.2.5.6 Temporary fatigue. The photocell-type meter shall be exposed to the approximate illumination level of the area to be measured for at least 15 minutes before taking readings.

5.2.5.7 Effect of temperature. Wide temperature variations affect the performance of photocells. Therefore, measurements shall be made at temperatures approximating those in which the meter was calibrated (usually 77°F). If photocells are used below 60°F or above 90°F, conversion factors recommended by the manufacturer of the equipment shall be used to correct the readings.

5.2.5.8 Meter accuracy. Since cell-type instruments have no provision for field calibration other than a zero reading correction, they should be frequently checked against a master instrument of known calibration or returned to a reliable laboratory periodically for calibration. The meter shall be checked or calibrated before making a photometric survey on each ship.

5.2.6 Drawings for photometric survey. Drawings showing the hull outline, bulkheads, access routes, location of lighting fixtures, outline of major furniture and equipment and compartment name and number shall be prepared to record the photometric survey readings. The drawings shall be to a scale that provides sufficient space to record the footcandle readings at the points required by 5.2.8. These drawings can be prepared by adding the photometric survey data to a drawing made of a compartment and access drawing required by ship specifications (see figure 68 for guidance).



1. CIRCLES INDICATE WHERE GENERAL ILLUMINATION READINGS ARE TO BE TAKEN.
2. HEXAGONS INDICATE WHERE DETAIL ILLUMINATION READINGS ARE TO BE TAKEN.
3. TAKE PHOTOMETRIC READINGS AND RECORD SAME IN THE CIRCLES AND HEXAGONS AS INDICATED
4. SHOWING OF OVERHEAD LIGHTING FIXTURES IN SMALL SPACES MAY BE OMITTED FOR CLARITY.

FIGURE 68. Typical format for photometric survey drawing.

5.2.7 Portable instruments. Recorded information pertaining to portable instruments shall be recorded on a form as shown on figure 69. The following equipment is required:

(a) Recently calibrated, color- and cosine-corrected photovoltaic cell, footcandle meter and brightness meter.
(b) Measuring tape.
(c) Watch.

The footcandle meter shall be positioned so that when readings are taken, the surface of the light sensitive cell is in a horizontal plane and 30 inches above the floor. This can be facilitated by means of a small portable stand of wood or other material that will support the cell at the correct height and in the proper plane.

Provide pertinent data in table below of all portable instruments used in measuring photometric and electrical quantities.

Name of instrument and manufacturer	Accuracy	Serial No.	Date of last calibration	Range

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FIGURE 69. Portable instrument tabulation (work form).

5.2.8 Measurements.

5.2.8.1 General. The measurement of illumination is complicated because lighting installation seldom provides absolute, even illumination, and most compartments aboard ship are irregular in shape. Measurements are sometimes made by placing the footcandle meter at random points throughout the compartment to obtain a “mental average” of the illumination values. The measurement obtained in this manner may be subject to controversy; therefore, the following methods which are in general agreement with the standard methods recommended by the Illuminating Engineering Society shall be used in taking photometric readings.

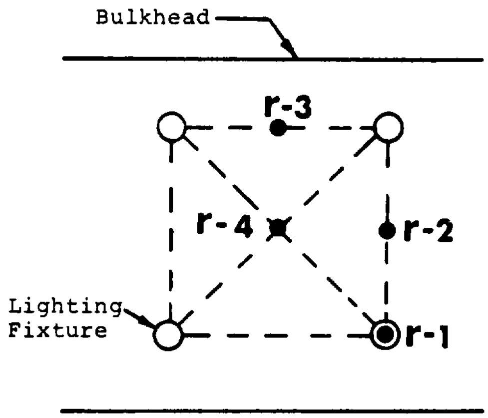
5.2.8.2 General illumination. General illumination shall be measured with all lights turned on except lights for detail illumination such as desk lights, berth lights, adjustable bracket lights and red lights. However, when detail illumination is provided by overhead lighting fixtures, these fixtures shall be energized during measurements of general illumination. Measurements shall be taken on a horizontal plane 30 inches above the deck.

5.2.8.2.1 The following method for determining average illumination results in a value that is within 10 percent of the value that would be obtained by dividing a compartment into 2-foot squares, taking a reading in center of each square and then averaging the results. This method is based on the flux of light principle by which an average footcandle is defined as the illumination on a surface 1 square foot in area on which 1 lumen of luminous flux is uniformly distributed.

5.2.8.2.2 For photometric survey purposes, each compartment shall be divided into areas known as bays. The three different type of bays are designated as whole bays, half bays and quarter bays (see figure 70). Lighting fixtures used to establish the outline of an area shall be the only fixtures within that area. Only an area whose sides are of either bulkhead space or equipment or furniture faces (see figure 73B) or a combination of the two shall be considered when dividing the compartment into bays. The division of the compartment and the stations where the photometric survey readings are to be taken shall be shown on the drawings used for the survey. Photometric survey readings for each bay shall be taken at stations shown on figure 70.

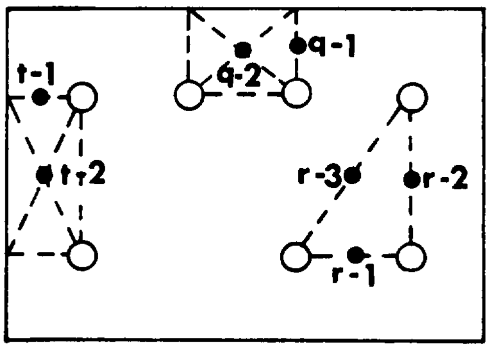
A whole bay is defined as a four sided area with lighting fixtures at each corner.

Photometric readings are taken at stations r-1 thru r-4.



A half bay is defined as a four sided area with lighting fixtures at two corners and bulkhead space or equipment face (running from deck to close to overhead) at the other two; or three-sided area with lighting fixtures at each corner.

Photometric readings are taken at stations q-1 and q-2 , t-1 and t-2, and r-1, r-2 and r-3.



A quarter bay is defined as a four sided area with a lighting fixture in one corner and bulkhead space or equipment face (running from deck to close to overhead) at the other three.

Photometric readings are taken at station p-1.

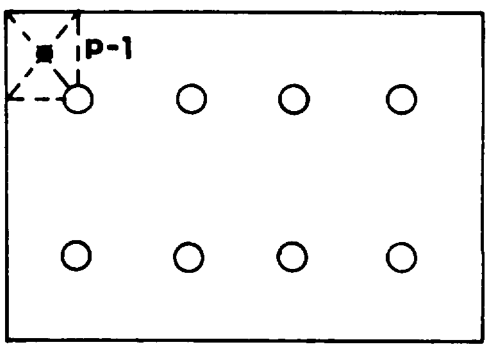


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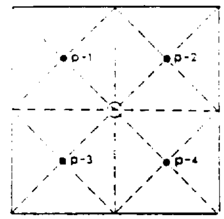
FIGURE 70. Division of a compartment into bays.

5.2.8.2.3 Average illumination of regular compartments with symmetrically spaced lighting fixtures shall be calculated in accordance with the procedures shown on figure 71. Average illumination for compartments with unsymmetric lighting fixture arrangements shall be calculated in accordance with the procedures shown on figure 72. Average illumination for machinery spaces shall be the arithmetic mean of the measured survey readings.

Step 1	
Station	fc
p-1	
p-2	
p-3	
p-4	
Total	
Average P =	

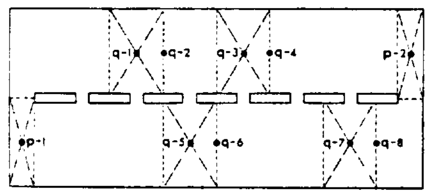


Step 1 - Take readings at stations p-1 thru p-4 in each quarter bay.

Step 2 - Average the 4 readings. This is P; the average illumination in the compartment.

A. REGULAR COMPARTMENT WITH SYMMETRICALLY LOCATED SINGLE LIGHTING FIXTURE

Step 1		Step 2	
Station	fc	Station	fc
q-1		p-1	
q-2		p-2	
q-3			
q-4			
q-5			
q-6			
q-7			
q-8			
Total			
Average Q =		P =	



Step 1 - Take readings at stations q-1 thru q-8 in 4 typical half bays located two on each side of the area. Average the 8 readings. This is Q in the equation.

Step 2 - Take readings at stations p-1 and p-2 for two typical corner quarter bays. Average the 2 readings. This is P in the equation.

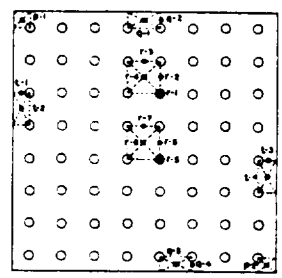
Step 3 - Determine the average illumination in the compartment by solving the equation:

$$\text{Average Illumination} = \frac{Q(N-1)+P}{N} \qquad \text{Eq. 44}$$

where: N = Number of lighting fixtures

B. REGULAR COMPARTMENT WITH SINGLE ROW OF INDIVIDUAL LIGHTING FIXTURES

Step 1		Step 2		Step 3		Step 4	
Station	fc	Station	fc	Station	fc	Station	fc
r-1		q-1		t-1		p-1	
r-2		q-2		t-2		p-2	
r-3		q-3		t-3			
r-4		q-4		t-4			
r-5							
r-6							
r-7							
r-8							
Total							
Average R =		Q =		T =		P =	



Step 1 - Take readings at stations r-1, r-2, r-3 and r-4 for a typical inner bay. Repeat at stations r-5, r-6, r-7 and r-8 for a typical centrally located bay. Average the 8 readings. This is R in the equation.

Step 2 - Take readings at stations q-1, q-2, q-3 and q-4 in two typical half bays on each side of compartment. Average the 4 readings. This is Q in the equation.

Step 3 - Take readings at stations t-1, t-2, t-3 and t-4 in two typical half bays at each end of compartment. Average the 4 readings. This is Q in the equation.

Step 4 - Take readings at stations p-1 and p-2 in two typical corner quarter bays. Average the 2 readings. This is P in the equation.

Step 5 - Determine the average illumination in the compartment by solving the equation:

$$\text{Average Illumination} = \frac{R(N-1)(M-1)+Q(N-1)+T(M-1)+P}{NM} \qquad \text{Eq. 45}$$

where: N = Number of lighting fixtures;
M = Number of rows.

C. REGULAR COMPARTMENT WITH SYMMETRICALLY SPACED LIGHTING FIXTURES IN TWO OR MORE ROWS

SH 964-71

FIGURE 71. Average illumination of regular compartments with symmetrically located lighting fixtures.

Average illumination in a compartment is given by the formula:

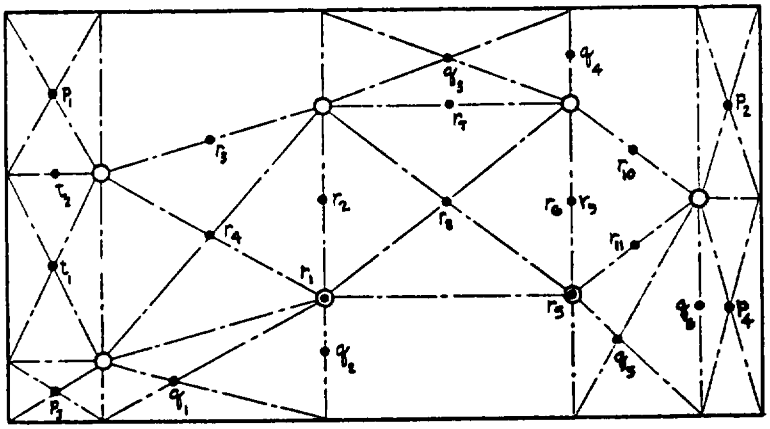
$$\text{Average illumination} = \frac{(PxA) + (QxB) + (TxC) + (RxD)}{A + B + C + D} \qquad \text{Eq. 46}$$

Where:

- P=(Pave)= average footcandles of quarter-bays.
- Q=(Qave)= average footcandles of half-bays at sides of compartment.
- T=(tave)= average footcandles of half-bays at ends of compartment.
- R=(rave)= average footcandles of whole bays & of three-sided half-bays.
- A= number of quarter-bays in compartment divided by 4.
- B= number of half-bays at sides of compartment divided by 2.
- C= number of half-bays at ends of compartment divided by 2.
- D= number of whole bays in compartment plus number of three-sided half-bays divided by 2=[whole bays + 3 sided half-bays/2]

In the examples below:

Step 1. Divide the compartment into bays in accordance with Fig. 70.
Step 2. Take readings for r, q, t and p's and average to determine R, Q, T and P respectively as described in Fig. 71.
Step 3. Count the number of bays to determine A, B, C and D.
Step 4. Using Eq. 46 calculate the average illumination for the compartment.

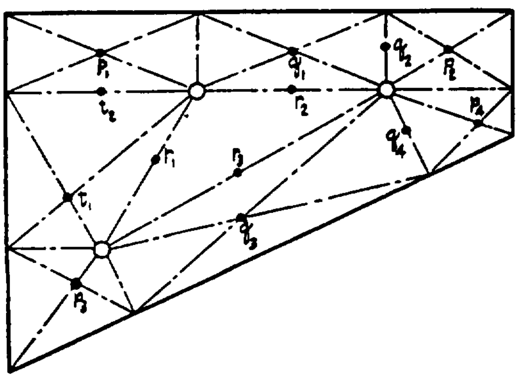


$$\text{Average illumination} = \frac{(PxA)+(QxB)+(TxC)+(RxD)}{A + B + C - D}$$

$$= \frac{(Px4/4)+(Qx6/2)+(Tx1/2)+R(2+1/2)}{1 + 3 + 1/2 + 2\ 1/2}$$

$$= \frac{(Px1)+(Qx3)+(Tx1/2)+(Rx2\ 1/2)}{7}$$

$$= \frac{2P + 6Q + T + 5R}{14}$$

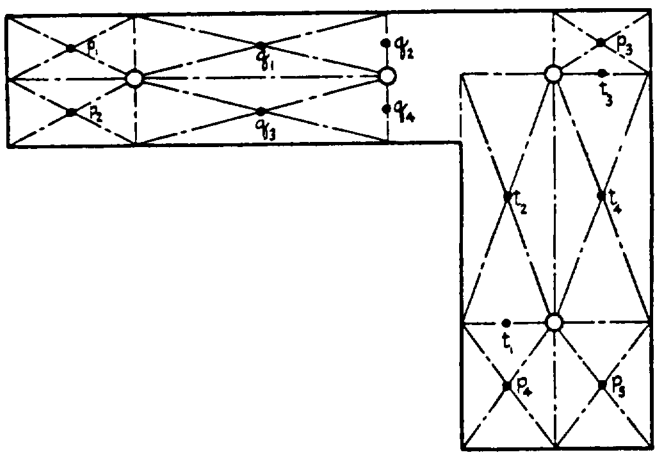


$$\text{Average Illumination} = \frac{(PxA)+(QxB)+(TxC)+(RxD)}{A + B + C + D}$$

$$= \frac{(Px4/4)+(Qx2/2)+(Tx1/2)+(Rx1/2)}{1 + 1 + 1/2 + 1/2}$$

$$= \frac{(Px1)+(Qx1)+(Tx1/2)+(Rx1/2)}{3}$$

$$= \frac{2P + 2Q + T + R}{6}$$



$$\text{Average illumination} = \frac{(PxA)+(QxB)+(TxC)}{A + B + C}$$

$$= \frac{(Px5/4)+(Qx4/2)+(Tx2/2)}{5/4 + 2 + 1}$$

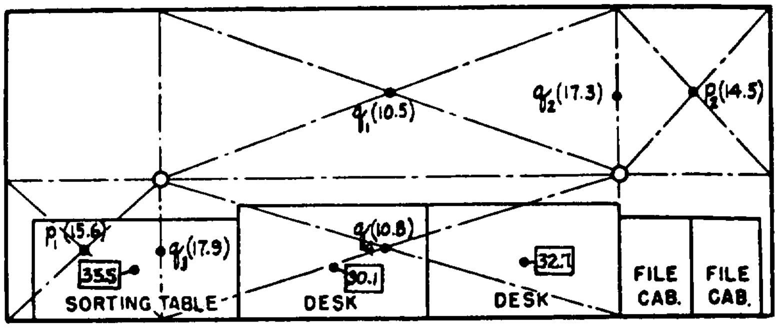
$$= \frac{5P + 8Q + 4T}{17}$$

SH 964-72

FIGURE 72. Average illumination of compartments with unsymmetrically arranged lighting fixtures.

5.2.8.2.4 Examples of computing the average illumination for typical compartments are shown on figure 73. Figure 74 shows a work form that may be used to compute the values used in the average illumination formulas. In compartments where two levels of illumination are provided, the illumination shall be . measured and calculated for the highest level.

A. SHIP'S OFFICE



☐ Detail lighting ( )General lighting

Using Eq. 44 of Fig. 71 we have:

$$P = \frac{P_1+P_2}{2} = \frac{15.6+14.5}{2} = \frac{30.1}{2} = 15.1 \text{ fc}$$

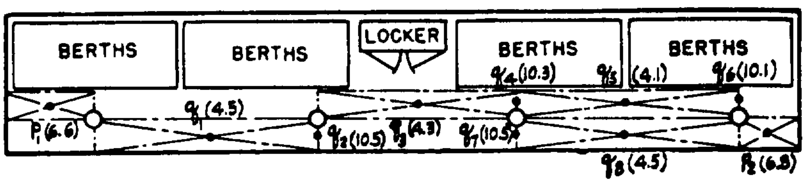
$$Q = \frac{q_1+q_2+q_3+q_4}{4} = \frac{10.5+17.3+17.9+10.8}{4} = 14.1 \text{ fc}$$

N = 2

Thus;

$$\text{Average illumination} = \frac{Q(N-1)+P}{N} = \frac{14.1(2-1)+15.1}{2} = \frac{29.2}{2} = 14.6 \text{ fc}$$

B. CREW'S BERTHING AND PASSAGE



Using Eq. 44 of Fig. 71 we have:

$$P = \frac{P_1+P_2}{2} = \frac{6.6+6.8}{2} = \frac{13.4}{2} = 6.7 \text{ fc}$$

$$Q = \frac{q_1+q_2+q_3+q_4+q_5+q_6+q_7+q_8}{8}$$

$$= \frac{4.5+10.5+4.3+10.3+4.1+10.1+10.5+4.5}{8}$$

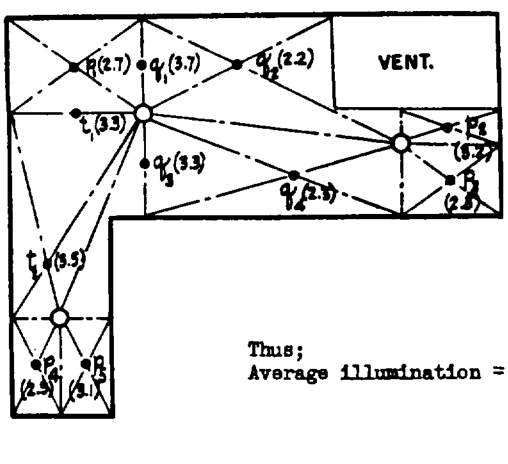
$$= \frac{58.8}{8} = 7.4 \text{ fc}$$

N = 4

Thus;

$$\text{Average illumination} = \frac{Q(N-1)+P}{N} = \frac{7.4(4-1)+6.7}{4} = \frac{28.9}{4} = 7.2 \text{ fc}$$

C. PASSAGE



Using Eq. 46 of Fig. 72 we have:

$$P = \frac{P_1+P_2+P_3+P_4+P_5}{5} = \frac{2.7+3.2+2.8+2.9+3.1}{5} = \frac{14.7}{5} = 2.9 \text{ fc}$$

$$Q = \frac{q_1+q_2+q_3+q_4}{4} = \frac{3.7+2.2+3.3+2.3}{4} = \frac{11.5}{4} = 2.9 \text{ fc}$$

$$T = \frac{t_1+t_2}{2} = \frac{3.3+3.5}{2} = \frac{6.8}{2} = 3.4 \text{ fc}$$

A = 5/4; B = 2/2 = 1; C = 1/2

Thus;

$$\text{Average illumination} = \frac{(P\text{x}A)+(Q\text{x}B)+(T\text{x}C)}{A+B+C} = \frac{(2.9\text{x}5/4)+(2.9\text{x}1)+(3.4\text{x}1/2)}{5/4+1+1/2} = \frac{8.2}{2.75} = 3.0 \text{ fc}$$

SH 964-73

FIGURE 73. Examples of computing average illumination.

Area or Compartment Title ____________________ Number ______________

Lighting fixture arrangement:
(In accordance with Figs 71 & 72)
(Check one)

☐ Regular compartment with symmetrically located single lighting fixture.
☐ Regular compartment with single row of individual lighting fixtures.
☐ Regular compartment with symmetrically spaced lighting fixtures in two or more rows.
☐ Compartment with unsymmetrically located lighting fixtures.

Calculate the average illumination for the area or compartment using the examples and equations shown in Figs 71, 72 and 73.

Step 1		step 2		Step 3		Step 4	
Station	fc	Station	fc	Station	fc	Station	fc
r-1		q-1		t-1		p-1	
r-2		q-2		t-2		p-2	
r-3		q-3		t-3		p-3	
r-4		q-4		t-4		p-3	
r-5		q-5		t-5		p-5	
r-6		q-6		t-6		p-6	
r-7		q-7		t-7		p-7	
r-8		q-8		t-8		P-8	
Total							
Average R=		Q=		T=		P=	

SH 964-74

FIGURE 74. Average illumination calculation (work form).

5.2.8.3 Detail illumination. Readings for detail illumination shall be taken in a manner that will reflect the average illumination on the working surface of the equipment selected. Detail illumination shall be measured with lights for both general and detail illumination turned on. For detail illumination at desks, tables, and workbenches, measurements shall be taken at the center of the working space, on the working level and with the operator in a normal working position. Measurements for mirrors shall be taken approximately 16 inches away from the surface of the mirror, with the cell in a position facing and parallel to the mirror. For berths and bunks, measurements shall be taken at a point 12 inches above the top of the mattress, 25 inches from the headboard and at an angle of 50 degrees.

5.2.8.4 Red illumination. Readings for red illumination shall be taken with the area or compartment in its normal operating condition, in other words, with all red lights on and all equipment operating. Readings shall be taken in areas and for equipment as required in 4.4 and 4.6.

5.2.8.5 Blue Illumination. Readings for blue illumination shall be taken with the compartment in its normal operating condition, in other words, with all blue lights on and all equipment operating. Readings shall be taken in areas and for equipment as required in 4.5.

5.2.8.6 Uniformity. Readings for uniformity ratio shall be taken directly under a lighting fixture and between it and the nearest adjacent fixture. For additional information see 4.3.2.4.

5.2.8.7 Brightness. Brightness shall be measured under actual working conditions with all lights (white , red or blue) and equipment in normal use. Readings for brightness contrast ratio shall be taken on the seeing task, adjacent surroundings and remote surroundings. For example, readings shall be taken on a printed page on the desk, desk top and the opposite bulkhead. For additional information see 3.3.5 and 4.3.2.5. Brightness readings for red and blue illumination shall be taken for areas and equipment as required by 4.4 and 4.5 respectively.

5.2.9 Tabulation of data. Required information for instrument calibration shall be recorded on a form as shown on figure 69. During the photometric survey, the main switchboard bus shall be monitored every 5 minutes and the bus voltage shall be recorded on a form as shown on figure 75. These data will be used for comparison of compartment voltage as shown on figure 76. Photometric survey readings shall be recorded on the photometric survey drawings. Overall photometric survey results shall be tabulated on a form as shown on figure 76.

Time	Bus Voltage	Time	Bus Voltage	Time	Bus Voltage	Time	Bus Voltage

SH 964-75

FIGURE 75. Bus voltage monitoring (work form).

Photometric Survey																		
Compartment	Compartment Number	Lighting Drawing		Time beginning & end of comp't survey		Voltage	Illumination			Uniformity				Brightness		Glare		Remarks
							General		Detail	Uniform Distribution	Uniformity Ratio	Objectionable Shadows	Spotty Conditions	Contrast Ratio	Req'd Levels	Direct	Reflected	
		Number	Rev.	Beg.	End		Req'd Level	Calculated										

PRELIMINARY WORK

All compartments shall be completed with all equipment installed. Decks, bulkheads and overhead shall be clean and completely painted.

Daylight shall be excluded by closing doors, airports, hatches, and other openings as necessary.

Personnel using the foot-candle meter shall prevent their own shadows from falling on the sensitive plate of the meter, and shall wear dark clothing so that their reflections will not cause inaccurate readings.

Preparations shall be made to read voltage at the switchboard bus at 5 minute intervals during the survey.

Keys to locked compartments shall be issued to test personnel or ship's force shall be available during the test to open and close locked compartments.

Power supply, lighting fixtures, light meter, photometric survey drawings and equipment shall comply with the requirements of 5.2.

PROCEDURE

Check that preliminary work has been accomplished. On the table above record:

- Compartment title and number.
- Applicable lighting drawing number and revision.
- The time at beginning and end of each compartment survey.

As soon as possible after conclusion of survey or portion of the survey, compare voltage record with compartment survey to determine if voltage has varied during any one compartment survey. If variation in voltage is more than 1%, the survey of that compartment shall be repeated.

- Illumination, uniformity, brightness, and glare.
- Deficiencies shall be corrected as directed by the Supervisor.

ILLUMINATION

- Record the required level for general illumination. From the photometric data obtained in accordance with 5.2.8.2 record the calculated average illumination for the compartment.
- Record any unacceptable peculiarities or discrepancies for detail illumination.

UNIFORMITY

- Ascertain whether or not the existing lighting fixtures give uniform distribution over the area which they should cover and note same. If the illumination is not uniform throughout the compartment and free of contrasting light and dark areas when all fixtures for general illumination are in use, note same giving appropriate area of contrasting light.
- The ratio of maximum Foot-Candles under a lighting fixture to the minimum Foot-Candles between it and the nearest adjacent fixtures shall not be greater than two to one. Uniformity of illumination is particularly desired in such compartments as offices, shops, electronic and living spaces.
- Objectionable shadows cast on the work by obstructions or by personnel as they perform their normal activities in that compartment shall be noted, and notations shall be made if it is necessary that existing fixtures be moved or additional fixtures be installed to overcome these shadows.
- Note whether overhead fixtures have been installed sufficiently close to bulkheads, so that bulkhead and corners are uniformly illuminated to overcome conditions of spotty distribution or dark corners and excessive lighting contrasts.

BRIGHTNESS

- The contrast between the lighted working area and the surrounding area shall be noted. A brightness contrast ratio of 3 to 1 between the seeing task and adjacent surroundings and a ratio of 10 to 1 between the seeing task and most remote surroundings is required.
- Ascertain whether the potometric brightness of equipment faces(0.02-0.08 FL) and indicator lights(2.0 FL max.) in red and blue illuminated areas are within requirements.

GLARE

- Ascertain whether or not there is any annoying glare, either directly from the fixtures or reflected from the working area and note same. If a glare condition exists, note the cause and location of this condition and recommend corrective action.

SH 964-76

FIGURE 76. Tabulation of photometric survey results.

5.3 Darkened ship survey (surface ships).

5.3.1 Inspection. An inspection of the entire hull envelope, main deck and above, shall be made to determine the satisfactory light integrity of the ship. Each opening and access shall be checked for direct or indirect light leaks to the exterior (weather). Each authorized access that can be opened or is normally open during darkened-ship conditions shall be protected by a door switch, light trap, or complete darkened-ship lighting circuit.

5.3.1.1 Entrances which are protected by light traps instead of door switches shall be checked for accessibility, light tightness, sufficient number of black light absorbing surfaces (minimum of two), general illumination in the vicinity of the inner entrance, and absence of light reflecting objects within the light trap. Direct lighting of the entrance should be avoided (no lights within a 5-foot radius of the light trap). If practical, lights should not be placed within a 10-foot radius of the entrance; these lights shall be shielded.

5.3.1.2 Sources of light, other than light traps and entrances and openings controlled by door switches, shall be shielded to prevent leakage to the weather. Ventilation ducts and other miscellaneous openings shall be protected by lightexcluding hoods or suitable light baffles. Red illumination shall be treated the same as general white light illumination with respect to light tightness. Red standing lights that have possible exposure to the exterior shall be suitably shielded. Indicator and pilot lights on equipment exposed to the weather shall be shielded.

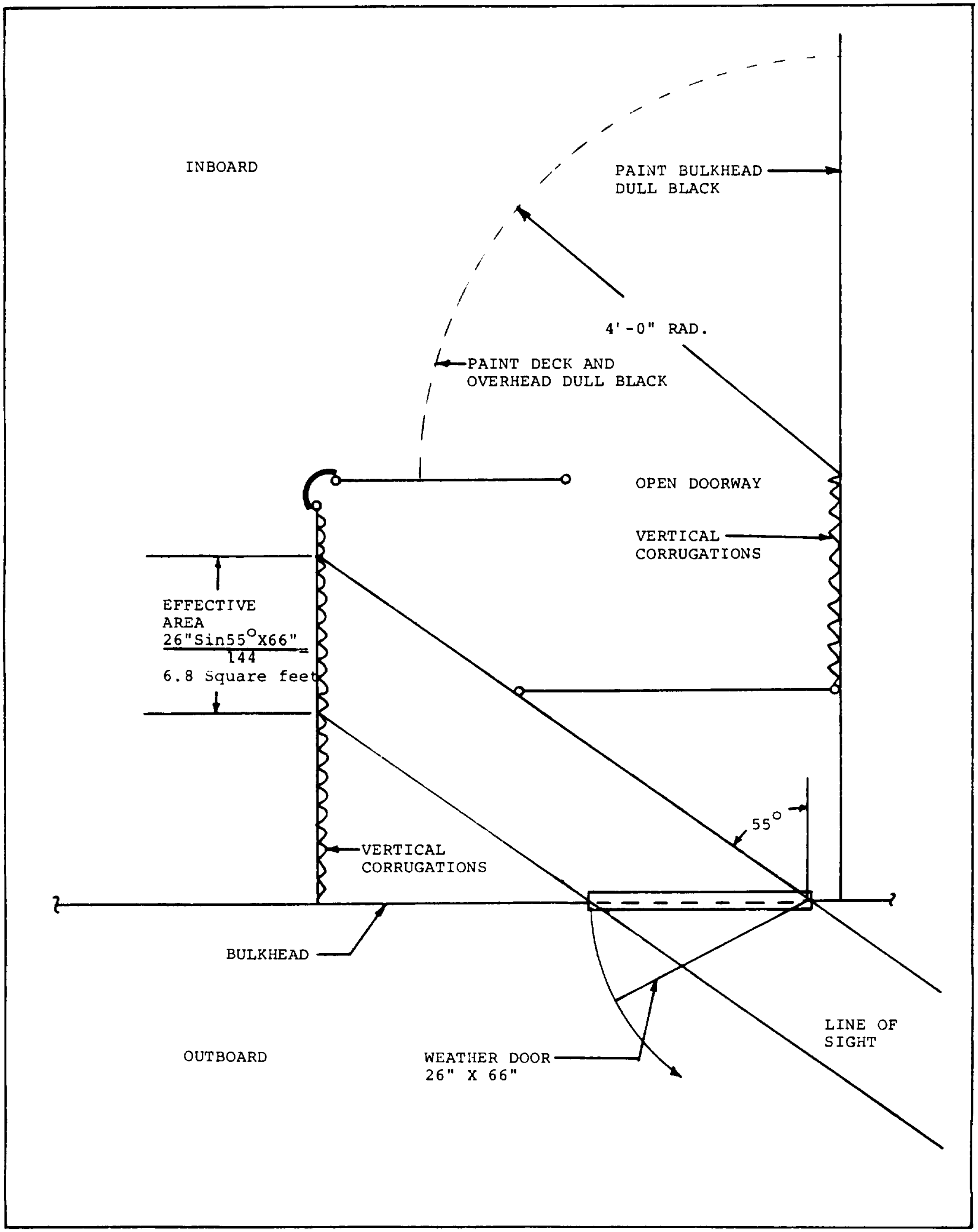
5.3.2 Operation. Door switches that control compartment and access lights shall be checked by opening and closing the doors or closures a sufficient number of times to insure consistent operation of the switches. The door switches should have lock-in devices or short circuiting (by-pass) switches installed to provide for both light ship and darkened-ship conditions. The doors or closures should operate the door switches on opening and closing without allowing any direct light leakage to the exterior or weather (the closure and closure frames should overlap when the door switches are actuated in order to have minimum light leakage). Lights in the compartment or access that are not on the darkened-ship circuit should be controlled by the door switches.

5.3.3 Light trap security. Low level photometers, of a type described in 5.2.5.2, shall be used to test the light security of the non-standard light traps. Light traps of standard design in accordance with Drawings 805-1630833 and 805-1630834 need not be checked. The visual range of light reflected from the light traps shall be held to a minimum and shall not exceed 1000 yards when calculated in accordance with the following paragraphs. The low level photometer provides a means of measuring the surface brightness of the light trap surfaces which are visible through an access from outboard the ship. The brightness measurement of a surface shall be made in accordance with the instructions furnished with the photometer used and as described herein.

5.3.3.1 In order to obtain accurate results when using the photometer, the observers should be dark-adapted (in other words, be in the dark, or wear dark-adaptation red goggles for approximately 30 minutes prior to taking the readings).

5.3.3.2 Before making brightness measurements, provision should be made to exclude any light which does not originate in the ship from the surface on which brightness measurements are to be made. Some form of portable black canvas hood shall be placed over the outboard opening. Space should be allowed for the observer to make photometric measurements from at least 6 feet away from the surface to be measured. When making brightness measurements, all lights in the ship which are normally on under darkened-ship conditions shall be turned on.

5.3.3.3 In making brightness readings on light trap installations, the first step is to select the brightest surface of the trap which is visible from outboard the ship. For example, in a typical light trap (see figure 77), the brightest visible surface is the corrugated bulkhead perpendicular to the weather door.



SH 964-77

FIGURE 77. Typical light trap.

5.3.3.4 The next step is to determine the maximum "effective" area (perpendicular to the line of sight) of this bulkhead which would be visible from outboard the ship. For example, the maximum effective area of the corrugated bulkhead shown on figure 77 is from an angle of approximately 55 degrees (counterclockwise from the vertical) through the outboard doorway. Assuming that this outboard door is 26 by 66 inches, and that visibility from outboard the ship is unrestricted, the visible area of the corrugated bulkhead is approximately 26 inches sin 55 degrees by 66 inches equals 15 by 66 inches, or 6.8 square feet.

5.3.3.5 Brightness measurements are then made on the "effective" area. In order to obtain representative readings, it is desirable to have readings made by two observers. If practicable, each observer should take two photometric readings at each of six spots on the surface being measured. The 24 readings should then be totaled, and this total divided by 24 to obtain the average surface brightness.

5.3.3.6 After determination of the surface brightness, the distance from which the surface can be seen by an experienced observer on a dark night is determined by the following formula:

$$R = K\sqrt{A} \qquad \text{Equation 47}$$

where: R = distance in yards
K = figure from the second column of table XXVII
A = "effective" area of the measured surface in square feet

For example, assume that the average brightness of the "effective" area of figure 77 was 175 millimicro lamberts. From table XXVII, it is determined that K = 173. Substituting in Equation 47:

$$R = 173 \times \sqrt{6.8} = 173 \times 2.61$$

$$R = 450 \text{ yards}$$

TABLE XXVII. Surface visibility range.

Surface brightness (millimicro lamberts)	Visual range of 1 square foot (yards)
16.3	56
20	60
30	70
40	80
50	88
60	96
70	105
80	113
90	121
100	128
110	135
120	142
130	148
140	154
150	160
175	173
200	186
250	211
300	233
400	270
500	303
600	328
700	351
800	373
900	390
1000	406
1100	421
1200	434
1300	447
1400	461
1500	473

When the range of visibility for a surface as determined herein is 1000 yards or less, it is considered to be satisfactory with regard to light security requirements.

5.3.4 Tabulation of data. Required information for instrument calibration shall be recorded on a form as shown on figure 69. Darkened-ship survey results shall be recorded on a form as shown on figure 78.

ACCESS OR OPENING (Location & Number)	INSPECTION			OPERATION			LIGHT TRAP SECURITY
	A	B	C	D	E	F	G

GENERAL

An inspection of the entire hull envelope, main deck and above shall be made to determine the satisfactory light integrity of the ship. Each opening and access shall be checked for direct or indirect light leaks to the exterior (weather). Each authorized access that can be opened or is normally open during darkened-ship conditions, shall be protected by a door switch, light trap, or complete darkened ship lighting circuit.

INSPECTION

Inspect each opening *or access* and enter “SAT” (for satisfactory) or describe unsatisfactory conditions on a separate sheet of paper.

A: Inspect all entrances that are protected by light traps instead of door switches for accessibility, light tightness, sufficient number of black light absorbing surfaces (minimum of two), general illumination in the vicinity of the inner entrance, and absence of light reflecting objects within the light trap. Direct lighting of the entrance should be avoided (no lights within a 5 foot radius of the light trap), these lights shall be shielded.

B. Inspect all sources of light, other than light traps and entrances and openings controlled by door switches, for shielding to prevent leakage to the weather. All ventilation ducts and other miscellaneous openings shall be protected by light excluding hoods or suitable light baffles. Low level illumination (red lights) shall be treated the same as general white light illumination with respect to light tightness. All red standing lights that have possible exposure to the exterior shall be suitably shielded. Indicator and pilot lights on equipment exposed to the weather shall be shielded.

C. Inspect to ensure that the door switches have lock-in devices or short circuiting (by-pass) switches installed to provide for both light ship and darkened-ship conditions.

OPERATION

Operate all door stitches and enter “SAT” (for satisfactory) or describe unsatisfactory conditions on a separate sheet of paper.

D. Operate all door switches, that control compartment and access lights, by opening and closing the doors or closures a sufficient number of times to insure consistent operation of the switches.

E. Check that the doors or closure operate the door switches on opening and closing without allowing any direct light leakage to the exterior or weatker (the closure and closure frames should overlap when the door switches are actuated in order to have minimum light leakage).

F. Check that all lights in the compartment or access that are not on the darkened-ship circuit are controlled by the door switches.

LIGHT TRAP SECURITY

G. Check the light trap security of non-standard light traps in accordance with 5.3.3 and enter “SAT” (for satisfactory) or describe unsatisfactory conditions on a separate sheet of paper.

SH 964-78

FIGURE 78. Tabulation of darkened-ship survey results.

5.4 Navigation and signal lights checkout.

5.4.1 Purpose. The purpose of this test is to ensure that the navigation and signal lights and associated hardware and control equipment have been installed according to drawings and specifications, have sufficient insulation resistance, and operate satisfactorily.

5.4.2 General description. A general description of navigation and signal. lights is provided in 4.7.

5.4.3 Portable instruments. Required information pertaining to portable instruments shall be recorded on a form as shown on figure 69.

5.4.4 Submarines.

5.4.4.1 Visual inspection. Inspect each light in accordance with instructions shown on figure 79.

Light	Visual Inspection				Insulation Resistance			Operation						Arcs of Visibility (Port or Stbd-Angles in Degrees)				Navigation lights location (Dim. in feet and inches)		
	A	B	C	D	Circuit Number	E	F	G	I	J	K	L	M	Required (para 4.7.3)	Max. allowable by Waiver 1/	Measured Stbd	Measured Port	Description of Dim.	Required	Measured
Forward Anchor																		Vert. Hgt: Deck to Fwd Anchor light 3/	Not less than 6'-0"	
Aft Anchor																		Vert. Dist.: Aft Anch. lt to Fwd Anc. light	Not less than 5'-0"	
Masthead														112 1/2	152			Vert. Hgt.: Deck to masthead light	Not less than 15'-0"	
Port Side														112 1/2	120					
Starboard Side														112 1/2	120					
Stern														67 1/2	126 2/			Stern lt Distance forward of stern	20'-0" to 190'-0"	
Identi-fication																		Vert. hgt between Ident and Masthead light	2' Min. 6' Max.	
Search-light																				
Gangway																				

1/ See Title 32, Chapter VI, Subchapter B, Part 706 of the United States Coast Guard publication CG-169, dated August 1, 1972.
2/ With rudder at full left or right. 3/ The forward anchor light may be carried up to a maximum of 60 feet aft of the stem.

VISUAL INSPECTION

Inspect each light and enter "SAT" (for satisfactory) or describe unsatisfactory conditions on a separate sheet of paper.

A. Rig each portable light first to the stowed position and then to the operating position. Check interferences, ease of operation to each position, locking device, correct positioning when rigged out and freedom from rattles. Check arc of train, elevation and depression of the searchlight.

B. Check each light for proper assembly, size and type of lamp, and globe.

C. Check that there are no projections that would obstruct personnel from readily accomplishing lamp replacement.

D. Check cable tags and individual conductor markings for correct inscriptions in accordance with applicable drawings.

INSULATION RESISTANCE

E. Measure, and record in Table above, the minimum insulation resistance (in megohms) to ground of all circuits emanating at the Running and Anchor Lights Panel (see figure 80).

F. With each portable light insulated from the hull and its plug inserted in the associated outboard receptacle, check the resistance between the light case and the ship's hull. The resistance should not exceed 0.1 ohm.

OPERATION

Check the following items to ensure satisfactory operation and record results in Table above.

G. Check the running and anchor lights panel circuit breakers for correct size, type, and mechanical operation.

H. Demonstrate satisfactory operation of the mechanical interlock on the port and starboard supply circuit breakers to the Running and Anchor Lights Panel. The interlock should prevent both supply circuit breakers from being switched to the ON position at the same time. Satisfactory ______________________.

I. *Energize each listed light individually*, first to the primary and then to the secondary filament position, as applicable. Check that each circuit breaker is correctly identified with its corresponding light unit and filament selection position and that those units cannot have the primary and secondary filaments energized at the same time.

J. Energize the identification beacon light and check that flashing occurs at approximately 90 flashes per minute, rotation is smooth and continuous through a complete circle, and arc of visibility is 360°.

K. Operate the searchlight continuously for 15 minutes with the lamp burning at approximate rated voltage. Operate the shutter mechanism to demonstrate satisfactory signaling capability. Demonstrate that the shutter mechanism can be locked open.

L. After dark, determine that the masthead light and identification beacon light are *sufficiently shielded so that no direct or reflected light* is falling into the eyes of bridge personnel.

M. Check satisfactory switching and operation of gangway lights *from each receptacle* (note that gangway lights are not necessarily energized from the Running and Anchor Lights Panel).

SH 964-79

FIGURE 79. Checkout results tabulation of submarine navigation, signal, and gangway lights (work form).

5.4.4.2 Insulation resistance. Measure the insulation resistance in accordance with instructions shown on figure 79.

5.4.4.3 Operation. Operate each light in accordance with instructions shown on figure 79.

5.4.4.4 Arcs of visibility. Check the arcs of visibility in accordance with the following paragraphs and tabulate the results shown on figure 79.

(a) Equipment required:

One pelorus with tripod stand
One 100-foot tape
One 100-foot chalked line

(b) Preparations. Prior to performing the work outlined in (c) and (d), perform the following:

(1) Lay out line "L-L" on dock, portside of submarine (see figure 80).
(2) Lay out line "R-R" on main deck of submarine at a distance "d" forward of side lights (see figure 80).
(3) From submarine, obtain dimension "c".

(c) Checking arcs of visibility:

(1) Masthead light (see figure 80a);
a. Set up portable pelorus and stand on submarine centerline at a point "P".
b. Measure distance "a" from masthead light to point "P".
c. Walk along Line "L-L" until the primary emission of the light source is no longer visible. This establishes point "1". Walk forward from point "1" the distance "a_1", which equals dimension "a" and establish point "2". Swing the pelorus to point "2" and read the angle a. If cut-off is correct, angle will be 112-1/2 degrees. If angle a is less than or greater than 112-1/2 degrees, the error is obtained by subtraction.
d. Repeat step "c." for starboard cut-off, except to opposite hand.

(2) Side lights (see figure 80b):
a. Set up portable pelorus and stand at point "P" as in (c)(l)a. , above.
b. Measure distance "b" from side light to point "P".
c. Walk along line "L-L" until the primary emission of the light source is no longer visible. This establishes point "3". Walk forward from point "3" the distance "b_1", which is equal to dimension "b" and establish point "4". At point "4" lay out a chalkline "P-P" perpendicular to line "L-L". On

line “P-P” measure off dimension "cl”, (in the direction shown) which equals dimension “c”. This establishes point “5”. Swing pelorus to point “5” and obtain angle 13. If cut-off is correct, angle β will read 112-1/2 degrees; if angle β is less than or greater than 112-1/2 degrees, the error is obtained by subtraction.

d. Repeat step “c.” for starboard side light, except to opposite hand.

(3) Stern light (see figure 80c):

a. Set up portable pelorus and stand on submarine centerline at a distance “e”, forward of the stem light.

b. Measure distance “e”.

c. Walk along line “L-L” until the primary emission of the light source is no longer visible. This establishes point “6”. Walk forward from point “6” the distance "e_1", which equals dimension “e” and establish point “7”. Swing pelorus to point “7” and read angle θ. If the cut-off is correct, angle θ will be 67-1/2 degrees. If angle θ is less than or greater than 67-1/2 degrees, the error is obtained by subtraction.

d. Repeat step “c.” for starboard cut-off, except to opposite hand.

(d) Forward side lights cut-offs:

(1) Port and starboard side lights (see figure 80d) :

a. From point "10" (intersection of submarine centerline and line “R-R”), walk outboard to port along line “R-R” until the primary emission of the light source is first observed. This establishes point “11”. Measure distance "C_2". If dimension "C_2" equals dimension "C" the light does not cross the bow. If "C_2" is greater than "C" the light diverges to port. If "C_2" is less than "C" the light will cross over the submarine centerline.

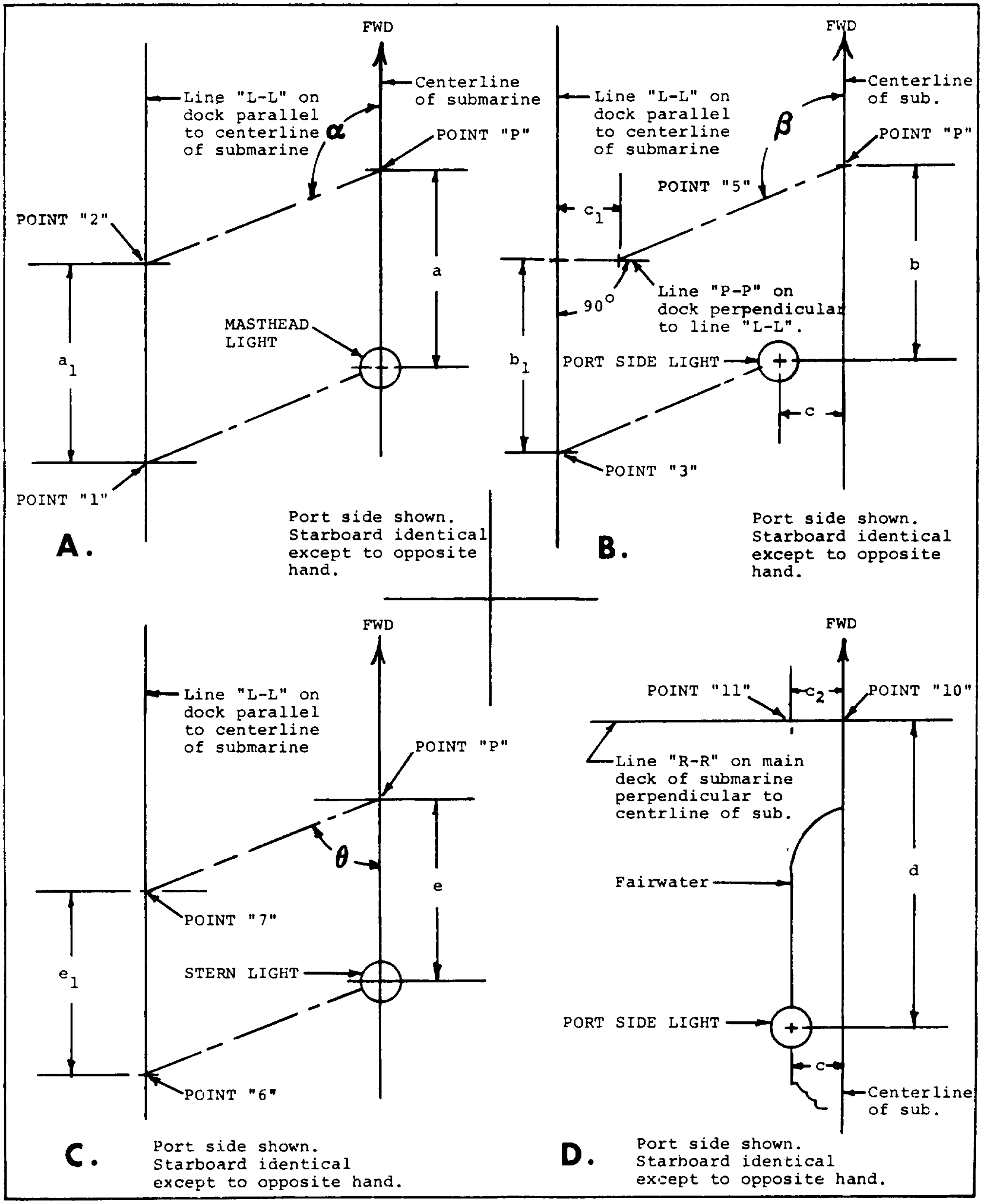
b. Repeat for the starboard side light, except to opposite hand.

(e) Use of data: The data obtained from observations made from (c) and (d) shall be used to make corrections to the installation, if necessary, and to compile the Navigation Lights Conformance Report which must be included in the submarine’s departure report.

(f) Notes:

(1) Inspection of the lights, outlined by paragraphs c and d should be conducted either after dark or during daylight if appropriate sighting equipment is used to see the lights.

(2) This procedure can be used whether the submarine is in drydock or at the berth.



SH 964-80

FIGURE 80. Layouts for checking arcs of visibility of submarine navigation lights.

5.4.4.5 Locations of navigation lights. Measure and record the dimensions of the navigation lights listed on figure 79 to ascertain that their locations conform to the latest directives.

5.4.5 Surface ships.

5.4.5.1 Visual inspections. Inspect all navigation and signal lights and associated equipment in accordance with instructions shown on figure 81. The forward screens of the side lights should be aligned parallel with the centerline of the ship. The outboard edges of the range, masthead and stern light screens should be equidistant from a line parallel to the centerline of the ship. Inspect all searchlights in accordance with instructions shown on figure 82.

LIGHT EQUIPMENT	VISUAL INSPECTION										
	A	B	C	D	E	F	G	H	I	J	REMARKS
Anchor, Aft											
Anchor, Fwd											
Masthead, aft											
Masthead, fwd											
Side, Port											
Side, Stbd											
Stern, White											
Minesweeping											
Task											
Towing Lights											
Breakdown & Man Overboard											
Blinker, Port											
Blinker, Stbd											
Aircraft Warning											
Hull Contour											
Polarity Signal											
Clearance/Obstruction											
Station Keeping											
Station Marking											
ASW											
Stern, Blue											
Wake											
Supply, Control & Telltale Pnl											
Dimmers for Nav & Sig Lts											
Supply & Control Panels											
Switches for Nav & Sig Lts											

A visual inspection shall be made of all running, anchor and signal lights and their associated circuitry for proper installation and workmanship emphasizing the following items during the inspection. Enter "SAT" for satisfactory in Table above or describe unsatisfactory conditions found on a separate sheet of paper. Enter "NA" for items not applicable.

A. Check all navigation and signal lights to determine that they conform to the requirements of 4.7 regarding their location, alignment and obstructions.

B. Check for damage or deterioration of any material and for secureness of mountings and tightness of all fastenings.

C. Rig the portable towing lights and check for interferences, ease of installation, locking devices, and correct positioning. Note that the secondary filament in the lamp is unconnected and that the third conductor of the supply cable is permanently connected to the metal housing of the towing lights on one end, and to the grounding contact of the plug on the other end.

D. Check all electrical equipment for proper, clean and tight connections. Check all electrical circuits for completeness and continuity and the absence of short and open circuits.

E. Check all nameplates for proper inscription and location.

F. Check that all fuses are installed and are the proper type and size.

G. Check that all indicating lamps and buzzers are properly installed and are not damaged in the Supply, Control and Telltale Panel.

H. Check that all switches are properly identified with their corresponding lights.

I. Check that there are no interferences in the way of the lights, that would obstruct personnel from readily accomplishing lamp replacement.

J. Check cable tags and individual conductor markings for correct inscriptions.

SH 964-81

FIGURE 81. Visual inspection of navigation and signal lights - surface ships.

Searchlight Type	Location	Visual inspection								
		A	B	c	D	E	F	G	H	1

An inspection shall be made of each searchlight for proper installation and workmanship with the following items considered during the inspection. Enter "SAT" for satisfactory in Table above or describe unsatisfactory conditions found on a separate sheet of paper.

A. Check for damage *or* deterioration of any material.

B. Check for secureness of mountings and tightness of all screws and fastenings (especially those of the reflector, lamp, focusing mount and lamp support).

C. Check that the trunnion bearings have been lubricated with grease.

D. Check that the reflector and cover glass are clean.

E. Check the five resistors of the ballast box for proper, tight and clean connections.

F. Check the starter assembly for secure wiring and for water tightness of the enclosure.

G. Check that all nameplates are satisfactorily located, inscribed and mounted.

H. Check the train and elevation (45° depression to 105° elevation) of each searchlight.

I. Check the shutter assembly for mechanical wear and ease of operation.

SH 964-82

FIGURE 82. Visual inspection of searchlights - surface ships.

5.4.5.2 <u>Insulation resistance.</u> Measure the insulation resistance in accordance with instructions shown on figure 83. Insulation resistance shall be measured with the system de-energized (circuit breakers opened or fuses removed) at each load side terminal of each circuit emanating at the navigation and signal lights panels. All switches in the circuits shall be closed.

Identificationof Circuit Measured (Feeder # or Main # or Sub-Main #)	Measured Insulation Resistance (Megohms to Ground)					Ambient Temp	Remarks (Include date & any Unusual Conditions)
	(DC)		(AC)				
	(+)	(-)	A	B	C		

Measure the insulation resistance of complete circuits and record the minimum measured value in megohms. Minimum acceptable value of insulation resistance is 1/2 megohm.

The insulation resistance shall be measured with an insulation resistance indicating meter having a full scale reading of 100 or 200 megohms, an open circuit voltage of 500 volts, and s voltage of at least 450 volts across a resistance of one megohm. For methods of conducting these tests, Chapter 300 of the Naval Ship Technical Manual, NAVSEA S9086-KC-STM-000/CH300 RI, may be used as a guide. In cases where the insulation resistance for lighting system circuits is below 1/2 megohm and It is determined that this low value is due to the cable, then the minimum acceptable insulation resistance value for the installed cable shall be determined from MS18297.

SH 964-83

FIGURE 83. Insulation resistance measurements and evaluation (work form).

5.4.5.2.1 Measure the insulation resistance of each searchlight both before and after 15 minutes of operation. This test may be combined with the operation test of 5.4.5.3. Insulation resistance (“cold”) of less than 1 megohm with the searchlight de-energized at the lighting panel is considered unsatisfactory and the searchlight shall not be operated until the trouble has been located and corrected by thorough cleaning, heating and drying.

5.4.5.3 Operation. Operate all navigation and signal lights and their associated equipment in accordance with instructions shown on figure 84.

LIGHT EQUIPMENT	OPERATION								
	A	B	C	D	REMARKS	SEARCHLIGHT TYPE LOCATION	E	F	G
Anchor, Aft									
Anchor, Fwd									
Masthead, aft									
Masthead, fwd									
Side, Port									
Side, Stbd									
Stern, White									
Minesweeping									
Task									
Towing Lights									
Breakdown & Man Overboard									
Blinker, Port									
Blinker, Stbd									
Aircraft Warning									
Hull Contour									
Polarity Signal									
Clearance/Obstruction									
Station Keeping									
Station Marking									
ASW									
Stern, Blue									
Wake									
Supply, Control & Telltale Pnl									
Dimmers for Nav & Sig Lts									
Supply & Control Panels									
Switches for Nav & Sig Lts									

Operate all running, anchor and signal lights from their respective power supply panels a sufficient length of time to demonstrate satisfactory operation emphasizing the following items during the inspection. Enter "SAT" for satisfactory in table above or describe unsatisfactory conditions found on a separate sheet of paper. Enter "NA" for items not applicable.

A. Energize all running, anchor and signal lights and check for proper operation of the lights and switching hardware. Each light shall show a steady (except ASW light) bright light and each switch shall have a smooth operation. Check the blinker, aircraft warning, man overboard, and task lights for proper switching, pulsing, and sequence of operation in accordance with 4.7. Check the ASW light for smooth rotation.

B. Demonstrate the proper functioning of the Supply, Control and Telltale Panel by simulating a burned out filament in the lamp of each running light by removing the proper fuse from the panel. Description and sequence of events of burned out filament are provided in 4.7.3.2.

C. For lights which are controlled by dimmers, check for proper intensity of the running lights (Dim-Bright) and for smooth variable intensity of the task lights on Replenishment-at-Sea delivery ships.

D. After dark, determine that the masthead, range, revolving beam ASW, blinker, and towing lights are sufficiently shielded so that no direct or reflected light is falling into the eyes of the lookout.

E. Operate each searchlight for 15 minutes with lamp burning at approximately rated voltage to determine that installation is satisfactory and that the equipment normally handled during operation does not become too hot to touch.

F. Operate the shutter of each searchlight to determine if it is functioning satisfactorily. It is essential that the shutters close tightly to prevent stray light when in the closed position.

G. Check the focus of each searchlight by switching on the lamp with the shutter locked open and the drum in level positon and directing the beam against a perpendicular flat surface at least 100 feet distant. The spot should be a concentrated image of the arc projected along the axis of the drum. In the event the lamp is out of focus it shall be adjusted in accordance with instruction book furnished with the searchlight.

SH 964-84

FIGURE 84. Operation of navigation and signal lights - surface ships.

5.5 Ship service lighting system checkout.

5.5.1 Purpose. The purpose of this test is to ensure that the ship service Lighting system has been installed according to applicable drawings and specifications, provides sufficient insulation resistance, and operates satisfactorily (also includes emergency lighting system or alternate supply for surface ships).

5.5.2 Portable instruments. Required information pertaining to portable instruments shall be recorded on a form as shown on figure 69.

5.5.3 Visual inspection. Inspect the ship service lighting system in accordance with instructions shown on figure 85.

Compartment	Compartment Number	Lighting Drawing Number	Rev	Visual Inspection A	B	C	D	E

A thorough visual inspection of the overall ship service lighting system shall be made for workmanship and satisfactory installation in accordance with the applicable drawings. Enter "SAT" for satisfactory in Table above or describe the unsatisfactory conditions found on a separate sheet of paper.

A. Inspect all lighting circuits to ensure that all hardware shown on the lighting drawings have been satisfactorily installed and are of the correct type.

B. Check all power and distribution panels for proper type and size of circuit breakers. Check for correct inscriptions on all nameplates. Check that all panels are readily accessible.

C. Check for correct type and size of cables. Chock for proper fastenings, supports, and marking of cables. Check that the cables have not suffered physical damage and deterioration during installation or transit. Ascertain that y splicing of cables that was accomplished has been accomplished in accordance with Drawing 803-5001027 Section 4. Inspect end seals, cable lugs, stuffing tubes, and cable tags for proper materials, workmanship and installation.

D. Check all lights for proper type and size of lamps. Check that all window assemblies, globes and roundels have not suffered any physical damage (cracked, painted, discolored, etc.) during installation. Check for sturdy installation of hangers. Check that there are no interferences in the way of the lights that would obstruct relamping.

E. Check all receptacle circuits for correct size and type of cable, receptacle marking, isolation transformers, and for adequacy of receptacles per compartment.

SH 964-85

FIGURE 85. Visual inspection of ship service lighting system.

5.5.4 Insulation resistance. Measure the insulation resistance of all circuits of the ship service lighting system in accordance with instructions shown on figure 83.

5.5.5 Operation. Operate the ship service lighting system in accordance with instructions shown on figure 86. Operation and grounding circuit checkout of receptacles may be readily accomplished with a special test device which may be constructed as follows: Connect one end of a 3-foot, 3-conductor cable (#14 AWG or larger) to an appropriate plug and the other end to a 120-volt indicating light, housed in an appropriate enclosure. The grounding conductor shall be connected to the ground prong of the plug and to the ship structure (ground) via a bridge or an ohmmeter capable of identifying 0.10 ohm.

Compartment	Equipment	Lighting Drawing		Operation						
		Number	Rev	A	B	c	D	E	F	G

Operate all circuits of the ship service lighting system from their respective power supply a sufficient length of time to demonstrate satisfactory operation emphasizing the following items during the operation. Enter "SAT" for satisfactory in Table above or describe unsatisfactory conditions found on a separate sheet of paper. Enter ‘‘M” for items not applicable.

A. Check all circuit breakers for correct size, type and mechanical operation of all lighting distribution panels. Check that each circuit breaker is correctly identified with its corresponding circuit.

B. Demonstrate satisfactory operation of all manual and automatic bus transfer switches.

C. Check that each switch is correctly identified with its corresponding circuit, operates properly, and is readily accessible.

D. Check for satisfactory operation of all overhead lights. All fluorescent lamps shall show a steady bright light.

E. Check for satisfactory operation of all lights for detail illumination. Detail lights shall properly illuminate the working area or task.

F. Check for satisfactory operation of all relay lanterns by pressure exerted on the pushbutton switch located on the lantern.

G. Check each receptacle for proper operation and grounding. The maximum acceptable ground circuit resistance of each receptacle is 0. 10 ohm.

SH 964-86

FIGURE 86. Operation of ship service lighting system.

5.6 Emergency lighting system checkout - submarines.

5.6.1 Purpose. The purpose of this test is to ensure that the ship emergency lighting system has been installed according to applicable drawings and specifications, provides sufficient insulation resistance, and operates satisfactorily.

5.6.2 Portable instruments. Required information pertaining to portable instruments shall be recorded on a form as shown on figure 69.

5.6.3 Visual inspection. Inspect the emergency lighting system in accordance with instructions shown on figure 87.

5.6.4 Insulation resistance. Measure the insulation resistance of all circuits of the emergency lighting system in accordance with instructions shown on figure 83.

5.6.5 Operation. Operate the emergency lighting system in accordance with instructions shown on figure 87.

Compartment	Equipment	Lighting drawing		Visual Inspection				Operation		
		Number	Rev	A	B	C	D	E	F	G

Conduct a visual inspection and an operation of the emergency lighting system and enter "SAT" for satisfactory in the Table above or describe the unsatisfactory conditions found on a separate sheet of paper.

VISUAL INSPECTION

A thorough visual inspection of the emergency lighting system shall be made for workmanship and satisfactory installation in accordance with the applicable drawings emphasizing the following items:

A. All hardware installed and located according to applicable drawings.

B. Check for proper type, size, fastening, supports, and marking of cables.

C. Check for correct type lights and type and size of lamps and globes.

D. Check for accessibility of fused distribution boxes and switches. Check for proper type and size of fuses and for proper identification of circuits.

OPERATION

Operate the emergency lighting system a sufficient length of time to demonstrate satisfactory operation emphasizing the following items:

E. Energize the emergency lighting system from the ship batteries, and check that all emergency lights operate satisfactorily.

F. With ship service lighting OFF and the emergency lighting ON, ensure that a satisfactory emergency illumination exists in operating areas, manned spaces, and access routes.

G. Demonstrate satisfactory operation of the battery disconnect switches, emergency lighting relays, and fused distribution boxes.

SH 964-87

FIGURE 87. Visual inspection and operation of the emergency lighting system - submarine.

6. MAINTENANCE AND PARTS IDENTIFICATION

6.1 General. The intensity of illumination produced by a lighting installation begins to depreciate at the time the system is placed in operation. This depreciation is due to the decrease in efficiency of the lighting fixtures and in the reflecting efficiency of the surrounding bulkheads and overhead which results from the natural deterioration of the surfaces with age.

6.1.1 The depreciation of the light caused by the aging of the lamps and by the accumulation of dirt, dust, and film on the lamps and fixtures greatly reduces the efficiency of a lighting system. The amount of light lost depends on the extent to which oil fumes, dust, and dirt are present in the surrounding atmosphere, and on the frequency with which the fixtures are cleaned.

6.1.2 In the design of Lighting installations, a maintenance factor is used to compensate for the difference in the average illumination obtained initially (when the lamps and fixtures are new) and the resulting average illumination maintained in service. The amount of depreciation varies from 25 to 45 percent, corresponding to a maintenance factor of 55 to 75 percent and depends on the following: type of fixtures, system of illumination employed, material of the reflecting surfaces (bulkheads and overhead), local conditions of dust and dirt, the frequency of cleaning the fixtures and repainting the bulkheads and overhead. Unless otherwise specified, a maintenance factor of 70 percent is used as specified in 4.1.3.

6.2 Precautions. Safety precautions shall always be observed by persons working around electrical circuits and equipment. Shipboard conditions are particularly conducive to the severity of shock because the body is likely to be in contact with the ship's metal structure and the body resistance may be low because of perspiration or damp clothing. Once a lighting system has been designed and the permanent lighting fixtures have been installed, operation is little more than turning light switches on and off. There also are certain precautions which, if observed by all hands, will result in more effective use of the lighting installation. These are:

(a) Safety precautions shall always be observed by persons working around electric circuits and equipment to avoid injury from:

(1) Electric shock.

(2) Short circuits caused by accidentally placing or dropping a metal tool, flashlight case, or other conducting article across an energized line. The resultant arc and fire, even on relatively low voltage circuits, could cause extensive damage to equipment and serious injury to personnel.

(b) The danger of shock from the 450-volt ac ship service system is reasonably well recognized by operating personnel as attested by the relatively few reports of serious shock received from this source despite its widespread use. On the other hand, a number of shipboard fatalities have been reported due to contact with 115-volt circuits. Despite a fairly widespread, but totally unfounded popular belief to the contrary, low voltage (115-volt and below) circuits are very dangerous and can cause death where the resistance of the body is lowered by moisture and especially when current passes through the chest. Conditions aboard ships affecting the hazard of electric shock are vastly different from those generally found ashore. These conditions and the general subject of electric shock hazard are presented in detail in NAVSEA 0283-236-0000.

(c) Since ship service power distribution systems are designed to be ungrounded, many persons believe it is safe to touch one conductor without causing electrical current to flow. This is not true, because each conductor and all electrical equipment connected to the system have an effective capacitance to ground that provides a current path between the electrical conductors and the ship’s hull. The higher the capacitance, the greater the current flow would be for a fixed body resistance if a conductor is accidentally touched. If the body resistance is low, such as might be caused by wet or sweaty hands, this inherent, unavoidable system capacitance is sufficient to cause a fatal electrical current to pass through the body when one conductor of an ungrounded system is touched while the body is in contact with the ship's hull or other metal equipment enclosures. For this reason, all live electrical circuits should be treated as potential hazards at all times.

(d) Replace burned-out lamps at once.

(e) If a lamp shatters in its socket, de-energize the circuit at the lighting distribution panel before removing the lamp. This is essential since the local switch controlling the fixture may open one side of the line and the other side may still be energized at the fixture, thereby resulting in possible danger of shock to the person removing the broken lamp.

(f) Use the right size lamp in every fixture. A 100-watt lamp in a fixture designed for a 50-watt lamp invariably produces glare.

(g) Install and remove fuses with fuse pullers, not with bare hands or metal pliers.

(h) Wiring and rewiring of fixtures should be accomplished only by qualified electricians and only after authorization has been obtained from the proper authority.

(i) Keep the lighting power supply voltage at its rated value. Low voltage decreases illumination, high voltage causes more frequent lamp burnouts.

(j) Never take a portable or extension light into a hazardous area without first checking to make sure that such light is clearly marked and approved for the particular hazardous atmosphere in that area.

(k) Additional information on Electrical Safety Precautions is to be found in Chapter 300 of the Naval Ships Technical Manual, NAVSHIPS S9086-KC-STM-000/CH 300 RI.

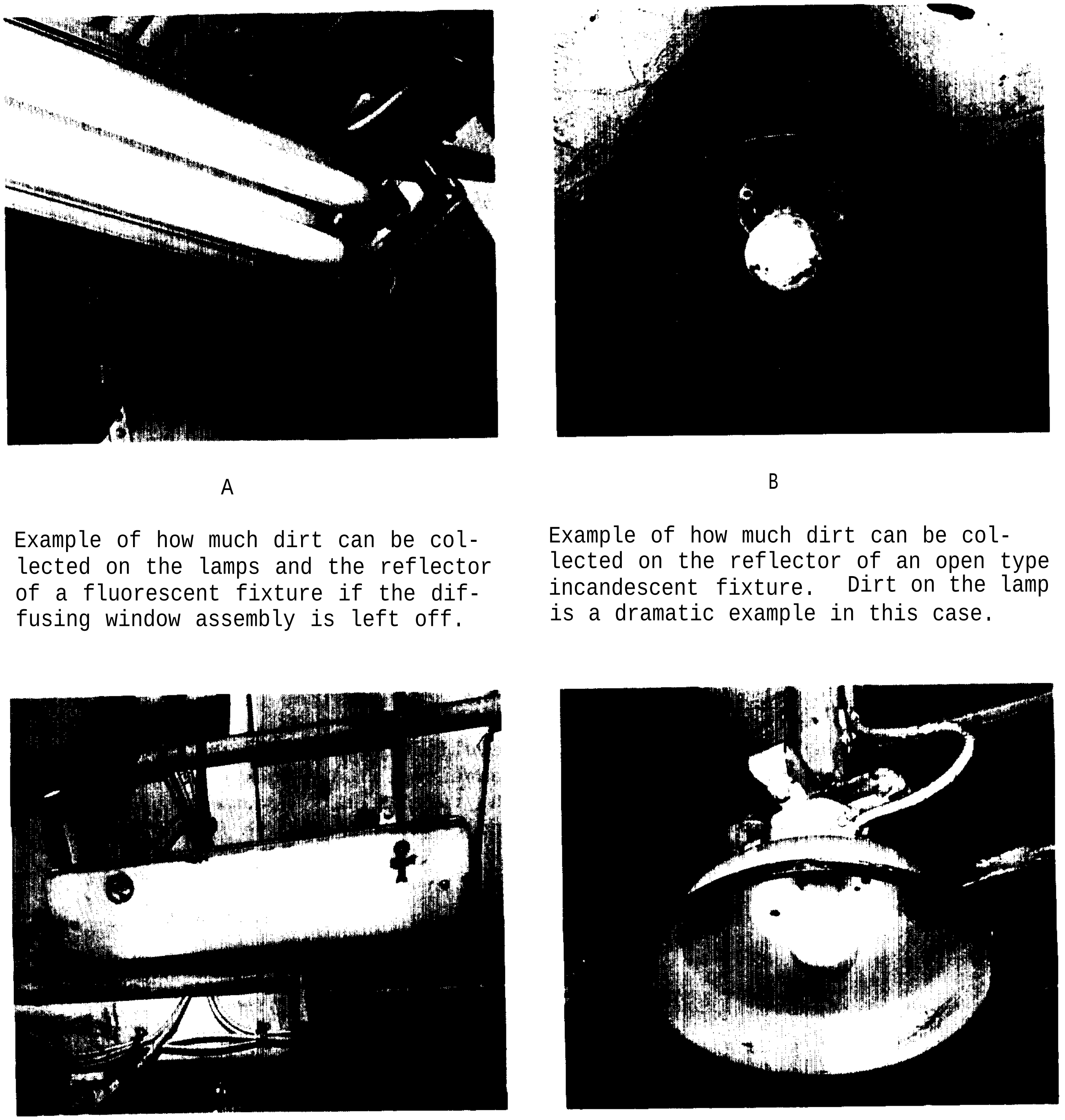
6.3 Causes of light loss.

6.3.1 General. Several factors contribute to light loss, and their effect varies with the activity, type of ventilation and location of the fixtures, and lamp and fixture type used. There are five principal factors that cause light loss in every installation, they are:

(a) Dirt on lamps and fixtures
(b) Dirt on room surfaces
(c) Lamp lumen depreciation
(d) Burnouts
(e) Operating lamp characteristics

The individual effect of each factor varies with the kind of work performed in the area and the atmospheric location of the area. For example, air is dirtier in a machine shop than in an air-conditioned office; the amount and type of dirt found in office air is different from that of machinery spaces.

6.3.2 Dirt on lamps and fixtures. The greatest loss of light can usually be attributed to dirt on lamps and fixtures (see figure 88). In a poorly maintained lighting system, it is common to have light losses of 30 percent or more because of dirt accumulation alone. The amount of light-loss depends on the kind and amount of dirt in the area and the rate of dirt accumulation which is influenced by the fixture type (open or enclosed) and fixture finish.



A

Example of how much dirt can be collected on the lamps and the reflector of a fluorescent fixture if the diffusing window assembly is left off.

B

Example of how much dirt can be collected on the reflector of an open type incandescent fixture. Dirt on the lamp is a dramatic example in this case.

C

Example of "art" and dirt accumulation on the diffusing window assembly of a fluorescent lighting fixture.

D

Example of dirt accumulation on the clear window assembly of an incandescent lighting fixture.

SH 964-88

FIGURE 88. Dirt accumulation on lighting fixtures causes light loss.

6.3.2.1 Fixture construction affects the rate at which dust collects. Open type fixtures (desk lights, berth lights, certain incandescent fixtures, and so forth) collect dirt much faster than those of the enclosed type (most of the overhead totally enclosed and watertight fixtures).

6.3.2.2 Dirt accumulation on a reflecting surface and on lamps can be minimized if the reflector and lamps are sealed from the air, as in dusttight and watertight fixtures.

6.3.2.3 Resistance to dirt accumulation differs with fixture finish. Processed aluminum finishes, while not as high in initial reflectance as enamels, tend to have a slower dirt accumulation rate. Enamels, however, are usually easier to clean. In addition, the ability of reflecting surfaces to reflect light tends to depreciate with age due to the deterioration of enamels or scratched surfaces in specular aluminum reflectors. The transmittance, reflectance and absorption properties of plastic diffusers depreciate and the colors fade with time; aging is accelerated upon exposure to ultraviolet radiation and heat.

6.3.3 Dirt on room surfaces. As specified in 4.2, a large portion of the illumination on the work planes is provided by light which has been reflected one or more times from the overhead bulkheads and deck.

6.3.3.1 Up-to-date lighting practices make use of room finishes with high reflectance values to create a pleasant environment by balancing the brightness and efficiently utilizing the light. Collection of dirt on room surfaces cuts the reflectance value, which in turn reduces the amount of reflected light. Losses due to this effect can be reduced by periodic cleaning and painting of the room surfaces. When repainting compartments, do not spray paint on the reflecting surfaces of lighting fixtures. Paint will materially reduce the reflection factor of the reflecting surfaces and decrease the illumination.

6.3.4 Lamp lumen depreciation. Light output of lamps decreases as they are used. This reduction in light output is called lumen depreciation and is an inherent characteristic of all lamps (see 3.6.3.4.2). Losses due to this effect can be reduced by lamp replacement programs such as planned relamping (see 6.4.3).

6.3.5 Burnouts. Lamp burnouts contribute to loss of light. If lamps are not replaced promptly after burnout, the average illumination level will be decreased proportionately.

6.3.6 Operating lamp characteristics. For proper light output, the lamps must be operated at their rated operating characteristics. A small variation in voltage or fixture ambient temperature, for instance, has a large effect in light output of lamps. Operating lamp characteristics are specified in 3.6.

6.4 Lamp replacement.

6.4.1 Replacement of incandescent lamps.

6.4.1.1 Blackening. The inside of the bulb of an incandescent lamp is gradually blackened by evaporation of the tungsten filament. The light output of a tungsten filament lamp near the end of its normal life is approximately 80 percent of its initial output. This is an inherent characteristic of incandescent lamps and is unavoidable.

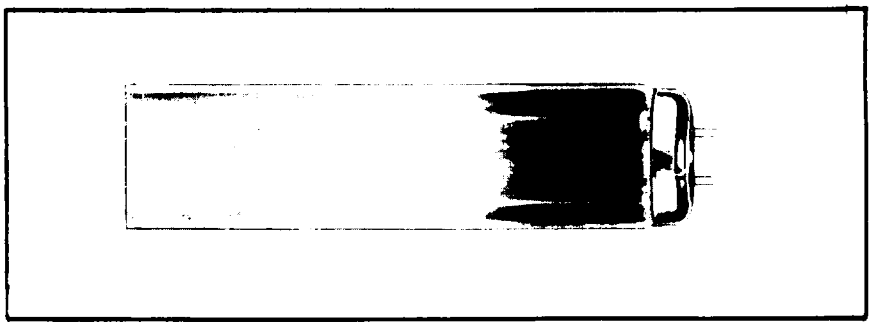
6.4.1.2 When to replace. Persons responsible for replacing burned-out incandescent lamps should examine a number of lamps that have failed in normal service to familiarize themselves with the degree of blackening typical of these lamps. When lamps of this general appearance are found still in service, they should be replaced at the first opportunity. This practice minimizes the inconvenience caused by unexpected lamp failures and contributes to the effectiveness of the lighting system. Good judgement must be used when replacing an old lamp or lamps will be wasted.

6.4.2 Replacement of fluorescent lamps.

6.4.2.1 Cause of trouble. Most of the trouble with fluorescent lamps is caused by worn out or defective starters, or by damaged or expended lamps. The remedy is to replace the starter or the lamp or both.

6.4.2.2 When to replace. A flickering fluorescent lamp should be removed immediately, even if no replacement is at hand. A flickering fluorescent lamp gives no useful light output, and, if allowed to run in this condition, will burn out the starter and ballast.

6.4.2.2.1 Dense blackening, at either end, that extends a distance of about 1 inch from the base indicates that the lamp is near failure (see figure 89). Lamps exhibiting this characteristic should be replaced as soon as possible. If the lamp has not provided the expected length of service when the blackening occurs, it may be due to improper starting, frequent starting with short operating periods, improper ballast, improper supply voltage, faulty wiring, or to a defect in the lamp itself.



SH 964-89

FIGURE 89. Dense blackening at either end indicates that the fluorescent lamp is near failure.

6.4.3 Planned relamping.

6.4.3.1 Periodic planned relamping. A properly planned relamping program will arrest lumen depreciation and prevent many burnouts, thereby improving and maintaining illumination levels. Lamps in a lighting system can be replaced individually as they burn out, or the entire lighting installation can be replaced at one time. Individual replacement is called spot relamping, while mass replacement is termed group relamping.

6.4.3.2 Spot relamping. Spot relamping is a system of replacing burned-out lamps as they fail. This is a tedious process that uses a considerable amount of productive time. A modified spot relamping program, however, can be used in many areas where appearance is not a factor. Here, the lighting system is checked periodically (weekly, for example) and burned-out lamps are replaced. While more efficient than individual relamping, this modified system is usually less economical than group relamping.

6.4.3.3 Group relamping. Group relamping offers five important advantages. The first three apply to all lighting systems; the last two chiefly to fluorescent lamps.

(a) Reduced labor costs. Group relamping saves on labor costs because much of the travel and set-up time required to change lamps individually is eliminated.
(b) More light. Lamps depreciate in light output as they are used. The earlier they are replaced, the higher the maintained illumination will be.
(c) Fewer interruptions. Group relamping can be done at a convenient time, such as while in port, when there will be no interruption of operations. The number of interruptions, to report burnouts or to replace them, is greatly reduced.
(d) Better appearance. Black ends, color variations, and differences in brightness between adjacent old and new fluorescent lamps are common with spot relamping. With group relamping all the lamps are the same age and appearance is uniform.
(e) Less maintenance. Abnormal operating conditions that may occur at the end of fluorescent lamp life can damage starters and ballasts. When most of the lamps are replaced before they reach the end of life, auxiliary equipment lasts longer.

The ideal interval for group relamping would be the point that gives the lowest total annual cost per footcandle. However, a practical method of group relamping uses lamp failures to indicate when to replace all the lamps in the installation. Convenient timing of group relamping is also an important factor.

6.4.3.3.1 Aboard ship there are approximately 7500 operating hours for a given lighting system per year. Since the average life of fluorescent lamps is 7500 hours, relamping once a year for fluorescent lamp installations is a practical interval. With incandescent lamps, group relamping intervals are shorter (2 to 3 months) because of their shorter average life (about 750 hours).

6.4.3.3.2 Group relamping should be accomplished when the lamps in an Installation have been operated for approximately 80 percent of their rated average life. The brightest lamps with the cleanest ends should be set aside for use as replacements for lamps that burn out before the next group relamping. As lamps burn out, they are replaced from the stock of interim replacement lamps. When this stock is exhausted, it signals that the next group relamping is due.

6.4.3.4 Spot versus group relamping. Group relamping is highly desirable and should be used for fluorescent lamp installations where critical and continuous work is involved (offices, chart room, control spaces) and where appearance is a major factor (living, messing, and recreation spaces). Spot relamping should be used for incandescent installations and for fluorescent installations in large areas where each location receives light from several fluorescent lamps, and where appearance of the lighting system is not a major factor.

6.4.4 Disposal of old lamps.

6.4.4.1 Incandescent lamps. Incandescent lamps may be disposed of at sea. For reasons of military security, it is undesirable to leave floating lamps behind; therefore, they shall be broken before they are thrown overboard. Because there is some danger of injury when disposing of old lamps, the following precautions should be followed:

(a) Wear goggles, gloves, and sufficient clothing to prevent injury by flying glass.
(b) Break the lamps topside and over the lee side so that glass fragments carried away by the wind fall into the sea.
(c) Wash down the area where the lamps were broken to get rid of fragments of glass.
(d) Do not dispose of lamps except where there is a considerable depth of water.

6.4.4.2 Fluorescent lamps. Fluorescent lamps contain a small amount of mercury gas (about 15 milligrams (mg) for 8-watt lamps and 30 mg for 20-watt lamps), which is poisonous. No danger arises from unbroken lamps, whether in use or not, because the mercury is sealed inside. There is some danger of injury, however, when disposing of old lamps. Since fluorescent lamps are filled with a very low gas pressure (almost a vacuum), implosions may occur during the breaking of the lamps. Proper equipment should be worn by the operator to protect the eyes and skin from flying glass. If lamps are to be broken, they should be broken outside, or in a well ventilated indoor area. The use of a waste container and local exhaust ventilation will minimize the dispersion of dust and mercury vapor. Fluorescent lamps shall be collected and turned in to a shore based control point for land disposal in a safe and ecologically acceptable manner. No lamps shall be dumped into any body of water including oceans.

6.5 Fixture cleaning.

6.5.1 Authorized personnel. Only qualified electricians shall be allowed to clean fixtures which have to be disassembled and reassembled as part of the cleaning operation.

6.5.2 Factors which affect frequency. There are three basic factors that influence the frequency of cleaning and the methods to be used. These are:

(a) Type of fixture. For cleaning purposes, shipboard lighting fixtures are classified as either open or enclosed. Different cleaning methods are needed for these types.
(b) Location and kind of dust. Lighting fixtures in staterooms and offices are subjected to much less dirt and dust than those in shops, galleys, machinery spaces, and messrooms. There is also a great difference in the kind of dust in these areas. The dust in staterooms and offices is usually of a dry powder type and in the other spaces it is likely to be greasy and adherent. There is practically no dust in air-conditioned spaces because the air is filtered as it circulates; therefore, fixtures in such spaces will seldom need to be cleaned.

6.5.3 Cleaning open type fixtures. The louvers or baffles, the reflector and the lamps of both incandescent and fluorescent open type fixtures should be cleaned periodically. When coated with the dry dust, they should be cleaned, in place, with a soft, dry, lint-free cloth. When the dust is greasy and adherent, it may be necessary to use a mild detergent such as synthetic detergent cleaner NSN G6850-00-282-9702 (diluted in accordance with MIL-D-16791). In this case, the reflector should be removed along with the baffles or louvers and the lamps. After cleaning with a cloth dampened with the detergent, components should be rinsed with a cloth dampened in fresh water and then thoroughly dried with a lint-free cloth. The fixture should not be reassembled until all components are thoroughly dry. If the reflector is of polished aluminum, the polish shall not be impaired.

6.5.4 Cleaning enclosed type fixtures. Enclosed fixtures are designed to be dustproof and the accumulation of dust is normally limited to the outside of the fixture. If the dust is dry and powdery, it can be removed by wiping the outside of the enclosure with a dry lint-free cloth. If the dust is of the greasy and adherent type, use a cloth dampened with detergent (see 6.5.3) and follow this with a rinse using a cloth dampened in fresh water. If the cover or window is of glass or plastic, it should be allowed to dry without wiping to avoid the development of a static charge that would subsequently attract dust particles.

6.5.4.1 Cleaning reflectors in enclosed fixtures. Usually the reflectors in enclosed fixtures do not require cleaning; however, if dry dust does accumulate, it can be cleaned with a soft, dry, lint-free cloth without removing the reflector. If a damp cloth must be used on a reflector because of greasy dirt, remove the reflector before cleaning to avoid the possibility of getting moisture into the socket or lampholders. This procedure will also eliminate the possibility of electric shock. The cleaning and rinsing procedure and the detergent to be used are the same as described for open fixtures. Reassembly in the housing should not be undertaken until all components are thoroughly dry.

6.6 Maintenance of lighting fixtures for general illumination.

6.6.1 Inspection of window assemblies. Window assemblies of shipboard lighting fixtures, besides being the light transmitting medium, also provide for dusttight, dripproof, or watertight integrity of the fixtures. Thus, it is imperative to replace broken or cracked window assemblies (see figure 90) as soon as possible in order to restore the fixtures in their original condition. Window assemblies should never be removed from the lighting fixtures in order to increase light output. Window assemblies for fluorescent and incandescent fixtures are provided in table XXVIII and XXIX respectively.

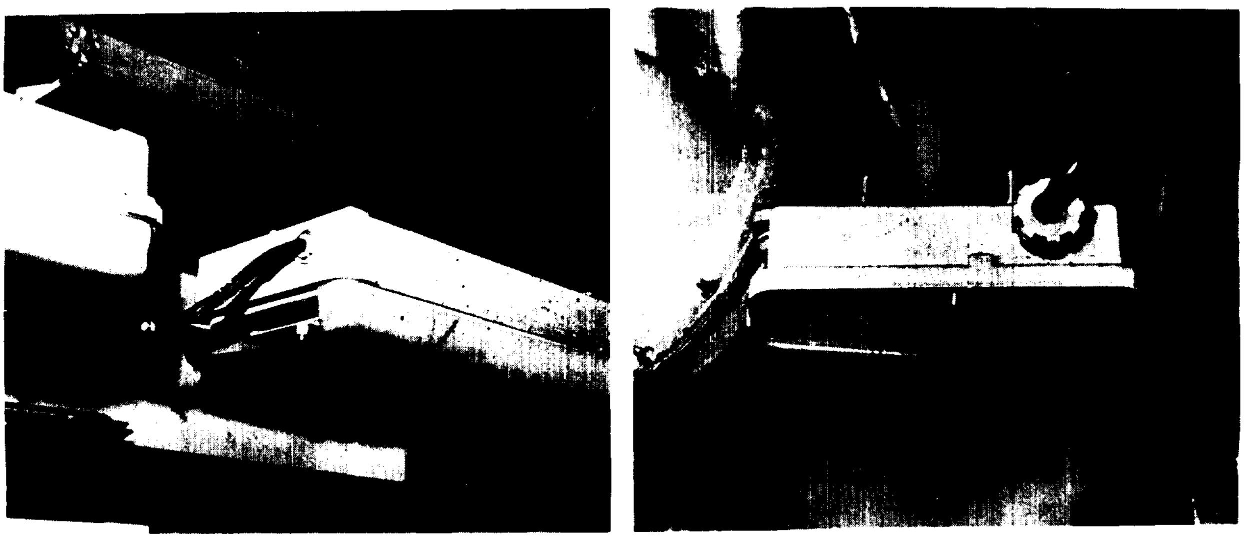


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FIGURE 90. Examples of broken window assemblies which must be replaced immediately.

TABLE XXVIII. Window assemblies for fluorescent lighting fixtures.

Line no.	Description: Specification	Description: Part number	National stock	Used with lighting fixture: Watts	Used with lighting fixture: Symbol number
		White diffusing			
1	MIL-F-16377/14	M16377/14-002	6210-00-647-2276	8	8001, 80.2
2	MIL-F-16377/5	M16377/5-001	6210-00-883-5592	15	338.1, 338.2
3	MIL-F-16377/7	Ml6377/7-001	6210-00-500-0742	16	70.3, 70.4
4	MIL-F-16377/8	M16377/8-001	6210-00-548-0601	20	331.1, 331.2
5	MIL-F-16377/9	M16377/9-001	6210-00-548-0214	24	73.3, 73.4
6	MIL-F-16377/65	M16377/65-001		30	81, 81.1
7	MIL-F-16377/11	M16377/11-001	6210-00-399-7035	40	77.4, 77.5
8	MIL-F-16377/66	M16377/66-001		45	82, 82.1
9	MIL-F-16377/12	M16377/12-001	6210-00-295-2849	60	333.1, 333.2
		Clear and white prismatic			
10	MIL-F-16377/5	M16377/5-002		15	339.1, 339.2
11	MIL-F-16377/7	M16377/7-002		16	336, 336.1
12	MIL-F-16377/8	M16377/8-003		20	347.2, 347.3
13	MIL-F-16377/9	M16377/9-003		24	346.2, 346.3
14	MIL-F-16377/65	M16377/65-002		30	345.2, 345.3
15	MIL-F-16377/11	M16377/11-003		40	344.2, 344.3
16	MIL-F-16377/66	M16377/66-002		45	343.1, 343.2
17	MIL-F-16377/12	M16377/12-004		60	342.2, 342.3
		Clear and white prismatic - diectional			
18	MIL-F-16377/6	M16377/6-002		16	149.4, 14905
19	MIL-F-16377/10	M16377/10-002		32	145.4, 145.5
		Clear black shielded - BBB			
20	MIL-F-16377/12	M16377/12-003	6210-00-725-9030	60	341.1, 341.2
		Clear prismatic			
21	MIL-F-16377/59	M16377/59-001	6210-00-115-9190	8	353
22	MIL-F-16377/58	M16377/58-002	6210-01-047-0209	30	35101, 352
23	MIL-F-16377/58	M16377/58-001	6210-00-115-9197	30	351, 352.1
24	MIL-F-16377/57	M16377/57-001	6210-00-115-9188	60	348
25	MIL-F-16377/57	M16377/57-002	6210-00-115-9189	80,120	349, 350
26	MIL-F-16377/13	M16377/13-001		180	74, 74.1

TABLE XXVIII. Window assemblies for fluorescent lighting fixtures. - Continued

Line no.	Description		National stock number (NSN)	Used with lighting fixture	
	Specification	Part number		Watts	Symbol number
		Red prismatic			
27	MIL-F-16377/59	M16377/59-002		8	353.1
28	MIL-F-16377/13	M16377/13-002		180	75, 75.1
		Blue prismatic			
29	MIL-F-16377/59	M16377/59-003		8	353.2
		Clear white shielded - directional			
30	MIL-F-16377/14	M16377/14-001	6210-00-553-6793	8	79.1, 79.2
31	MIL-F-16377/67	M16377/67-006	6210-00-295-2848	16	149.2, 149.3 1/
32	MIL-F-16377/67	M16377/67-007	6210-00-295-2850	32	145.2, 145.3 1/
		Clear white shielded			
33	MIL-F-16377/67	M16377/67-002	6210-00-814-5913	20	347, 347.1 1/
34	MIL-F-16377/67	M16377/67-003		24	346, 346.1 1/
35	MIL-F-16377/67	M16377/67-004	6210-00-814-8360	40	344, 344.1 1/
36	MIL-F-16377/67	M16377/67-005	6210-00-814-5914	60	342, 342.1 1/

1/ These symbol numbers are obsolete. They have been superseded by corresponding symbol numbers shown for clear and white prismatic - directional windows and clear and white prismatic windows respectively for fixtures of same wattage.

TABLE XXIX. Window assemblies, globes, and roundels for incandescent lighting fixtures.

Line no.	Description		National stock number (NSN)	Color	Used with lighting fixture	
	Specification	Part number			Watts	Symbol no.
1	MIL-F-16377/20	M16377/20-001	6210-00-897-6976	Clear	50	65
2	MIL-F-16377/21	M16377/21-001	6210-00-897-5652	Clear	100	89
3	MIL-F-16377/23	M16377/23-001	6210-00-299-2893	Clear	200	57, 103
4	MS24489	MS24489-1	6210-00-633-6886	Red	200	69
5	MIL-F-16377/25	M16377/25-002	6210-00-237-8775	Clear	110	48.2
6	MIL-F-16377/25	M16377/25-003	6210-00-399-6316	Red	110	68.2
7	MIL-F-16377/26	M16377/26-002	6210-00-635-8819	Clear	110	112
8	MIL-F-16377/26	M16377/26-003	6210-00-635-8820	Red	110	113
9	MIL-F-16377/27	M16377/27-001	6210-00-702-5773	Clear	50	92.2
10	MIL-F-16377/27	M16377/27-002	6210-00-914-4152	Red	50	93.2
11	MS24489	MS24489-1	6210-00-633-6886	Red	300	303
12	MIL-F-16377/62	M16377/62-003	6230-00-237-8021	Clear	500	30001
13	MIL-F-16377/62	M16377/62-002	6230-00-237-8023	Red	500	300

6.6.2 Inspection of internal components. Internal components and wiring should be periodically checked for deterioration resulting from deformation, wear, insulation failure, and so forth. Broken or cracked lampholder or starter sockets must be replaced immediately since these parts carry live electrical circuits which could become a hazard to maintenance personnel while they are servicing, cleaning, or checking out the lighting fixtures. Tables XXX and XXXI provide information as to the standard parts used in the construction of fluorescent lighting fixtures. Lampholder, NSN 6250-939-8126, in accordance with MIL-L-970 and MIL-L-970/6, is primarily used for incandescent fixtures utilizing the medium screw base lamp.

TABLE XXX. Standard parts used for fixtures using the 8-watt fluorescent lamp.

Name	Specification or Military part number	National stock number (NSN)	Remarks
Lamp	W-L-116/3	6240-00-299-5546	Industry no. F8T5/CW
Lamplock	M16377/40-001	6250-00-399-7039	
Lampholder	MIL-L-970/l0	6250-00-377-8590	Standard
Lampholder	MIL-L-970/15		Heat resistant
Starter socket	MIL-L-970/13	6250-00-295-2738	Standard
Starter socket	MIL-L-970/19		Heat resistant
Starter	FS-5, type III, W-S-755	6250-00-299-5962	Ac, simple glow switch
Starter	AT-58, type IV, W-S-755	6250-00-283-9904	Dc, thermal switch
Ballast	M16377/45-001	6250-00-295-2735	60-Hz standard
Ballast	M16377/45-002		60-Hz heat resistant
Ballast	M16377/45-003		400-Hz standard
Ballast	M16377/45-004		400-Hz heat resistant
Shockmount	M16377/41-009 or M16377/41-010	6210-00-973-1747, 6210-00-973-1748	Less than 10 pounds Over 10 pounds
Red filter tube	M16377/42-001	6210-00-399-6297	Red illumination
Blue filter tube	M16377/42-002	6210-00-503-2810	Blue illumination

TABLE XXXI. Standard parts used for fixtures using 15- and 20-watt fluorescent lamps.

Name	Specification or military part number	National stock number (NSN)	Remarks
Lamp - 15-watt	W-L-116/13	6240-00-583-3668	Industry no. F15T12/CW for mirror and general illumination
Lamp - 20-watt	W-L-116/16	6240-00-152-2996	Industry no. F20T12/CW for general illumination
Lamp - 20-watt	W-L-116/18	6240-00-152-2993	Industry no. F20T12/D for BBB
Lamp lock	M16377/40-002	6250-00-399-7040	
Lampholder	MIL-L-970/11	6250-00-284-0981	Standard
Lampholder	MIL-L-970/18		Heat resistant
Starter socket	MIL-L-970/13	6250-00-295-2738	Standard
Starter socket	MIL-L-970/19		Heat resistant
Starter	FS-2, type III, W-S-755	6250-00-299-2884	Ac, simple glow switch
Starter	AT-2, type IV, W-S-755	6250-00-884-2103	Dc, thermal switch
Ballast	M16377/44-001	6250-00-569-9502	60-Hz standard
Ballast	M16377/44-002		60-Hz heat resistant
Ballast	M16377/44-003		400-Hz standard
Ballast	M16377/44-004		400-Hz heat resistant
Shock mount	M16377/41-009 or M16377/41-010	6210-00-973-1747 6210-00-973-1748	Less than 10 pounds Over 10 pounds
Red filter tube	M16377/42-003	6210-00-295-2838	For 20-watt lamp
Red filter tube	M16377/42-004	6210-00-834-1621	For 15-watt lamp
Blue filter tube	M16377/42-005	6240-00-441-5138	For 20-watt lamp
Switch, toggle DPST	MS16569-1	5930-00-719-9659	Installed in fixtures

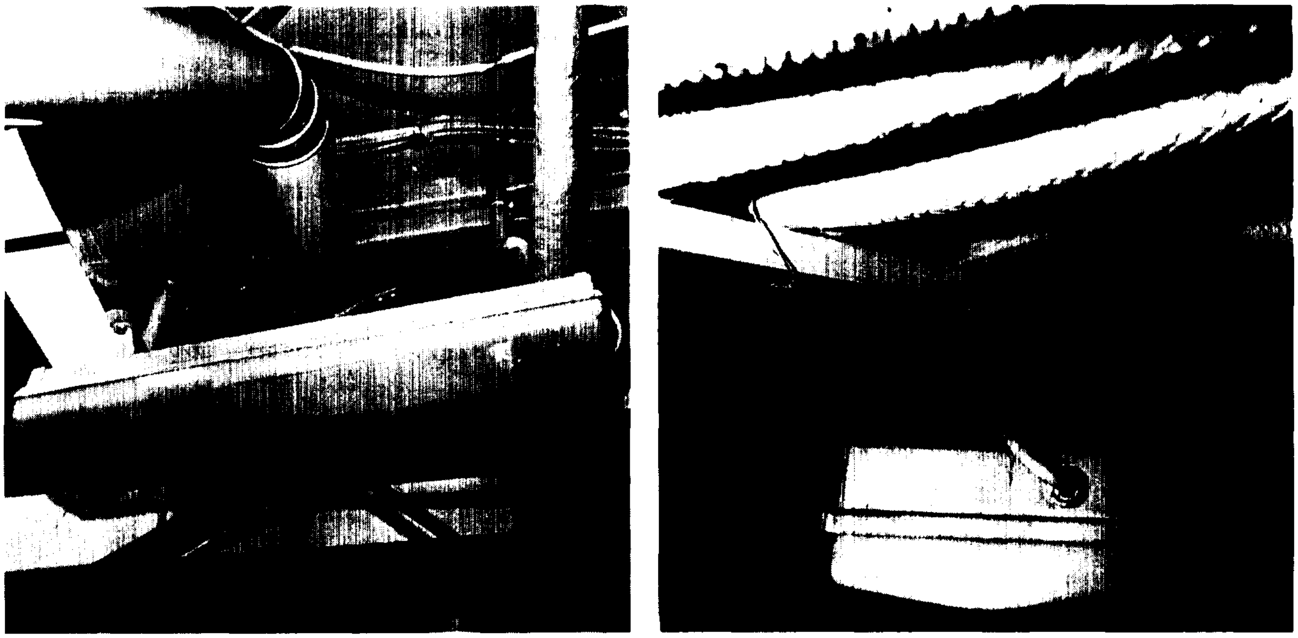

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FIGURE 91. Example of badly distorted shock mounts which must be replaced immediately.

6.6.3 Inspection of shock mounts. Shock mounts for lighting fixtures are expendable (like fuses are for electric circuits) and should be replaced if badly distorted (see figure 91). Following a severe shock, all lighting fixtures in the immediate area should be inspected for shock mount distortion. The shock mounts found seriously out of line may be bent back into shape as a temporary expedient until they can be replaced. Replacement shock mounts should be of the same configuration as those originally installed on the fixture. Shock mount replacement data for fluorescent fixtures are provided in tables XXX and XxXI. In general, mild steel shock mounts (NSN 6210-973-1747, shallow) should be used as replacements on all lighting fixtures installed throughout the ship except for minesweepers, localized areas requiring a low magnetic signature, or on weather decks where the use of aluminum or brass shock mounts should be continued.

6.7 Explosion proof extension lights.

6.7.1 Relamping. When a burnout occurs in an explosion proof light, it should be returned to the electric shop for relamping by authorized personnel. Under no circumstances should any person attempt relamping this light in areas containing explosive vapors. The size lamp to be used for relamping shall be as indicated on the name plate. Under no circumstances should a higher wattage lamp be used with these lights.

6.7.2 Inspection. Periodically inspect all explosion proof portable or extension lights as follows:

(a) Examine cable sheath. If frayed or damaged, replace with new cable.
(b) Make sure guard is not damaged. If damaged beyond repair, replace with new guard. (Never use light without guard.)
(c) Make sure guard is tightly secured to the handle. This assures a good ground connection and watertightness of the light.
(d) Check for continuity of ground circuit between guard and ground contact on plug tip.
(e) Check plug and tip. If damaged, replace with new tip or plug assembly.
(f) Upon relamping the explosion proof extension light, make sure all components are tight upon reassembly.

6.7.3 Acceptable lights. Presently, four explosion proof and watertight extension lights for 115-volt power supply operation are available in the Navy supply as follows:

(a) Symbol 306.2, NSN 9G6230-00-244-3996. This is an 8-watt fluorescent light furnished with a 50-foot, three-conductor cable. This light has a much lower operating temperature than the incandescent types, and it can be used where a cool light is desired. This light should not be used in conjunction with work on the internal surfaces (in other words, surface in contact with the fluid) of naval nuclear propulsion systems. The following repair parts are available for this light:

Globe	NSN 9G6230-00-451-6450
Lamp	NSN 9G6240-00-299-5546
Lamp lock	NSN 9G6250-00-399-7039
Lampholder	NSN 9G6250-00-377-8590
Starter socket	NSN 9G6250-00-295-2738
Starter	NSN 9G6250-00-299-5962
Ballast	NSN 9G6250-00-295-2735

Should the fluorescent lamp break, do not replace until adequate overboard ventilation is established.

(b) Symbol 290, NSN 9G6230-00-283-9671. This is a 25-watt incandescent light furnished with a 100-foot, three-conductor cable. It uses lamp NSN 9G6240-00-295-2005, and is intended for use as an inspection light where a relatively small diameter light is required. Its outside diameter is less than 1-13/16 inches.

(c) Symbol 291, NSN 9G6230-00-095-3674. Same as symbol 290 with the addition of a 30-inch extension handle. This light is intended for use in examing the interior of aircraft wing tanks, barrels, drums and ship ullage.

(d) Symbol 286, NSN 9G6230-00-701-2947. This is a 100-watt incandescent light with a 50-foot, three conductor cable for use as a general multipurpose extension light aboard ship. It uses lamp NSN 9G6240-00-246-5052.

All these lights are classified as watertight, since they meet the standard 3-foot submergence test. They are also considered explosion proof for class I, group C (symbol 286) and group D (symbols 206.2, 290, 291 and 286) atmospheres as defined by the National Electrical Code. The 1981 edition of the National Electrical Code lists the following atmospheres for the group indicated:

Group C atmospheres

acetaldehyde	ethylenimine
allyl alcohol	ethyl mercaptan
n-butyraldehyde	ethyl sulfide
carbon monoxide	hydrogen cyanide
crotonaldehyde	hydrogen sulfide
cyclopropane	morpholine
diethyl ether	2-nitropropane
diethylamine	tetrahydrofuran
epichlorohydrin	unsymmetrical dimethyl hydrazine
ethylene	(UDMH 1, l-dimethyl hydrazine)

Group D atmospheres (chemical)

acetic acid (glacial)
acetone
acrylonitrile
ammonia
benzene
butane
l-butanol (butyl alcohol)
2-butanol (secondary butyl alcohol)
n-butyl acetate
isobutyl acetate
di-isobutylene
ethane
ethanol (ethel alcohol)
ethyl acetate
ethylacrylate (inhibited)
ethylene diamine (anhydrous)
ethylene dichloride
ethyleneglycol monomethyl ether
gasoline
heptanes
hexanes
isoprene
isopropyl ether
mesityl oxide
methane (natural gas)
methanol (methyl alcohol)
3-methyl-l-butanol (isoamyl alcohol)
methyl ethyl ketone
methyl Isobutyl ketone
2-methyl-l-propanol (isobutyl alcohol)
2-methyl-w-propanol (tertiary butyl alcohol)
petroleum naptha
pyridine
octanes
pentanes
l-pentanol (amyl alcohol)
propane
l-propanol (propyl alcohol)
2-propanol (isopropyl alcohol)
propylene
styrene
toluene
vinyl acetate
vinyl chloride
xylenes

The following group D atmospheres are commonly found aboard ship: Gasoline, petroleum naptha, alcohol, acetone, lacquer solvent vapors, and natural gas. In areas in which potentially explosive atmospheres might occur, only approved extension lights shall be used. It should be emphasized that the symbol 286 light is the only one acceptable for group C hazardous atmospheres, and that all four lights mentioned above are the only ones acceptable for use in group D hazardous atmospheres.

6.8 Inspection of extension light for small boats. The acceptable light for small boats and craft with a 12- or 28-volt power supply is symbol 302.2, NSN 9G6230-00-548-0199. It should be noted that this light is not explosion proof and is not acceptable for use in any hazardous atmosphere. Periodically, this light should be inspected for damage of the cable, guard, globe and plug. If damaged, replace as appropriate. The following repair parts are available for this light:

Repair part	NSN
Globe	9G6230-00-399-6317
Guard	9G6230-00-215-6356
Lamp (12-16 volts)	9G6240-00-153-6514
Lamp (24-28 volts)	9G6240-00-155-8726

6.9 Battery powered emergency lights.

6.9.1 Damage control flood lanterns.

6.9.1.1 How to check charge. The degree of charge of the storage batteries in portable flood lanterns can be determined by observing the charge indicator balls through the plastic windows in the battery case. When a cell is fully charged, all three indicator balls float at the surface of the electrolyte in the cell. As the cell discharges, the indicator balls sink in the following order:

(a) A green ball sinks when approximately 10 percent of the cell capacity has been discharged.
(b) The white ball sinks when the cell is 50 percent discharged.
(c) The red ball sinks when the cell is 90 percent discharged.

6.9.1.2 When and how to charge. Batteries should be charged as soon as possible after the green ball sinks. Since a battery discharges at a slow rate even when not in use, a check should be made at least once a week to see if the green indicator ball is floating. If it is not, the battery should be charged. Dc must be used for charging. If ac only is available, a suitable rectifier must be used. Cells should be charged at a rate of 1-1/2 to 2 amperes until all three indicator balls are floating. This will require from 20 to 25 hours if the battery is completely discharged. Charging should not be continued beyond 1 hour after the charging voltage has remained constant at 10 volts.

6.9.1.3 Addition of water. Pure water should be added, when necessary, to keep the electrolyte level at the indicator line marked on the front of the cell. Do not overfill. Overfilling nullifies the nonspill feature of the battery and may cause electrolyte to spurt out through the vent tube. Furthermore, if the electrolyte level is not at the indicator line, the charge indicator balls will not correctly indicate the condition of charge in the battery.

6.9.2 Relay lanterns.

6.9.2.1 Batteries. The dry batteries in the permanently installed relay lanterns should be checked at least once each month by observing the brightness of the lamp. When operated to on, if emitted light is dim, the batteries should be replaced immediately. Lanterns located where the normal temperature is consistently higher than 90°F should be checked once a week. For example, the high temperature in boiler rooms may require that the batteries be replaced weekly in order to ensure adequate service from the lanterns.

6.9.2.2 Relays. In addition to the check of the batteries, the operation of the relay in the lantern should be checked at least once each quarter. Relay operation is satisfactory if the lighting circuit deenergizes when pressure is exerted on the push switch located on the relay housing.

6.9.3 Flashlights for repair stations. Flashlights required for repair stations shall be checked every 6 weeks by operating the flashlight and observing the brightness of the lamp. A dim lamp indicates the batteries need replacing.

6.10 Darkened-ship condition.

6.10.1 Light traps. Inspect the light traps to determine that they are free of all obstructions. A light colored object of any appreciable size placed in a light trap might be sufficiently illuminated by the interior lighting to be visible beyond the safe limit.

6.10.2 Door switches.

6.10.2.1 Check. The check on door switches should be made at night during darkened-ship conditions. Station a dark-adapted observer on deck to watch for light, and have another man open and close the door. No light should be detectable if the door switch is operating properly.

6.10.2.2 -Adjustment. If a door switch is not operating properly, it should be adjusted, as follows:

(a) Close and dog the door shut.
(b) On door switches that have a lock knob on the arm:

   (1) Move the arm (away from the door) as far as it will go.
   (2) Depress the knob labeled LOCK, hold it in, and let the arm return as far as it will go.
   (3) With the knob depressed, turn the threaded push rod until the button on its end meets the striker plate on the door, and continue for an additional 3/4 turn.
   (4) Release the LOCK knob.

(c) On door switches that do not have a LOCK knob:

   (1) Remove the cover on the door switch enclosure.
   (2) Turn the threaded push rod until the internal quick-break latch drops into place, and then turn an additional 3/4 turn.

6.11 Navigation and signal lights.

6.11.1 Check of alignment and location. The alignment of navigational lights on a ship or a craft and their locations shall be checked to measure compliance with the rules for preventing collisions at sea when considered necessary by Fleet personnel. Such factors as time elapsed since last previous check of navigational lights, rough weather encountered, topside alterations accomplished or scheduled, and so forth, should be considered when determining the need for rechecking the location, alignment and freedom from obstruction of navigational lights. Information on arcs of visibility and location is provided in 4.7.

6.11.2 Lamp replacement.

6.11.2.1 Bifilament lamps. Upon indication of primary filament burnout, the lamp should be replaced at the earliest convenient opportunity. Lights using these lamps are side, range, stern, and so forth.

6.11.2.2 Lamp cluster. Some navigational and signal lights employ a cluster of lamps. Lights in this category are aircraft warning, man-overboard and breakdown, ships task, and blinker lights. Upon experiencing a single lamp failure, all of the lamps in cluster should be replaced.

6.11.3 Supply, control and telltale panel. A weekly check to ascertain that the automatic features of the telltale panel are in good working condition may be made by simulating a burnout of the primary filament. This may be done by pulling the fuse of the primary filament circuit in the telltale panel. Operation of the supply, control. and telltale panel is provided in 4.7.

6.11.4 Multi-purpose signal light. These lights should be periodically inspected in accordance with the instructions furnished with the kit for the care, operation, and maintenance of the equipment.

6.11.5 Subject term (key word) listing.

Candlepower
Footcandle
Illumination, blue
Illumination, red
Lamps
Lighting
Lunun output

Preparing activity:
Navy - SH
(Project 62GP-N001)

APPENDIX A

PHOTOMETRIC DATA FOR STANDARD LIGHTING FIXTURES

10. GENERAL

10.1 Scope. This appendix provides computer-generated light output data using typical distribution curves, and coefficients of utilization calculated by the zonal and cavity method for the more common lighting fixtures used for general illumination.

10.2 Application. The light distrtibution data presented herein is a required input to the overall design procedure; however, this appendix is not considered a mandatory part of the military handbook since the data can be derived through calculations using the equations presented in the handbook.

20. REFERENCED DOCUMENTS

Military Specifications:

MIL-F-16377/22 - Fixtures, Lighting, Incandescent, General Lighting, 200 Watts, 115 Volts, Dripproof 15 Degrees, Symbol 94.1.

MIL-F-16377/36 - Fixtures, Lights, Incandescent, General Lighting, 21 Candlepower or 25 Watts, 115 Volts, Watertight, Symbols 95.1, 96.1, 97.1 and 98.1.

MIL-F-16377/64 - Fixtures, Lighting; Incandescent, General Lighting, Decorative, 150 Watts, 120 Volts, Dripproof 15 Degrees, Symbol 67.

30. DEFINITIONS

Not applicable.

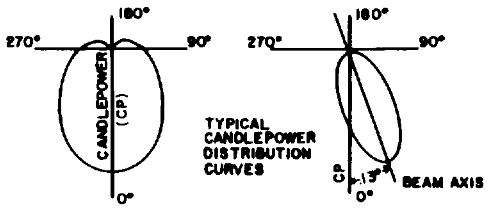
40. GENERAL DESIGN CONSIDERATIONS

40.1 Photometric data. The photometric data consists of candlepower distribution, footcandle distribution and coefficients of utilization for the common lighting fixtures specified in MIL-F-16377 and associated specification sheets.

50. DETAIL DESIGN CONSIDERATIONS

Not applicable.

I CANDLEPOWER DISTRIBUTION



DIFFUSING

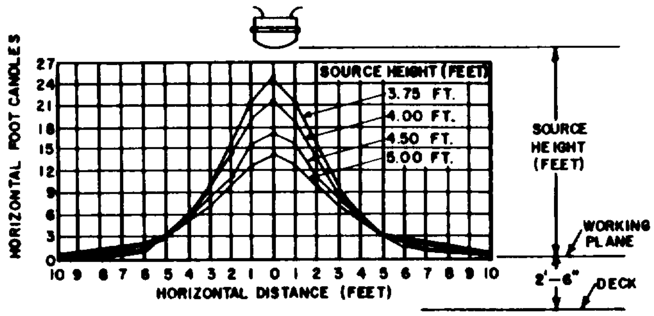
DIRECTIONAL

CLEAR PRISMATIC
CLEAR AND WHITE PRISMATIC

Note: Candlepower curve is symmetrical to beam axis. Candlepower values in table are for angles (13° + angle shown).

:	0	5	10	15	20	25	30	35	40	45	50	55
'	137	137	135	133	130	125	120	115	108	103	96	90
`	60	65	70	75	80	85	90	95	100	105	110	115
'	83	75	67	60	50	40	33	28	25	20	17	10

II FOOTCANDLE DISTRIBUTION



TYPICAL FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT (FEET)	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	3.32	2.95	2.20	1.45	0.91	0.59	0.38	0.26	0.18	0.11	0.10
4.00	2.92	2.63	2.02	1.40	0.92	0.59	0.39	0.27	0.19	0.14	0.10
4.25	2.59	2.35	1.87	1.32	0.89	0.59	0.40	0.28	0.20	0.14	0.11
4.50	2.31	2.11	1.57	1.25	0.86	0.59	0.41	0.29	0.20	0.15	0.11
4.75	2.07	1.91	1.56	1.19	0.84	0.59	0.41	0.29	0.21	0.15	0.12
5.00	1.87	1.73	1.46	1.12	0.81	0.58	0.41	0.30	0.21	0.16	0.12
5.25	1.69	1.58	1.35	1.06	0.79	0.57	0.41	0.30	0.22	0.16	0.13
5.50	1.54	1.45	1.26	1.00	0.76	0.56	0.41	0.30	0.22	0.17	0.13
5.75	1.41	1.33	1.17	0.95	0.73	0.55	0.41	0.30	0.23	0.17	0.13
6.00	1.30	1.23	1.09	0.90	0.70	0.53	0.40	0.30	0.23	0.18	0.13

III COEFFICIENTS OF UTILIZATION

% EFFECTIVE CEILING CAVITY REFLECTANCE RC →	80				70				50			30			10			0
% WALL REFLECTANCE RW →	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
ROOM CAVITY RATIO RCR ↓	EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 - ZONAL CAVITY METHOD																	
1	77	73	69	65	74	70	67	64	66	63	60	61	59	57	57	56	54	52
2	69	62	56	52	66	60	55	50	56	52	48	52	49	46	49	46	44	42
3	63	54	48	42	60	52	46	42	49	44	40	46	42	38	43	40	37	34
4	57	48	41	35	55	46	40	35	43	38	33	41	36	32	38	34	31	29
5	52	42	35	30	50	41	34	29	38	32	28	36	31	27	34	29	26	24
6	48	37	30	25	46	36	30	25	34	28	24	32	27	23	30	26	22	21
7	44	33	27	22	42	32	26	21	30	25	21	29	24	20	27	23	19	18
8	40	30	23	19	39	29	23	18	27	22	18	26	21	17	24	20	17	16
9	37	27	20	16	36	26	20	16	25	19	15	23	18	15	22	18	14	13
10	35	24	18	14	33	24	18	14	22	17	13	21	16	13	20	16	13	11

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 5A

MIL-F-16377/5 15W FLUOR SYM 338.1 AND 338.2 WHITE DIFFUSING
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	137	137	135	133	130	125	120	115	108	103	96	90

ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	83	75	67	60	50	40	33	28	25	20	17	10

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	9.74	8.53	5.96	3.72	2.28	1.42	0.91	0.60	0.41	0.29	0.21
4.00	8.56	7.61	5.52	3.60	2.28	1.44	0.94	0.63	0.43	0.31	0.22
4.25	7.58	6.83	5.12	3.46	2.24	1.45	0.97	0.66	0.46	0.33	0.24
4.50	6.77	6.16	4.75	3.31	2.19	1.46	0.98	0.68	0.48	0.34	0.25
4.75	6.07	5.58	4.41	3.15	2.14	1.46	1.00	0.70	0.50	0.36	0.26
5.00	5.48	5.07	4.10	3.00	2.09	1.46	1.01	0.71	0.51	0.37	0.28
5.25	4.97	4.63	3.82	2.86	2.04	1.44	1.01	0.72	0.52	0.39	0.29
5.50	4.53	4.25	3.57	2.72	1.99	1.42	1.02	0.73	0.54	0.40	0.30
5.75	4.14	3.91	3.33	2.58	1.93	1.39	1.01	0.74	0.55	0.41	0.31
6.00	3.81	3.60	3.11	2.45	1.86	1.36	1.01	0.74	0.55	0.42	0.32

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	77	73	69	65	74	70	67	64	66	63	60	61	59	57	57	56	54	52
2	69	62	56	52	66	60	55	50	56	52	48	52	49	46	49	46	44	42
3	63	54	48	42	60	52	46	42	49	44	40	46	42	38	43	40	37	34
4	57	48	41	35	55	46	40	35	43	36	33	41	36	32	38	34	31	29
5	52	42	35	30	50	41	34	29	38	32	28	36	31	27	34	29	26	24
6	46	37	30	25	46	36	30	25	34	28	24	32	27	23	30	26	22	21
7	44	33	27	22	42	32	26	21	30	25	21	29	24	20	27	23	19	18
8	40	30	23	19	39	29	23	18	27	22	18	26	21	17	24	20	17	15
9	37	27	20	16	36	26	20	16	25	19	15	23	18	15	22	18	14	13
10	35	24	18	14	33	24	18	14	22	17	13	21	16	13	20	16	13	11

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 5B

MIL-F-16377/5 15W FLUOR SYM 339.1 AND 339.2 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	158	157	156	154	151	147	145	141	135	126	114	104

ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	98	90	84	80	64	50	31	20	10	8	5	4

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	11.24	9.88	7.12	4.63	2.77	1.65	1.06	0.71	0.49	0.35	0.26
4.00	9.87	8.81	6.55	4.44	2.78	1.70	1.09	0.74	0.52	0.37	0.28
4.25	8.75	7.90	6.03	4.25	2.76	1.73	1.12	0.77	0.54	0.39	0.29
4.50	7.80	7.12	5.57	4.04	2.72	1.76	1.15	0.79	0.56	0.41	0.30
4.75	7.00	6.45	5.16	3.84	2.67	1.77	1.17	0.81	0.58	0.43	0.32
5.00	6.32	5.86	4.79	3.64	2.60	1.78	1.19	0.83	0.60	0.44	0.33
5.25	5.73	5.35	4.45	3.45	2.52	1.77	1.21	0.84	0.61	0.46	0.34
5.50	5.22	4.91	4.14	3.26	2.44	1.75	1.22	0.86	0.62	0.47	0.36
5.75	4.78	4.51	3.86	3.08	2.36	1.73	1.23	0.87	0.63	0.48	0.37
6.00	4.39	4.16	3.60	2.91	2.27	1.70	1.24	0.88	0.65	0.49	0.38

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	89	84	79	75	86	81	77	73	77	73	70	73	70	67	69	67	65	62
2	80	71	65	59	77	69	63	56	66	60	56	62	56	54	59	55	52	50
3	72	62	54	48	70	60	53	47	57	51	46	54	49	45	51	47	43	41
4	66	55	46	40	63	53	46	40	50	44	39	48	42	38	45	41	37	34
5	60	48	40	33	58	47	39	33	44	37	32	42	36	31	40	35	31	29
6	55	43	34	29	53	42	34	28	39	33	28	38	32	27	36	30	26	24
7	50	39	30	25	49	37	30	24	35	29	24	34	28	23	32	27	23	21
8	46	34	26	21	45	33	26	21	32	25	20	30	24	20	29	24	20	18
9	43	31	23	18	41	30	23	18	29	22	18	27	21	17	26	21	17	15
10	40	28	21	16	38	27	20	16	26	20	15	25	19	15	24	19	15	13

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 6A

MIL-F-16377/6 16W FLUOR SYM 149.4 AND 149.5 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS--DIRECTIONAL

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	420	400	355	300	235	185	155	132	110	95	80	60

ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	55	40	30	25	15	5	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	29.87	19.29	8.14	3.92	2.04	1.04	0.60	0.37	0.22	0.14	0.10
4.00	26.25	17.73	7.85	3.96	2.10	1.14	0.63	0.41	0.25	0.16	0.11
4.25	23.25	16.31	7.54	3.96	2.14	1.22	0.65	0.44	0.28	0.18	0.12
4.50	20.74	15.03	7.36	3.93	2.17	1.27	0.72	0.45	0.31	0.20	0.13
4.75	18.61	13.88	7.17	3.87	2.18	1.31	0.78	0.46	0.33	0.22	0.14
5.00	16.80	12.85	6.95	3.80	2.21	1.34	0.83	0.49	0.34	0.24	0.16
5.25	15.24	11.91	6.70	3.72	2.23	1.37	0.87	0.53	0.35	0.26	0.18
5.50	13.88	11.07	6.45	3.65	2.23	1.38	0.89	0.57	0.36	0.26	0.19
5.75	12.70	10.30	6.26	3.58	2.22	1.39	0.92	0.60	0.38	0.27	0.20
6.00	11.67	9.59	6.06	3.49	2.21	1.40	0.93	0.63	0.40	0.28	0.21

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	72	69	67	65	70	68	66	64	65	63	62	63	61	60	60	59	58	57
2	66	62	59	56	65	61	58	55	59	56	54	57	54	52	55	53	51	50
3	62	56	52	48	60	55	51	48	53	50	47	52	49	46	50	48	46	44
4	57	51	46	43	55	50	46	42	49	45	42	47	44	41	46	43	41	40
5	53	46	41	38	52	46	41	37	44	40	37	43	40	37	42	39	36	35
6	50	42	37	34	49	42	37	34	41	37	33	40	36	33	39	36	33	32
7	47	39	34	31	46	38	34	30	38	33	30	37	33	30	36	32	30	29
8	45	36	31	27	43	35	31	27	34	30	27	34	30	27	33	30	27	26
9	41	33	28	25	40	32	28	25	32	27	24	31	27	24	30	27	24	23
10	38	30	26	22	37	30	25	22	29	25	22	29	25	22	28	25	22	21

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 6B

MIL-F-16377/6 16W FLUOR SYM 149.4 AND 149.5 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM FRONT LAMP--DIRECTIONAL--RED FILTER ON REAR LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	205	193	173	146	110	85	70	60	55	47	42	40

ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	30	25	17	7	5	0	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	14.58	9.39	3.70	1.91	1.03	0.63	0.36	0.21	0.14	0.09	0.06
4.00	12.81	8.63	3.59	1.86	1.04	0.63	0.40	0.23	0.15	0.10	0.06
4.25	11.35	7.94	3.46	1.80	1.06	0.64	0.43	0.25	0.16	0.11	0.07
4.50	10.12	7.32	3.40	1.78	1.08	0.65	0.43	0.28	0.17	0.12	0.08
4.75	9.09	6.76	3.33	1.75	1.09	0.66	0.44	0.30	0.19	0.13	0.09
5.00	8.20	6.26	3.23	1.72	1.07	0.66	0.44	0.32	0.20	0.13	0.10
5.25	7.44	5.80	3.13	1.68	1.05	0.68	0.45	0.32	0.22	0.14	0.10
5.50	6.78	5.39	3.02	1.66	1.03	0.69	0.45	0.32	0.23	0.15	0.11
5.75	6.20	5.02	2.95	1.63	1.01	0.69	0.46	0.32	0.24	0.17	0.11
6.00	5.69	4.67	2.88	1.60	1.00	0.70	0.46	0.33	0.24	0.18	0.12

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 7A

MIL-F-16377/7 14W FLUOR SYM 70.3 AND 70.4 WHITE DIFFUSING
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	143	141	135	134	131	125	120	115	102	95	87	75
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	67	56	48	38	30	20	15	9	7	7	6	5

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	10.17	8.60	5.96	3.57	2.09	1.22	0.74	0.47	0.31	0.21	0.15
4.00	9.94	7.66	5.58	3.52	2.10	1.28	0.78	0.51	0.33	0.23	0.16
4.25	7.92	6.86	5.12	3.45	2.08	1.32	0.81	0.53	0.36	0.24	0.18
4.50	7.06	6.18	4.76	3.31	2.06	1.33	0.85	0.56	0.38	0.26	0.19
4.75	6.34	5.59	4.43	3.15	2.02	1.34	0.88	0.58	0.40	0.28	0.20
5.00	5.72	5.08	4.12	3.00	2.01	1.34	0.91	0.60	0.42	0.30	0.21
5.25	5.19	4.64	3.85	2.86	1.99	1.34	0.92	0.62	0.43	0.31	0.23
5.50	4.73	4.25	3.59	2.72	1.96	1.32	0.93	0.64	0.45	0.32	0.24
5.75	4.33	3.91	3.35	2.58	1.93	1.31	0.93	0.66	0.46	0.34	0.25
6.00	3.97	3.62	3.13	2.45	1.86	1.29	0.93	0.67	0.48	0.35	0.26

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	65	62	59	57	63	60	58	55	57	55	53	54	53	51	52	50	49	48
2	59	54	50	46	57	52	49	45	50	47	44	47	45	42	45	43	41	39
3	54	47	42	38	52	46	42	38	44	40	37	42	39	36	40	37	35	33
4	49	42	37	33	48	41	36	32	39	35	31	37	34	31	36	33	30	29
5	45	37	32	27	44	36	31	27	35	30	27	33	29	26	32	28	25	24
6	41	33	28	24	40	32	27	23	31	26	23	30	26	23	29	25	22	21
7	38	30	24	21	37	29	24	20	28	23	20	27	23	20	26	22	19	18
8	35	27	21	18	34	26	21	18	25	21	17	24	20	17	23	19	17	16
9	32	24	19	15	31	23	19	15	23	18	15	22	18	15	21	17	14	13
10	30	22	17	13	29	21	17	13	21	16	13	20	16	13	19	15	13	12

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 7B

MIL-F-16377/7 14W FLUOR SYM 336, 336.1 AND 78.2 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	157	157	157	155	153	149	147	143	136	122	107	92
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	82	63	53	37	28	20	13	7	5	5	5	3

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	11.16	9.94	7.22	4.67	2.65	1.50	0.91	0.56	0.34	0.24	0.17
4.00	9.81	8.87	6.64	4.49	2.70	1.57	0.95	0.62	0.39	0.26	0.18
4.25	8.69	7.95	6.11	4.31	2.71	1.63	0.99	0.65	0.42	0.28	0.20
4.50	7.75	7.17	5.65	4.10	2.71	1.67	1.04	0.68	0.46	0.30	0.21
4.75	6.96	6.49	5.23	3.89	2.69	1.70	1.08	0.71	0.49	0.33	0.23
5.00	6.28	5.90	4.85	3.69	2.63	1.73	1.12	0.74	0.51	0.36	0.25
5.25	5.70	5.39	4.51	3.49	2.55	1.73	1.15	0.76	0.53	0.38	0.27
5.50	5.19	4.94	4.20	3.30	2.48	1.74	1.17	0.79	0.55	0.40	0.29
5.75	4.75	4.54	3.91	3.12	2.40	1.73	1.19	0.81	0.57	0.41	0.31
6.00	4.36	4.19	3.64	2.95	2.30	1.72	1.20	0.83	0.59	0.42	0.32

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	76	72	69	66	74	70	68	65	67	65	63	64	62	60	61	60	58	57
2	69	63	58	54	67	62	57	54	59	55	52	56	53	51	54	51	49	47
3	63	56	50	46	61	55	49	45	52	46	44	50	46	43	48	45	42	40
4	58	49	43	39	56	48	43	36	46	41	36	44	40	37	43	39	36	35
5	53	44	37	33	51	43	37	32	41	36	32	39	35	31	38	34	31	29
6	48	39	33	25	47	35	32	26	37	31	27	35	31	27	34	30	27	25
7	45	35	29	24	43	34	28	24	33	28	24	32	27	23	31	26	23	22
8	41	31	25	21	40	31	25	21	29	24	20	26	24	20	27	23	20	19
9	38	28	22	19	36	27	22	18	26	21	18	25	21	17	25	20	17	16
10	35	25	20	16	34	25	19	16	24	19	15	23	19	15	22	18	15	14

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 8A

MIL-F-16377/8 20W FLUOR SYM 331.1 AND 331.2 WHITE DIFFUSING
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	243	242	240	238	230	285	216	205	194	182	170	160
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	145	130	117	100	85	70	60	48	44	38	33	25

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	17.28	15.87	10.72	6.67	4.04	2.58	1.60	1.04	0.71	0.50	0.36
4.00	15.19	13.60	9.94	6.43	4.08	2.55	1.66	1.10	0.75	0.53	0.39
4.25	13.45	12.19	9.21	6.17	3.98	2.57	1.72	1.15	0.79	0.56	0.41
4.50	12.00	10.98	8.52	5.91	3.92	2.58	1.75	1.20	0.83	0.59	0.44
4.75	10.77	9.94	7.88	5.65	3.84	2.58	1.77	1.24	0.87	0.62	0.46
5.00	9.72	9.03	7.31	5.39	3.75	2.57	1.78	1.27	0.90	0.65	0.48
5.25	8.82	8.24	6.78	5.14	3.65	2.55	1.79	1.28	0.93	0.68	0.50
5.50	8.03	7.55	6.31	4.89	3.55	2.53	1.80	1.30	0.95	0.70	0.52
5.75	7.35	6.94	5.89	4.65	3.44	2.49	1.79	1.31	0.97	0.72	0.54
6.00	6.75	6.40	5.51	4.42	3.33	2.45	1.79	1.31	0.98	0.74	0.56

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	84	80	75	72	81	77	73	70	72	69	66	67	64	62	62	60	59	56
2	76	68	62	57	73	66	60	55	61	57	53	57	54	50	54	50	48	45
3	69	60	53	47	66	58	51	46	54	48	44	50	46	42	47	43	40	38
4	63	52	45	39	60	51	44	38	48	42	37	45	39	35	42	37	34	32
5	57	46	38	33	55	46	37	32	42	36	31	39	34	30	37	32	28	26
6	52	41	33	28	50	40	32	27	37	31	26	35	30	25	33	28	25	23
7	48	37	29	24	46	36	29	24	33	27	23	31	26	22	30	25	21	19
8	44	33	26	21	42	32	25	20	30	24	20	28	23	19	27	22	18	17
9	41	29	22	18	39	29	22	17	27	21	17	25	20	16	24	19	16	14
10	38	27	20	16	36	26	20	15	25	19	15	23	18	14	22	17	14	12

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 8B

MIL-F-16377/8 20W FLUOR SYM 347.2 AND 347.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	285	282	281	278	270	260	255	250	253	318	200	185
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	168	150	140	125	100	78	50	40	20	10	3	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	20.27	17.84	12.55	8.54	6.24	2.93	1.85	1.21	0.82	0.59	0.43
4.00	17.81	15.90	11.56	8.04	7.03	2.99	1.93	1.28	0.87	0.62	0.46
4.25	15.78	14.25	10.45	7.55	6.32	3.14	1.99	1.33	0.92	0.65	0.48
4.50	14.07	12.84	9.88	7.15	5.65	3.65	2.03	1.38	0.96	0.69	0.51
4.75	12.63	11.62	9.17	6.77	5.04	4.10	2.07	1.43	1.00	0.72	0.53
5.00	11.40	10.57	8.53	6.41	4.80	4.50	2.09	1.47	1.04	0.75	0.56
5.25	10.34	9.65	7.94	6.06	4.59	4.13	2.36	1.49	1.07	0.78	0.58
5.50	9.42	8.84	7.41	5.73	4.38	3.78	2.64	1.52	1.10	0.81	0.61
5.75	8.62	8.13	6.91	5.43	4.19	3.46	2.90	1.53	1.13	0.83	0.63
6.00	7.92	7.47	6.46	5.14	4.02	3.18	3.12	1.64	1.14	0.86	0.65

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	94	89	84	80	91	86	82	78	81	78	75	77	74	72	73	71	69	67
2	84	76	69	63	81	74	67	62	70	64	60	66	62	58	63	59	56	54
3	76	66	58	52	74	64	57	51	61	55	50	58	53	48	55	51	47	45
4	70	58	50	43	67	57	49	43	54	47	42	51	45	41	49	44	40	38
5	63	51	42	36	61	50	42	36	47	40	35	45	39	34	43	38	33	31
6	58	45	37	31	56	44	36	31	42	35	30	40	34	29	39	33	29	27
7	54	41	32	27	52	40	32	26	38	31	26	36	30	25	35	29	25	23
8	49	36	28	23	48	36	28	23	34	27	22	33	26	22	31	26	21	20
9	45	33	25	20	44	32	25	19	31	24	19	29	23	19	28	22	18	17
10	42	30	22	17	41	29	22	17	28	21	17	27	21	16	26	20	16	15

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 9A

MIL-F-16377/9 24W FLUOR SYM 73.3 AND 73.4 WHITE DIFFUSING
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	212	212	210	208	202	195	190	180	165	155	138	128

ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	112	95	85	70	55	45	38	22	15	10	5	5

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	15.08	13.34	9.38	5.72	3.38	1.97	1.23	0.79	0.58	0.37	0.27
4.00	13.25	11.89	8.65	5.58	3.43	2.04	1.27	0.85	0.56	0.39	0.28
4.25	11.74	10.66	7.99	5.41	3.39	2.09	1.32	0.89	0.60	0.41	0.30
4.50	10.47	9.60	7.40	5.19	3.33	2.14	1.37	0.92	0.64	0.44	0.32
4.75	9.40	8.69	6.87	4.97	3.27	2.17	1.41	0.94	0.67	0.47	0.34
5.00	8.48	7.90	6.39	4.74	3.22	2.19	1.44	0.97	0.69	0.50	0.36
5.25	7.69	7.21	5.95	4.52	3.16	2.17	1.47	1.00	0.71	0.52	0.38
5.50	7.01	6.61	5.54	4.28	3.09	2.15	1.49	1.03	0.73	0.54	0.40
5.75	6.41	6.08	5.17	4.06	3.02	2.18	1.51	1.05	0.75	0.55	0.42
6.00	5.89	5.60	4.84	3.84	2.92	2.09	1.58	1.07	0.77	0.57	0.43

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	71	67	64	61	69	66	63	60	62	60	58	59	57	55	56	55	53	51
2	66	58	53	49	62	57	52	48	54	50	47	51	48	45	49	46	44	42
3	59	51	46	41	57	53	45	40	47	43	39	45	41	38	43	40	37	35
4	54	45	39	35	52	44	38	34	42	37	33	40	36	33	38	35	32	30
5	49	40	34	29	47	39	33	29	37	32	28	35	31	27	34	30	27	25
6	45	36	29	25	43	35	29	25	33	28	24	32	27	24	30	26	23	22
7	41	32	26	22	40	31	25	21	30	25	21	29	24	21	27	23	20	19
8	38	29	23	19	37	25	22	16	27	22	18	26	21	18	25	21	18	16
9	35	26	20	16	34	25	20	16	24	19	16	23	19	15	22	18	15	14
10	33	23	16	14	32	23	16	14	22	17	14	21	17	14	20	16	13	12

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 9B

MIL-F-16377/9 24W FLUOR SYM 73.3 AND 73.4 WHITE DIFFUSING
LIGHT OUTPUT: FROM CENTER LAMP ONLY

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	93	93	92	90	87	85	82	80	72	65	60	56

ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	50	43	35	30	25	20	15	10	5	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	6.61	5.78	4.06	2.51	1.44	0.88	0.55	0.36	0.23	0.16	0.11
4.00	5.81	5.16	3.76	2.46	1.44	0.90	0.58	0.38	0.25	0.17	0.12
4.25	5.15	4.63	3.48	2.40	1.44	0.91	0.60	0.40	0.27	0.19	0.13
4.50	4.59	4.18	3.22	2.29	1.44	0.92	0.61	0.42	0.29	0.20	0.14
4.75	4.12	3.79	2.98	2.17	1.43	0.92	0.62	0.43	0.30	0.21	0.15
5.00	3.72	3.45	2.76	2.06	1.41	0.92	0.63	0.44	0.31	0.22	0.16
5.25	3.37	3.15	2.57	1.95	1.39	0.92	0.63	0.45	0.32	0.23	0.17
5.50	3.07	2.89	2.39	1.85	1.37	0.92	0.64	0.46	0.33	0.24	0.18
5.75	2.81	2.66	2.23	1.76	1.34	0.92	0.64	0.46	0.34	0.25	0.19
6.00	2.58	2.46	2.09	1.67	1.29	0.91	0.64	0.46	0.34	0.26	0.19

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 9C

MIL-F-16377/9 24W FLUOR SYM 73.3 AND 73.4 WHITE DIFFUSING
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	150	150	148	145	137	135	130	180	114	105	95	85

ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	75	64	55	45	36	30	25	20	16	14	10	9

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	10.67	9.30	6.44	3.91	2.30	1.36	0.94	0.53	0.35	0.24	0.17
4.00	9.37	8.31	5.97	3.77	2.32	1.41	0.88	0.57	0.38	0.26	0.19
4.25	9.30	7.46	5.53	3.61	2.31	1.44	0.92	0.60	0.40	0.28	0.20
4.50	7.41	6.73	5.10	3.49	2.29	1.46	0.95	0.63	0.43	0.30	0.21
4.75	6.65	6.10	4.71	3.36	2.26	1.48	0.97	0.65	0.45	0.32	0.23
5.00	6.00	5.55	4.36	3.23	2.20	1.48	0.99	0.68	0.47	0.33	0.24
5.25	5.44	5.07	4.05	3.09	2.14	1.48	1.01	0.70	0.49	0.35	0.25
5.50	4.96	4.65	3.76	2.94	2.08	1.47	1.02	0.71	0.51	0.36	0.27
5.75	4.54	4.28	3.52	2.79	2.01	1.46	1.03	0.73	0.52	0.38	0.28
6.00	4.17	3.95	3.31	2.65	1.96	1.44	1.03	0.74	0.53	0.39	0.29

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 9D

MIL-F-16377/9 24W FLUOR SYM 346.2 AND 346.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	265	265	265	260	260	251	248	232	218	200	175	147

ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	125	97	75	57	40	30	20	15	10	9	6	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	18.84	16.46	11.99	7.51	4.34	2.42	1.42	0.86	0.53	0.35	0.24
4.00	16.56	14.89	11.10	7.26	4.42	2.55	1.51	0.94	0.59	0.39	0.27
4.25	14.67	13.37	10.28	6.99	4.41	2.66	1.59	1.01	0.65	0.42	0.29
4.50	13.09	12.06	9.53	6.67	4.37	2.73	1.68	1.07	0.71	0.47	0.32
4.75	11.75	10.93	8.84	6.36	4.32	2.79	1.76	1.12	0.76	0.51	0.35
5.00	10.60	9.94	8.25	6.05	4.22	2.83	1.83	1.18	0.80	0.55	0.38
5.25	9.61	9.09	7.65	5.76	4.12	2.82	1.87	1.23	0.84	0.59	0.41
5.50	8.76	8.33	7.13	5.47	4.01	2.81	1.91	1.28	0.87	0.62	0.44
5.75	8.02	7.66	6.63	5.19	3.89	2.79	1.94	1.33	0.91	0.64	0.47
6.00	7.36	7.06	6.17	4.93	3.75	2.75	1.96	1.36	0.94	0.67	0.49

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	82	78	75	72	80	76	73	71	73	70	68	69	67	65	66	65	63	61
2	75	69	64	59	73	67	62	58	64	60	57	61	58	55	58	56	53	52
3	68	61	55	50	66	59	54	49	57	52	48	54	50	47	52	49	46	44
4	63	56	47	42	61	53	47	42	51	45	41	48	44	40	47	43	40	33
5	57	48	41	36	56	47	40	36	45	39	35	43	38	34	41	37	34	32
6	53	43	36	31	51	42	35	31	40	34	30	39	34	30	37	33	29	28
7	48	38	31	27	47	37	31	27	36	30	26	35	30	26	33	29	26	24
8	45	34	28	23	43	34	27	23	32	27	23	31	26	22	30	25	22	21
9	41	31	24	20	40	30	26	20	29	23	19	28	23	19	27	22	19	18
10	38	28	22	17	37	27	21	17	25	21	17	25	20	17	25	20	17	15

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 9E

MIL-F-16377/9 24W FLUOR SYM 346.2 AND 346.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM CENTER LAMP ONLY

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	100	100	100	100	98	97	96	95	92	82	73	68
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	47	36	32	30	20	15	10	5	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	7.11	6.41	4.71	3.14	1.79	1.02	0.56	0.32	0.20	0.14	0.10
4.00	6.25	5.71	4.38	3.00	1.81	1.07	0.68	0.35	0.22	0.15	0.11
4.25	5.54	5.11	3.98	2.86	1.83	1.11	0.67	0.39	0.24	0.16	0.11
4.50	4.94	4.59	3.66	2.71	1.83	1.13	0.71	0.43	0.27	0.17	0.12
4.75	4.43	4.15	3.38	2.56	1.82	1.15	0.74	0.47	0.29	0.19	0.13
5.00	4.00	3.77	3.13	2.42	1.77	1.16	0.76	0.50	0.32	0.21	0.14
5.25	3.63	3.44	2.90	2.28	1.71	1.17	0.78	0.52	0.34	0.22	0.15
5.50	3.31	3.15	2.69	2.15	1.65	1.17	0.79	0.54	0.36	0.24	0.16
5.75	3.02	2.89	2.51	2.03	1.59	1.17	0.80	0.55	0.38	0.26	0.18
6.00	2.78	2.67	2.34	1.92	1.52	1.16	0.81	0.57	0.40	0.28	0.19

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 9F

MIL-F-16377/9 24W FLUOR SYM 346.2 AND 346.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	200	200	198	195	190	185	175	165	158	138	125	110
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	92	70	50	37	27	18	10	5	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	14.22	12.51	8.74	5.26	3.03	1.76	1.05	0.63	0.38	0.24	0.16
4.00	12.50	11.16	8.13	5.12	3.05	1.84	1.12	0.69	0.43	0.28	0.18
4.25	11.07	10.01	7.57	4.96	3.05	1.89	1.19	0.75	0.48	0.31	0.21
4.50	9.88	9.03	7.01	4.77	3.04	1.92	1.23	0.80	0.52	0.34	0.23
4.75	8.86	8.18	6.49	4.57	3.01	1.94	1.27	0.84	0.56	0.37	0.25
5.00	8.00	7.44	6.03	4.36	2.96	1.95	1.31	0.88	0.59	0.40	0.28
5.25	7.26	6.79	5.60	4.17	2.90	1.96	1.33	0.91	0.62	0.43	0.30
5.50	6.61	6.23	5.21	3.98	2.84	1.95	1.34	0.93	0.65	0.46	0.32
5.75	6.05	5.73	4.86	3.79	2.77	1.94	1.35	0.95	0.67	0.48	0.34
6.00	5.56	5.28	4.54	3.61	2.68	1.92	1.36	0.97	0.69	0.50	0.36

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 9G

MIL-F-16377/9 24W FLUOR SYM 73.3 AND 73.4 WHITE DIFFUSING
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS--RED FILTER ON CENTER LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	130	128	125	123	120	115	110	100	95	85	80	70
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	61	55	45	36	30	22	17	15	12	10	10	9

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	9.24	7.89	5.47	3.26	1.69	1.13	0.68	0.44	0.30	0.20	0.14
4.00	8.12	7.04	5.07	3.14	1.88	1.18	0.72	0.46	0.32	0.22	0.16
4.25	7.20	6.32	4.71	3.01	1.89	1.21	0.76	0.49	0.33	0.24	0.17
4.50	6.42	5.70	4.37	2.92	1.89	1.21	0.79	0.51	0.35	0.25	0.18
4.75	5.76	5.16	4.07	2.82	1.88	1.21	0.81	0.54	0.37	0.26	0.19
5.00	5.20	4.69	3.78	2.73	1.83	1.20	0.84	0.56	0.38	0.27	0.20
5.25	4.72	4.29	3.53	2.62	1.78	1.21	0.84	0.58	0.40	0.29	0.21
5.50	4.30	3.93	3.29	2.49	1.73	1.21	0.84	0.59	0.42	0.30	0.22
5.75	3.93	3.62	3.07	2.37	1.68	1.21	0.84	0.61	0.43	0.31	0.23
6.00	3.61	3.34	2.87	2.25	1.64	1.20	0.83	0.62	0.44	0.32	0.24

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 9H

MIL-F-16377/9 24W FLUOR SYM 346.2 AND 346.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS--RED FILTER ON CENTER LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	170	168	166	165	160	155	145	137	125	115	105	92
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	77	60	43	29	20	15	10	10	5	5	5	5

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	12.09	10.59	7.27	4.34	2.53	1.49	0.88	0.53	0.33	0.21	0.14
4.00	10.68	9.43	6.79	4.24	2.54	1.55	0.94	0.58	0.37	0.24	0.16
4.25	9.41	8.44	6.34	4.12	2.53	1.59	0.99	0.63	0.40	0.26	0.18
4.50	8.40	7.60	5.88	3.96	2.51	1.61	1.03	0.67	0.44	0.29	0.20
4.75	7.53	6.88	5.45	3.79	2.48	1.62	1.07	0.70	0.47	0.31	0.21
5.00	6.80	6.25	5.06	3.62	2.44	1.63	1.10	0.73	0.49	0.34	0.23
5.25	6.17	5.70	4.71	3.46	2.40	1.62	1.11	0.76	0.52	0.36	0.25
5.50	5.62	5.22	4.39	3.31	2.35	1.61	1.12	0.78	0.54	0.38	0.27
5.75	5.14	4.80	4.10	3.16	2.30	1.60	1.13	0.80	0.56	0.40	0.29
6.00	4.72	4.43	3.83	3.02	2.23	1.58	1.13	0.81	0.58	0.42	0.30

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 10A

MIL-F-16377/10 32W FLUOR SYM 145.4 AND 145.5 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS--DIRECTIONAL

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	740	720	650	560	450	360	290	240	200	160	120	108
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	80	40	20	10	0	0	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	52.62	36.00	15.48	7.13	3.30	1.73	0.97	0.49	0.22	0.12	0.07
4.00	46.25	32.95	15.12	7.20	3.54	1.78	1.07	0.60	0.29	0.15	0.09
4.25	40.97	30.21	14.65	7.19	3.72	1.85	1.16	0.67	0.36	0.18	0.11
4.50	36.54	27.77	14.27	7.20	3.85	2.01	1.20	0.74	0.44	0.23	0.13
4.75	32.80	25.58	13.84	7.16	3.95	2.15	1.23	0.81	0.49	0.28	0.15
5.00	29.60	20.63	13.37	7.07	4.01	2.26	1.25	0.86	0.54	0.33	0.19
5.25	26.85	21.87	12.87	6.97	4.05	2.36	1.34	0.88	0.59	0.38	0.22
5.50	24.46	20.29	12.36	6.92	4.05	2.43	1.43	0.90	0.63	0.41	0.26
5.75	22.38	18.85	11.93	6.83	4.05	2.49	1.51	0.92	0.66	0.45	0.30
6.00	20.56	17.53	11.49	6.72	4.05	2.54	1.57	0.96	0.67	0.48	0.32

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	60	59	57	56	59	57	56	55	55	54	53	53	52	51	51	51	50	49
2	57	53	51	49	55	52	50	48	51	49	47	49	47	46	48	46	45	44
3	53	49	46	43	52	48	45	43	47	44	42	45	43	41	44	42	41	40
4	50	45	41	38	49	44	41	38	43	40	38	42	39	37	41	39	37	36
5	46	41	37	34	45	40	37	34	39	36	34	38	36	33	37	35	33	32
6	43	38	34	31	42	37	34	31	36	33	31	35	33	30	35	32	30	29
7	41	35	31	28	40	34	31	28	33	30	28	33	30	28	32	29	27	27
8	38	32	28	25	37	31	28	25	31	27	25	30	27	25	30	27	25	24
9	35	29	25	23	35	29	25	23	28	25	23	28	25	22	27	24	22	22
10	33	27	23	21	32	27	23	21	26	23	21	26	23	21	25	22	20	20

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 10B

MIL-F-16377/10 32W FLUOR SYM 145.4 AND 145.5 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM TWO FRONT LAMPS-DIRECTIONAL-RED FILTERS ON REAR LMS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	360	355	320	270	210	165	142	120	107	95	85	75
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	55	45	25	10	0	0	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	25.60	17.36	7.37	3.74	2.08	1.21	0.67	0.38	0.25	0.14	0.08
4.00	22.50	15.96	7.06	3.68	2.10	1.25	0.74	0.42	0.27	0.17	0.10
4.25	19.93	14.69	6.73	3.61	2.12	1.29	0.81	0.46	0.29	0.20	0.12
4.50	17.78	13.54	6.57	3.58	2.13	1.32	0.84	0.51	0.31	0.21	0.14
4.75	15.96	12.51	6.40	3.54	2.12	1.33	0.87	0.56	0.34	0.23	0.16
5.00	14.40	11.57	6.20	3.47	2.10	1.34	0.89	0.60	0.38	0.24	0.17
5.25	13.06	10.74	5.99	3.40	2.08	1.35	0.91	0.62	0.41	0.26	0.18
5.50	11.90	9.98	5.77	3.32	2.05	1.36	0.92	0.63	0.44	0.28	0.19
5.75	10.89	9.28	5.60	3.23	2.08	1.36	0.93	0.65	0.46	0.31	0.21
6.00	10.00	8.63	5.43	3.14	2.01	1.35	0.93	0.66	0.47	0.33	0.22

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 11A

MIL-F-16377/11 40W FLUOR SYM 77.4 AND 77.5 WHITE DIFFUSING
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	560	550	550	540	520	505	470	450	410	385	350	310
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	265	230	180	135	90	60	50	30	25	20	10	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	39.82	34.65	23.62	14.25	8.46	4.99	3.00	1.89	1.25	0.83	0.57
4.00	35.00	30.93	22.09	13.92	8.51	5.17	3.18	2.01	1.35	0.92	0.63
4.25	31.00	27.75	20.65	13.53	8.48	5.30	3.34	2.14	1.43	1.00	0.70
4.50	27.65	25.03	19.15	12.95	8.29	5.38	3.47	2.26	1.52	1.06	0.76
4.75	24.82	22.68	17.75	12.35	8.12	5.43	3.57	2.37	1.60	1.13	0.82
5.00	22.40	20.64	16.48	11.76	8.01	5.44	3.66	2.47	1.69	1.18	0.86
5.25	20.32	18.86	15.32	11.20	7.88	5.40	3.71	2.55	1.76	1.24	0.91
5.50	18.51	17.30	14.27	10.73	7.73	5.34	3.75	2.61	1.84	1.30	0.95
5.75	16.94	15.91	13.34	10.27	7.54	5.26	3.77	2.67	1.90	1.36	0.99
6.00	15.56	14.66	12.48	9.82	7.28	5.18	3.78	2.71	1.95	1.41	1.04

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	75	72	69	66	73	70	67	65	67	64	62	66	62	60	61	59	58	56
2	69	63	58	54	66	61	57	53	58	55	52	56	53	50	53	51	49	47
3	63	55	50	45	61	54	49	45	52	47	44	49	46	43	47	44	42	40
4	57	49	43	38	56	48	42	38	46	41	37	44	40	36	42	39	36	34
5	52	43	37	32	51	42	36	32	40	35	31	39	34	31	37	33	30	29
6	48	39	32	28	46	38	32	27	36	31	27	35	30	27	34	29	26	25
7	44	35	28	24	43	34	28	24	33	27	23	31	27	23	30	26	23	21
8	41	31	25	21	39	30	25	21	29	24	20	28	24	20	27	23	20	19
9	37	28	22	18	36	27	23	18	26	21	16	25	21	17	24	20	17	16
10	35	25	20	16	34	25	19	16	24	19	15	23	19	15	22	18	15	14

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 11B

MIL-F-16377/11 40W FLUOR SYM 344.2 AND 344.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	590	590	590	590	580	570	550	530	500	460	410	360
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	300	240	190	140	100	80	50	48	20	10	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	41.96	37.85	27.24	17.20	10.04	5.82	3.43	2.08	1.31	0.87	0.60
4.00	36.87	33.67	25.21	16.60	10.16	6.04	3.67	2.27	1.45	0.96	0.67
4.25	32.66	30.13	23.34	15.96	10.13	6.22	3.88	2.44	1.58	1.05	0.73
4.50	29.14	27.10	21.56	15.23	10.04	6.36	4.04	2.60	1.70	1.14	0.79
4.75	26.15	24.50	19.93	14.49	9.90	6.45	4.17	2.75	1.82	1.23	0.86
5.00	23.60	22.25	18.45	13.77	9.68	6.51	4.28	2.87	1.93	1.32	0.93
5.25	21.41	20.29	17.12	13.08	9.43	6.49	4.37	2.97	2.03	1.41	0.99
5.50	19.50	18.58	15.92	12.43	9.16	6.45	4.44	3.05	2.13	1.49	1.06
5.75	17.84	17.06	14.82	11.80	8.88	6.39	4.49	3.12	2.21	1.56	1.12
6.00	16.39	15.73	13.83	11.20	8.56	6.31	4.52	3.19	2.27	1.63	1.18

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	85	82	78	75	83	79	76	73	76	73	71	72	70	68	69	67	66	64
2	78	71	66	61	76	70	65	60	66	62	59	63	60	57	61	58	55	54
3	71	63	57	51	69	61	56	51	59	54	50	56	52	48	54	50	47	46
4	65	56	49	44	63	55	48	43	52	47	42	50	45	41	48	44	41	39
5	59	49	42	37	56	48	41	36	46	40	36	44	39	35	43	38	35	33
6	55	44	37	32	53	43	36	31	41	35	31	40	34	30	38	34	30	28
7	50	39	32	27	49	39	32	27	37	31	27	36	30	26	34	30	26	24
8	46	35	28	23	45	34	28	23	33	27	23	32	27	23	31	26	22	21
9	42	31	25	20	41	31	24	20	30	24	20	29	23	20	28	23	19	18
10	39	28	22	18	38	28	22	18	27	21	17	26	21	17	25	20	17	16

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 12A

MIL-F-16377/12 60W FLUOR SYM 333.1 AND 333.2 WHITE DIFFUSING
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	780	770	760	750	730	700	660	620	570	530	475	430
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	370	310	260	210	170	130	90	70	40	30	25	10

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	55.47	48.12	32.99	19.75	11.60	6.86	4.17	2.61	1.69	1.16	0.82
4.00	48.75	42.91	30.75	19.24	11.71	7.05	4.42	2.80	1.84	1.25	0.89
4.25	43.18	38.46	28.64	18.65	11.63	7.20	4.63	2.98	1.98	1.35	0.96
4.50	38.52	34.68	26.61	17.93	11.48	7.35	4.77	3.15	2.11	1.45	1.03
4.75	34.57	31.41	24.74	17.19	11.29	7.44	4.88	3.29	2.23	1.55	1.10
5.00	31.20	28.56	23.03	16.45	11.11	7.50	4.97	3.42	2.35	1.64	1.18
5.25	28.30	26.08	21.46	15.72	10.90	7.46	5.06	3.50	2.45	1.73	1.25
5.50	25.79	23.91	20.03	15.01	10.66	7.39	5.13	3.57	2.55	1.81	1.32
5.75	23.59	21.99	18.69	14.38	10.40	7.30	5.18	3.63	2.62	1.89	1.38
6.00	21.67	20.29	17.46	13.66	10.09	7.20	5.21	3.69	2.68	1.96	1.44

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	72	68	65	62	70	66	64	61	63	61	59	60	58	56	57	55	54	52
2	65	59	55	51	63	58	53	50	55	51	48	52	49	47	50	47	45	43
3	60	52	47	42	58	51	46	42	49	44	41	46	43	39	44	41	36	37
4	55	46	40	36	53	45	40	35	43	38	35	41	37	34	39	36	33	31
5	50	41	35	30	48	40	34	30	38	33	29	36	32	29	35	31	28	26
6	46	37	30	26	44	36	30	26	34	29	25	33	28	25	31	27	24	23
7	42	33	27	22	41	32	26	22	31	26	22	29	25	22	28	24	21	20
8	39	29	23	19	38	29	23	19	28	23	19	27	22	19	25	21	18	17
9	36	26	21	17	35	26	20	17	25	20	16	24	19	16	23	19	15	15
10	33	24	18	15	32	24	18	15	23	18	14	22	17	14	21	17	14	13

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 12B

MIL-F-16377/12 60W FLUOR SYM 333.1 AND 333.2 WHITE DIFFUSING
LIGHT OUTPUT: FROM CENTER LAMP ONLY

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	275	275	270	270	260	250	235	225	210	187	170	147
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	135	110	95	70	50	40	30	20	10	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	19.56	17.32	11.76	7.25	4.11	2.39	1.48	0.94	0.60	0.42	0.30
4.00	17.19	15.41	10.97	7.02	4.13	2.50	1.53	1.02	0.66	0.45	0.32
4.25	15.22	13.79	10.23	6.77	4.17	2.58	1.59	1.07	0.71	0.48	0.34
4.50	13.58	12.40	9.50	6.47	4.17	2.61	1.66	1.11	0.77	0.52	0.37
4.75	12.19	11.21	8.82	6.17	4.16	2.64	1.72	1.14	0.81	0.56	0.39
5.00	11.00	10.18	8.21	5.88	4.08	2.64	1.77	1.17	0.83	0.60	0.42
5.25	9.98	9.29	7.65	5.60	3.98	2.66	1.80	1.22	0.86	0.63	0.45
5.50	9.09	8.50	7.14	5.35	3.88	2.67	1.82	1.26	0.88	0.65	0.48
5.75	8.32	7.81	6.67	5.11	3.77	2.67	1.83	1.29	0.90	0.67	0.50
6.00	7.64	7.21	6.24	4.88	3.64	2.65	1.84	1.32	0.93	0.68	0.52

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 12C

MIL-F-16377/12 60W FLUOR SYM 333.1 AND 333.2 WHITE DIFFUSING
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	550	545	540	525	510	490	470	440	400	360	340	300
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	260	220	180	150	1200	100	80	60	50	30	20	10

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	39.11	33.69	23.34	13.91	8.02	4.84	2.92	1.84	1.20	0.81	0.57
4.00	34.37	30.13	21.63	13.60	7.95	5.02	3.09	1.97	1.30	0.89	0.62
4.25	30.45	27.08	20.06	13.23	7.99	5.14	3.23	2.09	1.39	0.96	0.68
4.50	27.16	24.46	18.62	12.74	7.98	5.14	3.36	2.20	1.48	1.03	0.73
4.75	24.38	22.19	17.30	12.22	7.92	5.13	3.47	2.30	1.57	1.09	0.78
5.00	22.00	20.22	16.10	11.71	7.82	5.09	3.55	2.39	1.64	1.16	0.83
5.25	19.95	18.49	15.00	11.19	7.70	5.11	3.57	2.47	1.71	1.22	0.88
5.50	18.18	16.97	14.00	10.64	7.55	5.11	3.57	2.54	1.78	1.27	0.93
5.75	16.64	15.62	13.06	10.11	7.38	5.09	3.56	2.59	1.84	1.32	0.97
6.00	15.28	14.41	12.21	9.61	7.17	5.06	3.54	2.62	1.89	1.37	1.01

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 12D

MIL-F-16377/12 60W FLUOR SYM 342.2 AND 242.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	850	850	840	840	825	820	790	750	700	650	570	550
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	410	320	250	200	150	110	100	50	40	20	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	60.44	53.88	39.16	24.15	14.12	8.56	4.94	2.82	1.75	1.16	0.79
4.00	53.12	47.94	36.25	23.40	14.36	8.60	5.48	3.09	1.95	1.28	0.88
4.25	47.06	42.69	33.58	22.58	14.27	8.66	5.69	3.45	2.14	1.40	0.97
4.50	41.98	38.59	30.94	21.63	14.10	8.90	5.95	3.80	2.38	1.54	1.06
4.75	37.67	34.89	28.53	20.67	13.86	9.07	5.97	4.13	2.53	1.67	1.15
5.00	34.00	31.68	26.36	19.73	13.59	9.19	5.97	4.34	2.78	1.80	1.25
5.25	30.84	28.69	24.40	18.80	13.27	9.15	6.10	4.37	3.01	1.94	1.34
5.50	28.10	26.45	22.64	17.84	12.93	9.07	6.22	4.39	3.22	2.11	1.44
5.75	25.71	24.30	21.09	16.96	12.57	8.97	6.32	4.39	3.32	2.28	1.53
6.00	23.61	22.48	19.68	16.11	12.17	8.84	6.38	4.44	3.34	2.43	1.65

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	81	78	74	71	79	76	73	70	72	70	67	69	67	65	66	64	63	61
2	74	68	63	58	72	66	62	58	63	59	56	60	57	54	58	55	53	51
3	68	60	54	49	66	59	53	48	56	51	47	54	50	46	52	48	45	43
4	62	53	46	41	60	52	46	41	50	45	40	48	43	40	46	42	39	37
5	57	47	40	35	55	46	39	35	44	38	34	42	37	34	41	36	33	31
6	52	42	35	30	50	41	34	30	39	34	29	38	33	29	37	32	27	27
7	48	37	31	26	46	37	30	26	35	30	25	34	29	25	33	28	25	23
8	44	33	27	22	43	33	27	22	32	26	22	30	25	22	29	25	21	20
9	40	30	23	19	39	29	23	19	28	23	19	27	22	19	26	22	18	17
10	37	27	21	17	36	27	21	17	26	20	17	25	20	16	24	19	16	15

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 12E

MIL-F-16377/12 60W FLUOR SYM 342.2 AND 342.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM CENTER LAMP ONLY

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	300	300	300	300	300	295	290	272	265	245	220	185
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	150	115	80	55	45	35	25	15	5	5	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	21.33	19.24	14.26	9.04	5.36	3.04	1.74	1.03	0.63	0.40	0.26
4.00	18.75	17.12	13.12	8.62	5.41	3.21	1.88	1.13	0.70	0.45	0.30
4.25	16.61	15.38	12.09	8.20	5.39	3.34	2.00	1.23	0.78	0.50	0.34
4.50	14.81	13.78	11.16	7.87	5.33	3.40	2.11	1.32	0.85	0.56	0.37
4.75	13.30	12.46	10.31	7.55	5.25	3.44	2.21	1.41	0.91	0.61	0.41
5.00	12.00	11.31	9.55	7.23	5.08	3.46	2.29	1.48	0.98	0.66	0.45
5.25	10.88	10.32	8.86	6.89	4.91	3.45	2.34	1.55	1.04	0.70	0.49
5.50	9.92	9.45	8.23	6.52	4.73	3.43	2.37	1.61	1.09	0.75	0.52
5.75	9.07	8.68	7.65	6.16	4.56	3.39	2.39	1.67	1.14	0.79	0.56
6.00	8.33	8.00	7.18	5.83	4.43	3.34	2.41	1.71	1.19	0.83	0.59

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 12F

MIL-F-16377/12 60W FLUOR SYM 342.2 AND 342.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	610	610	610	600	600	590	560	540	500	450	410	360
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	300	245	200	160	130	100	75	40	20	10	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	43.38	38.50	27.92	17.29	9.90	5.82	3.43	2.10	1.34	0.90	0.63
4.00	38.12	34.35	25.97	16.80	9.94	6.04	3.67	2.27	1.47	0.99	0.69
4.25	33.77	30.82	24.15	16.25	9.99	6.21	3.88	2.44	1.59	1.07	0.75
4.50	30.12	27.79	22.31	15.51	9.97	6.30	4.04	2.60	1.70	1.16	0.81
4.75	27.04	25.18	20.62	14.76	9.90	6.35	4.17	2.75	1.82	1.24	0.87
5.00	24.40	22.91	19.09	14.03	9.73	6.36	4.28	2.87	1.93	1.33	0.94
5.25	22.13	20.93	17.71	13.33	9.52	6.39	4.35	2.97	2.03	1.41	1.00
5.50	20.17	19.19	16.46	12.71	9.30	6.39	4.39	3.05	2.13	1.49	1.06
5.75	18.45	17.64	15.29	12.11	9.05	6.37	4.41	3.12	2.21	1.56	1.12
6.00	16.94	16.26	14.23	11.54	8.72	6.32	4.42	3.19	2.27	1.63	1.18

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 12G

MIL-F-16377/12 60W FLUOR SYM 333.1 AND 333.2 WHITE DIFFUSING
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS--RED FILTER ON CENTER LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	440	430	425	420	400	380	360	340	320	290	260	240
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	215	180	155	120	100	70	55	50	45	40	30	20

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	31.29	26.95	17.96	11.02	6.35	3.80	2.38	1.51	0.98	0.68	0.49
4.00	27.50	24.02	16.71	10.64	6.41	3.88	2.49	1.63	1.07	0.73	0.53
4.25	24.36	21.54	15.55	10.24	6.42	3.94	2.56	1.71	1.15	0.78	0.56
4.50	21.73	19.41	14.48	9.82	6.40	4.02	2.64	1.79	1.22	0.84	0.60
4.75	19.50	17.57	13.49	9.40	6.34	4.07	2.69	1.85	1.29	0.90	0.64
5.00	17.60	15.98	12.58	8.98	6.20	4.10	2.72	1.90	1.34	0.95	0.68
5.25	15.96	14.59	11.74	8.57	6.04	4.11	2.77	1.94	1.39	1.00	0.72
5.50	14.55	13.37	10.98	8.18	5.87	4.10	2.81	1.97	1.43	1.04	0.76
5.75	13.31	12.30	10.28	7.79	5.70	4.08	2.83	1.99	1.46	1.08	0.80
6.00	12.22	11.34	9.64	7.43	5.52	4.04	2.85	2.02	1.48	1.11	0.83

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 12H

MIL-F-16377/12 60W FLUOR SYM 342.2 AND 342.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS--RED FILTER ON CENTER LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	470	470	470	465	460	450	440	410	385	345	310	270
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	230	200	160	140	95	80	60	40	20	10	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	33.42	29.83	21.68	13.26	7.55	4.38	2.60	1.64	1.09	0.73	0.51
4.00	29.37	26.59	19.98	12.82	7.62	4.56	2.77	1.74	1.17	0.80	0.56
4.25	26.02	23.83	18.44	12.34	7.67	4.70	2.91	1.86	1.25	0.87	0.61
4.50	23.21	21.47	17.04	11.89	7.67	4.79	3.04	1.97	1.32	0.92	0.66
4.75	20.83	19.44	15.76	11.42	7.62	4.85	3.15	2.07	1.39	0.98	0.71
5.00	18.80	17.68	14.61	10.95	7.46	4.88	3.24	2.15	1.47	1.03	0.75
5.25	17.05	16.14	13.57	10.46	7.28	4.91	3.30	2.23	1.54	1.08	0.79
5.50	15.54	14.79	12.62	9.90	7.08	4.91	3.34	2.30	1.60	1.13	0.82
5.75	14.22	13.59	11.74	9.38	6.88	4.90	3.37	2.36	1.66	1.18	0.86
6.00	13.06	12.53	10.95	8.88	6.69	4.86	3.39	2.41	1.71	1.23	0.90

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 13A

MIL-F-16377/13 150W FLUOR SYM 74 AND 74.1 CLEAR PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	3500	3475	3375	3300	3075	2900	2750	2560	2350	2060	1800	1525
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	1300	1050	800	600	350	200	150	100	50	20	10	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	248.6	211.7	137.16	81.47	44.68	25.00	14.72	9.05	5.74	3.77	2.55
4.00	218.7	189.1	127.59	79.41	45.58	26.30	15.64	9.83	6.31	4.18	2.85
4.25	193.7	169.8	118.69	77.01	46.19	27.36	16.49	10.50	6.85	4.59	3.15
4.50	172.8	153.3	110.65	74.24	46.50	28.14	17.36	11.11	7.38	4.98	3.45
4.75	155.1	138.9	103.25	71.35	46.50	28.78	18.13	11.67	7.85	5.37	3.75
5.00	140.0	126.5	96.43	68.43	45.83	29.13	18.78	12.21	8.28	5.74	4.04
5.25	126.9	115.6	90.16	65.49	44.98	29.50	19.29	12.76	8.67	6.09	4.32
5.50	115.7	106.1	84.40	62.44	44.01	29.71	19.69	13.24	9.03	6.39	4.59
5.75	105.8	97.6	79.30	59.51	42.95	29.78	20.00	13.67	9.40	6.68	4.85
6.00	97.2	90.2	74.60	56.71	41.76	29.70	20.23	14.08	9.77	6.95	5.08

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	76	75	72	69	76	73	70	68	70	66	56	67	65	63	64	63	61	60
2	71	66	61	57	69	64	60	57	62	58	55	59	56	54	57	55	52	51
3	65	58	53	49	64	57	52	48	55	51	47	53	49	46	51	48	45	44
4	60	52	46	41	58	51	45	41	49	44	40	47	43	40	46	42	39	38
5	55	46	40	35	53	45	39	35	44	39	35	42	38	34	41	37	34	32
6	51	41	35	31	49	41	35	31	39	34	30	38	33	30	37	33	30	28
7	47	37	31	27	46	37	31	27	35	30	26	34	30	26	33	29	26	24
8	43	34	27	23	42	33	27	23	32	27	23	31	26	23	30	26	23	21
9	40	30	24	20	39	30	24	20	29	24	20	28	23	20	27	25	20	18
10	37	27	22	18	36	27	22	18	26	21	16	25	21	18	25	21	17	16

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 13B

MIL-F-16377/13 150W FLUOR SYM 75 AND 75.1 CLEAR PRISMATIC --NEW--
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	125	125	120	110	100	95	85	70	55	45	35	25
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	15	10	5	0	0	0	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	8.89	7.07	4.24	2.00	0.94	0.44	0.20	0.10	0.05	0.03	0.02
4.00	7.81	6.39	4.11	2.06	0.99	0.49	0.24	0.11	0.06	0.04	0.02
4.25	6.92	5.80	3.88	2.09	1.04	0.54	0.27	0.14	0.07	0.04	0.03
4.50	6.17	5.28	3.62	2.10	1.07	0.58	0.31	0.16	0.08	0.05	0.03
4.75	5.54	4.83	3.37	2.09	1.09	0.61	0.34	0.18	0.10	0.06	0.04
5.00	5.00	4.43	3.14	2.07	1.12	0.64	0.36	0.20	0.11	0.06	0.04
5.25	4.54	4.07	2.94	2.03	1.15	0.66	0.39	0.23	0.13	0.07	0.05
5.50	4.13	3.76	2.74	1.96	1.17	0.68	0.41	0.24	0.14	0.08	0.05
5.75	3.78	3.47	2.59	1.89	1.18	0.69	0.43	0.26	0.16	0.10	0.06
6.00	3.47	3.21	2.45	1.83	1.18	0.70	0.44	0.28	0.17	0.11	0.06

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2
2	3	3	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2
3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
6	2	2	2	1	2	2	2	1	2	2	1	2	2	1	2	1	1	1
7	2	2	1	1	2	2	1	1	2	1	1	2	1	1	1	1	1	1
8	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
9	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
10	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 14A

MIL-F-16377/14 8W FLUOR SYM 79.1 AND 79.2 CLEAR AND WHITE DIRECTIONAL
LIGHT OUTPUT: FROM ALL LAMPS--DIRECTIONAL

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	76	74	73	72	68	60	55	45	38	29	26	20
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	18	15	14	12	12	11	11	11	10	10	9	9

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	5.40	4.62	2.78	1.35	0.63	0.34	0.20	0.13	0.08	0.06	0.04
4.00	4.75	4.12	2.61	1.36	0.64	0.37	0.21	0.14	0.09	0.06	0.05
4.25	4.21	3.69	2.45	1.35	0.69	0.39	0.22	0.14	0.10	0.07	0.05
4.50	3.75	3.33	2.32	1.35	0.72	0.40	0.24	0.15	0.10	0.07	0.05
4.75	3.37	3.02	2.20	1.35	0.75	0.41	0.25	0.15	0.11	0.08	0.05
5.00	3.04	2.74	2.08	1.34	0.76	0.41	0.27	0.16	0.11	0.08	0.06
5.25	2.76	2.51	1.97	1.31	0.76	0.43	0.26	0.17	0.12	0.08	0.06
5.50	2.51	2.30	1.87	1.26	0.76	0.45	0.28	0.19	0.12	0.09	0.06
5.75	2.30	2.11	1.75	1.21	0.76	0.47	0.28	0.20	0.13	0.09	0.07
6.00	2.11	1.95	1.64	1.16	0.75	0.48	0.28	0.20	0.13	0.09	0.07

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	68	65	62	60	66	63	60	58	58	56	54	54	52	50	49	48	47	45
2	63	57	53	49	60	55	51	48	51	48	45	47	45	42	44	42	40	38
3	57	51	46	42	55	49	44	41	46	42	39	42	39	37	39	37	35	33
4	53	45	40	36	51	44	39	35	41	37	33	38	35	32	35	33	30	28
5	48	40	35	31	46	39	34	30	36	32	29	34	30	27	32	29	26	25
6	45	36	31	27	43	35	30	26	33	28	25	31	27	24	29	26	23	22
7	41	33	27	23	40	32	27	23	30	25	22	28	24	21	26	23	20	19
8	38	30	24	20	37	29	24	20	27	22	19	25	21	19	24	20	18	16
9	35	27	21	19	34	26	21	17	24	20	17	23	19	16	21	19	16	14
10	33	24	19	16	31	24	19	15	22	18	15	21	17	14	20	16	14	13

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 14B

MIL-F-16377/14 8W FLUOR SYM 80.1 AND 80.2 WHITE DIFFUSING
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	53	52	52	52	51	51	50	49	48	46	44	42
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	39	37	34	31	28	25	24	22	21	20	18	16

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	3.77	3.34	2.46	1.63	1.03	0.66	0.43	0.29	0.20	0.14	0.11
4.00	3.31	2.97	2.27	1.56	1.02	0.66	0.44	0.30	0.21	0.15	0.11
4.25	2.93	2.66	2.09	1.48	1.00	0.66	0.45	0.31	0.22	0.16	0.12
4.50	2.62	2.39	1.92	1.40	0.98	0.66	0.46	0.32	0.23	0.17	0.12
4.75	2.35	2.16	1.77	1.33	0.95	0.66	0.46	0.33	0.23	0.17	0.13
5.00	2.12	1.96	1.63	1.26	0.92	0.65	0.46	0.33	0.24	0.18	0.13
5.25	1.92	1.79	1.51	1.19	0.89	0.64	0.46	0.34	0.25	0.18	0.14
5.50	1.75	1.64	1.40	1.12	0.85	0.63	0.46	0.34	0.25	0.19	0.14
5.75	1.60	1.50	1.30	1.06	0.82	0.62	0.46	0.34	0.25	0.19	0.15
6.00	1.47	1.39	1.22	1.01	0.79	0.60	0.45	0.34	0.26	0.20	0.15

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	86	81	76	72	81	77	73	69	69	66	63	62	59	57	55	53	52	48
2	77	69	62	56	72	65	59	54	59	54	50	52	49	45	47	44	41	34
3	69	60	52	46	65	57	50	44	51	45	41	46	41	37	41	37	34	31
4	63	52	44	38	59	50	42	37	45	39	34	40	35	31	36	32	28	26
5	57	46	38	32	54	43	36	30	39	33	28	35	30	26	31	27	24	21
6	52	41	33	27	49	39	31	25	35	29	24	31	26	22	28	24	20	18
7	48	36	28	23	45	34	27	22	31	25	20	28	23	19	25	21	17	15
8	44	32	25	20	42	31	24	19	28	22	19	25	20	16	23	18	15	13
9	41	29	22	17	39	28	21	15	25	19	15	23	17	14	20	16	13	11
10	38	26	19	15	36	25	19	14	23	17	13	21	16	12	19	14	11	9

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 20A

MIL-F-16377/20 50W INCANDESCENT SYM 64.1
LIGHT OUTPUT: FROM 50W LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	110	110	108	106	101	96	93	90	82	72	57	42
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	25	16	16	6	0	0	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	7.82	6.80	4.60	2.45	1.51	0.73	0.34	0.16	0.09	0.06	0.05
4.00	6.87	6.07	4.25	2.78	1.59	0.81	0.40	0.19	0.11	0.07	0.05
4.25	6.09	5.45	3.93	2.71	1.61	0.87	0.46	0.23	0.12	0.07	0.05
4.50	5.43	4.91	3.66	2.58	1.62	0.93	0.51	0.27	0.14	0.08	0.05
4.75	4.98	4.45	3.41	2.45	1.62	0.98	0.55	0.31	0.16	0.10	0.06
5.00	4.40	4.05	3.18	2.33	1.60	1.02	0.59	0.34	0.19	0.11	0.07
5.25	3.99	3.70	2.97	2.21	1.58	1.03	0.63	0.37	0.22	0.12	0.08
5.50	3.64	3.40	2.77	2.10	1.55	1.04	0.66	0.40	0.24	0.14	0.08
5.75	3.33	3.13	2.59	1.99	1.51	1.04	0.68	0.43	0.27	0.16	0.09
6.00	3.06	2.88	2.43	1.89	1.45	1.04	0.71	0.45	0.29	0.16	0.11

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	65	63	61	59	64	62	60	58	59	57	56	56	55	54	54	53	52	51
2	61	57	54	51	59	56	53	50	53	51	49	51	49	47	49	47	46	45
3	56	51	47	44	55	50	46	43	48	45	42	46	44	41	45	42	41	39
4	52	46	42	38	51	45	41	38	43	40	37	42	39	36	40	38	36	35
5	48	41	36	33	47	40	36	33	39	35	32	38	34	32	36	34	31	30
6	44	37	32	29	43	36	32	29	35	31	28	34	31	28	33	30	28	26
7	41	33	29	25	40	33	28	25	32	28	25	31	27	25	30	27	24	23
8	38	30	25	22	37	30	25	22	29	25	22	28	24	21	27	24	21	20
9	35	27	22	19	34	28	22	19	26	22	19	25	21	19	24	21	18	17
10	32	24	20	17	31	24	20	17	23	19	17	23	19	16	22	19	16	15

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 20B

MIL-F-16377/20 50W INCANDESCENT SYM 65
LIGHT OUTPUT: FROM 50W LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	110	110	107	103	99	95	92	90	89	87	82	77
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	68	61	35	24	5	2	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	7.82	6.61	4.55	3.02	1.94	1.21	0.76	0.49	0.33	0.20	0.12
4.00	6.87	5.92	4.21	2.87	1.92	1.23	0.80	0.52	0.35	0.23	0.14
4.25	6.09	5.33	3.89	2.72	1.87	1.24	0.83	0.54	0.37	0.26	0.17
4.50	5.43	4.82	3.61	2.58	1.82	1.24	0.84	0.57	0.39	0.28	0.19
4.75	4.88	4.38	3.36	2.44	1.76	1.24	0.85	0.59	0.41	0.29	0.22
5.00	4.40	4.00	3.12	2.31	1.70	1.23	0.86	0.61	0.43	0.31	0.23
5.25	3.99	3.66	2.91	2.19	1.63	1.21	0.86	0.62	0.44	0.32	0.24
5.50	3.64	3.36	2.72	2.08	1.57	1.18	0.86	0.62	0.46	0.33	0.25
5.75	3.33	3.10	2.54	1.97	1.51	1.15	0.86	0.63	0.47	0.34	0.25
6.00	3.06	2.86	2.38	1.87	1.45	1.12	0.85	0.63	0.47	0.35	0.24

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	88	86	81	78	86	82	79	77	79	77	76	76	74	72	73	71	70	68
2	80	73	68	64	78	72	67	63	69	65	61	66	63	60	64	61	59	57
3	73	64	58	53	71	63	57	52	61	56	51	59	54	51	57	53	50	48
4	66	57	50	44	64	56	49	44	54	48	43	52	47	43	50	46	42	40
5	60	49	42	37	58	48	42	36	47	41	36	45	40	36	44	39	35	33
6	55	44	36	31	53	43	36	31	42	35	31	40	35	30	39	34	30	28
7	50	39	32	27	49	38	31	26	37	31	26	36	30	26	35	30	26	24
8	46	35	28	23	45	34	27	23	33	27	22	32	26	22	31	26	22	21
9	42	31	24	19	41	31	24	19	30	23	19	29	23	19	28	23	19	17
10	39	28	21	17	38	28	21	17	27	21	17	26	21	17	25	20	17	15

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 21A

MIL-F-16377/21 100W INCANDESCENT SYM 89
LIGHT OUTPUT: FROM 100W LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	292	290	285	279	274	272	265	259	247	236	220	204
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	185	158	123	38	20	10	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	20.76	17.90	13.08	8.47	5.23	3.23	2.04	1.31	0.86	0.57	0.39
4.00	18.25	15.99	12.07	8.14	5.21	3.29	2.12	1.40	0.93	0.63	0.43
4.25	16.17	14.35	11.14	7.80	5.13	3.33	2.19	1.47	1.00	0.69	0.48
4.50	14.42	12.95	10.27	7.41	5.02	3.35	2.24	1.53	1.06	0.74	0.52
4.75	12.94	11.74	9.47	7.03	4.89	3.35	2.28	1.58	1.11	0.78	0.56
5.00	11.68	10.69	8.75	6.65	4.77	3.34	2.30	1.62	1.15	0.82	0.60
5.25	10.59	9.77	8.10	6.30	4.63	3.29	2.32	1.65	1.18	0.86	0.63
5.50	9.65	8.96	7.52	5.97	4.49	3.24	2.33	1.67	1.22	0.89	0.66
5.75	8.83	8.25	7.00	5.66	4.34	3.18	2.33	1.69	1.24	0.92	0.69
6.00	8.11	7.61	6.54	5.36	4.17	3.12	2.32	1.70	1.26	0.94	0.71

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	88	85	82	79	86	83	80	78	80	77	75	76	74	73	73	72	70	69
2	81	75	70	65	79	73	68	64	70	66	63	67	64	61	65	62	60	59
3	74	66	60	55	72	65	59	54	62	57	53	60	56	52	58	54	51	49
4	67	58	51	46	66	57	51	46	55	49	45	53	48	44	51	47	44	42
5	61	51	43	38	59	50	43	38	48	42	37	46	41	37	45	40	36	35
6	56	45	38	32	54	44	37	32	43	36	32	41	36	32	40	35	31	30
7	51	40	33	28	50	39	33	28	38	32	27	37	31	27	36	31	27	25
8	47	36	29	24	46	35	28	24	34	28	23	33	27	23	32	27	23	21
9	43	32	25	20	42	31	25	20	30	24	20	29	24	20	29	23	20	19
10	40	29	22	18	39	28	22	18	28	22	18	27	21	17	26	21	17	16

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 21B

MIL-F-16377/21 100W INCANDESCENT SYM 90.2
LIGHT OUTPUT: FROM 100W LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	301	299	292	282	273	266	256	246	218	183	133	83
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	60	35	24	16	10	4	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	21.40	18.10	12.69	7.65	3.74	1.56	0.73	0.38	0.19	0.12	0.08
4.00	18.81	16.20	11.76	7.58	4.04	1.82	0.82	0.45	0.24	0.14	0.09
4.25	16.66	14.58	10.89	7.45	4.17	2.06	0.92	0.51	0.29	0.16	0.10
4.50	14.86	13.13	10.08	7.11	4.26	2.26	1.08	0.57	0.33	0.19	0.11
4.75	13.34	11.97	9.33	6.76	4.31	2.44	1.24	0.62	0.37	0.22	0.13
5.00	12.04	10.91	8.66	6.42	4.31	2.59	1.38	0.69	0.41	0.25	0.15
5.25	10.92	9.99	8.05	6.09	4.25	2.66	1.50	0.80	0.45	0.28	0.18
5.50	9.95	9.17	7.49	5.77	4.23	2.71	1.61	0.89	0.49	0.31	0.20
5.75	9.10	8.45	6.99	5.50	4.15	2.74	1.71	0.98	0.54	0.34	0.22
6.00	8.36	7.30	6.54	5.22	4.00	2.76	1.80	1.06	0.61	0.36	0.24

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	61	59	57	56	60	58	56	55	56	54	53	53	52	51	51	50	50	49
2	57	54	51	48	56	52	50	48	51	48	46	49	47	45	47	46	44	43
3	53	48	45	42	52	48	44	42	46	43	41	44	42	40	43	41	39	38
4	49	44	40	37	48	43	39	36	42	38	36	40	38	35	39	37	35	34
5	45	39	35	32	44	39	35	32	38	34	31	37	33	31	36	33	31	30
6	42	34	31	28	41	35	31	28	34	31	28	33	30	28	32	30	27	26
7	39	37	28	25	38	32	28	25	31	27	25	30	27	24	29	26	24	23
8	36	28	25	22	35	29	25	22	28	24	22	27	24	21	27	24	21	20
9	33	26	22	19	32	26	22	19	25	21	19	25	21	19	24	21	19	18
10	31	24	20	17	30	23	19	17	23	19	17	22	19	17	22	19	16	16

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 22A

MIL-F-16377/22 200W INCANDESCENT SYM 94.1
LIGHT OUTPUT: FROM 200W LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	1476	1427	1360	1251	1150	1035	980	733	520	389	225	160
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	120	95	70	44	35	17	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	104.96	80.35	45.91	19.54	7.47	2.83	1.44	0.81	0.48	0.32	0.22
4.00	92.25	72.59	44.12	20.31	8.60	3.16	1.59	0.90	0.55	0.35	0.24
4.25	81.72	65.84	42.19	21.35	9.29	3.56	1.75	1.01	0.61	0.39	0.27
4.50	72.89	59.94	39.90	21.95	9.34	4.29	1.97	1.11	0.67	0.43	0.29
4.75	65.42	54.77	37.64	21.78	10.26	4.74	2.16	1.20	0.74	0.48	0.32
5.00	59.04	50.21	35.49	21.48	10.99	5.50	2.33	1.31	0.81	0.52	0.35
5.25	53.55	46.19	33.47	21.09	11.59	5.86	2.73	1.44	0.88	0.57	0.38
5.50	48.79	42.61	31.56	20.65	12.05	6.17	3.13	1.57	0.94	0.62	0.42
5.75	44.64	39.39	29.73	20.15	12.35	6.41	3.50	1.68	1.02	0.66	0.45
6.00	41.00	36.45	28.02	19.61	12.34	6.65	3.82	1.87	1.11	0.71	0.48

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	84	82	79	77	82	80	78	76	76	75	73	73	72	71	70	69	68	67
2	79	74	71	67	77	73	69	67	70	67	65	68	65	63	65	63	62	60
3	74	68	63	60	72	67	63	59	65	61	58	62	59	57	60	58	56	54
4	69	62	57	53	68	61	57	53	59	55	52	58	54	51	56	53	51	49
5	65	57	52	48	63	56	51	47	54	50	47	53	49	46	52	48	46	44
6	61	53	47	43	59	52	47	43	50	46	43	49	45	42	48	44	42	40
7	57	48	43	39	55	48	43	39	46	42	39	45	41	38	44	41	38	37
8	53	44	39	35	52	44	39	35	43	38	35	42	38	34	41	37	34	33
9	49	40	35	31	48	40	35	31	39	34	31	38	34	31	37	34	31	30
10	46	37	32	28	45	37	32	28	36	31	28	35	31	28	35	31	28	27

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 23A

MIL-F-16377/23 200W INCANDESCENT SYM 57 AND 103
LIGHT OUTPUT: FROM 200W LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	967	951	910	860	787	725	640	562	460	377	300	230
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	180	135	115	77	60	42	27	17	10	6	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	68.76	55.21	32.86	16.50	7.93	3.93	2.12	1.23	0.74	0.51	0.36
4.00	60.44	49.63	31.23	16.76	8.33	4.29	2.31	1.36	0.83	0.55	0.39
4.25	53.54	44.81	29.59	16.83	8.68	4.60	2.51	1.49	0.93	0.59	0.42
4.50	47.75	40.64	27.80	16.57	8.93	4.89	2.73	1.62	1.01	0.66	0.45
4.75	42.86	37.01	26.09	16.19	9.09	5.13	2.94	1.74	1.10	0.72	0.49
5.00	38.68	33.83	24.48	15.76	9.28	5.33	3.12	1.87	1.19	0.79	0.53
5.25	35.08	31.03	22.99	15.30	9.40	5.51	3.30	2.01	1.27	0.85	0.58
5.50	31.97	28.55	21.60	14.84	9.46	5.66	3.45	2.14	1.35	0.91	0.63
5.75	29.25	26.35	20.36	14.37	9.45	5.76	3.59	2.26	1.44	0.97	0.67
6.00	26.86	24.38	19.21	13.88	9.32	5.84	3.70	2.37	1.54	1.03	0.72

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	79	70	68	65	71	68	66	64	65	64	62	63	61	60	60	59	58	57
2	67	63	59	56	66	61	58	55	59	56	54	57	54	52	55	53	51	49
3	63	57	52	48	61	56	51	48	53	50	47	52	48	46	50	47	45	44
4	58	51	46	42	56	50	46	42	48	44	41	47	43	41	45	42	40	39
5	54	46	41	37	52	45	40	37	44	40	36	42	39	36	41	38	35	34
6	50	42	37	33	49	41	36	33	40	36	32	39	35	32	38	34	32	31
7	46	38	33	29	45	38	33	29	37	32	29	36	32	29	35	31	28	27
8	43	35	29	26	42	34	29	26	33	29	26	32	28	25	31	28	25	24
9	40	31	26	23	39	31	26	23	30	26	23	29	25	22	29	25	22	21
10	37	29	24	20	36	28	24	20	28	23	20	27	23	20	26	23	20	19

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 25A

MIL-F-16377/25 110W INCANDESCENT SYM 48.2
LIGHT OUTPUT: FROM 110W LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	337	332	324	312	298	284	263	243	220	199	173	152
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	130	105	83	66	50	41	30	27	21	18	15	13

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	23.96	20.02	13.24	7.66	4.31	2.46	1.47	0.91	0.57	0.38	0.26
4.00	21.06	17.94	12.41	7.50	4.40	2.55	1.56	0.98	0.63	0.42	0.29
4.25	18.66	16.15	11.61	7.31	4.41	2.63	1.64	1.05	0.69	0.46	0.32
4.50	16.64	14.61	10.61	7.06	4.39	2.71	1.71	1.11	0.74	0.50	0.35
4.75	14.94	13.27	10.06	6.80	4.36	2.77	1.76	1.16	0.78	0.54	0.37
5.00	13.48	12.10	9.38	6.54	4.31	2.81	1.81	1.21	0.83	0.57	0.40
5.25	12.23	11.08	8.75	6.27	4.24	2.82	1.86	1.25	0.87	0.61	0.43
5.50	11.14	10.18	8.18	6.01	4.17	2.82	1.90	1.29	0.90	0.64	0.46
5.75	10.19	9.38	7.65	5.76	4.08	2.80	1.93	1.32	0.93	0.67	0.49
6.00	9.36	8.66	7.17	5.51	3.97	2.78	1.95	1.35	0.96	0.69	0.51

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	95	91	87	84	92	88	85	82	83	81	78	79	76	74	75	73	71	69
2	87	80	74	69	84	78	72	67	73	69	65	69	66	62	66	63	60	58
3	80	71	64	58	77	69	62	57	65	60	55	62	57	53	59	55	52	49
4	73	63	55	49	71	61	54	49	58	52	47	55	50	46	53	48	45	43
5	67	56	48	42	65	54	47	41	52	45	40	49	44	39	47	42	38	36
6	62	50	42	36	60	49	41	36	47	40	35	44	39	34	42	37	34	32
7	57	45	37	32	55	44	37	31	42	35	31	40	34	30	38	33	29	28
8	53	40	33	28	51	40	32	27	38	31	27	36	30	25	35	30	26	24
9	48	36	29	24	47	36	29	24	34	28	23	33	27	23	31	26	22	21
10	45	33	26	21	44	32	26	21	31	25	21	30	24	20	29	23	20	18

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 26A

MIL-F-16377/26 110W INCANDESCENT SYM 112
LIGHT OUTPUT: FROM 110W LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	330	320	318	315	300	280	260	240	214	185	163	145
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	125	105	85	55	50	40	35	25	20	15	11	9

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	23.47	20.21	13.08	7.48	4.02	2.33	1.41	0.88	0.57	0.39	0.27
4.00	20.62	18.01	12.24	7.37	4.09	2.41	1.49	0.95	0.62	0.42	0.30
4.25	18.27	16.14	11.45	7.21	4.17	2.48	1.56	1.01	0.67	0.46	0.32
4.50	16.30	14.54	10.71	6.98	4.22	2.54	1.62	1.06	0.71	0.49	0.35
4.75	14.63	13.16	10.02	6.72	4.23	2.59	1.67	1.11	0.75	0.52	0.37
5.00	13.20	11.96	9.37	6.46	4.21	2.62	1.70	1.15	0.79	0.56	0.40
5.25	11.97	10.92	8.78	6.20	4.16	2.66	1.74	1.19	0.83	0.58	0.42
5.50	10.91	10.01	8.23	5.94	4.10	2.69	1.78	1.22	0.86	0.61	0.44
5.75	9.98	9.20	7.71	5.69	4.03	2.71	1.80	1.24	0.89	0.64	0.47
6.00	9.17	8.48	7.23	5.44	3.92	2.71	1.82	1.27	0.91	0.66	0.49

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	91	87	83	80	88	85	81	78	80	77	75	76	74	72	72	70	69	66
2	85	77	71	66	81	74	69	65	71	66	63	67	63	60	64	61	58	56
3	77	68	61	56	74	66	60	55	63	58	53	60	55	52	57	53	50	48
4	70	60	53	48	68	59	52	47	56	50	46	54	49	45	51	47	44	42
5	64	54	46	41	62	52	45	40	50	44	39	48	42	38	46	41	37	35
6	59	48	41	35	57	47	40	35	45	39	34	43	38	33	41	36	33	31
7	55	43	36	31	53	42	35	31	41	34	30	39	33	29	37	32	29	27
8	50	39	32	27	49	38	31	27	37	30	26	35	30	26	34	29	25	23
9	47	35	28	23	45	34	28	23	33	27	23	32	26	22	30	26	22	20
10	43	32	25	21	42	31	25	21	30	24	20	29	24	20	28	23	19	18

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 27A

MIL-F-16377/27 50W INCANDESCENT SYM 92.2
LIGHT OUTPUT: FROM 50W LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	30	32	32	33	33	34	34	34	33	32	32	32
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	31	31	31	31	30	30	30	28	27	27	25	23

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	2.13	2.12	1.66	1.13	0.73	0.49	0.33	0.23	0.17	0.13	0.10
4.00	1.87	1.87	1.52	1.08	0.71	0.49	0.34	0.24	0.17	0.13	0.10
4.25	1.66	1.67	1.39	1.03	0.69	0.48	0.34	0.24	0.18	0.13	0.10
4.50	1.48	1.49	1.27	0.97	0.67	0.47	0.34	0.25	0.18	0.14	0.11
4.75	1.33	1.34	1.16	0.91	0.65	0.46	0.34	0.25	0.18	0.14	0.11
5.00	1.20	1.22	1.07	0.86	0.63	0.45	0.34	0.25	0.19	0.14	0.11
5.25	1.09	1.11	0.98	0.81	0.61	0.44	0.33	0.25	0.19	0.14	0.11
5.50	0.99	1.01	0.91	0.76	0.59	0.44	0.33	0.25	0.19	0.15	0.11
5.75	0.91	0.93	0.84	0.72	0.57	0.43	0.32	0.25	0.19	0.15	0.12
6.00	0.83	0.85	0.78	0.68	0.54	0.42	0.31	0.25	0.19	0.15	0.12

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	61	57	53	50	57	53	50	47	47	45	42	42	40	38	37	35	33	31
2	54	48	42	38	50	45	40	36	40	36	32	35	32	29	30	28	26	23
3	49	41	35	31	45	39	33	29	34	30	26	30	26	23	26	23	21	18
4	44	36	30	25	41	34	28	24	30	25	22	26	22	19	23	20	17	15
5	40	31	25	21	37	29	24	20	26	21	18	23	19	16	20	17	14	12
6	37	27	22	17	34	26	21	17	23	18	15	20	16	13	18	14	12	10
7	34	25	19	15	31	23	18	14	21	16	13	18	14	11	16	13	10	9
8	31	22	17	13	29	21	16	12	19	14	11	16	13	10	14	11	9	7
9	29	20	15	11	27	19	14	10	17	12	9	15	11	9	13	10	7	6
10	27	18	13	10	25	17	12	9	15	11	8	13	10	7	12	9	6	5

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 36A

MILF-16377/36 25W INCANDESCENT SYM 95.1 AND 96.1
LIGHT OUTPUT: FROM 25W LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	58	58	57	56	54	51	48	45	43	38	36	31
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	28	24	21	17	14	11	9	7	6	2	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	4.12	3.59	2.40	1.47	0.85	0.50	0.31	0.20	0.13	0.09	0.07
4.00	3.62	3.21	2.24	1.42	0.84	0.53	0.32	0.21	0.14	0.10	0.07
4.25	3.21	2.88	2.09	1.36	0.85	0.54	0.33	0.22	0.15	0.10	0.08
4.50	2.86	2.60	1.95	1.30	0.85	0.54	0.35	0.23	0.16	0.11	0.08
4.75	2.57	2.35	1.81	1.25	0.85	0.54	0.36	0.24	0.17	0.12	0.09
5.00	2.32	2.14	1.69	1.20	0.83	0.54	0.38	0.25	0.17	0.12	0.09
5.25	2.10	1.95	1.53	1.14	0.80	0.54	0.38	0.26	0.18	0.13	0.10
5.50	1.92	1.79	1.48	1.09	0.78	0.55	0.38	0.27	0.18	0.14	0.10
5.75	1.75	1.65	1.39	1.04	0.75	0.55	0.38	0.27	0.19	0.14	0.10
6.00	1.61	1.52	1.30	1.00	0.73	0.54	0.37	0.28	0.20	0.14	0.11

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	71	67	64	61	68	65	62	60	61	59	57	58	56	54	55	53	52	50
2	64	58	53	49	62	57	52	48	53	50	46	50	47	45	47	45	43	41
3	59	51	46	41	56	50	45	40	47	43	39	44	41	38	42	39	36	35
4	54	45	39	35	52	44	39	34	42	37	33	40	35	32	37	34	31	29
5	49	40	34	29	47	39	33	29	37	32	28	35	31	27	33	29	26	25
6	45	36	30	25	43	35	29	25	33	28	24	31	27	24	30	26	23	21
7	41	32	26	22	40	31	26	22	30	25	21	28	24	21	27	23	20	19
8	38	29	23	19	37	28	23	19	27	22	18	26	21	18	24	20	17	16
9	35	26	20	16	34	25	20	16	24	19	16	23	19	15	22	18	15	14
10	33	24	18	14	32	23	18	14	22	17	14	21	17	14	20	16	13	12

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 57A

MIL-F-16377/57 40W FLUSH SYM 348 CLEAR PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	825	810	800	760	750	715	670	620	550	440	330	240
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	180	130	110	90	45	20	10	5	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	58.67	45.79	33.55	19.26	9.09	4.20	2.16	1.21	0.71	0.49	0.35
4.00	51.56	43.81	31.35	19.00	9.72	4.66	2.37	1.35	0.81	0.53	0.38
4.25	45.67	39.53	29.25	18.62	10.22	5.03	2.63	1.51	0.91	0.57	0.40
4.50	40.74	35.82	27.22	18.01	10.60	5.32	2.92	1.66	1.01	0.64	0.43
4.75	36.57	32.60	25.33	17.34	10.87	5.90	3.19	1.80	1.11	0.71	0.47
5.00	33.00	29.79	23.61	16.65	10.83	6.22	3.43	1.96	1.22	0.78	0.52
5.25	29.93	27.30	22.03	15.96	10.73	6.49	3.69	2.14	1.31	0.85	0.57
5.50	27.27	25.11	20.58	15.27	10.59	6.70	3.93	2.31	1.41	0.92	0.62
5.75	24.95	23.15	19.25	14.59	10.40	6.86	4.14	2.47	1.52	1.00	0.67
6.00	22.92	21.36	17.86	13.93	10.13	6.96	4.32	2.63	1.64	1.06	0.72

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	52	51	49	47	51	49	48	47	47	46	45	46	45	44	44	43	42	41
2	46	45	42	40	47	44	42	40	43	41	39	41	39	32	40	38	37	36
3	45	41	37	35	44	40	37	34	39	36	34	37	35	33	36	34	33	32
4	42	37	33	30	41	36	33	30	35	32	30	34	31	29	33	31	29	28
5	38	33	29	26	37	32	29	26	31	28	26	31	28	26	30	27	25	24
6	36	30	26	23	35	29	26	23	29	25	23	28	25	23	27	25	23	22
7	32	27	23	21	32	27	23	20	26	23	20	25	22	20	25	22	20	19
8	30	24	21	18	30	24	20	13	23	20	18	23	20	18	23	20	16	17
9	28	22	18	16	27	22	18	16	21	18	16	21	18	15	20	17	15	15
10	26	20	16	14	25	20	16	14	19	16	14	19	15	14	19	16	14	13

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 57B

MIL-F-16377/57 80W FLUSH SYM 349 CLEAR PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	1120	1120	1100	1080	1070	1035	1000	935	890	825	600	450
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	275	220	165	55	45	25	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	79.64	69.30	49.51	30.54	16.88	7.77	3.65	1.91	1.20	0.78	0.53
4.00	70.00	61.85	45.80	29.38	16.23	8.53	4.31	2.08	1.33	0.87	0.59
4.25	62.01	55.51	42.39	28.17	18.12	9.27	4.91	2.47	1.45	0.96	0.66
4.50	55.31	50.07	39.28	27.08	17.91	10.19	5.40	2.89	1.56	1.05	0.72
4.75	49.64	45.37	36.44	26.00	17.63	10.99	5.84	3.30	1.77	1.13	0.79
5.00	44.80	41.29	33.85	24.90	17.18	11.67	6.24	3.66	2.06	1.21	0.85
5.25	40.63	37.72	31.50	23.79	16.69	11.62	6.77	3.97	2.33	1.32	0.91
5.50	37.02	34.59	29.36	22.58	16.19	11.52	7.27	4.25	2.60	1.52	0.97
5.75	33.88	31.83	27.31	21.44	15.68	11.40	7.72	4.50	2.83	1.72	1.03
6.00	31.11	29.38	25.45	20.35	15.23	11.23	8.10	4.60	3.04	1.92	1.17

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	61	59	57	55	60	58	56	55	56	54	53	53	52	51	52	51	50	49
2	57	53	50	47	55	52	49	47	50	48	45	49	47	45	47	45	44	43
3	53	46	44	41	51	47	43	41	45	42	40	44	41	39	43	40	39	38
4	49	43	39	35	47	42	38	35	41	37	35	40	37	34	39	36	34	33
5	45	38	34	31	44	38	34	30	37	33	30	36	32	30	35	[illegible]	[illegible]	28
6	41	34	30	27	40	34	30	27	33	29	26	32	29	26	31	28	26	25
7	38	31	26	23	37	31	26	23	30	26	23	29	26	23	28	25	23	22
8	35	28	23	20	34	27	23	20	27	23	20	26	22	20	25	22	20	19
9	32	25	20	17	31	25	20	17	24	20	17	23	20	17	22	19	17	16
10	30	23	18	15	29	22	18	15	22	18	15	21	18	15	21	17	15	14

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 57C

MIL-F-16377/57 120W FLUOR SYM 350 CLEAR PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	1760	1760	1740	1720	1670	1630	1550	1475	1365	1255	880	660
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	440	330	220	110	55	25	0	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET / HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)

FEET	0	1	2	3	4	5	6	7	8	9	10
3.75	125.16	110.35	77.22	47.22	25.40	11.40	5.59	2.99	1.81	1.12	0.71
4.00	110.00	98.38	71.75	45.48	27.73	12.51	6.43	3.32	2.04	1.29	0.83
4.25	97.44	88.19	66.72	44.38	27.65	13.65	7.20	3.84	2.26	1.45	0.95
4.50	86.91	79.47	61.74	42.52	27.40	15.21	7.92	4.38	2.48	1.61	1.07
4.75	78.01	71.95	57.16	40.61	27.03	16.58	8.57	4.89	2.78	1.77	1.
5.00	70.40	65.43	53.01	38.73	26.56	17.75	9.15	5.37	3.15	1.92	1.30
5.25	63.85	59.74	49.24	36.90	26.01	17.71	10.04	5.82	3.50	2.09	1.42
5.50	58.18	54.74	45.53	35.17	25.40	17.61	10.90	6.23	3.84	2.36	1.53
5.75	53.23	50.34	42.77	33.50	24.72	17.45	11.66	6.60	4.16	2.61	1.64
6.00	48.59	46.44	39.98	31.90	23.92	17.24	12.33	7.08	4.45	2.86	1.82

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	61	59	57	56	60	58	56	55	56	54	53	54	52	51	52	51	50	49
2	57	53	50	47	56	52	49	47	50	48	46	49	47	45	47	45	44	43
3	53	46	44	41	51	47	43	41	45	42	40	44	41	39	43	40	39	38
4	49	43	39	35	47	42	38	35	41	37	35	40	37	34	38	36	34	33
5	45	38	34	31	44	36	33	30	37	33	30	35	32	30	35	32	29	28
6	41	34	30	27	40	34	30	27	33	29	26	32	29	26	31	28	26	25
7	38	31	26	23	37	31	25	23	30	26	23	29	25	22	28	25	23	22
8	35	22	23	20	34	27	23	20	27	23	20	26	22	20	25	22	20	19
9	32	25	20	17	31	24	20	17	24	20	17	23	20	17	23	19	17	16
10	30	22	18	15	29	22	16	15	22	18	15	21	16	15	21	17	15	14

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 57D

MIL-F-16377/57 60W FLUOR SYM 348 CLEAR PRISMATIC
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS--RED FILTER ON CENTER LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	455	455	430	390	350	316	275	240	200	162	120	58
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	50	42	30	21	15	6	4	2	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET / HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)

FEET	0	1	2	3	4	5	6	7	8	9	10
3.75	32.36	25.05	14.21	7.13	3.33	1.54	0.69	0.35	0.23	0.15	0.10
4.00	28.44	22.70	13.56	7.20	3.58	1.70	0.83	0.38	0.25	0.17	0.11
4.25	25.19	20.63	12.89	7.19	3.75	1.85	0.96	0.46	0.27	0.18	0.12
4.50	22.47	18.82	12.17	7.09	3.87	2.02	1.07	0.55	0.28	0.20	0.14
4.75	20.17	17.23	11.48	6.94	3.95	2.17	1.16	0.64	0.33	0.21	0.15
5.00	18.20	15.82	10.81	6.77	4.01	2.29	1.25	0.72	0.39	0.22	0.16
5.25	16.51	14.57	10.19	6.58	4.05	2.38	1.35	0.78	0.45	0.24	0.17
5.50	15.04	13.46	9.61	6.41	4.05	2.45	1.44	0.84	0.51	0.29	0.18
5.75	13.76	12.46	9.09	6.22	4.04	2.50	1.58	0.90	0.56	0.33	0.19
6.00	12.64	11.54	8.60	6.03	3.99	2.54	1.59	0.96	0.60	0.37	0.22

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 57E

MIL-F-16377/57 120W FLUOR SYM 350 CLEAR PRISMATIC
LIGHT OUTPUT: FROM FOUR LAMPS-RED FILTERS ON NO. 2 AND NO. 5 LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	1000	1000	990	986	970	942	900	826	740	658	500	378
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	250	182	130	95	70	22	8	7	6	5	4	3

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET / HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)

FEET	0	1	2	3	4	5	6	7	8	9	10
3.75	71.11	63.38	44.76	25.84	13.64	6.51	3.19	1.69	1.00	0.64	0.42
4.00	62.50	56.40	41.54	25.40	14.54	7.12	3.67	1.88	1.14	0.72	0.48
4.25	55.36	50.49	38.56	24.82	14.68	7.69	4.12	2.19	1.27	0.80	0.53
4.50	49.38	45.43	35.72	24.05	14.71	8.32	4.52	2.50	1.40	0.90	0.59
4.75	44.32	41.08	33.11	23.21	14.65	8.86	4.88	2.80	1.58	0.99	0.66
5.00	40.00	37.32	30.73	22.34	14.53	9.31	5.20	3.07	1.79	1.09	0.73
5.25	36.28	34.04	28.56	21.42	14.36	9.38	5.57	3.32	2.00	1.19	0.80
5.50	33.06	31.17	26.62	20.39	14.13	9.41	5.91	3.55	2.20	1.34	0.87
5.75	30.25	28.64	24.79	19.40	13.86	9.40	6.21	3.75	2.38	1.49	0.93
6.00	27.78	26.42	23.14	18.46	13.53	9.36	6.46	3.97	2.54	1.63	1.04

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 64A

MIL-F-16377/64 150W INCANDESCENT SYM 67
LIGHT OUTPUT: FROM 150W LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	447	432	410	385	359	336	316	291	258	219	193	165
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	132	97	61	30	10	5	3	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET / HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)

FEET	0	1	2	3	4	5	6	7	8	9	10
3.75	31.79	24.78	15.81	8.89	4.76	2.70	1.54	0.89	0.53	0.32	0.20
4.00	27.94	22.25	14.75	8.65	4.84	2.63	1.67	0.99	0.60	0.37	0.24
4.25	24.75	20.11	13.75	8.73	4.93	2.93	1.78	1.09	0.67	0.43	0.27
4.50	22.07	18.25	12.84	8.46	4.97	3.01	1.87	1.17	0.74	0.48	0.31
4.75	19.81	16.64	12.00	8.16	4.99	3.06	1.95	1.25	0.81	0.53	0.35
5.00	17.88	15.22	11.23	7.85	5.00	3.10	2.01	1.32	0.86	0.57	0.39
5.25	16.22	13.97	10.51	7.53	4.99	3.14	2.06	1.38	0.92	0.62	0.42
5.50	14.74	12.86	9.85	7.19	4.95	3.17	2.10	1.42	0.97	0.66	0.46
5.75	13.52	11.88	9.26	6.87	4.88	3.19	2.13	1.47	1.02	0.70	0.49
6.00	12.42	10.99	8.71	6.55	4.76	3.19	2.15	1.50	1.05	0.74	0.52

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	52	50	48	47	51	49	48	46	47	46	45	45	44	43	44	43	42	41
2	48	45	42	40	47	44	41	39	42	40	38	41	39	38	39	38	37	36
3	44	40	37	34	43	39	36	34	38	36	33	37	35	33	36	34	32	31
4	41	36	32	30	40	35	32	29	34	31	29	33	31	29	32	30	28	27
5	38	32	28	25	37	32	28	25	31	27	25	30	27	25	29	26	24	24
6	35	29	25	22	34	28	25	22	28	24	22	27	24	22	26	24	22	21
7	32	26	22	19	31	26	22	19	25	22	19	24	21	19	24	21	19	18
8	30	23	20	17	29	23	19	17	23	19	17	22	19	17	21	19	17	16
9	27	21	17	15	27	21	17	15	20	17	15	20	17	15	19	17	15	14
10	25	19	16	13	25	19	16	13	19	15	13	18	15	13	18	15	13	12

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 65A

MIL-F-16377/65 30W FLUOR SYM 81 AND 81.1 WHITE DIFFUSING
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	290	290	285	280	275	265	255	235	222	205	177	160
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	140	120	95	75	55	42	25	10	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	20.62	17.97	12.65	7.63	4.43	2.56	1.57	0.99	0.65	0.44	0.30
4.00	18.12	16.03	11.71	7.36	4.53	2.63	1.65	1.06	0.71	0.48	0.33
4.25	16.06	14.39	10.85	7.08	4.51	2.69	1.72	1.12	0.75	0.52	0.36
4.50	14.38	12.98	10.06	6.83	4.46	2.78	1.77	1.18	0.80	0.56	0.40
4.75	12.85	11.76	9.34	6.59	4.40	2.85	1.82	1.23	0.84	0.59	0.43
5.00	11.60	10.70	8.69	6.33	4.29	2.90	1.85	1.27	0.88	0.62	0.45
5.25	10.52	9.77	8.09	6.07	4.18	2.89	1.90	1.30	0.92	0.65	0.48
5.50	9.59	8.96	7.55	5.77	4.06	2.87	1.95	1.33	0.95	0.68	0.50
5.75	8.77	8.25	7.03	5.48	3.94	2.84	1.99	1.35	0.98	0.71	0.52
6.00	8.06	7.61	6.56	5.20	3.84	2.80	2.01	1.38	1.00	0.73	0.54

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	64	61	58	56	62	59	57	55	57	55	53	56	53	51	52	51	49	46
2	58	53	49	45	56	52	48	45	49	46	43	47	45	42	45	43	41	40
3	53	47	42	38	51	46	41	37	44	40	37	42	39	36	40	38	35	34
4	48	41	36	32	47	40	35	32	39	35	31	37	34	31	36	33	30	29
5	44	36	31	27	43	35	31	27	34	30	26	33	29	26	32	28	25	24
6	41	32	27	23	39	32	27	23	31	26	23	30	26	23	29	25	22	21
7	37	29	24	20	36	29	24	20	28	23	20	27	23	20	26	22	19	18
8	34	26	21	17	33	26	21	17	25	20	17	24	20	17	23	20	17	16
9	32	23	18	15	31	23	18	15	22	18	15	22	18	15	21	17	14	13
10	29	21	16	13	29	21	16	13	20	16	13	20	16	13	19	15	13	12

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 65B

MIL-F-16377/65 30W FLUOR SYM 81 AND 81.1 WHITE DIFFUSING
LIGHT OUTPUT: FROM ONE LAMP ONLY

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	162	162	160	156	153	148	141	134	125	115	103	94
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	93	73	52	47	38	30	17	11	5	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	11.52	10.01	7.02	4.31	2.52	1.50	0.93	0.59	0.40	0.25	0.17
4.00	10.12	8.95	6.52	4.18	2.54	1.53	0.97	0.63	0.43	0.29	0.19
4.25	8.97	8.04	6.06	4.03	2.53	1.56	1.01	0.66	0.45	0.32	0.21
4.50	8.00	7.26	5.62	3.86	2.51	1.59	1.04	0.70	0.48	0.34	0.24
4.75	7.18	6.58	5.21	3.69	2.48	1.61	1.06	0.72	0.50	0.35	0.26
5.00	6.48	5.99	4.84	3.52	2.43	1.63	1.08	0.75	0.52	0.37	0.27
5.25	5.88	5.48	4.50	3.36	2.37	1.62	1.10	0.76	0.54	0.39	0.29
5.50	5.36	5.03	4.20	3.20	2.31	1.61	1.11	0.78	0.56	0.40	0.30
5.75	4.90	4.63	3.91	3.04	2.25	1.60	1.12	0.79	0.57	0.42	0.31
6.00	4.50	4.27	3.65	2.90	2.17	1.58	1.13	0.80	0.58	0.43	0.32

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 65C

MIL-F-16377/65 30W FLUOR SYM 345.2 AND 345.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	320	320	320	320	315	305	290	280	265	245	225	195
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	160	130	95	75	55	40	25	16	10	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	22.76	20.53	14.45	9.11	5.41	3.17	1.84	1.12	0.71	0.46	0.30
4.00	20.00	18.26	13.43	8.78	5.41	3.31	1.94	1.21	0.78	0.51	0.34
4.25	17.72	16.34	12.48	8.43	5.37	3.41	2.10	1.31	0.85	0.57	0.38
4.50	15.80	14.79	11.57	8.04	5.33	3.44	2.20	1.40	0.91	0.62	0.43
4.75	14.19	13.29	10.73	7.65	5.25	3.46	2.28	1.48	0.97	0.66	0.46
5.00	12.80	12.07	9.97	7.27	5.12	3.46	2.35	1.56	1.04	0.71	0.50
5.25	11.61	11.01	9.28	6.90	4.99	3.45	2.38	1.62	1.10	0.75	0.53
5.50	10.58	10.07	8.64	6.56	4.84	3.43	2.40	1.67	1.15	0.80	0.57
5.75	9.68	9.26	8.05	6.27	4.69	3.39	2.41	1.71	1.20	0.84	0.60
6.00	8.89	8.53	7.51	5.97	4.52	3.34	2.41	1.74	1.24	0.88	0.63

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 — ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	73	70	67	64	71	68	66	63	65	63	61	62	61	59	60	58	57	55
2	67	61	57	53	65	60	56	52	57	54	51	55	52	49	53	50	48	46
3	61	54	49	46	59	53	48	44	51	46	43	49	45	42	47	44	41	40
4	56	48	42	37	54	47	41	37	45	40	36	43	39	36	42	38	35	34
5	51	42	36	32	49	41	36	31	40	35	31	38	34	30	37	33	30	28
6	47	38	32	27	45	37	31	27	36	30	27	34	30	26	33	29	26	25
7	43	34	28	23	42	33	27	23	32	27	23	31	26	23	30	26	23	21
8	40	30	24	20	38	30	24	20	29	24	20	28	23	20	27	23	19	18
9	36	27	21	17	35	27	21	17	26	21	17	25	20	17	24	20	17	15
10	34	24	19	15	33	24	19	15	23	18	15	23	18	15	22	18	15	13

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 65D

MIL-F-16377/65 30W FLUOR SYM 345.2 AND 345.3 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM ONE LAMP ONLY

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	180	180	180	178	177	173	168	160	150	140	126	110
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	92	75	60	47	37	27	15	12	11	9	5	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	12.80	11.42	8.30	5.17	3.07	1.78	1.05	0.64	0.41	0.27	0.19
4.00	11.25	10.18	7.67	5.00	3.09	1.85	1.12	0.70	0.45	0.30	0.21
4.25	9.97	9.13	7.09	4.82	3.07	1.91	1.19	0.75	0.49	0.33	0.23
4.50	8.89	8.22	6.55	4.61	3.03	1.95	1.24	0.80	0.52	0.35	0.25
4.75	7.98	7.44	6.06	4.40	2.97	1.97	1.28	0.84	0.56	0.38	0.27
5.00	7.20	6.77	5.62	4.20	2.91	1.98	1.32	0.88	0.59	0.41	0.29
5.25	6.53	6.18	5.22	4.00	2.84	1.97	1.34	0.91	0.62	0.43	0.31
5.50	5.95	5.66	4.86	3.79	2.76	1.95	1.36	0.94	0.65	0.46	0.33
5.75	5.44	5.21	4.51	3.59	2.68	1.92	1.37	0.96	0.68	0.48	0.34
6.00	5.00	4.80	4.21	3.41	2.59	1.89	1.37	0.98	0.70	0.50	0.36

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 66A

MIL-F-16377/66 45W FLUOR SYM 82 AND 82.1 WHITE DIFFUSING
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	440	430	425	420	410	390	370	350	330	300	270	235
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	210	180	150	130	100	80	60	40	20	10	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	31.29	26.95	18.45	11.35	6.57	3.81	2.33	1.49	0.98	0.67	0.47
4.00	27.50	24.02	17.16	10.96	6.63	3.97	2.44	1.59	1.06	0.73	0.51
4.25	24.36	21.54	15.96	10.54	6.64	4.09	2.54	1.67	1.13	0.78	0.56
4.50	21.73	19.41	14.85	10.11	6.60	4.17	2.65	1.75	1.20	0.84	0.60
4.75	19.50	17.57	13.83	9.67	6.53	4.22	2.74	1.81	1.26	0.89	0.64
5.00	17.60	15.98	12.90	9.23	6.39	4.24	2.82	1.88	1.31	0.94	0.68
5.25	15.96	14.59	12.04	8.81	6.22	4.25	2.87	1.94	1.36	0.98	0.71
5.50	14.55	13.37	11.25	8.40	6.05	4.24	2.91	2.00	1.40	1.02	0.75
5.75	13.31	12.30	10.49	8.01	5.87	4.21	2.93	2.06	1.44	1.05	0.78
6.00	12.22	11.34	9.50	7.63	5.68	4.17	2.95	2.09	1.49	1.08	0.81

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	66	62	59	57	64	61	58	56	58	56	54	55	53	51	52	51	50	48
2	60	54	50	46	58	53	49	45	50	47	44	48	45	42	46	43	41	40
3	54	48	42	38	53	46	42	38	44	40	37	42	39	36	40	37	35	33
4	50	42	37	32	48	41	36	32	39	35	31	38	34	31	36	33	30	20
5	45	37	31	27	44	36	31	27	35	30	26	33	29	26	32	28	25	24
6	42	33	26	23	40	32	27	23	31	26	23	30	26	22	29	25	22	21
7	38	30	24	20	37	29	24	20	28	23	20	27	23	20	26	22	19	18
8	35	27	21	18	34	26	21	17	25	20	17	24	20	17	23	20	17	15
9	33	24	19	15	32	24	19	15	23	18	15	22	18	15	21	17	14	13
10	30	22	17	13	29	21	17	13	21	16	13	20	16	13	19	15	13	12

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 66B

MIL-F-16377/66 45W FLUOR SUM 82 AND 82.1 WHITE DIFFUSING
LIGHT OUTPUT: FROM CENTER LAMP ONLY

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	160	155	155	155	150	145	135	130	121	110	97	87
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	67	62	50	37	28	20	15	12	7	5	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	11.38	9.94	6.78	4.18	2.39	1.39	0.79	0.49	0.34	0.23	0.16
4.00	10.00	8.85	6.34	4.05	2.43	1.44	0.87	0.51	0.36	0.25	0.17
4.25	8.86	7.91	5.93	3.91	2.43	1.47	0.94	0.56	0.37	0.27	0.19
4.50	7.90	7.12	5.50	3.74	2.42	1.51	0.97	0.61	0.39	0.28	0.21
4.75	7.09	6.44	5.11	3.56	2.40	1.54	0.99	0.66	0.41	0.29	0.22
5.00	6.40	5.85	4.74	3.38	2.35	1.56	1.01	0.69	0.45	0.30	0.23
5.25	5.80	5.33	4.42	3.22	2.30	1.56	1.04	0.71	0.48	0.32	0.24
5.50	5.29	4.88	4.12	3.08	2.24	1.55	1.06	0.73	0.51	0.34	0.24
5.75	4.84	4.48	3.84	2.95	2.18	1.54	1.07	0.74	0.53	0.36	0.25
6.00	4.44	4.13	3.59	2.82	2.10	1.53	1.06	0.75	0.54	0.39	0.27

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 66C

MIL-F-16377/66 45W FLUOR SYM 82 AND 82.1 WHITE DIFFUSING
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	310	310	305	295	285	275	267	250	230	213	190	165
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	147	125	105	85	75	50	37	30	20	17	10	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	22.04	18.93	13.19	7.97	4.65	2.68	1.63	1.04	0.68	0.47	0.33
4.00	19.37	16.94	12.19	7.76	4.71	2.79	1.71	1.11	0.74	0.51	0.36
4.25	17.16	15.24	11.26	7.52	4.68	2.88	1.78	1.17	0.79	0.54	0.39
4.50	15.31	13.78	10.44	7.24	4.63	2.94	1.86	1.22	0.84	0.58	0.42
4.75	13.74	12.51	9.69	6.95	4.56	2.99	1.93	1.27	0.88	0.62	0.44
5.00	12.40	11.40	9.01	6.65	4.48	3.01	1.98	1.32	0.92	0.65	0.47
5.25	11.25	10.44	8.39	6.35	4.40	3.00	2.02	1.37	0.95	0.69	0.50
5.50	10.25	9.58	7.82	6.02	4.30	2.98	2.06	1.41	0.98	0.71	0.52
5.75	9.38	8.83	7.30	5.71	4.19	2.94	2.08	1.45	1.01	0.74	0.55
6.00	8.61	8.15	6.83	5.42	4.07	2.91	2.09	1.48	1.05	0.76	0.57

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION TABLE NO. 66D

MIL-F-16377/66 45W FLUOR SYM 343.1 AND 343.2 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM ALL LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	460	460	460	460	455	450	440	415	390	360	320	280
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	225	185	150	130	120	80	60	40	20	10	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	0	1	2	3	4	5	6	7	8	9	10
	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET)										
3.75	32.71	29.51	21.68	13.43	7.85	4.53	2.62	1.58	1.01	0.68	0.47
4.00	28.75	26.25	19.98	12.98	7.95	4.71	2.83	1.70	1.10	0.74	0.52
4.25	25.47	23.49	18.44	12.50	7.92	4.86	3.02	1.85	1.19	0.81	0.57
4.50	22.72	21.13	17.00	11.99	7.84	4.97	3.15	1.99	1.28	0.87	0.61
4.75	20.39	19.10	15.69	11.48	7.72	5.04	3.25	2.12	1.37	0.94	0.66
5.00	18.40	17.35	14.51	10.98	7.56	5.09	3.34	2.23	1.47	1.00	0.71
5.25	16.69	15.82	13.45	10.46	7.37	5.08	3.41	2.31	1.56	1.06	0.75
5.50	15.21	14.48	12.49	9.90	7.17	5.04	3.47	2.38	1.65	1.13	0.80
5.75	13.91	13.30	11.62	9.38	6.96	4.99	3.51	2.44	1.72	1.20	0.84
6.00	12.78	12.26	10.83	8.86	6.75	4.92	3.54	2.49	1.77	1.26	0.89

COEFFICIENTS OF UTILIZATION

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20 ZONAL CAVITY METHOD

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
1	74	70	67	64	72	69	66	63	65	63	61	62	60	58	59	58	56	55
2	67	61	56	52	65	60	55	51	57	53	50	54	51	48	52	49	47	45
3	61	54	48	44	59	53	47	43	52	46	42	48	44	41	46	43	40	39
4	56	48	42	37	54	47	41	37	45	40	36	43	39	35	41	37	34	33
5	51	42	36	31	50	41	35	31	40	34	30	35	33	30	36	32	29	28
6	47	38	31	27	46	37	31	27	35	30	26	34	29	26	33	29	25	24
7	43	34	28	23	42	33	27	23	32	27	23	31	26	22	29	25	22	21
8	40	30	24	20	39	30	24	20	28	23	20	27	23	19	26	22	19	18
9	37	27	21	17	36	27	21	17	26	20	17	25	20	17	24	19	16	15
10	34	25	19	15	33	24	19	15	23	18	15	22	18	15	22	17	14	13

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 66E

MIL-F-163777/66 45W FLUOR SYM 343.1 AND 343.2 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM CENTER LAMP ONLY

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	170	170	170	170	170	165	162	158	145	137	122	105
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	83	63	43	30	20	15	12	0	0	0	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	12.09	10.91	7.97	5.03	2.99	1.71	0.97	0.57	0.35	0.22	0.14
4.00	10.62	9.70	7.34	4.90	3.03	1.79	1.06	0.63	0.39	0.25	0.16
4.25	9.41	8.68	6.76	4.75	2.99	1.85	1.13	0.69	0.43	0.28	0.18
4.50	8.40	7.81	6.26	4.52	2.94	1.89	1.19	0.74	0.47	0.31	0.20
4.75	7.53	7.06	5.80	4.29	2.87	1.92	1.23	0.79	0.51	0.33	0.23
5.00	6.80	6.41	5.39	4.07	2.83	1.94	1.27	0.84	0.55	0.36	0.25
5.25	6.17	5.85	5.01	3.85	2.78	1.92	1.30	0.87	0.58	0.39	0.27
5.50	5.62	5.35	4.66	3.64	2.72	1.89	1.32	0.90	0.62	0.42	0.29
5.75	5.14	4.92	4.33	3.45	2.65	1.86	1.34	0.93	0.65	0.45	0.31
6.00	4.72	4.53	4.03	3.26	2.54	1.83	1.35	0.95	0.67	0.47	0.33

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 66F

MIL-F-163777/66 45W FLUOR SYM 343.1 AND 343.2 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	340	340	335	335	330	325	315	300	280	255	235	205
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	175	140	115	90	65	45	35	25	15	8	0	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	24.18	21.49	15.58	9.66	5.63	3.32	1.98	1.21	0.77	0.52	0.36
4.00	21.25	19.12	14.39	9.36	5.63	3.46	2.10	1.32	0.84	0.56	0.40
4.25	18.82	17.11	13.31	9.03	5.64	3.56	2.21	1.41	0.92	0.61	0.43
4.50	16.79	15.39	12.29	8.65	5.60	3.59	2.31	1.49	0.99	0.67	0.46
4.75	15.07	13.91	11.35	8.26	5.54	3.61	2.39	1.57	1.06	0.72	0.50
5.00	13.60	12.63	10.51	7.87	5.43	3.61	2.45	1.64	1.11	0.77	0.54
5.25	12.34	11.52	9.75	7.49	5.31	3.61	2.48	1.69	1.17	0.82	0.58
5.50	11.24	10.55	9.06	7.11	5.17	3.60	2.50	1.75	1.21	0.86	0.62
5.75	10.28	9.69	8.43	6.74	5.03	3.57	2.51	1.79	1.26	0.90	0.65
6.00	9.44	8.95	7.86	6.40	4.86	3.54	2.50	1.82	1.30	0.93	0.68

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 66G

MIL-F-16377/66 45W FLUOR SYM 82 AND 82.1 WHITE DIFFUSING
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS-RED FILTER ON CENTER LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	240	240	237	235	220	213	198	190	176	163	150	130
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	118	100	83	70	55	45	35	27	20	15	10	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	17.07	15.08	9.95	6.09	3.60	2.11	1.30	0.83	0.55	0.37	0.26
4.00	15.00	13.43	9.32	5.91	3.60	2.20	1.35	0.89	0.59	0.40	0.29
4.25	13.29	12.04	8.71	5.72	3.58	2.27	1.40	0.94	0.63	0.44	0.31
4.50	11.85	10.84	8.08	5.46	3.54	2.29	1.47	0.97	0.67	0.47	0.33
4.75	10.64	9.81	7.50	5.21	3.49	2.31	1.52	1.00	0.71	0.50	0.36
5.00	9.60	8.92	6.96	4.95	3.42	2.31	1.57	1.04	0.73	0.53	0.38
5.25	8.71	8.14	6.45	4.72	3.35	2.30	1.59	1.08	0.75	0.55	0.40
5.50	7.93	7.46	6.04	4.52	3.27	2.28	1.60	1.11	0.77	0.57	0.42
5.75	7.26	6.86	5.67	4.33	3.18	2.25	1.60	1.14	0.80	0.59	0.44
6.00	6.67	6.33	5.33	4.14	3.07	2.22	1.60	1.16	0.82	0.60	0.46

COEFFICIENTS OF UTILIZATION

CU Data Not Required

LIGHTING FIXTURE IDENTIFICATION — TABLE NO. 66H

MIL-F-163777/66 45W FLUOR SYM 343.1 AND 343.2 CLEAR AND WHITE PRISMATIC
LIGHT OUTPUT: FROM TWO OUTSIDE LAMPS--RED FILTER ON CENTER LAMP

CANDLEPOWER DISTRIBUTION

ANGLE	0	5	10	15	20	25	30	35	40	45	50	55
CP	280	280	280	275	270	267	255	240	228	207	185	177
ANGLE	60	65	70	75	80	85	90	95	100	105	110	115
CP	140	120	100	75	60	45	30	20	12	10	5	0

FOOTCANDLE DISTRIBUTION

SOURCE HEIGHT FEET	HORIZONTAL DISTANCE FROM AXIS OF LIGHT SOURCE (FEET) 0	1	2	3	4	5	6	7	8	9	10
3.75	19.91	17.65	12.68	7.83	4.52	2.76	1.64	0.99	0.65	0.45	0.31
4.00	17.50	15.75	11.77	7.54	4.57	2.79	1.78	1.06	0.71	0.49	0.34
4.25	15.50	14.13	10.93	7.23	4.58	2.81	1.90	1.16	0.75	0.52	0.37
4.50	13.83	12.75	10.08	6.94	4.56	2.86	1.92	1.25	0.80	0.56	0.40
4.75	12.41	11.55	9.31	6.65	4.51	2.90	1.93	1.34	0.86	0.59	0.43
5.00	11.20	10.51	8.61	6.36	4.40	2.93	1.94	1.40	0.92	0.62	0.45
5.25	10.16	9.60	7.98	6.07	4.28	2.93	1.97	1.41	0.98	0.66	0.48
5.50	9.26	8.81	7.41	5.78	4.15	2.93	2.00	1.42	1.04	0.71	0.50
5.75	8.47	8.10	6.90	5.50	4.02	2.91	2.02	1.42	1.07	0.75	0.52
6.00	7.78	7.46	6.44	5.23	3.90	2.88	2.03	1.44	1.08	0.79	0.56

COEFFICIENTS OF UTILIZATION

CU Data Not Required

APPENDIX B

TYPICAL INSTALLATION METHODS FOR LIGHTING FIXTURES

10. GENERAL

10.1 Scope. This appendix contains a copy of Drawing 803-5184170, which provides typical installation methods for optimum utilization of lighting fixtures and light installations.

10.2 Application. Related typical installation methods are grouped by section and are further identified in the title block of Drawing 803-5184170 by the following alpha-numeric designation:

```
METHOD    D - 4 - C
          |   |   |
          |   |   └── METHOD OR DETAIL (in the drawing field)
          |   |
          |   └────── SHEET
          |
          └────────── SECTION
```

20. REFERENCED DOCUMENTS

Federal Specifications
- QQ-A-200/87 - Aluminum Alloy Bar, Rod, Shapes, Tube, and Wire, Extruded 5456.
- QQ-A-250/9 - Aluminum Alloy 5456, Plate and Sheet.
- WW-T-700/5 - Tube, Aluminum Alloy, Drawn, Seamless 5086.

Military Specifications
- MIL-T-16343 - Tubing, Steel, Carbon, Structural (Navy).
- MIL-S-22698 - Steel Plate and Shapes, Weldable Ordinary Strength and Higher Strength: Hull Structural.

30. DEFINITIONS

Not applicable.

40. GENERAL DESIGN CONSIDERATIONS

40.1 Symbol numbers. Symbol numbers are in accordance with NAVSEA S0300-AT-GTP-010/EsL.

40.2 Drawing sheet status. The absence of an entry in the table of contents revision column indicates initial issue.

50. DETAIL DESIGN CONSIDERATIONS

50.1 Installation. Distribution and wiring equipments shall be installed in accordance with applicable methods shown on Drawing 803-5001027. Lighting shall be installed in accordance with applicable methods shown on Drawing 803-5184170.

50.2 Material. The following materials shall be used in the fabrication of extension hangers:

Type	Specification	Alloy	Condition
	Aluminum		
Tubing	WW-T-700/5	5086	H32
Flat bar	QQ-A-200/7	5456	Hill or H116
Plate	QQ-A-250/9	5456	H321 or H116
	Steel		
Tubing	MIL-T-16343		Type I
Flat bar and plate	MIL-S-22698		Grade M

50.3 Construction. The following notes apply to the construction of lighting fixtures: ‘

(a) All holes shall be drilled and slightly countersunk.
(b) All sharp corners shall be slightly rounded.
(c) All parts shall be positioned by jig while welding to insure proper alignment.
(d) All dimensions are in inches unless otherwise specified on the individual sheets.
(e) Pads, stud pads, and so forth, shall be tapped or threaded before being welded to ship’s structure.
(f) All hand-operated appliances including switch boxes, individual switches, receptacles with switches, and other similar appliances shall be installed on bulkheads at a height of not more than 6 feet above the deck.

(g) Receptacles shall not be located so as to be subject to water splashing or spray through open air ports.
(h) Mounting details should be provided by the installing activity when not shown by the typical installation methods.
(i) unless otherwise specified, tolerances are in inches.

CONTENTS

ACTIVE SHEETS - DRAWING 803-5184170

Sheet no	Title	Revision
	SECTION A - MEDICAL SPACES	
A-1	Arrangement of surgical lights and lanterns over surgical table in operating room.	A
A-2	Arrangement of surgical lights and lanterns over surgical table in surgical/battle dressing stations (amphibious warfare ships only).	B
A-3	Arrangement of surgical lights and lanterns over surgical table in surgical dressing room.	A
A-4	Arrangement of surgical light and lanterns for surgical and dressing table or examining chair per list of facilities	B
A-5	Arrangement of surgical light and lanterns over surgical table in battle dressing stations (submarines).	A
A-6	Modification to relay-controlled lanterns, and installatlon of lanterns for surgical tables.	B
A-7	Installation of surgical light, symbol 1071 NSN 9L 6530-00-185-0034.	
A-8	Installation of adjustable surgical light, symbol 109 NSN 9L 6530-01-052-6838.	
A-9	Installation of four adjustable surgical lights, symbol 109.	
A-10	Installation of two adjustable surgical lights, symbol 109.	
A-11	Arrangement of surgical light and lanterns for surgical and dressing table on examining chair per list of facilities.	

CONTENTS

ACTIVE SHEETS - DRAWING 803-5184170 - Continued

Sheet no.	Title	Revision
	SECTION B - BERTH ILLUMINATION	
B-1	Fluorescent berth lights for lower and middle berths.	A
B-2	Fluorescent berth lights for top berths.	A
B-3	Arrangement of lighting fixtures in berthing and reading table units for troop ships.	A
B-4	Fluorescent berth lights for hospital, crew and CPO berths.	A
B-5	Berth illumination of berth - locker unit.	A
B-6	Mounting of berth lights, symbols 5.1 and 8.1 (minesweepers only).	A
B-7	Wiring of fluorescent berth lights.	
	SECTION C - MIRROR ILLUMINATION	
c-1	Multiple mirror illumination - sanitary spaces.	A
c-2	Mirror illumination - flat mirrors in living spaces.	
c-3	Illumination of lavatory unit for officers' stateroom.	
c-4	Mirror illumination - toilet article case.	
c-5	Mirror illumination - living spaces.	
C-6	Mirror illumination - toilet article case.	

CONTENTS

ACTIVE SHEETS - DRAWING 803-5184170 - Continued

CONTENTS

ACTIVE SHEETS - DRAWING 803-5184170 - Continued

CONTENTS

ACTIVE SHEETS - DRAWING 803-5184170 - Continued

Sheet no	Title	Revision
	SECTION H - GENERAL AND DETAIL ILLUMINATION - SPECIFIC	
H-1	General and detail lighting for squadron ready rooms.	
H-2	Incandescent steering light.	
H-3	Installation of ammunition hoist light, symbol 23.1.	
H-4	Incandescent lighting fixture for boiler casing.	A
H-5	Installation of psychiatric ward light, symbol 137.	
H-6	Installation of spot light, symbol 147.2.	A
H-7	Lighting fixture for propulsion motors and generators, symbol 126.3.	
H-8	Installation of relay lanterns, symbols 101.2, 102.2, and 108.	A
H-9	Installation of portable lanterns, symbol 100.2.	
H-10	Boiler water gauge lights, symbol 134.1.	
H-11	Boiler water gauge lights symbols 151, 152, 153 and 154.	
H-12	Mounting of sight glass lights, symbols 136.1 and 156.	
H-13	Installation of step light, symbol 353.	
H-14	Typical illumination of a living complex.	
H-15	Installation of explosion proof fixtures symbols 48.2 and 68.2.	

CONTENTS

ACTIVE SHEETS - DRAWING 803-5184170 - Continued

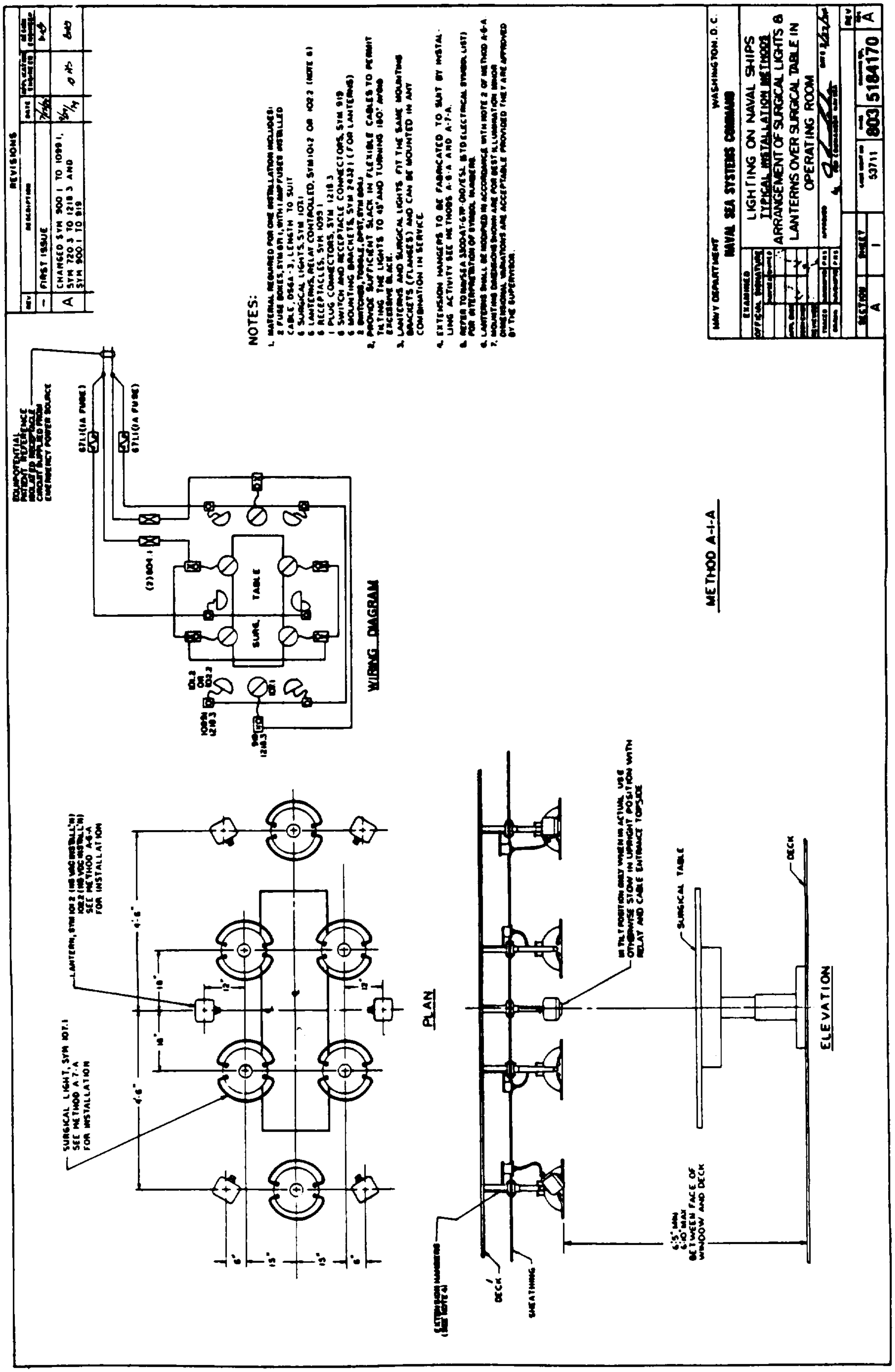
Sheet no.	Title	Revision
	SECTION I - TOPSIDE LIGHTING	
I-1	Dress ship lighting system.	B
I-2	Waterline security lighting.	A
I-3	Navigation lights required by international law.	A
I-4	Navigation light kit for landing boats symbol 2554.	A
I-5	Location of navigational lights on landing boats.	A
I-6	Installation of bow and anchor light on landing boats.	A
I-7	Installation of side lights masthead, not-under-command, and stern light on landing boats.	A
I-8	Installation of stern light on landing boats.	A
I-9	Running signal, identification and anchor lights - submarines	B
I-10	Log desk, gangway and water line security lights - submarines.	A
I-11	Navigational lights elementary wiring diagram - surface ships.	A
I-12	Anchor and signal lights elementary wiring diagram - surface ships.	B
I-13	Portable clearance/obstruction lights for tenders and repair ships.	B
I-14	Permanent clearance/obstruction lights for ATF, ATS, ARS, and ASR ships.	
I-15	Task, not-under-command, man-overboard, aircraft warning and replenishment approach lights.	
I-16	Task, deep draft, not-under-command, man overboard, aircraft warning, and replenishment lights for deep draft ships (CV, CVN, AUT, AO, AOE, AOR, TAO).	

CONTENTS

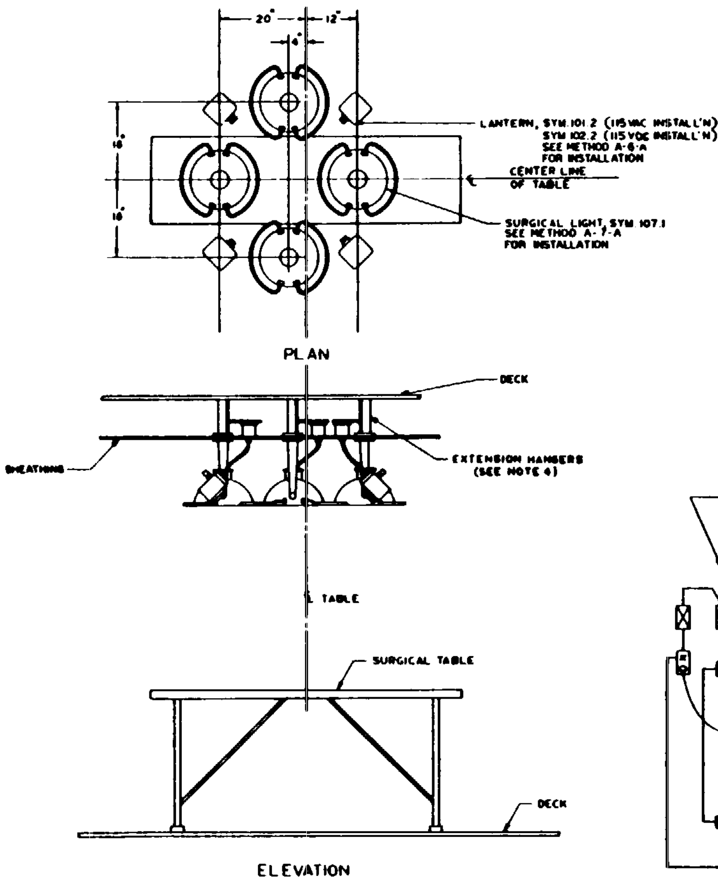
ACTIVE SHEETS - DRAWING 803-5184170 - Continued

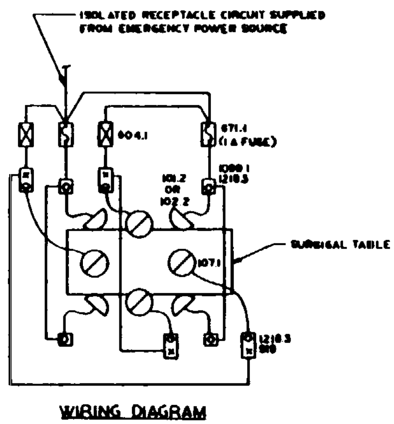
CONTENTS

ACTIVE SHEETS - DRAWING 803-5184170 - Continued


REVISIONS
REV
DESCRIPTION
DATE
APPL ENGINEER
DESIGN ENGINEER
—
FIRST ISSUE
A
CHANGED SYM 900.1 TO 1099.1, SYM 720.3 TO 1218.3 AND SYM 900.1 TO 919
SURGICAL LIGHT, SYM 107.1 SEE METHOD A-7-A FOR INSTALLATION
LANTERN, SYM 101.2 (115 VAC INSTALL'N) 102.2 (115 VDC INSTALL'N) SEE METHOD A-6-A FOR INSTALLATION
4'-6"
18"
12"
6"
15"
PLAN
EQUIPOTENTIAL PATIENT REFERENCE ISOLATED RECEPTACLE CIRCUIT SUPPLIED FROM EMERGENCY POWER SOURCE
67L1(1A FUSE)
(2) 804.1
1099.1 1218.3
101.2 OR 102.2
919 1218.3
107.1
SURG. TABLE
WIRING DIAGRAM
NOTES:
1. MATERIAL REQUIRED FOR ONE INSTALLATION INCLUDES:
2 FUSE BOXES, SYM 671.1, WITH 1 AMP FUSES INSTALLED
CABLE, DSGA-3, LENGTH TO SUIT
6 SURGICAL LIGHTS, SYM 107.1
6 LANTERNS, RELAY CONTROLLED, SYM 101.2 OR 102.2 (NOTE 6)
6 RECEPTACLES, SYM 1099.1
1 PLUG CONNECTORS, SYM 1218.3
6 SWITCH AND RECEPTACLE CONNECTORS, SYM 919
6 MOUNTING BRACKETS, SYM 2432.1 (FOR LANTERNS)
2 SWITCHES, TOGGLE, DPST, SYM 804.1
2. PROVIDE SUFFICIENT SLACK IN FLEXIBLE CABLES TO PERMIT TILTING THE LIGHTS TO 45° AND TURNING 180°. AVOID EXCESSIVE SLACK.
3. LANTERNS AND SURGICAL LIGHTS FIT THE SAME MOUNTING BRACKETS (FLANGES) AND CAN BE MOUNTED IN ANY COMBINATION IN SERVICE.
4. EXTENSION HANGERS TO BE FABRICATED TO SUIT BY INSTALLING ACTIVITY SEE METHODS A-6-A AND A-7-A.
5. REFER TO NAVSEA S9300-AT-GTP-010/ESL (STD ELECTRICAL SYMBOL LIST) FOR INTERPRETATION OF SYMBOL NUMBERS.
6. LANTERNS SHALL BE MODIFIED IN ACCORDANCE WITH NOTE 2 OF METHOD A-6-A.
7. MOUNTING DIMENSIONS SHOWN ARE FOR BEST ILLUMINATION. MINOR DIMENSIONAL VARIATIONS ARE ACCEPTABLE PROVIDED THEY ARE APPROVED BY THE SUPERVISOR.
EXTENSION HANGERS (SEE NOTE 4)
DECK
SHEATHING
IN TILT POSITION ONLY WHEN IN ACTUAL USE OTHERWISE STOW IN UPRIGHT POSITION WITH RELAY AND CABLE ENTRANCE TOPSIDE
6'-5" MIN 6'-10" MAX BETWEEN FACE OF WINDOW AND DECK
SURGICAL TABLE
DECK
ELEVATION
METHOD A-1-A
NAVY DEPARTMENT
WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
ARRANGEMENT OF SURGICAL LIGHTS & LANTERNS OVER SURGICAL TABLE IN OPERATING ROOM
EXAMINED
OFFICIAL SIGNATURE
SECTION
A
SHEET
1
53711
803
5184170
REV
A

REVISIONS				
REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
–	FIRST ISSUE			
A	CHANGED SYM 900.1 TO 1080.1, SYM 730.3 TO 1210.3 AND SYM 900.1 TO 910			
B	REVISED VOLTAGE FOR SYM 102.2 WAS 115 VAC.			





METHOD A-2-A

NOTES:

1. MATERIAL REQUIRED FOR ONE INSTALLATION
   - 2 SWITCHES TOGGLE, DPST. SYM 604.1
   - 2 FUSE BOXES, SYM 671.1, WITH 1 AMP FUSES INSTALLED CABLE, DSGA-3, LENGTH TO SUIT
   - 4 SURGICAL LIGHTS, SYM. 107.1
   - 4 LANTERNS, RELAY CONTROLLED, SYM. 101.2 OR 102.2 (SEE NOTE 6).
   - 4 RECEPTACLES, SYM 1080.1
   - 8 PLUG CONNECTORS, SYM. 1210.3
   - 4 SWITCH AND RECEPTACLE CONNECTORS, SYM. 910
   - 4 MOUNTING BRACKETS, SYM. 2432.1 (FOR LANTERNS)
2. PROVIDE SUFFICIENT SLACK IN FLEXIBLE CABLES TO PERMIT TILTING LIGHTS OR LANTERNS TO 45° AND TURNING 180°. AVOID EXCESSIVE SLACK
3. LANTERNS AND SURGICAL LIGHTS FIT THE SAME MOUNTING BRACKETS (FLANGES) AND CAN BE MOUNTED IN ANY COMBINATION IN SERVICE.
4. EXTENSION HANGERS TO BE FABRICATED TO SUIT BY INSTALLING ACTIVITY SEE METHODS A-6-A AND A-7-A.
5. REFER TO NAVSEA S300-AF-STD-010/ESL STANDARD ELECTRICAL SYMBOL LIST FOR INTERPRETATION OF SYMBOL NUMBERS.
6. LANTERNS SHALL BE MODIFIED PER NOTE 2 OF METHOD A-6-A.
7. MOUNTING DIMENSIONS SHOWN ARE FOR BEST ILLUMINATION. MINOR DIMENSIONAL VARIATIONS ARE ACCEPTABLE PROVIDED THEY ARE APPROVED BY THE SUPERVISOR.

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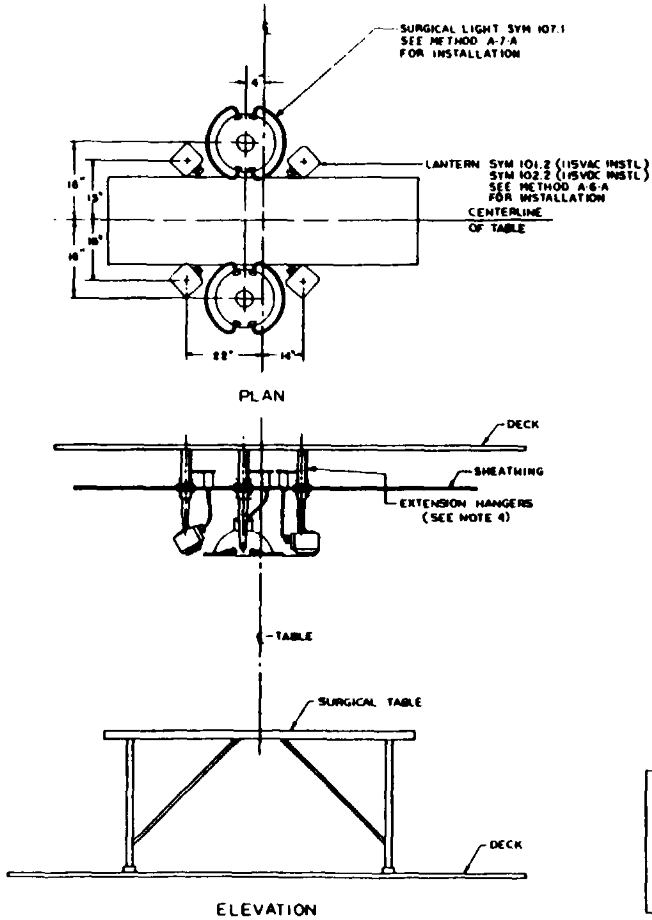
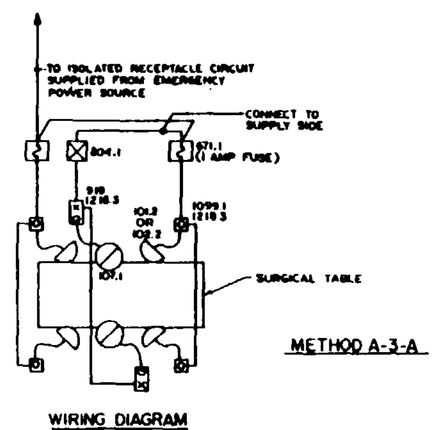
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
ARRANGEMENT OF SURGICAL LIGHTS & LANTERNS OVER SURGICAL TABLE IN SURGICAL/BATTLE DRESSING STATIONS AMPHIBIOUS WARFARE SHIPS ONLY–

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
A	2	53711	803	5184170	B

REVISIONS				
REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
–	FIRST ISSUE			
A	CHANGED SYM 900.1 TO 1099.1, SYM 720.3 TO 1218.3 AND SYM 900.1 TO 919			





METHOD A-3-A

NOTES

1. MATERIAL REQUIRED FOR ONE INSTALLATION
   - 1 SWITCH, TOGGLE, DPST, SYM 804.1
   - 2 FUSE BOXES, SYM 671.1 WITH 1 AMP FUSES INSTALLED
   - 2 SURGICAL LIGHTS SYM 107.1
   - 4 LANTERNS RELAY CONTROLLED, SYM. 101.2 OR 102.2 (SEE NOTE 6)
   - 4 RECEPTACLES, SYM. 1099.1
   - 4 PLUG CONNECTORS, SYM. 1218.3
   - 2 SWITCH AND RECEPTACLE CONNECTORS, SYM. 919
   - 4 MOUNTING BRACKETS, SYM 2432.1 (FOR LANTERNS)
   - CABLE, DSGA-3, LENGTH TO SUIT
2. PROVIDE SUFFICIENT SLACK IN FLEXIBLE CABLES TO PERMIT TILTING LIGHTS OR LANTERNS TO 45° AND TURNING 180°.
3. LANTERNS AND SURGICAL LIGHTS FIT THE SAME MOUNTING BRACKETS (FLANGES) AND CAN BE MOUNTED IN ANY COMBINATION IN SERVICE.
4. EXTENSION HANGERS TO BE FABRICATED TO SUIT BY INSTALLING ACTIVITY. SEE METHODS A-6-A AND A-7-A.
5. REFER TO NAVSEA S300-AT-GTP-010-ESL STANDARD ELECTRICAL SYMBOL LIST) FOR INTERPRETATION OF SYMBOL NUMBERS
6. LANTERNS SHALL BE MODIFIED IN ACCORDANCE WITH NOTE 2 OF METHOD A-6-A.
7. MOUNTING DIMENSIONS SHOWN ARE FOR BEST ILLUMINATION. MINOR DIMENSIONAL VARIATIONS ARE ACCEPTABLE PROVIDED THEY ARE APPROVED BY THE SUPERVISOR.

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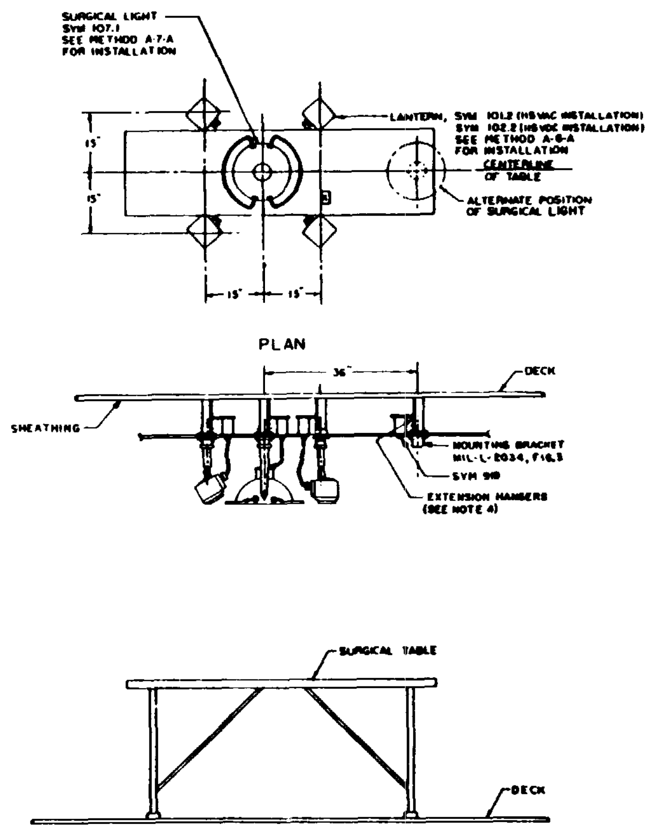
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
ARRANGEMENT OF SURGICAL LIGHTS AND LANTERNS OVER SURGICAL TABLE IN SURGICAL DRESSING ROOM

SECTION	SHEET			DRAWING NO	REV
A	3	53711	803	5184170	A

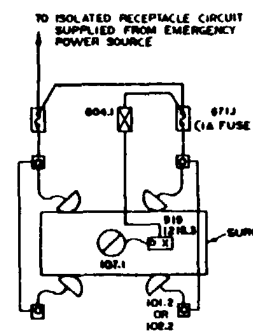
REVISIONS

REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
—	FIRST ISSUE	[illegible]	[illegible]	[illegible]
A	CHANGED SYM 900.1 TO 1099.1 SYM 720.3 TO 1218.3 AND SYM 900.1 TO 919	[illegible]	[illegible]	[illegible]
B	REVISED VOLTAGE FOR SYM 102.2 WAS 115 VAC.	[illegible]	[illegible]	T [illegible]



AVIATION EXAMINING ROOM AND EYE-EAR-NOSE-THROAT ROOM
MAIN BATTLE DRESSING STATION
EYE-EAR-NOSE-THROAT ROOM
MEDICAL TREATMENT RM (DESTROYER OR SMALLER TYPE SHIPS)
PHARMACY

LIST OF FACILITIES
ULTILIZING METHOD A-4-A



WIRING DIAGRAM

METHOD A-4-A

NOTES

1. MATERIAL REQUIRED FOR ONE INSTALLATION:
   - 1 SWITCH, TOGGLE, DPST, SYM 804.1
   - 2 FUSE BOXES, SYM 671.1 WITH 1 AMP FUSES INSTALLED
   - 1 MOUNTING BRACKET, MIL-L-2034, FIG 3
   - CABLE, DSGA-3, LENGTH TO SUIT
   - 1 SURGICAL LIGHT, SYM 107.1
   - 4 LANTERNS, RELAY CONTROLLED, SYM 101.2 OR 102.2 (SEE NOTE 6)
   - 4 RECEPTACLES SYM, 1099.1
   - 5 PLUG CONNECTORS, SYM 1218.3
   - 2 SWITCH AND RECEPTACLE CONNECTOR, SYM 919
   - 4 MOUTING BRACKET, SYM 24321 (FOR LANTERNS)
2. PROVIDE SUFFICIENT SLACK IN FLEXIBLE CABLES TO PERMIT TILTING LIGHTS OR LANTERNS TO 45° AND TURNING 180°. AVOID EXCESSIVE SLACK
3. LANTERNS AND SURGICAL LIGHT FIT THE SAME MOUNTING BRACKETS (FLANGES) AND CAN BE MOUNTED IN ANY COMBINATION IN SERVICE.
4. EXTENSION HANGERS TO BE FABRICATED TO SUIT BY INSTALLING ACTIVITY. SEE METHODS A-6-A AND A-7-A
5. A SUITABLE STOWAGE BOX SHALL BE PROVIDED IN AREAS WHERE SURGICAL LIGHTS AND LANTERNS ARE REMOVED AND STOWED WHEN NOT IN ACTUAL USE. THE LANTERNS SHALL BE MODIFIED PER METHOD A-6-A, AND SHALL BE STOWED IN AN UPRIGHT POSITION WITH RELAY TOPSIDE.
6. REFER TO NAVSEA S300-AT-GTP-010/ESL (STANDARD ELECTRICAL SYMBOL LIST) FOR INTERPRETATION OF SYMBOL NUMBERS
7. MOUNTING DIMENSIONS SHOWN ARE FOR BEST ILLUMINATION MINOR DEMINSIONAL VARIANCES ARE ACCEPTABLE PROVIDED THEY ARE APPROVED BY THE SUPERVISOR.

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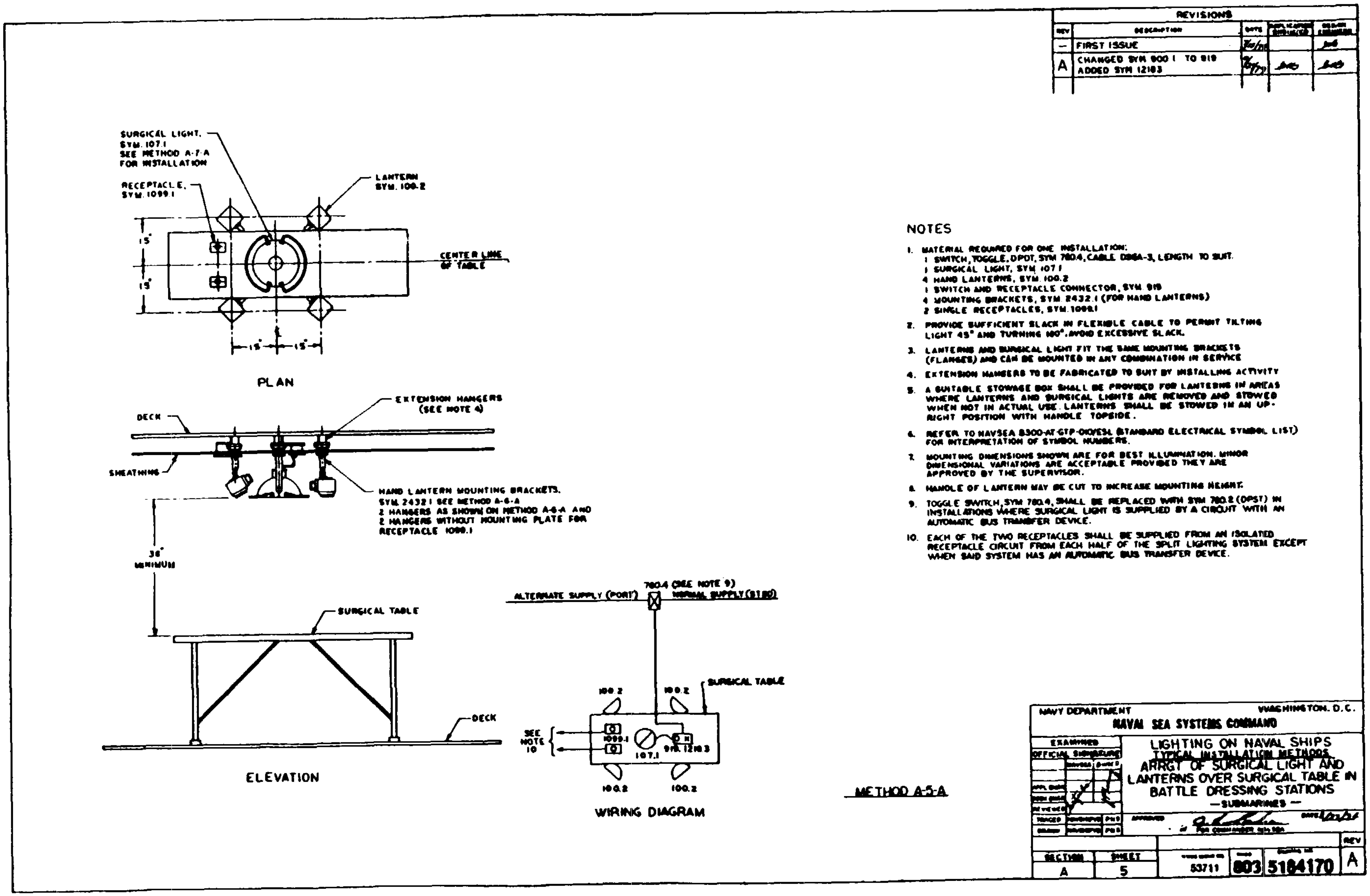
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
ARRANGEMENT OF SURGICAL LIGHT AND LANTERNS FOR SURGICAL AND DRESSING TABLE OR EXAMINING CHAIR PER LIST OF FACILITIES

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
A	4	53711	803	5184170	B


REVISIONS
REV
DESCRIPTION
DATE
— FIRST ISSUE
A CHANGED SYM 900.1 TO 919
ADDED SYM 12183
SURGICAL LIGHT, SYM. 107.1
SEE METHOD A-7-A FOR INSTALLATION
RECEPTACLE, SYM. 1099.1
LANTERN SYM. 100.2
CENTER LINE OF TABLE
15"
PLAN
EXTENSION HANGERS (SEE NOTE 4)
DECK
SHEATHING
HAND LANTERN MOUNTING BRACKETS.
SYM. 2432.1 SEE METHOD A-6-A
2 HANGERS AS SHOWN ON METHOD A-6-A AND
2 HANGERS WITHOUT MOUNTING PLATE FOR
RECEPTACLE 1099.1
36" MINIMUM
SURGICAL TABLE
DECK
ELEVATION
780.4 (SEE NOTE 9)
ALTERNATE SUPPLY (PORT)
NORMAL SUPPLY (STBD)
SURGICAL TABLE
100.2
1099.1
107.1
SYM 12183
SEE NOTE 10
WIRING DIAGRAM
METHOD A-5-A
NOTES
1. MATERIAL REQUIRED FOR ONE INSTALLATION:
1 SWITCH, TOGGLE, DPDT, SYM 780.4, CABLE DHGA-3, LENGTH TO SUIT.
1 SURGICAL LIGHT, SYM 107.1
4 HAND LANTERNS, SYM. 100.2
1 SWITCH AND RECEPTACLE CONNECTOR, SYM. 919
4 MOUNTING BRACKETS, SYM. 2432.1 (FOR HAND LANTERNS)
2 SINGLE RECEPTACLES, SYM. 1099.1
2. PROVIDE SUFFICIENT SLACK IN FLEXIBLE CABLE TO PERMIT TILTING LIGHT 45° AND TURNING 180°. AVOID EXCESSIVE SLACK.
3. LANTERNS AND SURGICAL LIGHT FIT THE SAME MOUNTING BRACKETS (FLANGES) AND CAN BE MOUNTED IN ANY COMBINATION IN SERVICE
4. EXTENSION HANGERS TO BE FABRICATED TO SUIT BY INSTALLING ACTIVITY
5. A SUITABLE STOWAGE BOX SHALL BE PROVIDED FOR LANTERNS IN AREAS WHERE LANTERNS AND SURGICAL LIGHTS ARE REMOVED AND STOWED WHEN NOT IN ACTUAL USE. LANTERNS SHALL BE STOWED IN AN UP-RIGHT POSITION WITH HANDLE TOPSIDE.
6. REFER TO NAVSEA 8300-AT-GTP-010/ESL (STANDARD ELECTRICAL SYMBOL LIST) FOR INTERPRETATION OF SYMBOL NUMBERS.
7. MOUNTING DIMENSIONS SHOWN ARE FOR BEST ILLUMINATION. MINOR DIMENSIONAL VARIATIONS ARE ACCEPTABLE PROVIDED THEY ARE APPROVED BY THE SUPERVISOR.
8. HANDLE OF LANTERN MAY BE CUT TO INCREASE MOUNTING HEIGHT.
9. TOGGLE SWITCH, SYM 780.4, SHALL BE REPLACED WITH SYM 780.2 (DPST) IN INSTALLATIONS WHERE SURGICAL LIGHT IS SUPPLIED BY A CIRCUIT WITH AN AUTOMATIC BUS TRANSFER DEVICE.
10. EACH OF THE TWO RECEPTACLES SHALL BE SUPPLIED FROM AN ISOLATED RECEPTACLE CIRCUIT FROM EACH HALF OF THE SPLIT LIGHTING SYSTEM EXCEPT WHEN SAID SYSTEM HAS AN AUTOMATIC BUS TRANSFER DEVICE.
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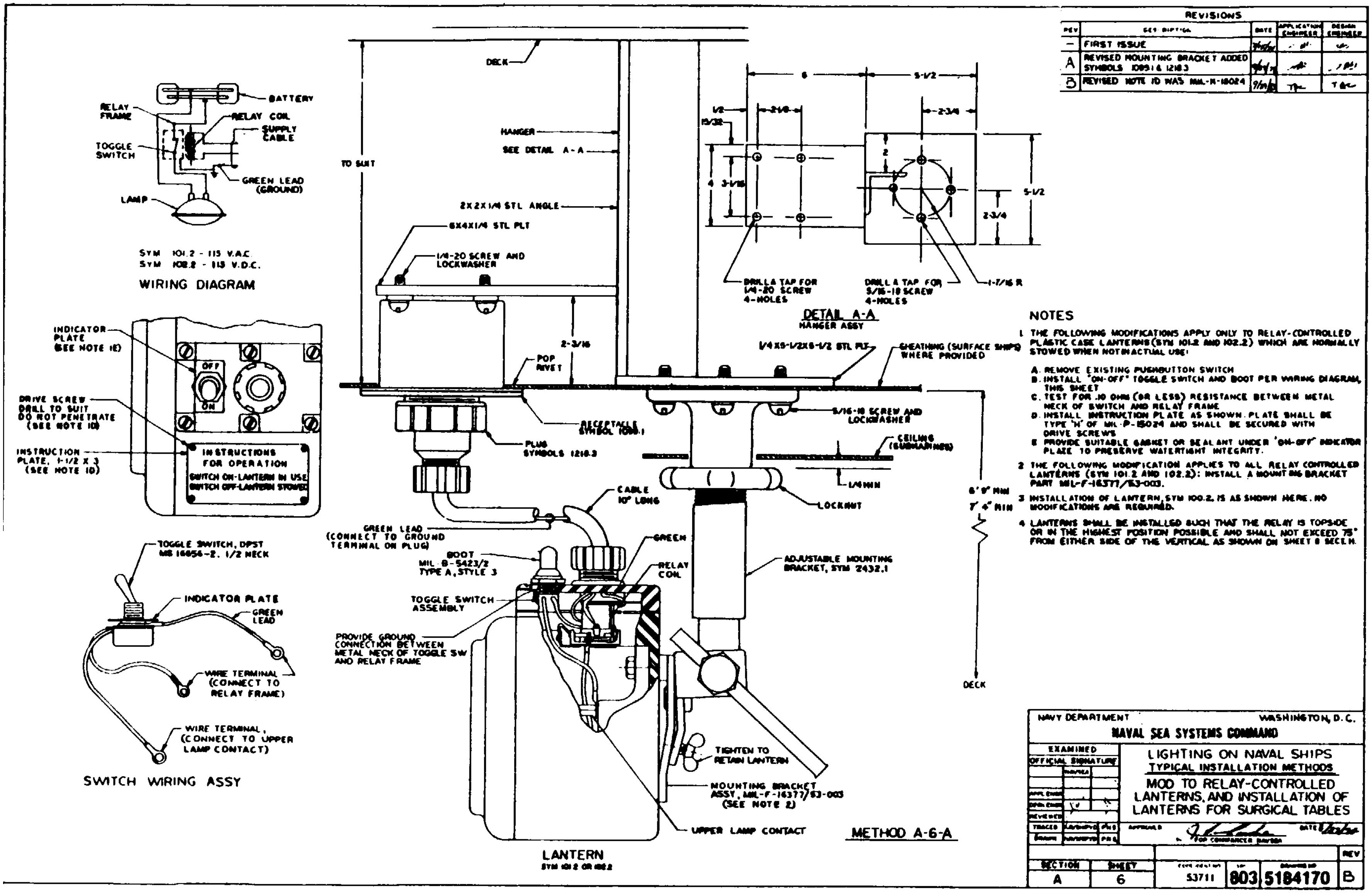
WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
ARRGT OF SURGICAL LIGHT AND LANTERNS OVER SURGICAL TABLE IN BATTLE DRESSING STATIONS
— SUBMARINES —
SECTION A
SHEET 5
53711
803
5184170
REV A


REVISIONS
FIRST ISSUE
REVISED MOUNTING BRACKET ADDED SYMBOLS 1095.1 & 1218.3
REVISED NOTE 1D WAS MIL-N-18024
BATTERY
RELAY FRAME
RELAY COIL
SUPPLY CABLE
TOGGLE SWITCH
GREEN LEAD (GROUND)
LAMP
SYM 101.2 - 115 V.A.C.
SYM 102.2 - 115 V.D.C.
WIRING DIAGRAM
INDICATOR PLATE (SEE NOTE 1E)
DRIVE SCREW DRILL TO SUIT DO NOT PENETRATE (SEE NOTE 1D)
INSTRUCTION PLATE, 1-1/2 X 3 (SEE NOTE 1D)
OFF
ON
INSTRUCTIONS FOR OPERATION
SWITCH ON-LANTERN IN USE
SWITCH OFF-LANTERN STOWED
TOGGLE SWITCH, DPST MS 16656-2, 1/2 NECK
INDICATOR PLATE
GREEN LEAD
WIRE TERMINAL (CONNECT TO RELAY FRAME)
WIRE TERMINAL, (CONNECT TO UPPER LAMP CONTACT)
SWITCH WIRING ASSY
DECK
TO SUIT
HANGER
SEE DETAIL A-A
2X2X1/4 STL ANGLE
6X4X1/4 STL PLT
1/4-20 SCREW AND LOCKWASHER
2-3/16
POP RIVET
RECEPTACLE SYMBOL 1095.1
PLUG SYMBOLS 1218.3
CABLE 10" LONG
GREEN LEAD (CONNECT TO GROUND TERMINAL ON PLUG)
BOOT MIL-B-5423/2 TYPE A, STYLE 3
GREEN
RELAY COIL
TOGGLE SWITCH ASSEMBLY
PROVIDE GROUND CONNECTION BETWEEN METAL NECK OF TOGGLE SW AND RELAY FRAME
LANTERN
SYM 101.2 OR 102.2
TIGHTEN TO RETAIN LANTERN
MOUNTING BRACKET ASSY, MIL-F-16377/53-003 (SEE NOTE 2)
UPPER LAMP CONTACT
METHOD A-6-A
ADJUSTABLE MOUNTING BRACKET, SYM 2432.1
LOCKNUT
1/4 MIN
CEILING (SUBMARINES)
5/16-18 SCREW AND LOCKWASHER
1/4X5-1/2X6-1/2 STL PLT
SHEATHING (SURFACE SHIPS) WHERE PROVIDED
6'9" MIN
7'4" MIN
DECK
6
5-1/2
1/2
15/32
2-1/8
2-3/4
4
3-1/16
2
5-1/2
2-3/4
DRILL & TAP FOR 1/4-20 SCREW 4-HOLES
DRILL & TAP FOR 5/16-18 SCREW 4-HOLES
1-7/16 R
DETAIL A-A
HANGER ASSY
NOTES
1 THE FOLLOWING MODIFICATIONS APPLY ONLY TO RELAY-CONTROLLED PLASTIC CASE LANTERNS (SYM 101.2 AND 102.2) WHICH ARE NORMALLY STOWED WHEN NOT IN ACTUAL USE:
A. REMOVE EXISTING PUSHBUTTON SWITCH
B. INSTALL "ON-OFF" TOGGLE SWITCH AND BOOT PER WIRING DIAGRAM, THIS SHEET
C. TEST FOR .10 OHM (OR LESS) RESISTANCE BETWEEN METAL NECK OF SWITCH AND RELAY FRAME
D. INSTALL INSTRUCTION PLATE AS SHOWN. PLATE SHALL BE TYPE "H" OF MIL-P-15024 AND SHALL BE SECURED WITH DRIVE SCREWS
E PROVIDE SUITABLE GASKET OR SEALANT UNDER "ON-OFF" INDICATOR PLATE TO PRESERVE WATERTIGHT INTEGRITY.
2 THE FOLLOWING MODIFICATION APPLIES TO ALL RELAY CONTROLLED LANTERNS (SYM 101.2 AND 102.2): INSTALL A MOUNTING BRACKET PART MIL-F-16377/53-003.
3 INSTALLATION OF LANTERN, SYM 100.2, IS AS SHOWN HERE. NO MODIFICATIONS ARE REQUIRED.
4 LANTERNS SHALL BE INSTALLED SUCH THAT THE RELAY IS TOPSIDE OR IN THE HIGHEST POSITION POSSIBLE AND SHALL NOT EXCEED 75° FROM EITHER SIDE OF THE VERTICAL AS SHOWN ON SHEET 8 SECT. H.
NAVY DEPARTMENT
WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
MOD TO RELAY-CONTROLLED LANTERNS, AND INSTALLATION OF LANTERNS FOR SURGICAL TABLES
SECTION
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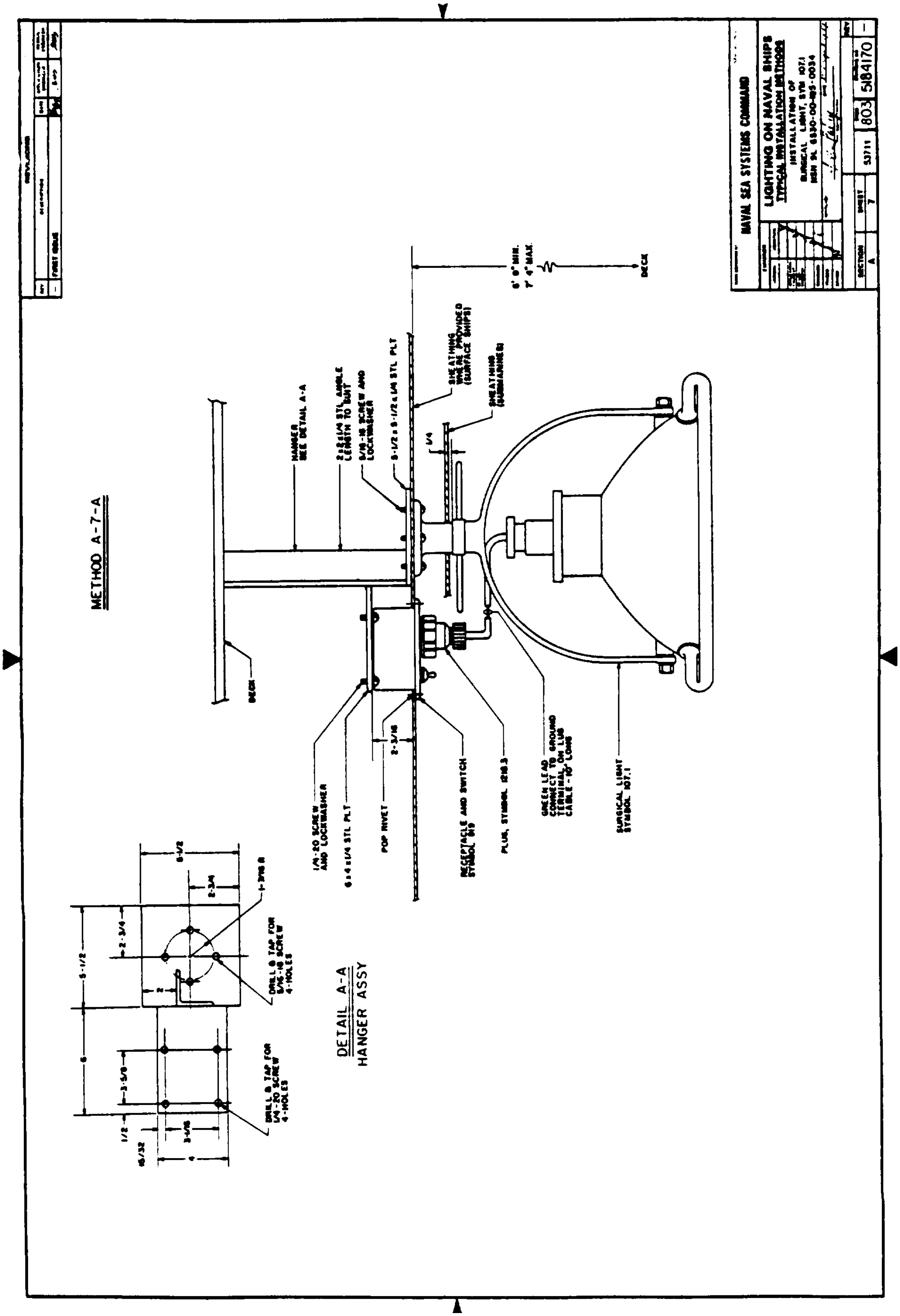
B


METHOD A-7-A
DETAIL A-A
HANGER ASSY
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
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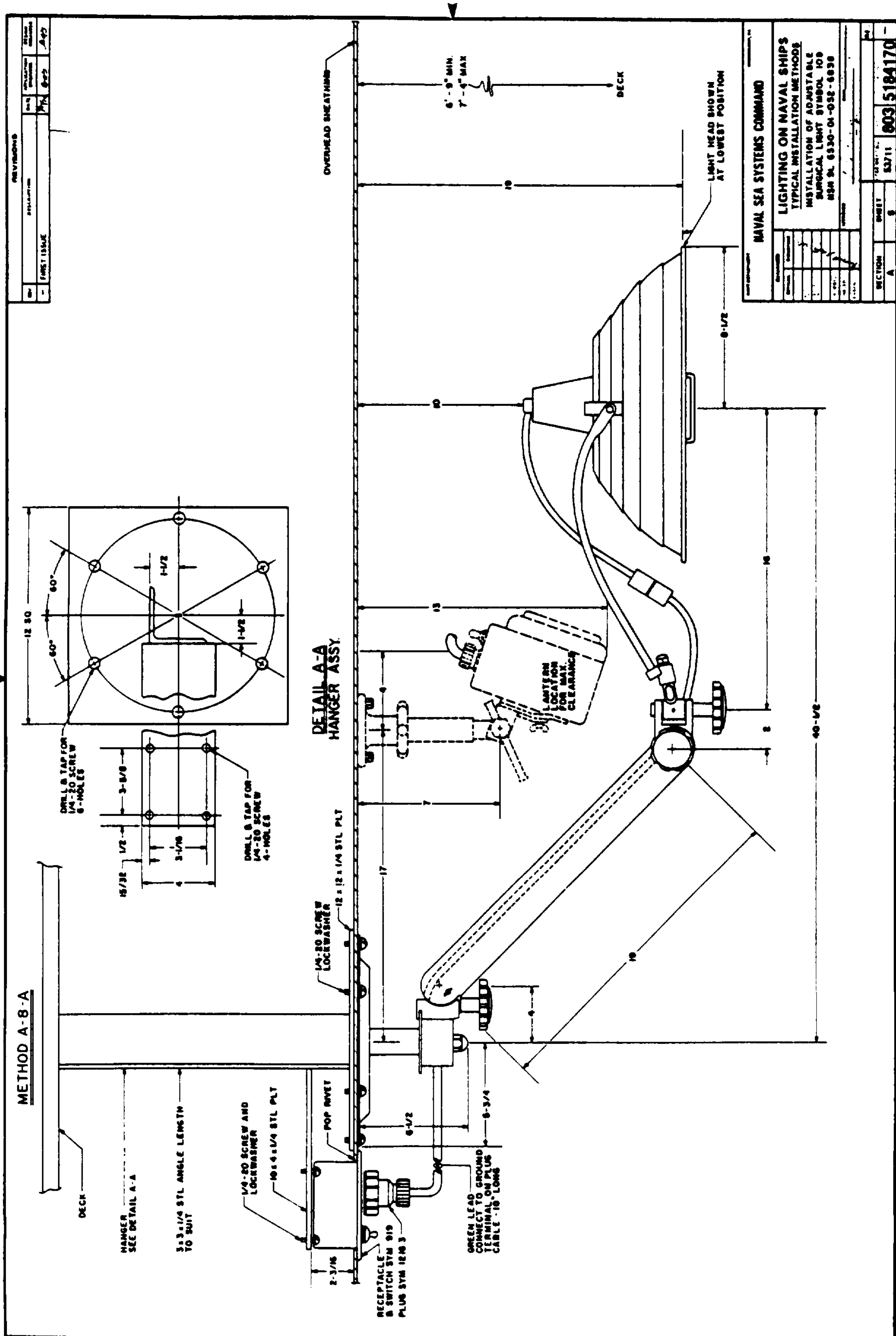
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
INSTALLATION OF ADJUSTABLE SURGICAL LIGHT SYMBOL 109
803 5184170
METHOD A-8-A
DETAIL A-A
HANGER ASSY.
OVERHEAD SHEATHING
DECK
LIGHT HEAD SHOWN AT LOWEST POSITION
LANTERN LOCATION FOR MAX. CLEARANCE
POP RIVET
1/4-20 SCREW LOCKWASHER
FIRST ISSUE
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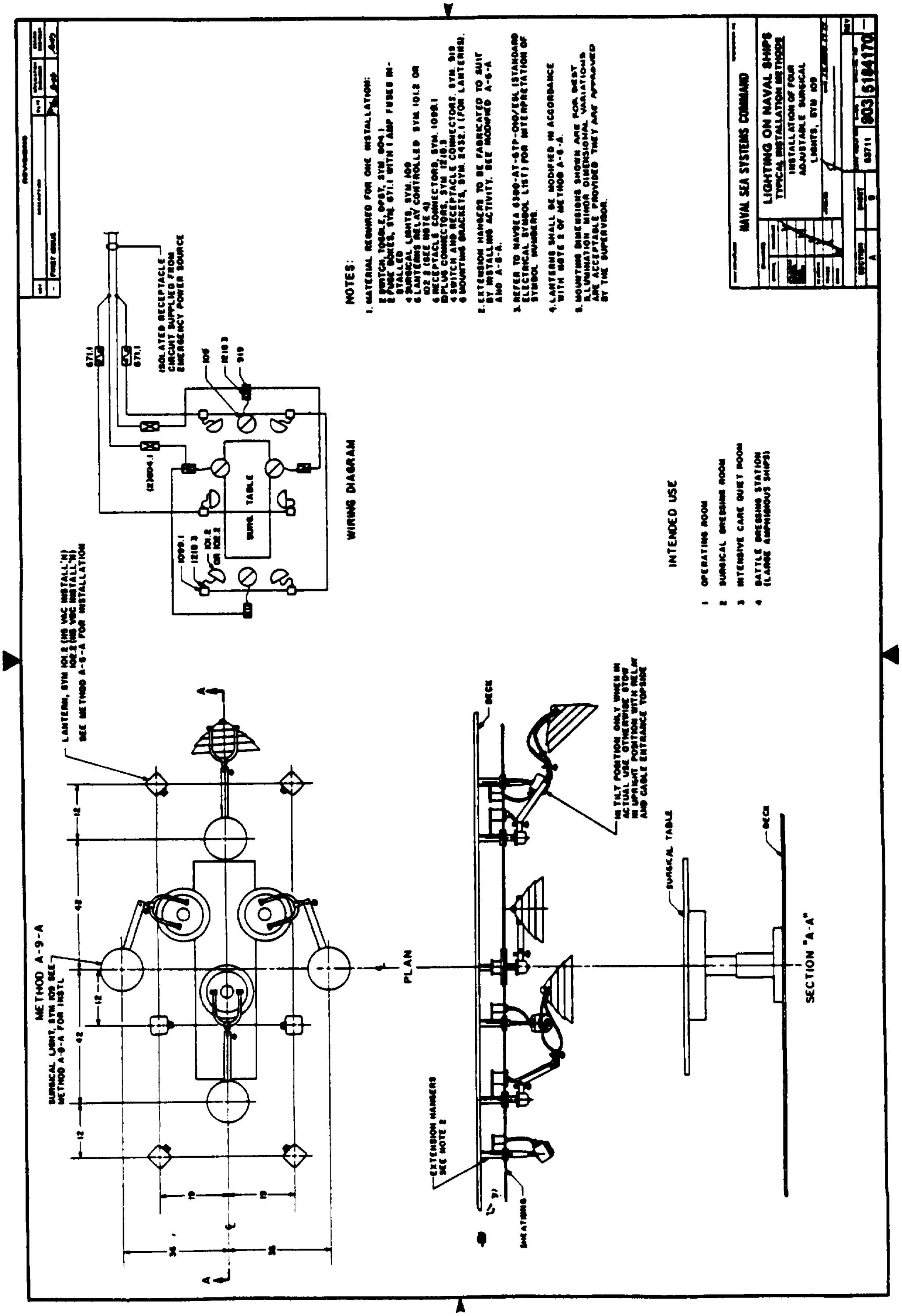
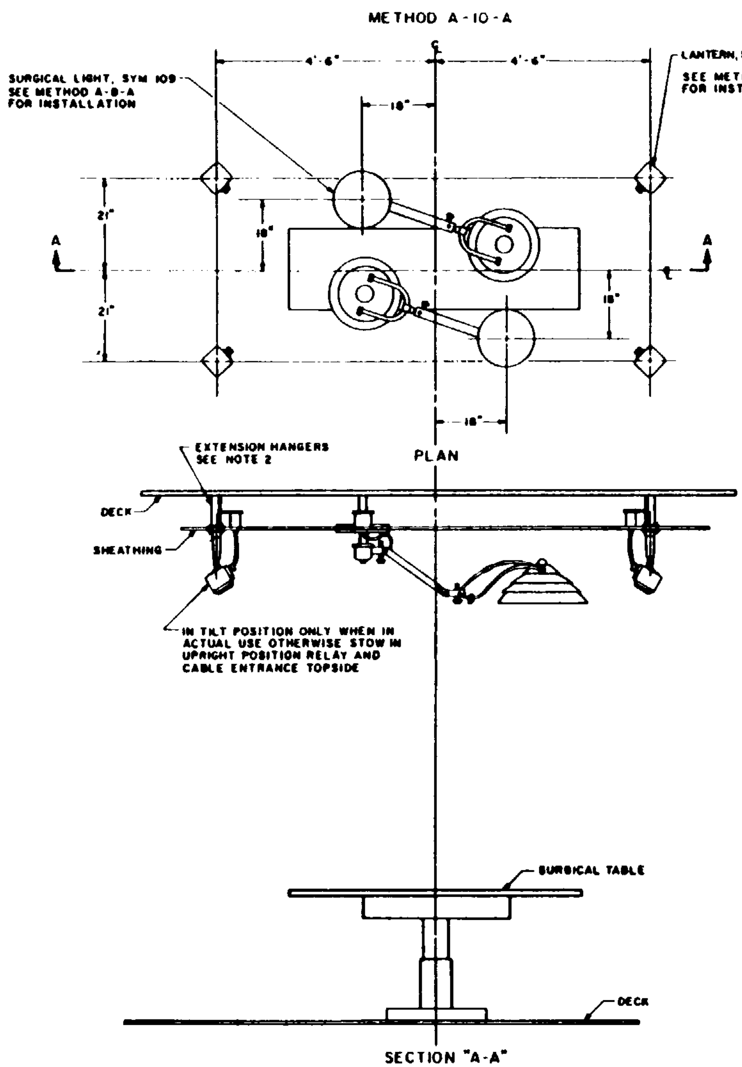
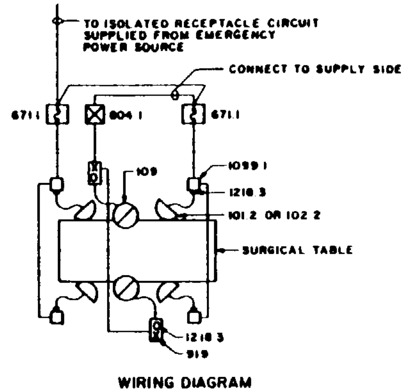

NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
INSTALLATION OF FOUR ADJUSTABLE SURGICAL LIGHTS, SYM 109
803 5184170
NOTES:
1. MATERIAL REQUIRED FOR ONE INSTALLATION:
4 SURGICAL LIGHTS, SYM. 109
WIRING DIAGRAM
SURG. TABLE
ISOLATED RECEPTACLE CIRCUIT SUPPLIED FROM EMERGENCY POWER SOURCE
INTENDED USE
1 OPERATING ROOM
2 SURGICAL DRESSING ROOM
3 INTENSIVE CARE QUIET ROOM
4 BATTLE DRESSING STATION (LARGE AMPHIBIOUS SHIPS)
METHOD A-9-A
PLAN
DECK
SURGICAL TABLE
SECTION "A-A"
EXTENSION HANGERS SEE NOTE 2
SHEATHING





NOTES:

1. MATERIAL REQUIRED FOR ONE INSTALLATION
   - 1 SWITCH, TOGGLE, DPST, SYM 804.1
   - 2 FUSE BOXES, SYM 671.1 WITH 1 AMP FUSES INSTALLED
   - 2 SURGICAL LIGHTS, SYM 109
   - 4 LANTERNS RELAY CONTROLLED, SYM 101.2 OR 102.2 (SEE NOTE 6)
   - 4 RECEPTACLE CONNECTORS, SYM. 1099.1
   - 6 PLUG CONNECTORS, SYM 1218.3
   - 2 SWITCH AND RECEPTACLE CONNECTORS, SYM 919
   - 4 MOUNTING BRACKETS, SYM 2432
2. EXTENSION HANGERS TO BE FABRICATED TO SUIT BY INSTALLING ACTIVITY. SEE METHODS A-6-A AND A-8-A.
3. REFER TO NAVSEA S300-AT-GTP-010/ESL (STANDARD ELECTRICAL SYMBOL LIST) FOR INTERPRETATION OF SYMBOL NUMBERS
4. LANTERNS SHALL BE MODIFIED IN ACCORDANCE WITH NOTE 2 OF METHOD A-6-A.
5. MOUNTING DIMENSIONS SHOWN ARE FOR BEST ILLUMINATION. MINOR DIMENSIONAL VARIATIONS ARE ACCEPTABLE PROVIDED THEY ARE APPROVED BY THE SUPERVISOR.

INTENDED USE

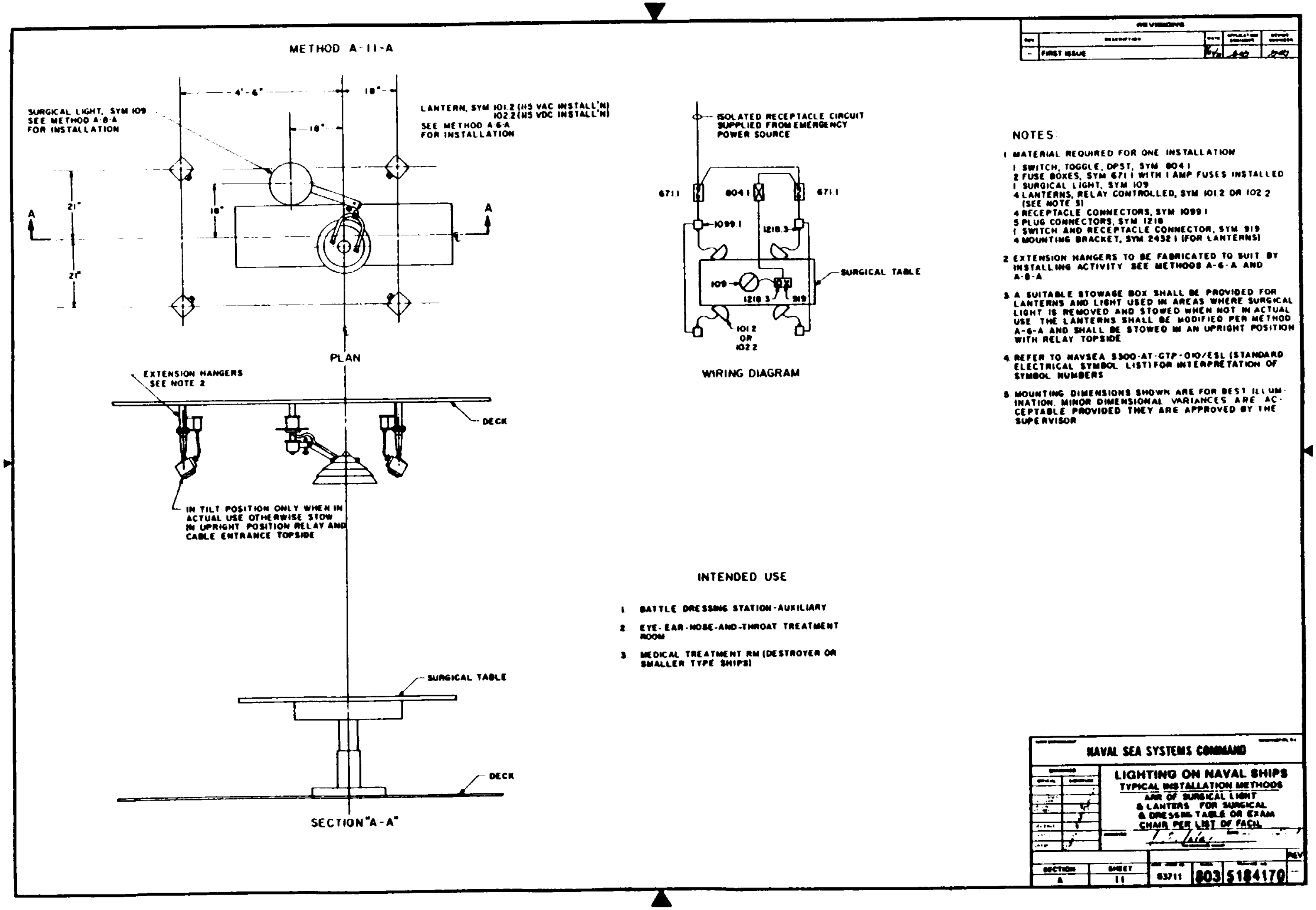
1. AVIATION EXAMINING ROOM
2. BATTLE DRESSING STATION MAIN (SMALL SHIPS)
3. DENTAL OPERATING ROOM (ORAL SURGERY)

REV	DESCRIPTION
—	FIRST ISSUE

NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
INSTALLATION OF TWO ADJUSTABLE SURGICAL LIGHTS SYMBOL 109

SECTION	SHEET				REV
A	10	53711	803	5184170	—


METHOD A-11-A
SURGICAL LIGHT, SYM 109
SEE METHOD A-8-A
FOR INSTALLATION
4'-6"
18"
18"
21"
21"
18"
A
A
LANTERN, SYM 101.2 (115 VAC INSTALL'N)
102.2 (115 VDC INSTALL'N)
SEE METHOD A-6-A
FOR INSTALLATION
PLAN
EXTENSION HANGERS
SEE NOTE 2
DECK
IN TILT POSITION ONLY WHEN IN
ACTUAL USE OTHERWISE STOW
IN UPRIGHT POSITION RELAY AND
CABLE ENTRANCE TOPSIDE
SURGICAL TABLE
DECK
SECTION "A-A"
ISOLATED RECEPTACLE CIRCUIT
SUPPLIED FROM EMERGENCY
POWER SOURCE
671.1
804.1
671.1
1099.1
1218.3
SURGICAL TABLE
109
1218.3
919
1012
OR
1022
WIRING DIAGRAM
INTENDED USE
1 BATTLE DRESSING STATION-AUXILIARY
2 EYE-EAR-NOSE-AND-THROAT TREATMENT ROOM
3 MEDICAL TREATMENT RM (DESTROYER OR SMALLER TYPE SHIPS)
NOTES:
1 MATERIAL REQUIRED FOR ONE INSTALLATION
1 SWITCH, TOGGLE, DPST, SYM 804.1
2 FUSE BOXES, SYM 671.1 WITH 1 AMP FUSES INSTALLED
1 SURGICAL LIGHT, SYM 109
4 LANTERNS, RELAY CONTROLLED, SYM 101.2 OR 102.2 (SEE NOTE 3)
4 RECEPTACLE CONNECTORS, SYM 1099.1
5 PLUG CONNECTORS, SYM 1218
1 SWITCH AND RECEPTACLE CONNECTOR, SYM 919
4 MOUNTING BRACKET, SYM 2432.1 (FOR LANTERNS)
2 EXTENSION HANGERS TO BE FABRICATED TO SUIT BY INSTALLING ACTIVITY SEE METHODS A-6-A AND A-8-A
3 A SUITABLE STOWAGE BOX SHALL BE PROVIDED FOR LANTERNS AND LIGHT USED IN AREAS WHERE SURGICAL LIGHT IS REMOVED AND STOWED WHEN NOT IN ACTUAL USE THE LANTERNS SHALL BE MODIFIED PER METHOD A-6-A AND SHALL BE STOWED IN AN UPRIGHT POSITION WITH RELAY TOPSIDE
4 REFER TO NAVSEA S300-AT-GTP-010/ESL (STANDARD ELECTRICAL SYMBOL LIST) FOR INTERPRETATION OF SYMBOL NUMBERS
5 MOUNTING DIMENSIONS SHOWN ARE FOR BEST ILLUMINATION. MINOR DIMENSIONAL VARIANCES ARE ACCEPTABLE PROVIDED THEY ARE APPROVED BY THE SUPERVISOR
FIRST ISSUE
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
ARR OF SURGICAL LIGHT & LANTERNS FOR SURGICAL & DRESSING TABLE OR EXAM CHAIR PER LIST OF FACIL
SECTION A
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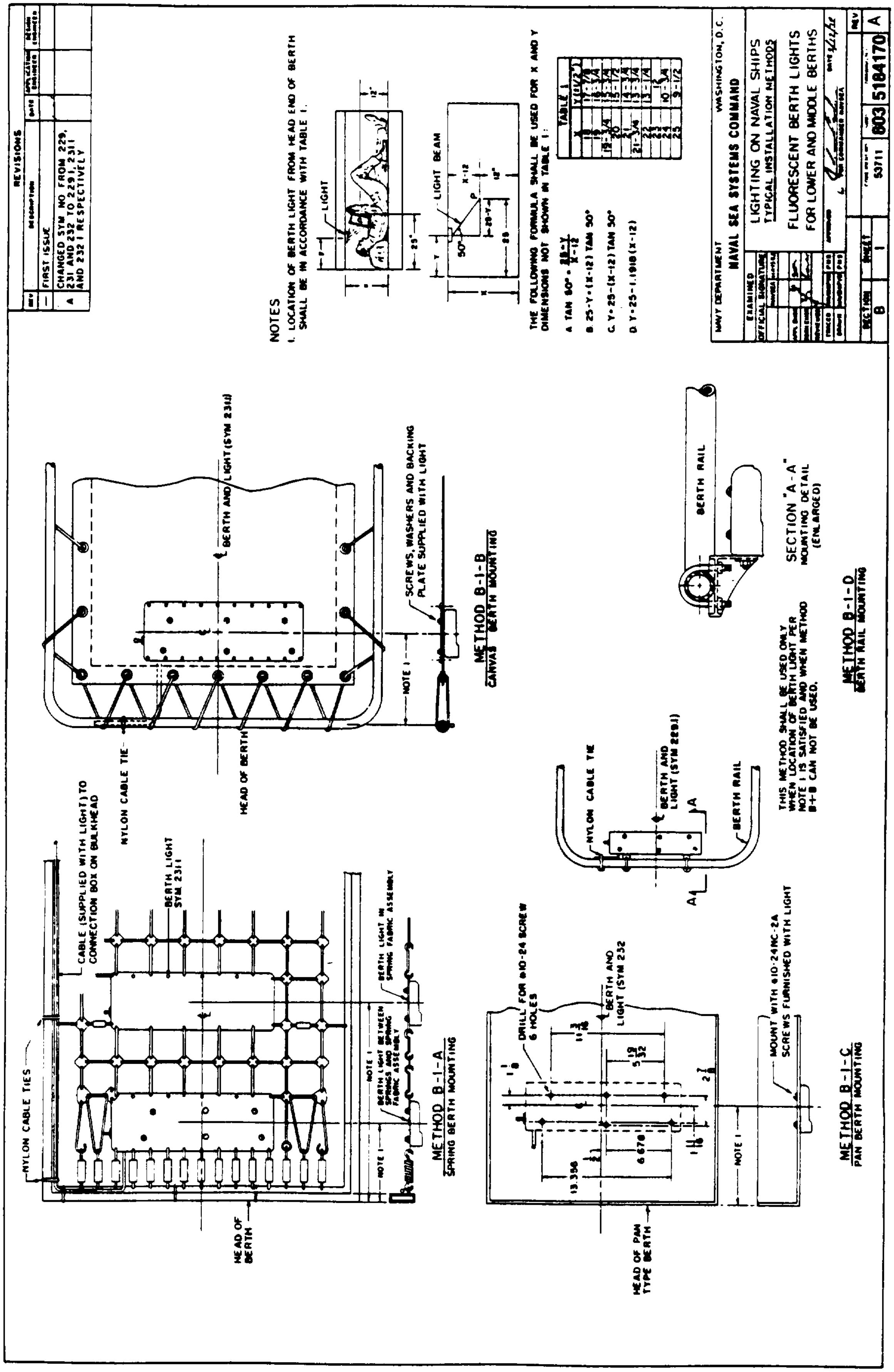
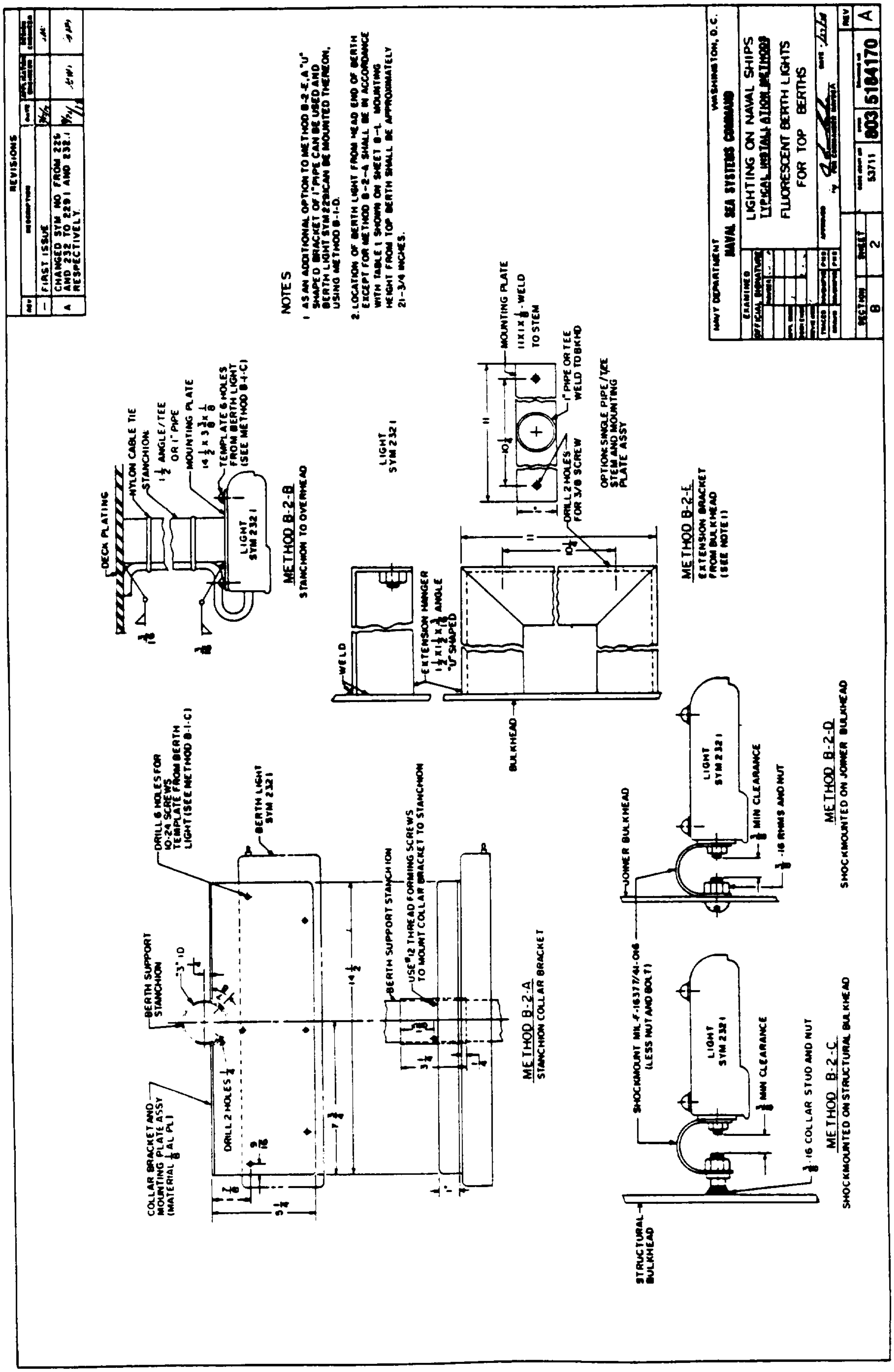


TABLE 1

X	Y (11/2")
18	17-7/8
19	16-1/4
19-1/4	15-3/4
20	15-1/2
21	14-3/4
21-3/4	13-3/4
22	13-1/4
23	12
24	10-3/4
25	9-1/2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NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C.
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
FLUORESCENT BERTH LIGHTS
FOR TOP BERTHS
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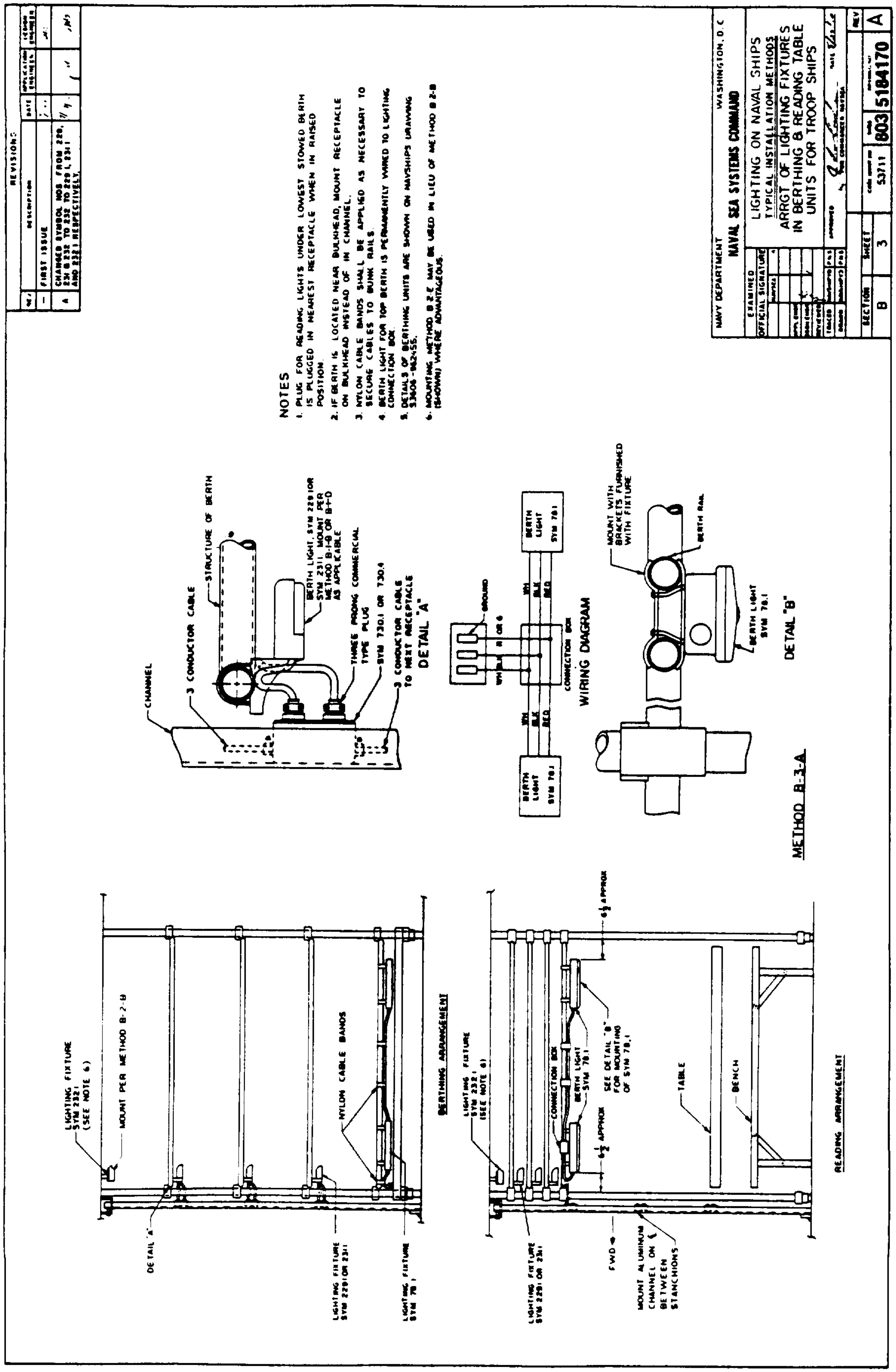
NOTES
METHOD B-2-A
STANCHION COLLAR BRACKET
METHOD B-2-B
STANCHION TO OVERHEAD
METHOD B-2-C
SHOCKMOUNTED ON STRUCTURAL BULKHEAD
METHOD B-2-D
SHOCKMOUNTED ON JOINER BULKHEAD
METHOD B-2-E
EXTENSION BRACKET
FROM BULKHEAD
(SEE NOTE 1)
LIGHT
SYM 2321
BULKHEAD
JOINER BULKHEAD
STRUCTURAL BULKHEAD
DECK PLATING
BERTH SUPPORT STANCHION


REVISIONS
FIRST ISSUE
CHANGED SYMBOL NOS. FROM 229, 231 & 232 TO 232 TO 229 L 231 I AND 232 I RESPECTIVELY.
LIGHTING FIXTURE SYM 232 I (SEE NOTE 6)
MOUNT PER METHOD B-2-B
DETAIL "A"
LIGHTING FIXTURE SYM 229 I OR 231 I
NYLON CABLE BANDS
LIGHTING FIXTURE SYM 78.1
BERTHING ARRANGEMENT
LIGHTING FIXTURE SYM 232 I (SEE NOTE 6)
LIGHTING FIXTURE SYM 229 I OR 231 I
CONNECTION BOX
BERTH LIGHT SYM 78.1
6½ APPROX
SEE DETAIL "B" FOR MOUNTING OF SYM 78.1
6½ APPROX
FWD
MOUNT ALUMINUM CHANNEL ON ℄ BETWEEN STANCHIONS
TABLE
BENCH
READING ARRANGEMENT
CHANNEL
3 CONDUCTOR CABLE
STRUCTURE OF BERTH
BERTH LIGHT, SYM 229 I OR SYM 231 I MOUNT PER METHOD B-1-B OR B-1-D AS APPLICABLE
THREE PRONG COMMERCIAL TYPE PLUG
SYM 730.1 OR 730.4
3 CONDUCTOR CABLE TO NEXT RECEPTACLE
DETAIL "A"
GROUND
WH BLK R OR G
BERTH LIGHT SYM 78.1
WH BLK RED
CONNECTION BOX
WH BLK RED
BERTH LIGHT SYM 78.1
WIRING DIAGRAM
MOUNT WITH BRACKETS FURNISHED WITH FIXTURE
BERTH RAIL
BERTH LIGHT SYM 78.1
DETAIL "B"
METHOD B-3-A
NOTES
1. PLUG FOR READING LIGHTS UNDER LOWEST STOWED BERTH IS PLUGGED IN NEAREST RECEPTACLE WHEN IN RAISED POSITION.
2. IF BERTH IS LOCATED NEAR BULKHEAD, MOUNT RECEPTACLE ON BULKHEAD INSTEAD OF IN CHANNEL.
3. NYLON CABLE BANDS SHALL BE APPLIED AS NECESSARY TO SECURE CABLES TO BUNK RAILS.
4. BERTH LIGHT FOR TOP BERTH IS PERMANENTLY WIRED TO LIGHTING CONNECTION BOX.
5. DETAILS OF BERTHING UNITS ARE SHOWN ON NAVSHIPS DRAWING S3606-962455.
6. MOUNTING METHOD B-2-E MAY BE USED IN LIEU OF METHOD B-2-B (SHOWN) WHERE ADVANTAGEOUS.
NAVY DEPARTMENT
WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
EXAMINED
OFFICIAL SIGNATURE
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
ARRGT OF LIGHTING FIXTURES IN BERTHING & READING TABLE UNITS FOR TROOP SHIPS
APPROVED
FOR COMMANDER NAVSEA
SECTION B
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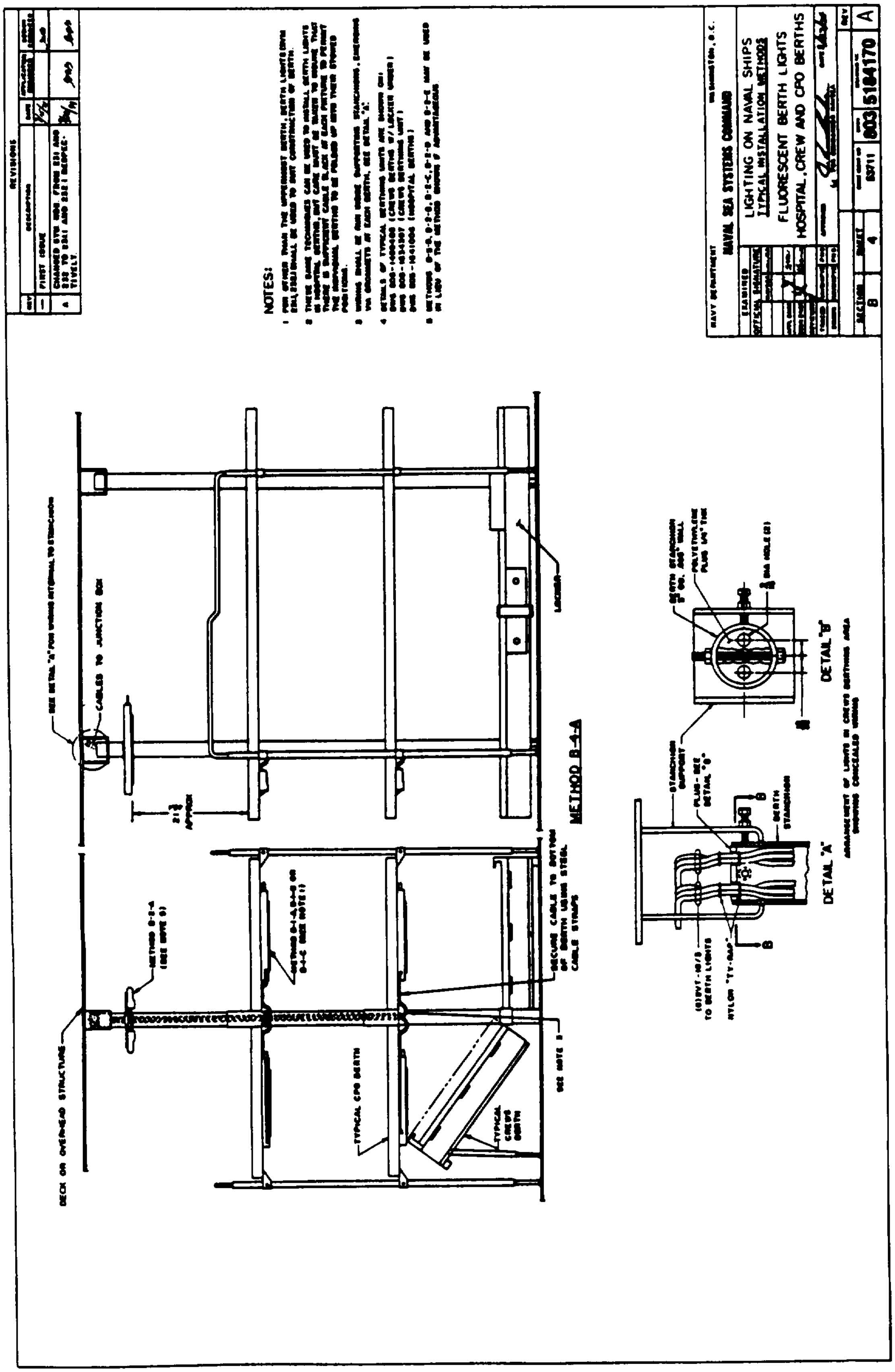
NAVY DEPARTMENT
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C.
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
FLUORESCENT BERTH LIGHTS
HOSPITAL, CREW AND CPO BERTHS
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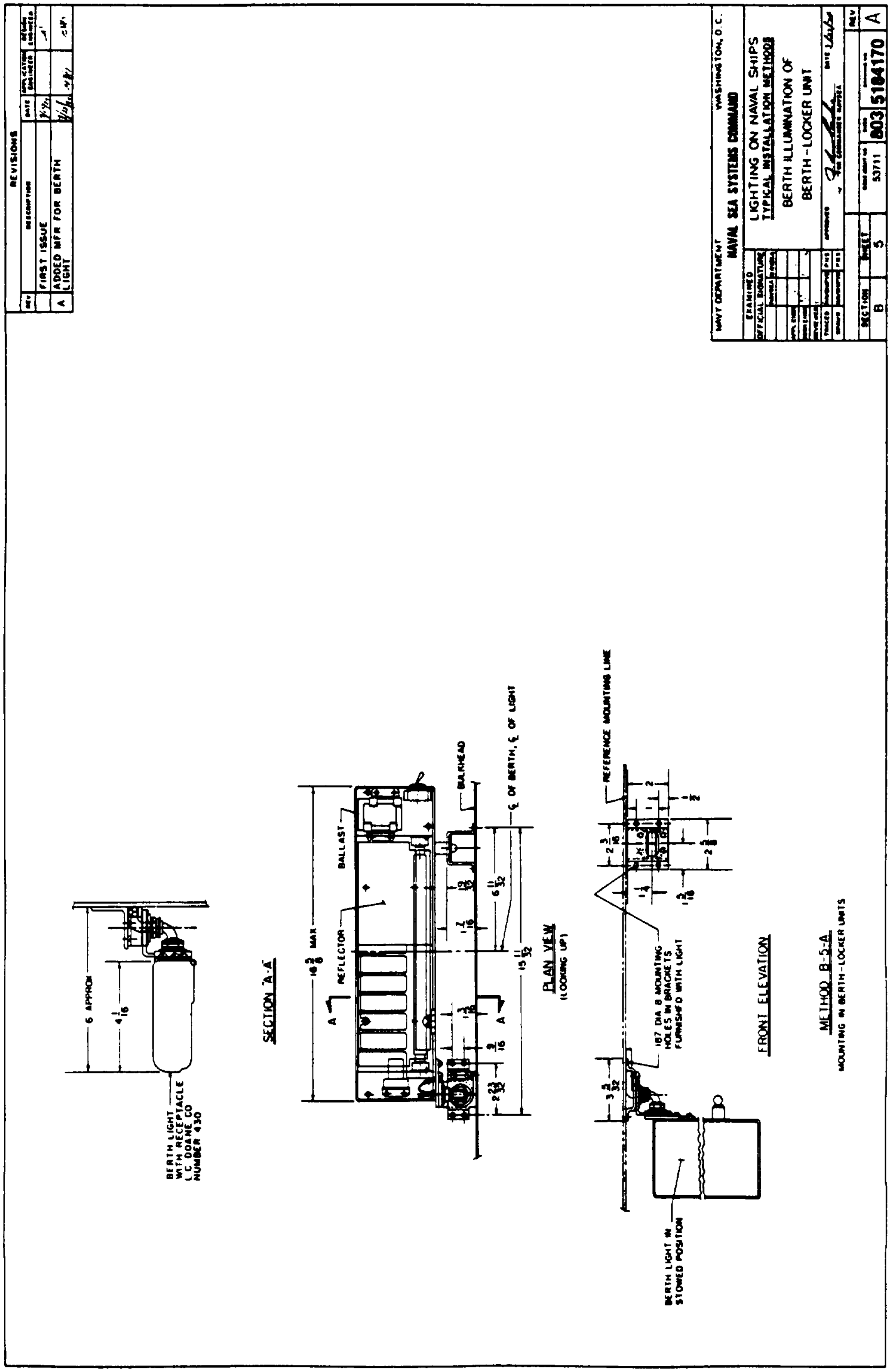
NOTES:
METHOD B-4-A
DETAIL "A"
DETAIL "B"


REVISIONS
FIRST ISSUE
A ADDED MFR FOR BERTH LIGHT
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NAVAL SEA SYSTEMS COMMAND
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LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
BERTH ILLUMINATION OF
BERTH-LOCKER UNIT
SECTION B
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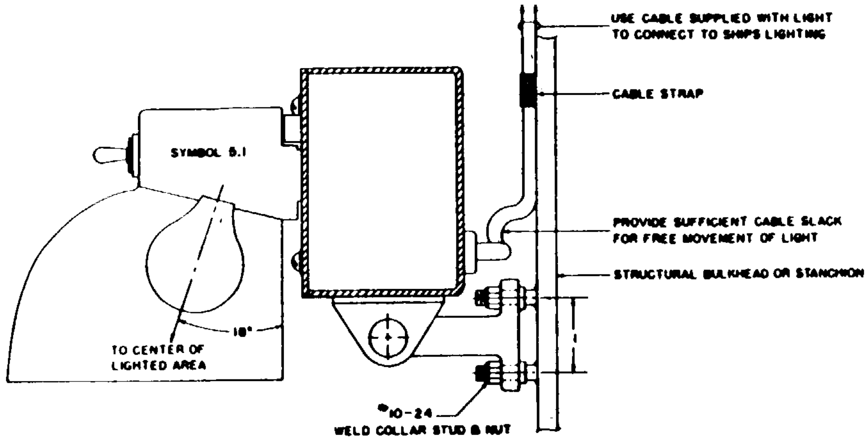
BERTH LIGHT WITH RECEPTACLE L.C. DOANE CO NUMBER 430
6 APPROX
SECTION A-A
BALLAST
REFLECTOR
BULKHEAD
℄ OF BERTH, ℄ OF LIGHT
PLAN VIEW
(LOOKING UP)
REFERENCE MOUNTING LINE
.187 DIA 8 MOUNTING HOLES IN BRACKETS FURNISHED WITH LIGHT
FRONT ELEVATION
BERTH LIGHT IN STOWED POSITION
METHOD B-5-A
MOUNTING IN BERTH-LOCKER UNITS

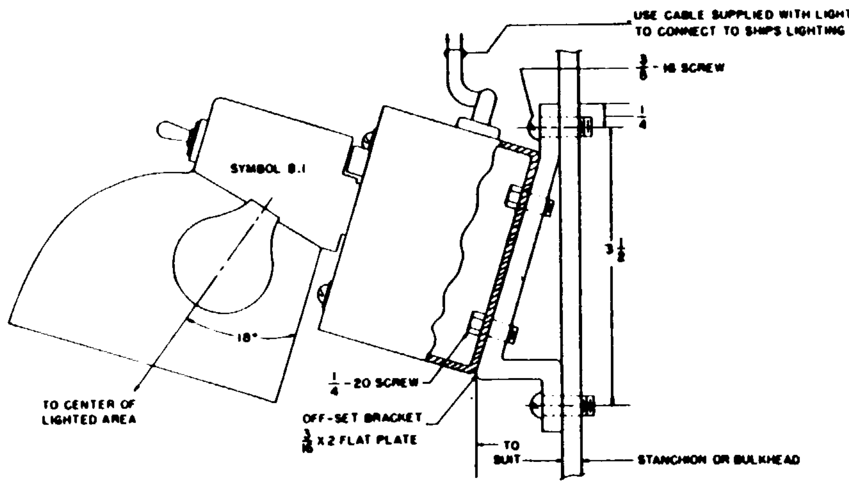
REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
—	FIRST ISSUE			
A	CHANGED SYM NOS FROM 229 231 AND 232 TO 229.1, 231.1 AND 232.1 DELETED SYM 230			



METHOD B-6-A

NOTES

1. BERTH LIGHTS, SYMBOLS 5.1 & 8.1, SHALL BE USED ON LIMITED APPLICATIONS ON MINESWEEPERS IN WHICH MAGNETIC MATERIAL OF FLUORESCENT BERTH LIGHTS, SYMBOLS 229.1, 230.1, 231.1 & 232.1 CAN NOT BE TOLERATED. LIGHT OUTPUT OF FLUORESCENT BERTH LIGHTS IS SUPERIOR TO THAT OF SYMBOLS 5.1 & 8.1.



METHOD B-6-B

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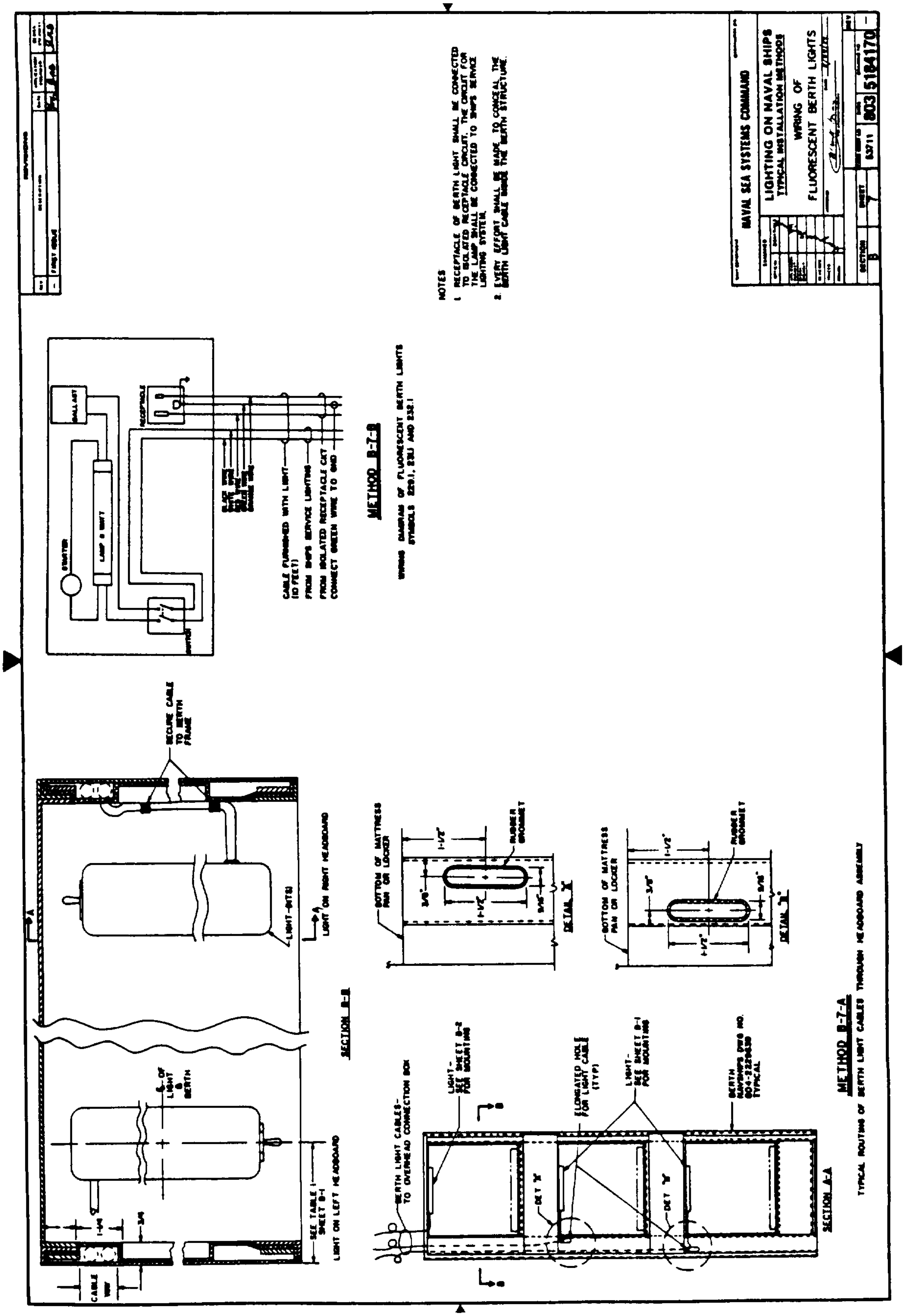
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS

TYPICAL INSTALLATION METHODS

MOUNTING OF BERTH LIGHTS SYMBOLS 5.1 & 8.1 (MINESWEEPERS ONLY)

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO.	REV
B	6	53711	803	5184170	A


NOTES
1. RECEPTACLE OF BERTH LIGHT SHALL BE CONNECTED TO ISOLATED RECEPTACLE CIRCUIT. THE CIRCUIT FOR THE LAMP SHALL BE CONNECTED TO SHIPS SERVICE LIGHTING SYSTEM.
2. EVERY EFFORT SHALL BE MADE TO CONCEAL THE BERTH LIGHT CABLE INSIDE THE BERTH STRUCTURE.
STARTER
BALLAST
LAMP 8 WATT
RECEPTACLE
SWITCH
CABLE FURNISHED WITH LIGHT (10 FEET)
FROM SHIPS SERVICE LIGHTING
FROM ISOLATED RECEPTACLE CKT
CONNECT GREEN WIRE TO GND
METHOD B-7-B
WIRING DIAGRAM OF FLUORESCENT BERTH LIGHTS SYMBOLS 229.1, 231.1 AND 232.1
CABLE WAY
1-1/4
3/4
℄ OF LIGHT & BERTH
SECURE CABLE TO BERTH FRAME
LIGHT-(KITS)
SEE TABLE 1 SHEET B-1
LIGHT ON LEFT HEADBOARD
LIGHT ON RIGHT HEADBOARD
SECTION B-B
BERTH LIGHT CABLES-TO OVERHEAD CONNECTION BOX
LIGHT-SEE SHEET B-2 FOR MOUNTING
DET "X"
ELONGATED HOLE FOR LIGHT CABLE (TYP)
LIGHT-SEE SHEET B-1 FOR MOUNTING
DET "Y"
BERTH NAVSHIPS DWG NO. 804-2229639 TYPICAL
SECTION A-A
METHOD B-7-A
TYPICAL ROUTING OF BERTH LIGHT CABLES THROUGH HEADBOARD ASSEMBLY
BOTTOM OF MATTRESS PAN OR LOCKER
3/8"
1-1/2"
5/16"
RUBBER GROMMET
DETAIL "X"
DETAIL "Y"
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
WIRING OF FLUORESCENT BERTH LIGHTS
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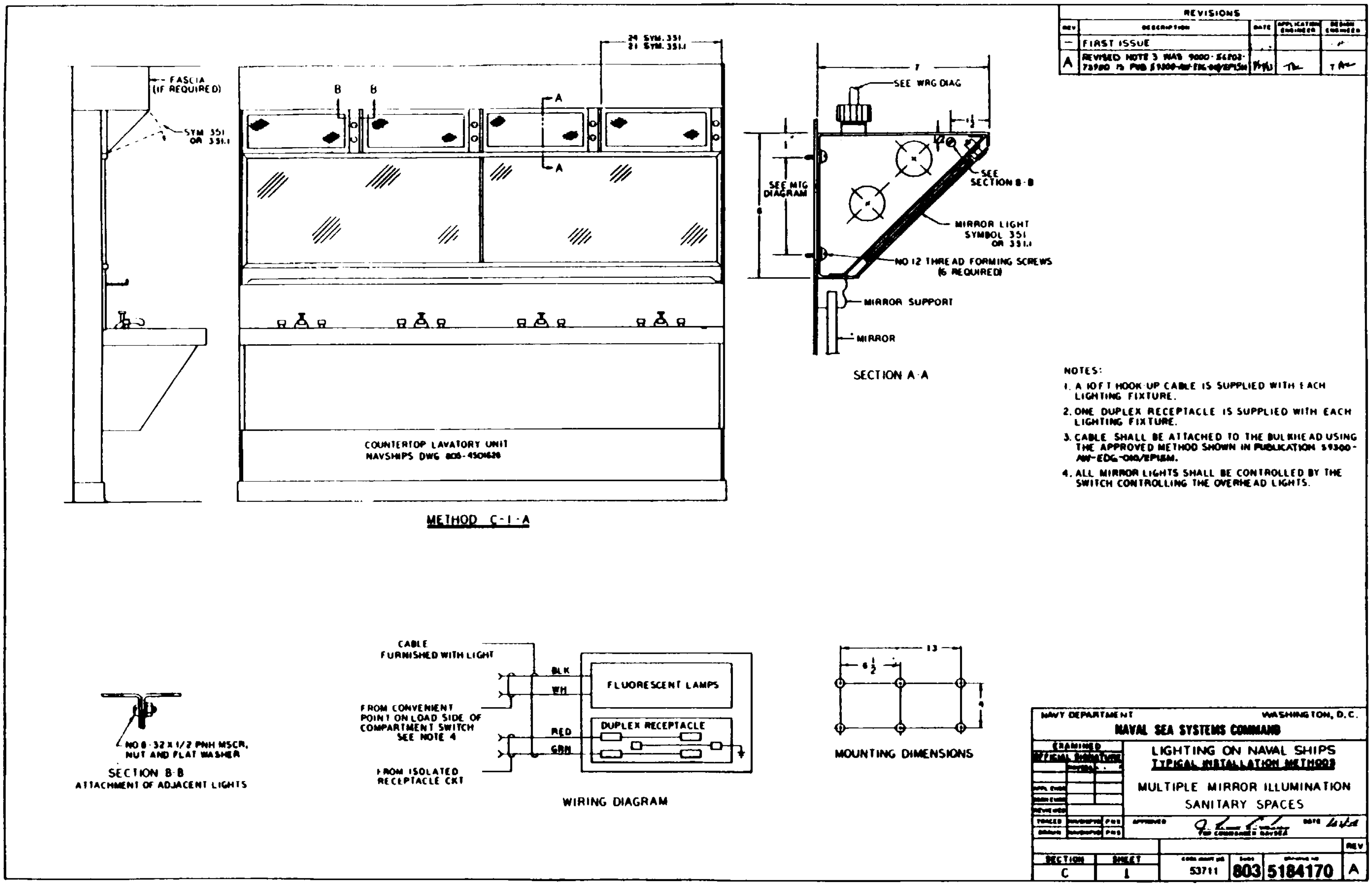
REVISIONS
FIRST ISSUE
A REVISED NOTE 3 WAS 9000-S6202-73980 TO PUB S9300-AW-EDG-010/EPISM
FASCIA (IF REQUIRED)
SYM 351 OR 351.1
24 SYM. 351
21 SYM. 351.1
B
B
A
A
SEE WRG DIAG
7
1/2
1
SEE MTG DIAGRAM
6
SEE SECTION B-B
MIRROR LIGHT SYMBOL 351 OR 351.1
NO 12 THREAD FORMING SCREWS (6 REQUIRED)
MIRROR SUPPORT
MIRROR
SECTION A-A
COUNTERTOP LAVATORY UNIT NAVSHIPS DWG 805-4501626
METHOD C-1-A
NOTES:
1. A 10FT HOOK-UP CABLE IS SUPPLIED WITH EACH LIGHTING FIXTURE.
2. ONE DUPLEX RECEPTACLE IS SUPPLIED WITH EACH LIGHTING FIXTURE.
3. CABLE SHALL BE ATTACHED TO THE BULKHEAD USING THE APPROVED METHOD SHOWN IN PUBLICATION S9300-AW-EDG-010/EPISM.
4. ALL MIRROR LIGHTS SHALL BE CONTROLLED BY THE SWITCH CONTROLLING THE OVERHEAD LIGHTS.
CABLE FURNISHED WITH LIGHT
FROM CONVENIENT POINT ON LOAD SIDE OF COMPARTMENT SWITCH SEE NOTE 4
FROM ISOLATED RECEPTACLE CKT
BLK
WH
RED
GRN
FLUORESCENT LAMPS
DUPLEX RECEPTACLE
WIRING DIAGRAM
13
6 1/2
4
MOUNTING DIMENSIONS
NO 8-32 X 1/2 PNH MSCR, NUT AND FLAT WASHER
SECTION B-B
ATTACHMENT OF ADJACENT LIGHTS
NAVY DEPARTMENT
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NAVAL SEA SYSTEMS COMMAND
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TYPICAL INSTALLATION METHODS
MULTIPLE MIRROR ILLUMINATION
SANITARY SPACES
SECTION C
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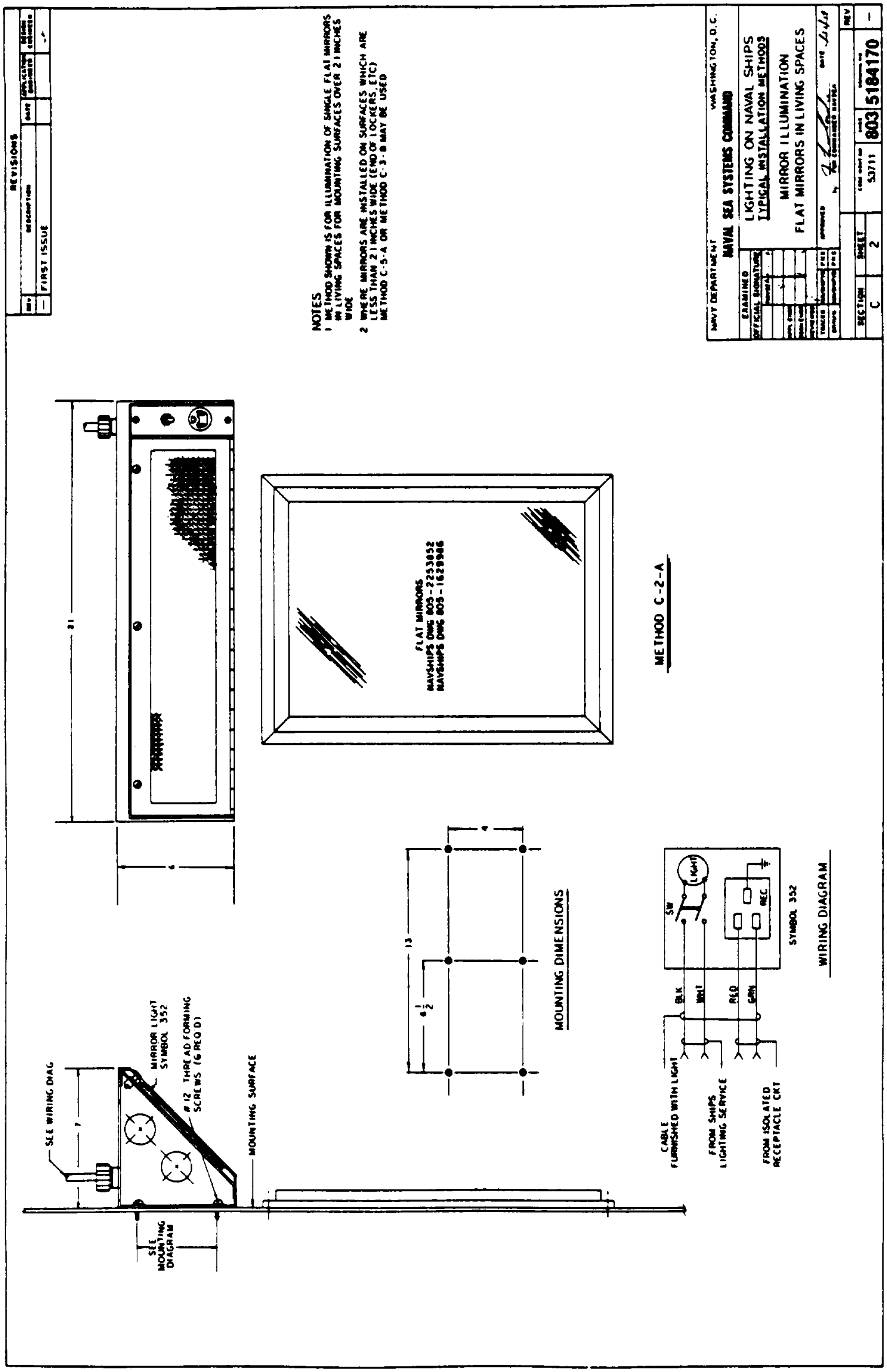
REVISIONS
— FIRST ISSUE
NOTES
1 METHOD SHOWN IS FOR ILLUMINATION OF SINGLE FLAT MIRRORS IN LIVING SPACES FOR MOUNTING SURFACES OVER 21 INCHES WIDE
2 WHERE MIRRORS ARE INSTALLED ON SURFACES WHICH ARE LESS THAN 21 INCHES WIDE (END OF LOCKERS, ETC) METHOD C-5-A OR METHOD C-3-B MAY BE USED
NAVY DEPARTMENT
WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
MIRROR ILLUMINATION
FLAT MIRRORS IN LIVING SPACES
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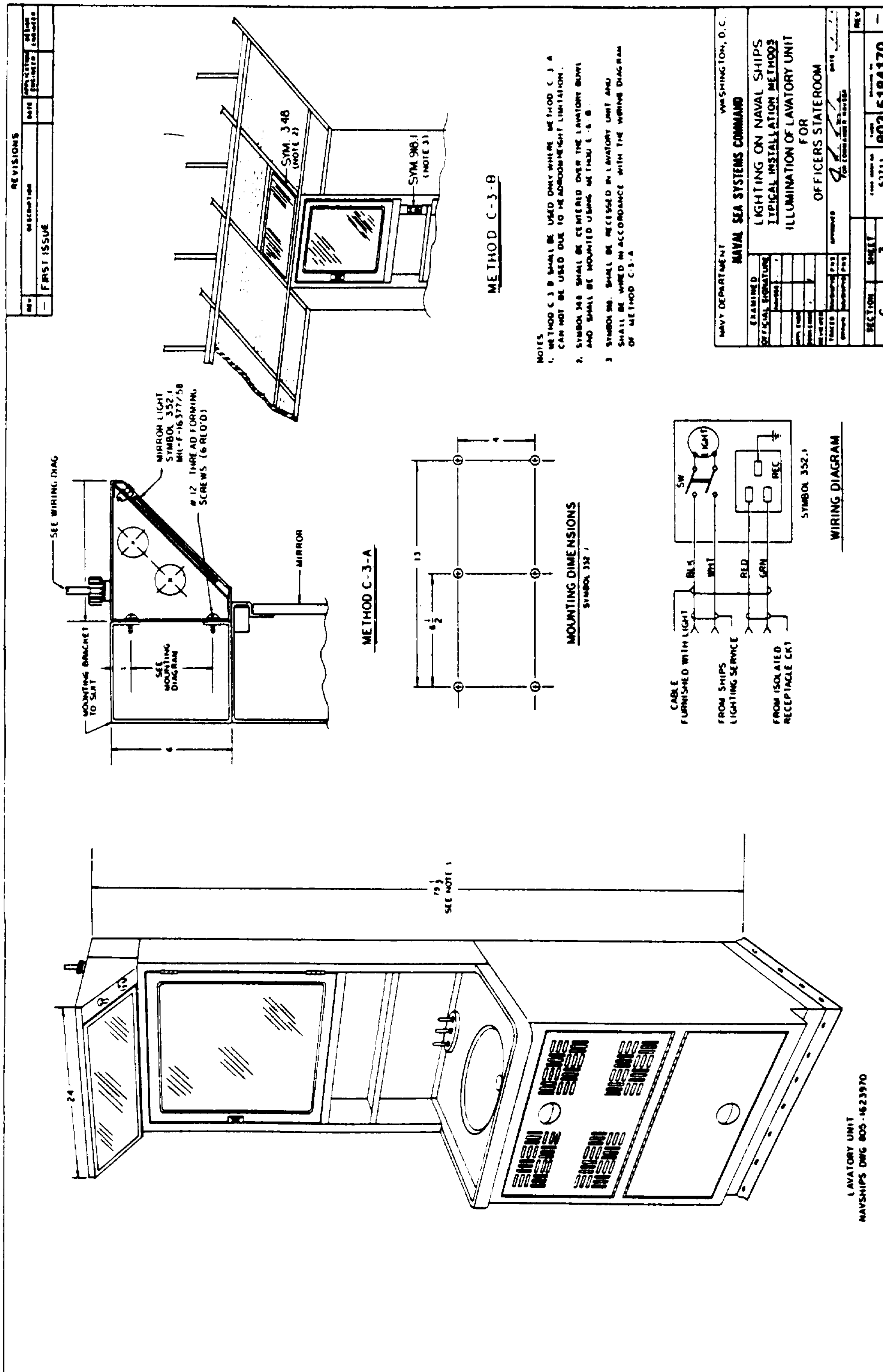
FLAT MIRRORS
NAVSHIPS DWG 803-2253852
NAVSHIPS DWG 803-1629946
METHOD C-2-A
4
13
4 1/2
MOUNTING DIMENSIONS
SW
LIGHT
REC
SYMBOL 352
WIRING DIAGRAM
BLK
WHT
RED
GRN
CABLE FURNISHED WITH LIGHT
FROM SHIPS LIGHTING SERVICE
FROM ISOLATED RECEPTACLE CKT
SEE WIRING DIAG
7
MIRROR LIGHT SYMBOL 352
#12 THREAD FORMING SCREWS (6 REQ'D)
MOUNTING SURFACE
SEE MOUNTING DIAGRAM


REVISIONS
FIRST ISSUE
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NAVAL SEA SYSTEMS COMMAND
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LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
ILLUMINATION OF LAVATORY UNIT
FOR
OFFICERS STATEROOM
SECTION C
SHEET 3
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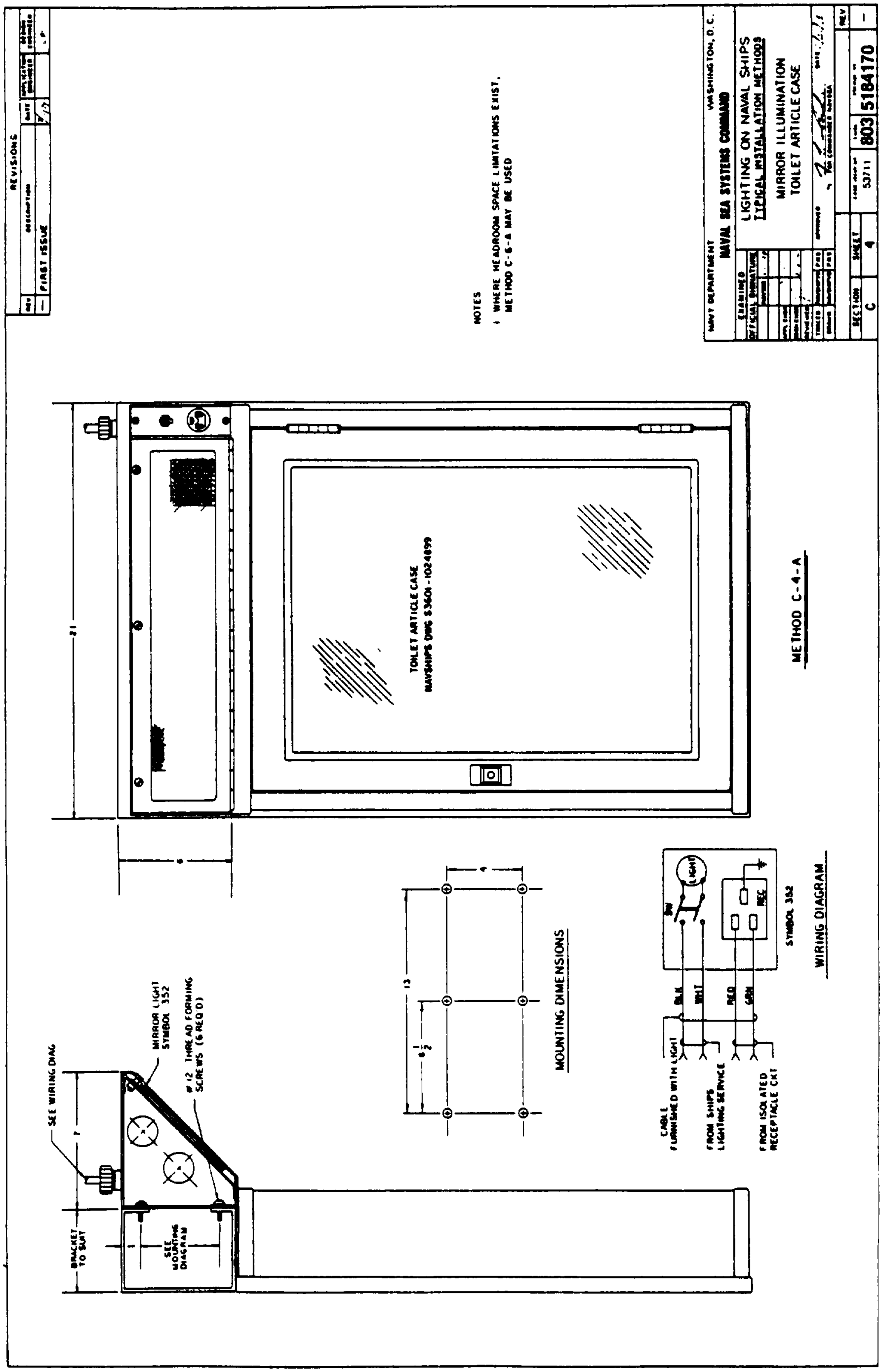
METHOD C-3-B
SYM. 348 (NOTE 2)
SYM 98.1 (NOTE 3)
NOTES
1. METHOD C-3-B SHALL BE USED ONLY WHERE METHOD C-3-A CAN NOT BE USED DUE TO HEADROOM/HEIGHT LIMITATION.
2. SYMBOL 348 SHALL BE CENTERED OVER THE LAVATORY BOWL AND SHALL BE MOUNTED USING METHOD L-6-B.
3. SYMBOL 98.1 SHALL BE RECESSED IN LAVATORY UNIT AND SHALL BE WIRED IN ACCORDANCE WITH THE WIRING DIAGRAM OF METHOD C-3-A
MIRROR LIGHT SYMBOL 352.1 MIL-F-16377/58
#12 THREAD FORMING SCREWS (6 REQ'D)
SEE WIRING DIAG
MIRROR
MOUNTING BRACKET TO SUIT
SEE MOUNTING DIAGRAM
METHOD C-3-A
MOUNTING DIMENSIONS
SYMBOL 352.1
SW
LIGHT
REC
SYMBOL 352.1
BLK
WHT
RED
GRN
CABLE FURNISHED WITH LIGHT
FROM SHIPS LIGHTING SERVICE
FROM ISOLATED RECEPTACLE CKT
WIRING DIAGRAM
79 3/4 SEE NOTE 1
24
LAVATORY UNIT
NAVSHIPS DWG 805-1623970


REVISIONS
FIRST ISSUE
NOTES
1 WHERE HEADROOM SPACE LIMITATIONS EXIST, METHOD C-6-A MAY BE USED
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NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C.
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MIRROR ILLUMINATION
TOILET ARTICLE CASE
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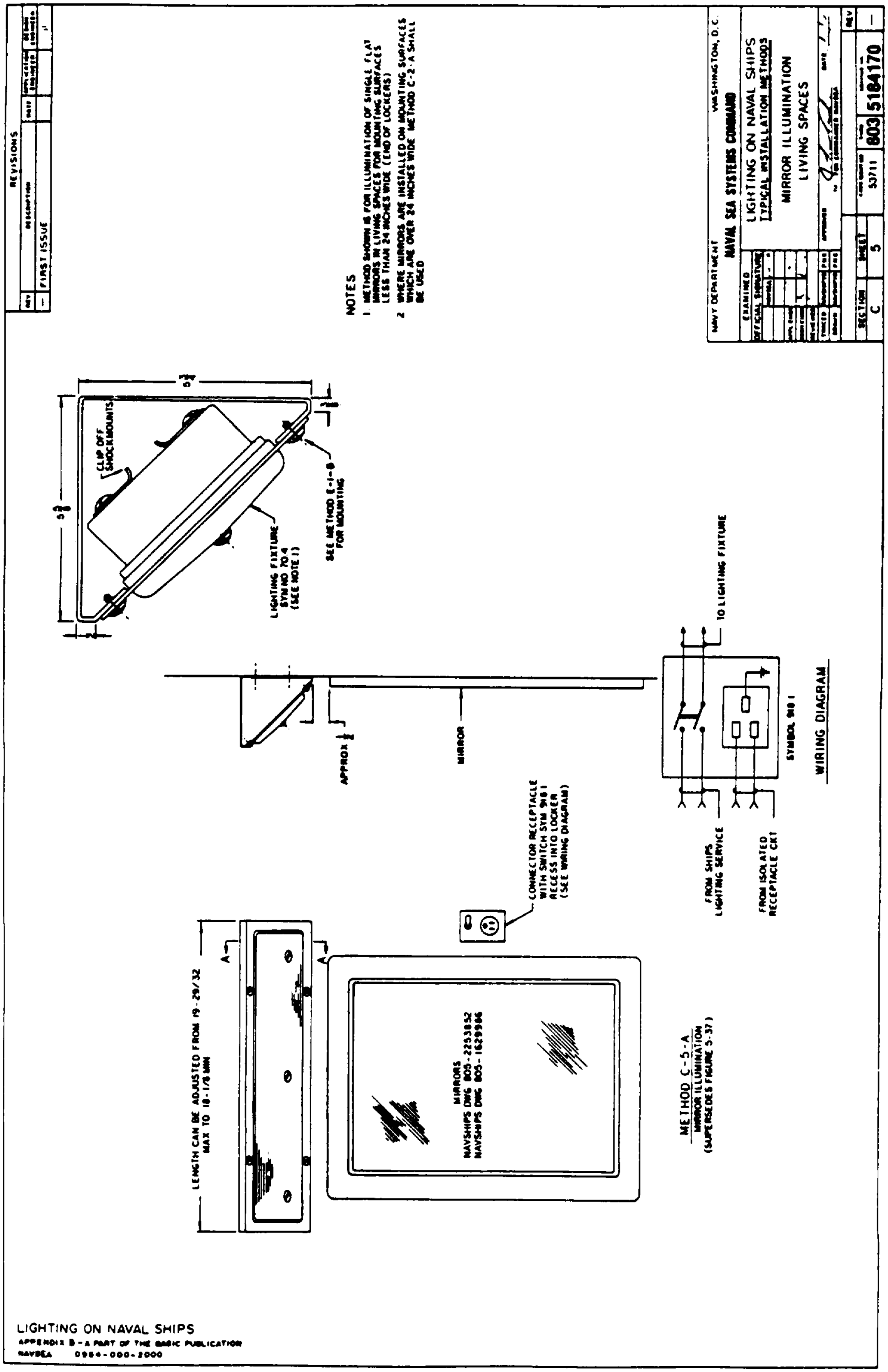
SECTION C
SHEET 4
TOILET ARTICLE CASE
NAVSHIPS DWG S3601-1024899
METHOD C-4-A
MOUNTING DIMENSIONS
WIRING DIAGRAM
SYMBOL 352
BLK
WHT
RED
GRN
CABLE FURNISHED WITH LIGHT
FROM SHIPS LIGHTING SERVICE
FROM ISOLATED RECEPTACLE CKT
SEE WIRING DIAG
MIRROR LIGHT SYMBOL 352
#12 THREAD FORMING SCREWS (6 REQ'D)
BRACKET TO SUIT
SEE MOUNTING DIAGRAM
21
13
4
6


REVISIONS
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NOTES
1. METHOD SHOWN IS FOR ILLUMINATION OF SINGLE FLAT MIRRORS IN LIVING SPACES FOR MOUNTING SURFACES LESS THAN 24 INCHES WIDE (END OF LOCKERS)
2. WHERE MIRRORS ARE INSTALLED ON MOUNTING SURFACES WHICH ARE OVER 24 INCHES WIDE METHOD C-2-A SHALL BE USED
CLIP OFF SHOCKMOUNTS
LIGHTING FIXTURE SYM NO 70.4 (SEE NOTE 1)
SEE METHOD E-1-B FOR MOUNTING
LENGTH CAN BE ADJUSTED FROM 19-29/32 MAX TO 18-1/8 MIN
MIRRORS
NAVSHIPS DWG 805-2253852
NAVSHIPS DWG 805-1629986
CONNECTOR RECEPTACLE WITH SWITCH SYM 918.1 RECESS INTO LOCKER (SEE WIRING DIAGRAM)
APPROX
MIRROR
FROM SHIPS LIGHTING SERVICE
FROM ISOLATED RECEPTACLE CKT
TO LIGHTING FIXTURE
SYMBOL 918.1
WIRING DIAGRAM
METHOD C-5-A
MIRROR ILLUMINATION
(SUPERSEDES FIGURE 5-37)
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MIRROR ILLUMINATION
LIVING SPACES
SECTION
C
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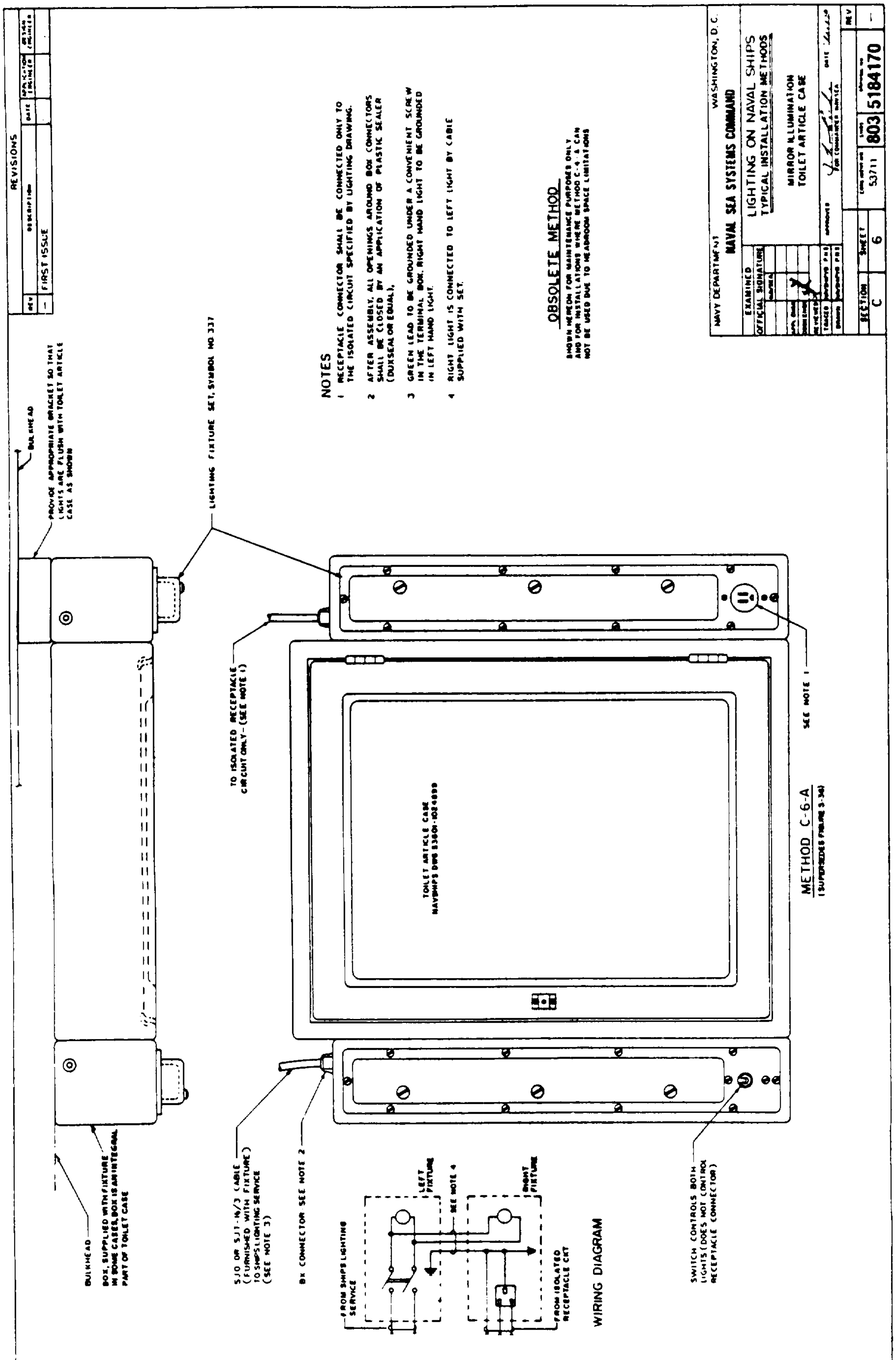
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BULKHEAD
PROVIDE APPROPRIATE BRACKET SO THAT LIGHTS ARE FLUSH WITH TOILET ARTICLE CASE AS SHOWN
BOX, SUPPLIED WITH FIXTURE IN SOME CASES, BOX IS AN INTEGRAL PART OF TOILET CASE
LIGHTING FIXTURE SET, SYMBOL NO 337
SJO OR SJT-16/3 CABLE (FURNISHED WITH FIXTURE) TO SHIPS LIGHTING SERVICE (SEE NOTE 3)
TO ISOLATED RECEPTACLE CIRCUIT ONLY - (SEE NOTE 1)
BX CONNECTOR SEE NOTE 2
FROM SHIPS LIGHTING SERVICE
LEFT FIXTURE
SEE NOTE 4
RIGHT FIXTURE
FROM ISOLATED RECEPTACLE CKT
WIRING DIAGRAM
TOILET ARTICLE CASE
NAVSHIPS DWG 83801-1024899
SWITCH CONTROLS BOTH LIGHTS (DOES NOT CONTROL RECEPTACLE CONNECTOR)
METHOD C-6-A
(SUPERSEDES FIGURE 3-36)
SEE NOTE 1
NOTES
1 RECEPTACLE CONNECTOR SHALL BE CONNECTED ONLY TO THE ISOLATED CIRCUIT SPECIFIED BY LIGHTING DRAWING.
2 AFTER ASSEMBLY, ALL OPENINGS AROUND BOX CONNECTORS SHALL BE CLOSED BY AN APPLICATION OF PLASTIC SEALER (DUXSEAL OR EQUAL).
3 GREEN LEAD TO BE GROUNDED UNDER A CONVENIENT SCREW IN THE TERMINAL BOX. RIGHT HAND LIGHT TO BE GROUNDED IN LEFT HAND LIGHT.
4 RIGHT LIGHT IS CONNECTED TO LEFT LIGHT BY CABLE SUPPLIED WITH SET.
OBSOLETE METHOD
SHOWN HEREON FOR MAINTENANCE PURPOSES ONLY AND FOR INSTALLATIONS WHERE METHOD C-4-A CAN NOT BE USED DUE TO HEADROOM SPACE LIMITATIONS
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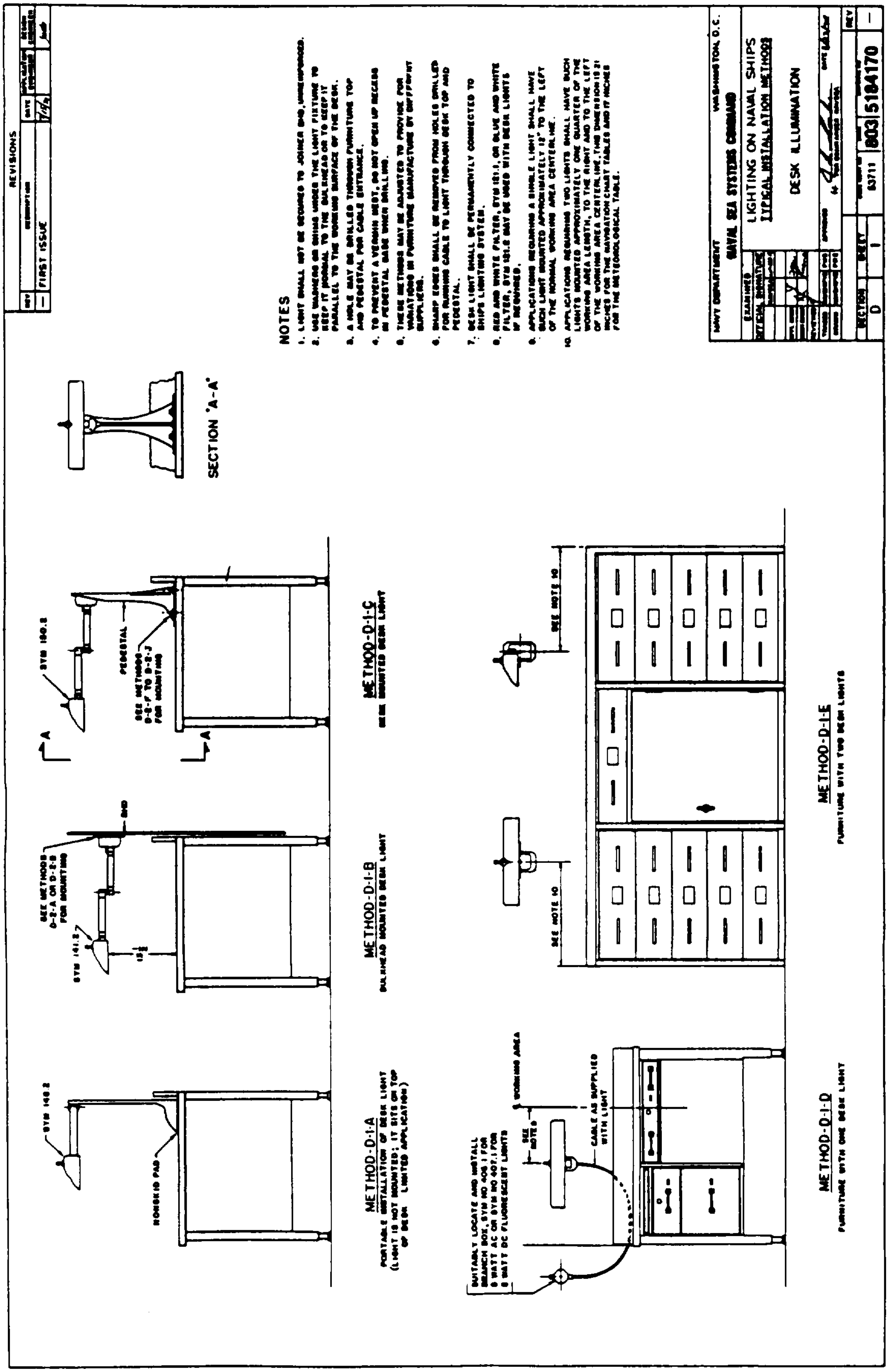
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SYM 140.2
NONSKID PAD
METHOD-D-1-A
PORTABLE INSTALLATION OF DESK LIGHT (LIGHT IS NOT MOUNTED; IT SITS ON TOP OF DESK LIMITED APPLICATION)
SEE METHODS D-2-A OR D-2-B FOR MOUNTING
SYM 141.2
BHD
METHOD-D-1-B
BULKHEAD MOUNTED DESK LIGHT
SYM 150.2
PEDESTAL
SEE METHODS D-2-F TO D-2-J FOR MOUNTING
METHOD-D-1-C
DESK MOUNTED DESK LIGHT
SECTION 'A-A'
SUITABLY LOCATE AND INSTALL BRANCH BOX, SYM NO 406.1 FOR 8 WATT AC OR SYM NO 407.1 FOR 8 WATT DC FLUORESCENT LIGHTS
SEE NOTE 9
WORKING AREA
CABLE AS SUPPLIED WITH LIGHT
METHOD-D-1-D
FURNITURE WITH ONE DESK LIGHT
SEE NOTE 10
SEE NOTE 10
METHOD-D-1-E
FURNITURE WITH TWO DESK LIGHTS
NOTES
1. LIGHT SHALL NOT BE SECURED TO JOINER BHD, UNREINFORCED.
2. USE WASHERS OR SHIMS UNDER THE LIGHT FIXTURE TO KEEP IT NORMAL TO THE BULKHEAD OR TO KEEP IT PARALLEL TO THE WORKING SURFACE OF THE DESK.
3. A HOLE MAY BE DRILLED THROUGH FURNITURE TOP AND PEDESTAL FOR CABLE ENTRANCE.
4. TO PREVENT A VERMIN NEST, DO NOT OPEN UP RECESS IN PEDESTAL BASE WHEN DRILLING.
5. THESE METHODS MAY BE ADJUSTED TO PROVIDE FOR VARIATIONS IN FURNITURE MANUFACTURE BY DIFFERENT SUPPLIERS.
6. SHARP EDGES SHALL BE REMOVED FROM HOLES DRILLED FOR RUNNING CABLE TO LIGHT THROUGH DESK TOP AND PEDESTAL.
7. DESK LIGHT SHALL BE PERMANENTLY CONNECTED TO SHIPS LIGHTING SYSTEM.
8. RED AND WHITE FILTER, SYM 121.1, OR BLUE AND WHITE FILTER, SYM 121.2 MAY BE USED WITH DESK LIGHTS IF REQUIRED.
9. APPLICATIONS REQUIRING A SINGLE LIGHT SHALL HAVE SUCH LIGHT MOUNTED APPROXIMATELY 12" TO THE LEFT OF THE NORMAL WORKING AREA CENTERLINE.
10. APPLICATIONS REQUIRING TWO LIGHTS SHALL HAVE SUCH LIGHTS MOUNTED APPROXIMATELY ONE QUARTER OF THE WORKING AREA LENGTH, TO THE RIGHT AND TO THE LEFT OF THE WORKING AREA CENTERLINE. THIS DIMENSION IS 21 INCHES FOR THE NAVIGATION CHART TABLES AND 17 INCHES FOR THE METEOROLOGICAL TABLE.
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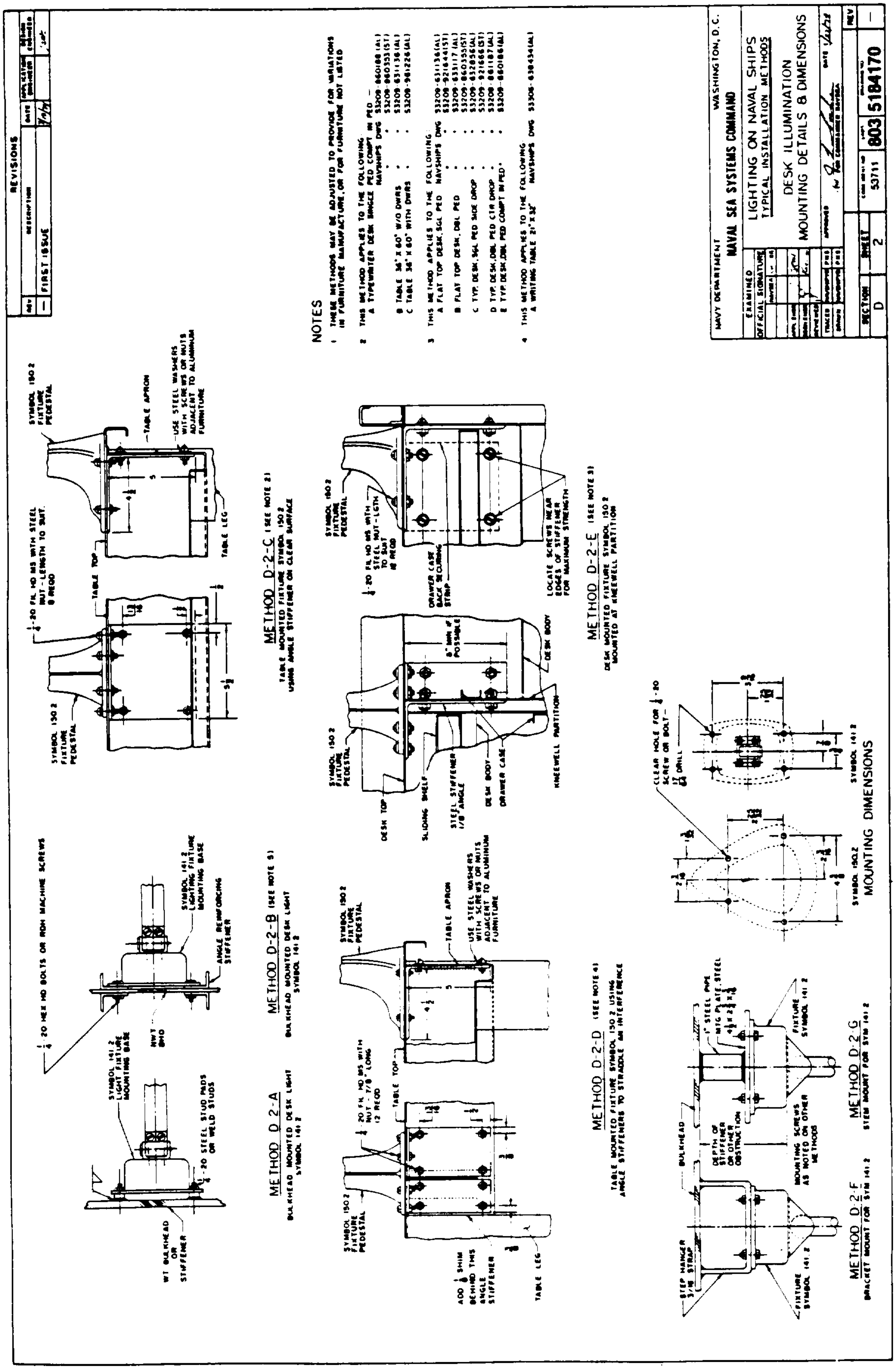
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METHOD D-2-B
METHOD D-2-C
METHOD D-2-D
METHOD D-2-E
METHOD D-2-F
METHOD D-2-G
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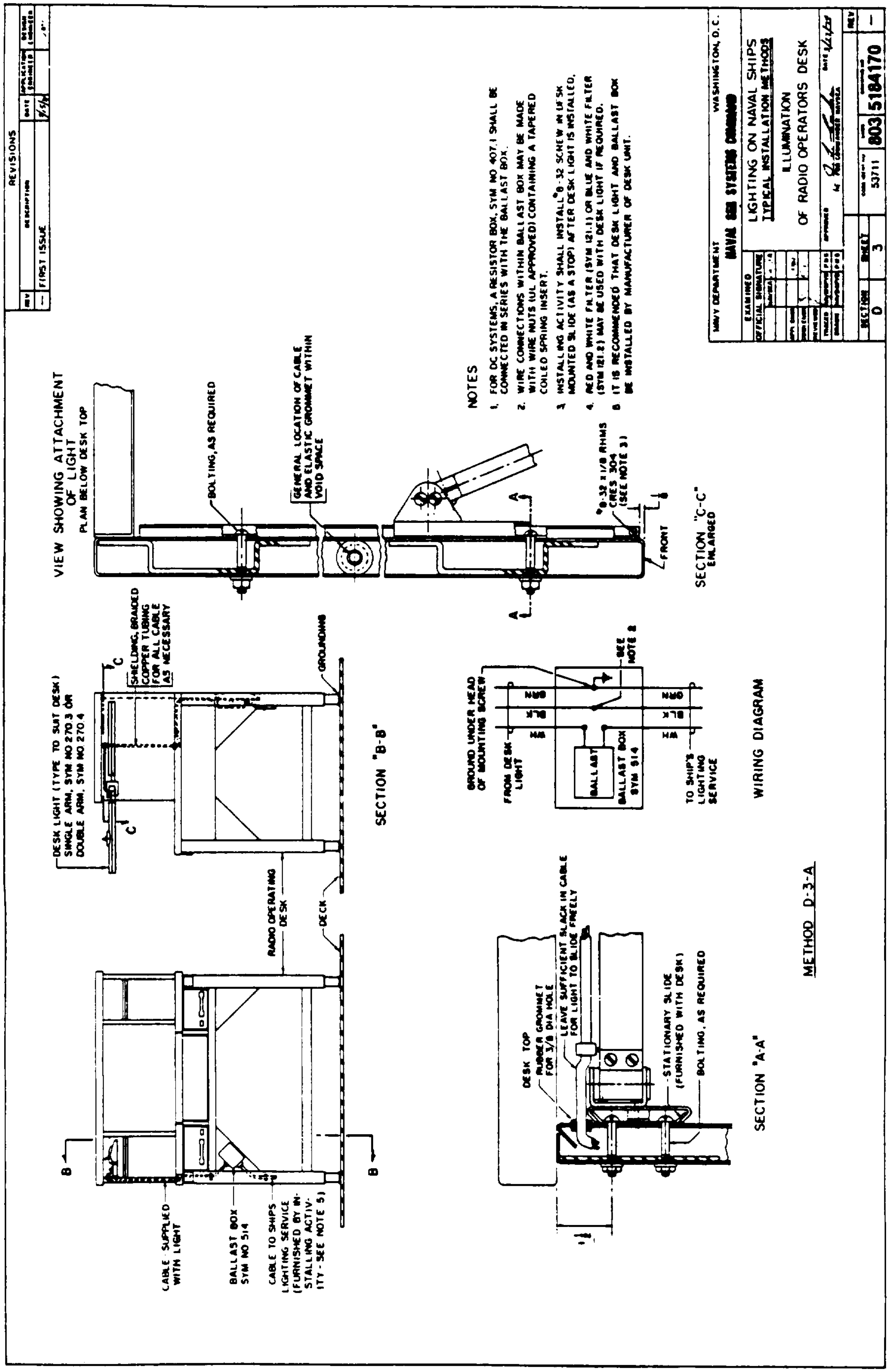
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VIEW SHOWING ATTACHMENT OF LIGHT
PLAN BELOW DESK TOP
BOLTING, AS REQUIRED
GENERAL LOCATION OF CABLE AND ELASTIC GROMMET WITHIN VOID SPACE
8-32 x 1/8 RHMS CRES 304 (SEE NOTE 3)
FRONT
SECTION "C-C" ENLARGED
NOTES
1. FOR DC SYSTEMS, A RESISTOR BOX, SYM NO 407.1 SHALL BE CONNECTED IN SERIES WITH THE BALLAST BOX.
2. WIRE CONNECTIONS WITHIN BALLAST BOX MAY BE MADE WITH WIRE NUTS (UL APPROVED) CONTAINING A TAPERED COILED SPRING INSERT.
3. INSTALLING ACTIVITY SHALL INSTALL 8-32 SCREW IN DESK MOUNTED SLIDE (AS A STOP) AFTER DESK LIGHT IS INSTALLED.
4. RED AND WHITE FILTER (SYM 121.1) OR BLUE AND WHITE FILTER (SYM 121.2) MAY BE USED WITH DESK LIGHT IF REQUIRED.
5. IT IS RECOMMENDED THAT DESK LIGHT AND BALLAST BOX BE INSTALLED BY MANUFACTURER OF DESK UNIT.
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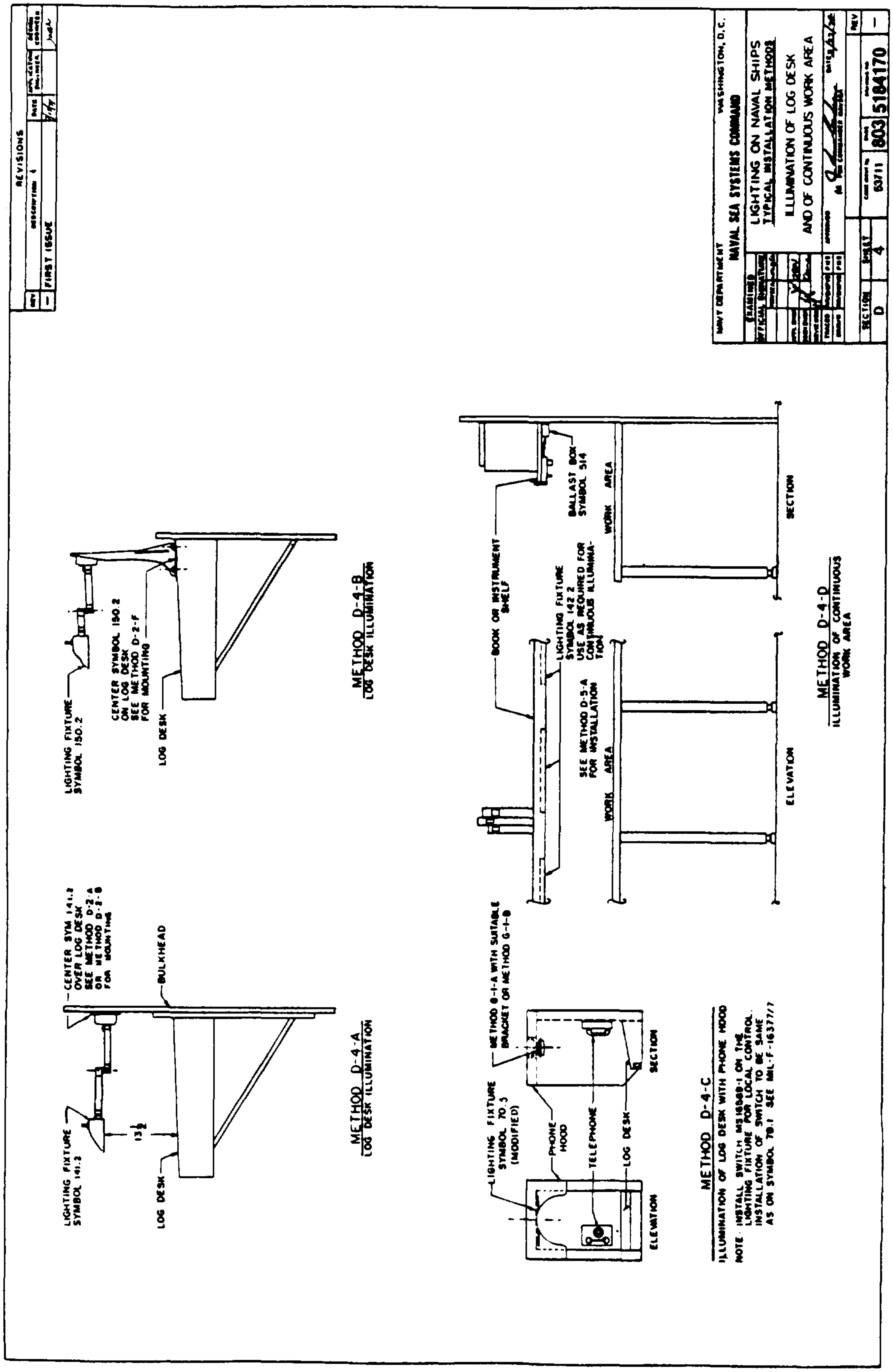
SHEET 3
DESK LIGHT (TYPE TO SUIT DESK) SINGLE ARM, SYM NO 270.3 OR DOUBLE ARM, SYM NO 270.4
SHIELDING, BRAIDED COPPER TUBING FOR ALL CABLE AS NECESSARY
GROUNDING
RADIO OPERATING DESK
DECK
SECTION "B-B"
GROUND UNDER HEAD OF MOUNTING SCREW
FROM DESK LIGHT
BALLAST
BALLAST BOX SYM 514
SEE NOTE 2
TO SHIP'S LIGHTING SERVICE
WH
BLK
GRN
WIRING DIAGRAM
CABLE SUPPLIED WITH LIGHT
BALLAST BOX SYM NO 514
CABLE TO SHIPS LIGHTING SERVICE (FURNISHED BY INSTALLING ACTIVITY - SEE NOTE 5)
DESK TOP
RUBBER GROMMET FOR 3/8 DIA HOLE
LEAVE SUFFICIENT SLACK IN CABLE FOR LIGHT TO SLIDE FREELY
STATIONARY SLIDE (FURNISHED WITH DESK)
BOLTING, AS REQUIRED
SECTION "A-A"
METHOD D-3-A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AND OF CONTINUOUS WORK AREA
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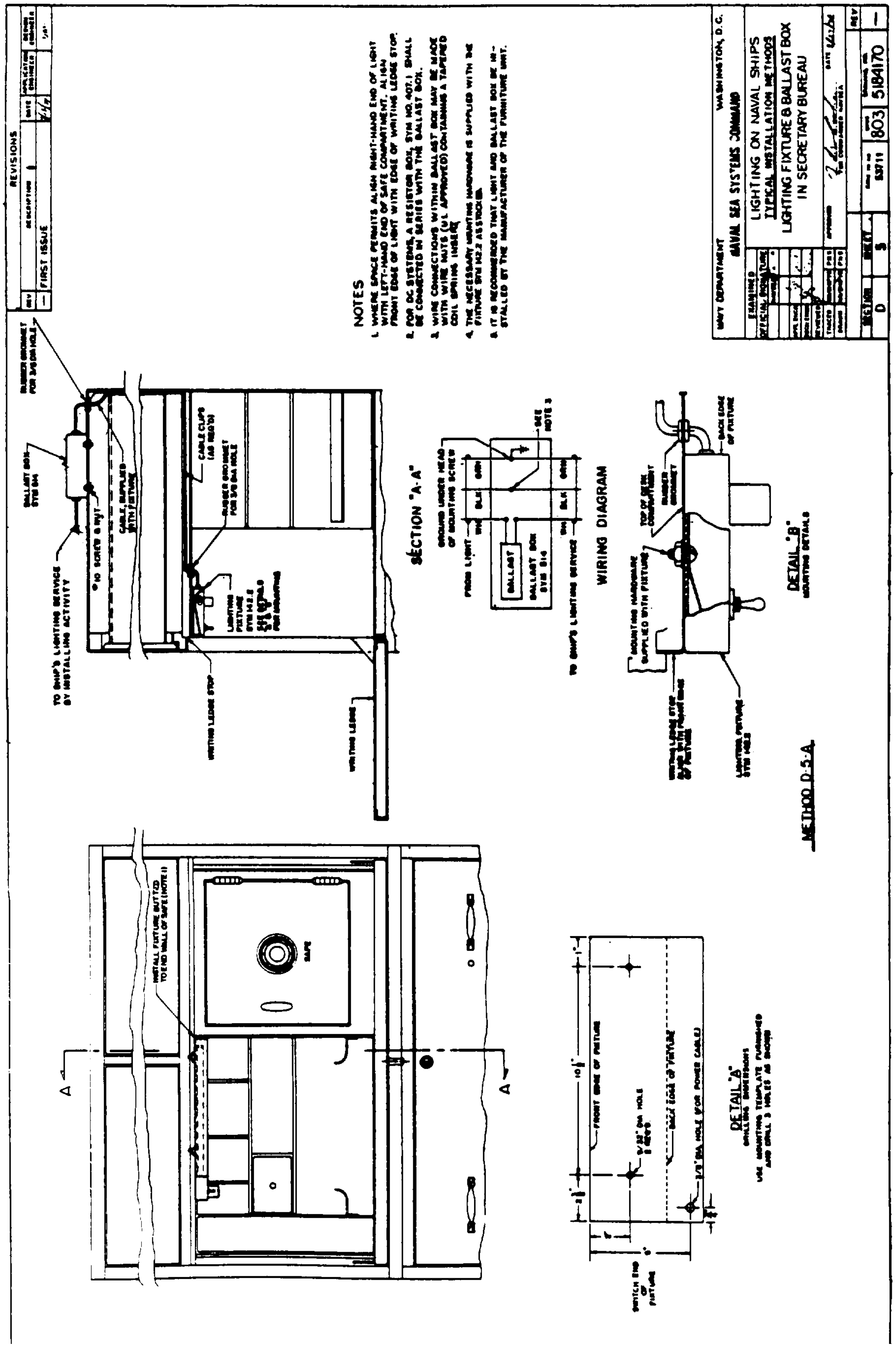
LIGHTING FIXTURE SYMBOL 141.2
LOG DESK
CENTER SYM 141.2 OVER LOG DESK SEE METHOD D-2-A OR METHOD D-2-B FOR MOUNTING
BULKHEAD
13 1/2
METHOD D-4-A
LOG DESK ILLUMINATION
LIGHTING FIXTURE SYMBOL 150.2
CENTER SYMBOL 150.2 ON LOG DESK SEE METHOD D-2-F FOR MOUNTING
LOG DESK
METHOD D-4-B
LOG DESK ILLUMINATION
LIGHTING FIXTURE SYMBOL 70.3 (MODIFIED)
PHONE HOOD
TELEPHONE
LOG DESK
METHOD G-1-A WITH SUITABLE BRACKET OR METHOD G-1-B
ELEVATION
SECTION
METHOD D-4-C
ILLUMINATION OF LOG DESK WITH PHONE HOOD
BOOK OR INSTRUMENT SHELF
LIGHTING FIXTURE SYMBOL 142.2 USE AS REQUIRED FOR CONTINUOUS ILLUMINATION
SEE METHOD D-5-A FOR INSTALLATION
WORK AREA
BALLAST BOX SYMBOL 514
WORK AREA
ELEVATION
SECTION
METHOD D-4-D
ILLUMINATION OF CONTINUOUS WORK AREA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NOTES
1. WHERE SPACE PERMITS ALIGN RIGHT-HAND END OF LIGHT WITH LEFT-HAND END OF SAFE COMPARTMENT. ALIGN FRONT EDGE OF LIGHT WITH EDGE OF WRITING LEDGE STOP.
2. FOR DC SYSTEMS, A RESISTOR BOX, SYM NO. 407.1 SHALL BE CONNECTED IN SERIES WITH THE BALLAST BOX.
3. WIRE CONNECTIONS WITHIN BALLAST BOX MAY BE MADE WITH WIRE NUTS (UL APPROVED) CONTAINING A TAPERED COIL SPRING INSERT.
4. THE NECESSARY MOUNTING HARDWARE IS SUPPLIED WITH THE FIXTURE SYM 142.2 AS STOCKED.
5. IT IS RECOMMENDED THAT LIGHT AND BALLAST BOX BE INSTALLED BY THE MANUFACTURER OF THE FURNITURE UNIT.
A
INSTALL FIXTURE BUTTED TO END WALL OF SAFE (NOTE 1)
SAFE
TO SHIP'S LIGHTING SERVICE BY INSTALLING ACTIVITY
BALLAST BOX SYM 814
RUBBER GROMMET FOR 3/8 DIA HOLE
#10 SCREW & NUT
CABLE, SUPPLIED WITH FIXTURE
WRITING LEDGE STOP
CABLE CLIPS (AS REQ'D)
RUBBER GROMMET FOR 3/8 DIA HOLE
LIGHTING FIXTURE SYM 142.2 SEE DETAILS "A" "B" FOR MOUNTING
WRITING LEDGE
SECTION "A-A"
GROUND UNDER HEAD OF MOUNTING SCREW
FROM LIGHT
WH
BLK
GRN
BALLAST
BALLAST BOX SYM 814
SEE NOTE 3
TO SHIP'S LIGHTING SERVICE
WIRING DIAGRAM
FRONT EDGE OF FIXTURE
SWITCH END OF FIXTURE
BACK EDGE OF FIXTURE
3/8" DIA HOLE (FOR POWER CABLE)
DETAIL "A"
DRILLING DIMENSIONS
USE MOUNTING TEMPLATE FURNISHED AND DRILL 3 HOLES AS SHOWN
MOUNTING HARDWARE SUPPLIED WITH FIXTURE
TOP OF DESK COMPARTMENT
RUBBER GROMMET
WRITING LEDGE STOP ALIGN WITH FRONT EDGE OF FIXTURE
LIGHTING FIXTURE SYM 142.2
BACK EDGE OF FIXTURE
DETAIL "B"
MOUNTING DETAILS
METHOD D-5-A
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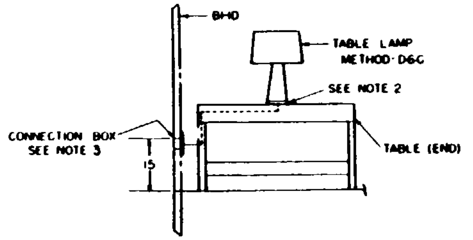
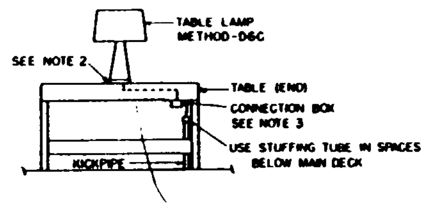


METHOD-D-6-A

TABLE LAMP ADJACENT TO BHD

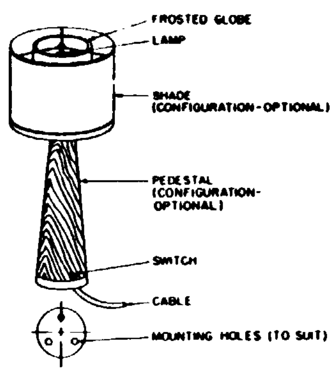


METHOD-D-6-B

TABLE LAMP NOT ADJACENT TO BHD

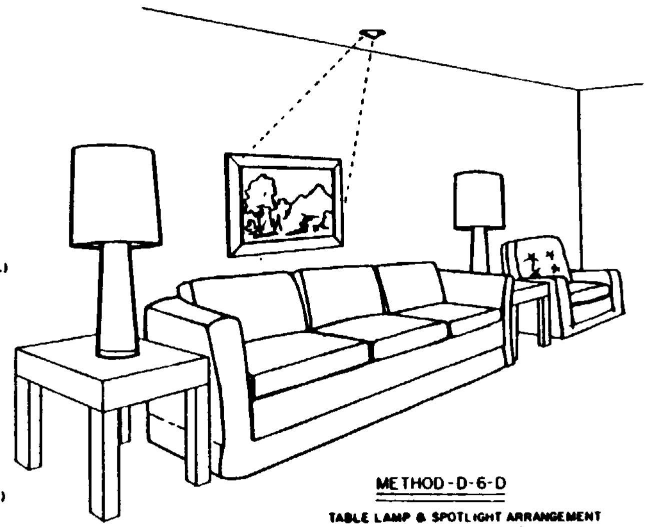
NOTES:

1. TABLE LAMPS SHALL BE UNDERWRITERS LABORATORIES APPROVED IN ACCORDANCE WITH UL 595-MARINE-TYPE ELECTRIC LIGHTING FIXTURES AND AS FOLLOWS:
   A. MATERIAL SHALL NOT BE HIGHLY FLAMMABLE.
   B. TO BE DESIGNED FOR PERMANENT MOUNTING ON TABLES.
   C. TO BE PROVIDED WITH 6 FEET (MINIMUM) OF SJO OR SJT 3-CONDUCTOR CABLE (BLACK, WHITE, GREEN). THE GREEN CONDUCTOR SHALL BE USED FOR GROUNDING.
   D. TO ACCOMODATE A 50 WATT OR 100 WATT MEDIUM SCREW BASE LAMP.
   E. TO BE PROVIDED WITH A DOUBLE POLE SINGLE THROW TOGGLE SWITCH. THE SWITCH SHALL BREAK BOTH SIDES OF THE LINE.
   F. TO BE GENERALLY AS SHOWN ON METHOD D-6-C.
   G. TO WITHSTAND SHOCK TESTS IN ACCORDANCE WITH MIL-C-901 (GRADE B) AND VIBRATIONS TESTS IN ACCORDANCE WITH MIL-STD-167.
2. TABLE LAMPS SHALL BE PERMANENTLY MOUNTED ON TABLES BY SUITABLE MEANS.
3. TABLE LAMPS SHALL BE GROUNDED TO SHIPS STRUCTURE.
4. COMMERCIAL TABLE LAMPS SHALL BE SELECTED BY THE PROSPECTIVE COMMANDING OFFICERS OR APPROPRIATE TYPE COMMANDERS FOR THE AREAS PROVIDED WITH END TABLES.



METHOD-D-6-C

TABLE LAMP (SEE NOTE 1)



METHOD-D-6-D

TABLE LAMP & SPOTLIGHT ARRANGEMENT (SEE NOTE 2)

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TABLE LAMPS

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
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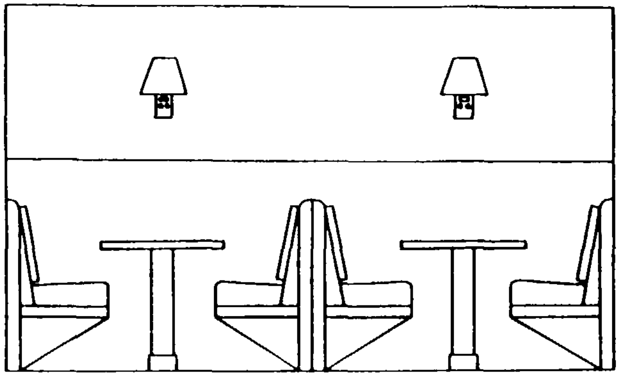
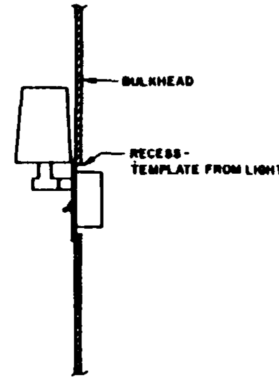


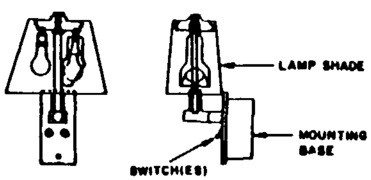
METHOD D-7-A

TYPICAL APPLICATION



METHOD D-7-B

TYPICAL MOUNTING



METHOD D-7-C

TYPICAL SCONCE LIGHT (SEE NOTE 1)

NOTES:

1. SCONCE LIGHTS SHALL BE UNDERWRITERS LABORATORIES APPROVED IN ACCORDANCE WITH UL 595-MARINE-TYPE ELECTRIC LIGHTING FIXTURES AND AS FOLLOWS:
   a. SHALL BE PERMANENTLY MOUNTED (RECESSED) ON BULKHEADS.
   b. SHALL BE PROVIDED WITH A METAL MOUNTING BASE WHICH SHALL ALSO SERVE AS A CONNECTION BOX FOR ELECTRICAL WIRING. THE MOUNTING BASE SHALL BE CAPABLE OF BEING RECESSED ON BULKHEADS.
   c. SHALL BE HARD WIRED, I.E. NO PORTABLE PLUG-IN WIRE
   d. SHALL BE DESIGNED TO ACCOMODATE ONE, TWO, OR THREE 25 OR 50 WATT MEDIUM SCREW BASE INCANDESCENT LAMP(S).
   e. SHALL BE PROVIDED WITH A DOUBLE POLE SINGLE THROW TOGGLE SWITCH(ES). THE SWITCH(ES) SHALL BREAK BOTH SIDES OF THE LINE.
   f. SHALL BE DESIGNED TO WITHSTAND SHOCK TESTS IN ACCORDANCE WITH MIL-C-901 (GRADE B) AND VIBRATION TESTS IN ACCORDANCE WITH MIL-STD-167.
   g. SHALL HAVE WIRE FRAMED LAMP SHADES. THE SHADE SPIDER SHALL SECURELY ATTACH TO THE MOUNTING BASE.
2. SCONCE LIGHTS SHALL BE PERMANENTLY MOUNTED ON BULKHEADS.
3. SCONCE LIGHTS SHALL BE GROUNDED TO SHIPS STRUCTURE.
4. COMMERCIAL SCONCE LIGHTS SHALL BE SELECTED BY THE PROSPECTIVE COMMANDING OFFICERS OR APPROPRIATE TYPE COMMANDERS.
5. AMONG OTHERS, THE FOLLOWING ARE ACCEPTABLE SOURCE OF SUPPLY FOR SCONCE LIGHTS:
   a. HARVARD INTERIORS MANUFACTURING CORPORATION, (FORMERLY MURLIN) QUAKERTOWN PA, 18951
      TYPE-1698.
   b. SIMES COMPANY, INC. 34-15 18TH AVE. COLLEGE PT. NEW YORK, NY 11356
      TYPE-48642, TYPE-48164, TYPE-48199, TYPE-48384.

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SCONCE LIGHTS

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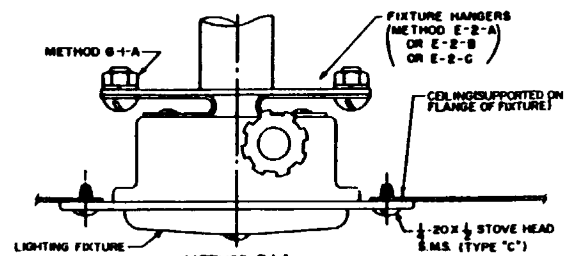
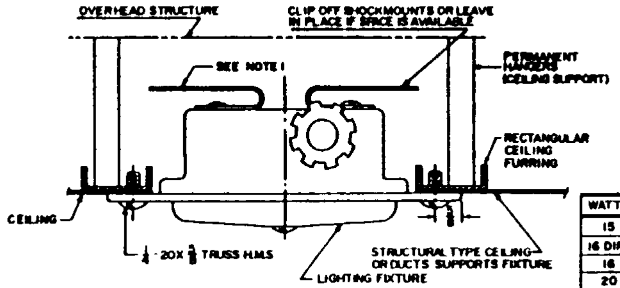
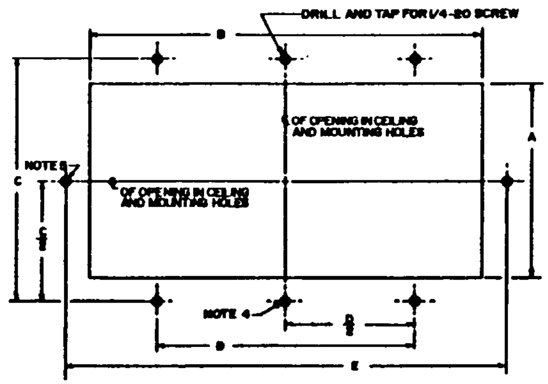
A	ADDED MIL-F-16377/65 & 66 FIXTURES IN TABLE, AND TYPE OF CEILING IN METHODS E-1-A & E-1-B.	[illegible]	[illegible]	[illegible]



METHOD E-1-A
TYPICAL FIXTURE MOUNTING FOR TYPE CBD CEILINGS OF DWG 804-5000994



METHOD E-1-B
TYPICAL FIXTURE MOUNTING FOR TYPE CBD CEILINGS OF DWG 804-5000994



CEILING OPENING

NOTES

1 EXTENSION HANGERS FOR LIGHTING FIXTURES MAY BE OMITTED IF STRUCTURE OF FALSE CEILING IS ADEQUATE TO SUPPORT THE WEIGHT OF THE FIXTURES AND IF FALSE CEILING IS NOT TO BE REMOVED DURING WARTIME "STRIPSHIP" CONDITIONS.

2 WHEN LIGHTING FIXTURES ARE RECESSED IN VENTILATION DUCTWORK, THE AIRTIGHT INTEGRITY OF THE DUCTWORK SHALL BE MAINTAINED BY USE OF A SUITABLE SEALING COMPOUND, WHICH SHALL BE APPLIED TO THE MATING SURFACES OF THE FIXTURE FLANGE AND THE STRUCTURE OF THE DUCTWORK.

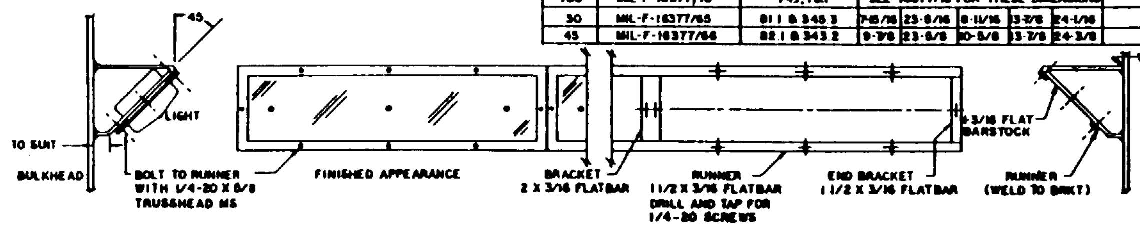
3 WHERE CONDITIONS PERMIT IN FALSE CEILINGS CONNECTION BOXES FEEDING FIXTURES SHOULD BE INSTALLED TO BE ACCESSIBLE BY REMOVING THE LIGHTING FIXTURES.

4 THIS AND HOLE OPPOSITE ARE NOT REQUIRED FOR FIXTURES HAVING ONLY 4 OR 6 MOUNTING HOLES.

5 THIS AND HOLE OPPOSITE ARE NOT REQUIRED FOR FIXTURES HAVING BUT 4 MOUNTING HOLES.

TABLE 1-CEILING OPENING & MOUNTING HOLE DIMENSIONS

WATTS	SPECIFICATION NO	SYM NO	A	B	C	D	E	MOUNTING HOLES REQUIRED
15	MIL-F-16377/5	338.2	8-1/4	23-9/16	6	13-7/8	24-5/16	8
16 DIR	MIL-F-16377/6	149.3	7-15/16	16-11/16	8-11/16	9-1/4	17-7/16	6
16	MIL-F-16377/7	70.4,	5-1/4	17-29/32	6	9-1/4	18-21/32	6
20	MIL-F-16377/8	331.2, 347.1	5-1/4	29-9/16	6	19-7/8	30-5/16	8
24	MIL-F-16377/9	734, 346.1	7-15/16	16-11/16	8-11/16	9-1/4	17-7/16	6
32 DIR	MIL-F-16377/10	145.3,	7-15/16	29-5/16	8-11/16	19-7/8	30-1/16	8
40	MIL-F-16377/11	77.5, 344.1	7-15/16	29-5/16	8-11/16	19-7/8	30-1/16	8
60	MIL-F-16377/12	333.2, 341.2, 342.1	9-7/8	29-5/8	10-5/8	19-7/8	30-3/8	8
8	MIL-F-16377/14	782, 80.2	3-7/32	16-7/8	3-31/32	9-5/16	—	4
180	MIL-F-16377/13	74.1, 75.1	SEE 16377/13 FOR THESE DIMENSIONS					16
30	MIL-F-16377/65	81.1 & 348.3	7-15/16	23-5/16	8-11/16	13-7/8	24-1/16	8
45	MIL-F-16377/66	82.1 & 343.2	9-7/8	23-5/8	10-5/8	13-7/8	24-3/8	8

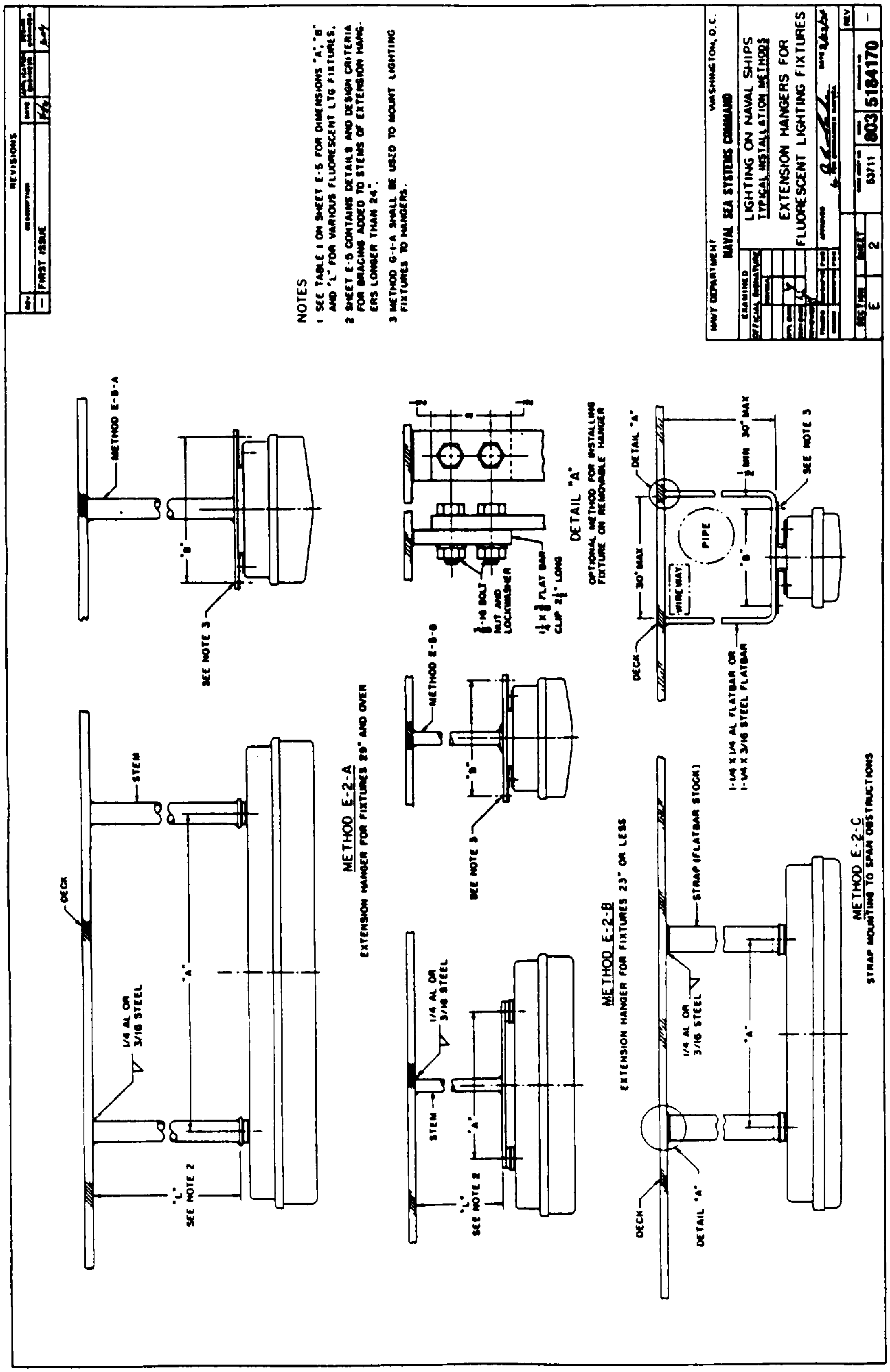


METHOD E-1-C
BRACKET ASSEMBLY FOR CONTINUOUS ROW OF LIGHTING FIXTURES

NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
RECESSED MOUNTING OF OVERHEAD FLUORESCENT LIGHTING FIXTURES

SECTION	SHEET				REV
E	1	53711	803	5184170	A


NOTES
1 SEE TABLE I ON SHEET E-5 FOR DIMENSIONS "A", "B" AND "L" FOR VARIOUS FLUORESCENT LTG FIXTURES.
2 SHEET E-5 CONTAINS DETAILS AND DESIGN CRITERIA FOR BRACING ADDED TO STEMS OF EXTENSION HANGERS LONGER THAN 24".
3 METHOD G-1-A SHALL BE USED TO MOUNT LIGHTING FIXTURES TO HANGERS.
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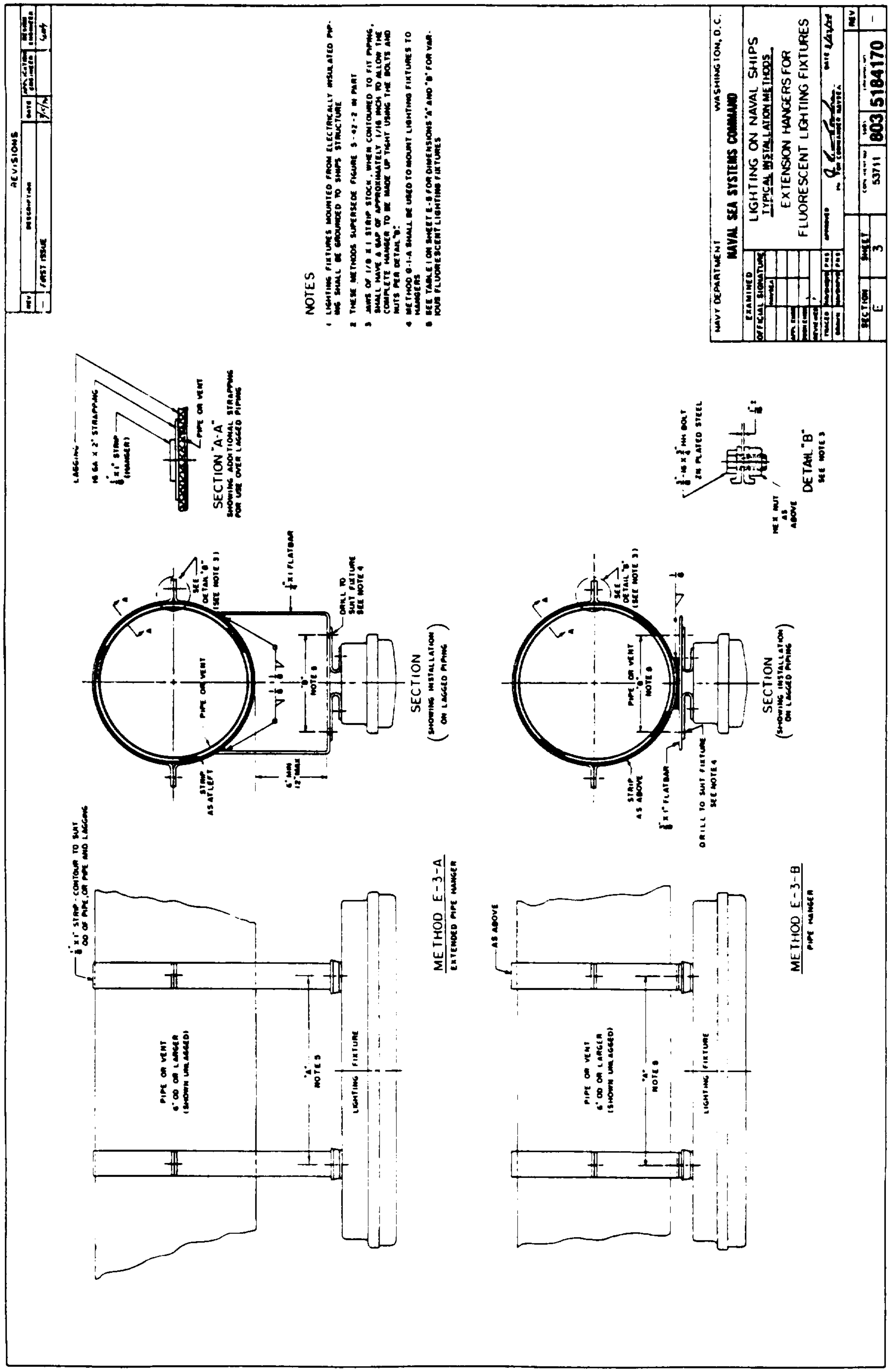
E
2
METHOD E-2-A
EXTENSION HANGER FOR FIXTURES 28" AND OVER
METHOD E-2-B
EXTENSION HANGER FOR FIXTURES 23" OR LESS
METHOD E-2-C
STRAP MOUNTING TO SPAN OBSTRUCTIONS
DETAIL "A"
OPTIONAL METHOD FOR INSTALLING FIXTURE ON REMOVABLE HANGER
METHOD E-8-A
METHOD E-8-B
SEE NOTE 3
SEE NOTE 2
DECK
STEM
1/4 AL OR 3/16 STEEL
STRAP (FLATBAR STOCK)
PIPE
WIRE WAY
30" MAX
30" MAX
FLAT BAR CLIP
1-1/4 X 1/4 AL FLATBAR OR 1-1/4 X 3/16 STEEL FLATBAR


REVISIONS
REV | DESCRIPTION | DATE
– | FIRST ISSUE
1/8" X 1" STRIP - CONTOUR TO SUIT OD OF PIPE, OR PIPE AND LAGGING
PIPE OR VENT 6" OD OR LARGER (SHOWN UNLAGGED)
"A" NOTE 5
LIGHTING FIXTURE
METHOD E-3-A
EXTENDED PIPE HANGER
STRIP AS AT LEFT
PIPE OR VENT
SEE DETAIL "B" (SEE NOTE 3)
6" MIN 12" MAX
1/8" X 1 FLATBAR
"B" NOTE 5
DRILL TO SUIT FIXTURE SEE NOTE 4
SECTION
(SHOWING INSTALLATION ON LAGGED PIPING)
LAGGING
16 GA X 2" STRAPPING
1/8" X 1" STRIP (HANGER)
PIPE OR VENT
SECTION "A-A"
SHOWING ADDITIONAL STRAPPING FOR USE OVER LAGGED PIPING
NOTES
1 LIGHTING FIXTURES MOUNTED FROM ELECTRICALLY INSULATED PIPING SHALL BE GROUNDED TO SHIPS STRUCTURE
2 THESE METHODS SUPERSEDE FIGURE 5-42-2 IN PART
3 JAWS OF 1/8 X 1 STRIP STOCK, WHEN CONTOURED TO FIT PIPING, SHALL HAVE A GAP OF APPROXIMATELY 1/16 INCH TO ALLOW THE COMPLETE HANGER TO BE MADE UP TIGHT USING THE BOLTS AND NUTS PER DETAIL "B".
4 METHOD G-1-A SHALL BE USED TO MOUNT LIGHTING FIXTURES TO HANGERS
5 SEE TABLE I ON SHEET E-5 FOR DIMENSIONS "A" AND "B" FOR VARIOUS FLUORESCENT LIGHTING FIXTURES
AS ABOVE
PIPE OR VENT 6" OD OR LARGER (SHOWN UNLAGGED)
"A" NOTE 5
LIGHTING FIXTURE
METHOD E-3-B
PIPE HANGER
STRIP AS ABOVE
PIPE OR VENT
"B" NOTE 5
SEE DETAIL "B" (SEE NOTE 3)
1/8" X 1" FLATBAR
DRILL TO SUIT FIXTURE SEE NOTE 4
SECTION
(SHOWING INSTALLATION ON LAGGED PIPING)
3/8"-16 X 3/4" HH BOLT ZN PLATED STEEL
HEX NUT AS ABOVE
DETAIL "B"
SEE NOTE 3
NAVY DEPARTMENT WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
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TYPICAL INSTALLATION METHODS
EXTENSION HANGERS FOR FLUORESCENT LIGHTING FIXTURES
SECTION E
SHEET 3
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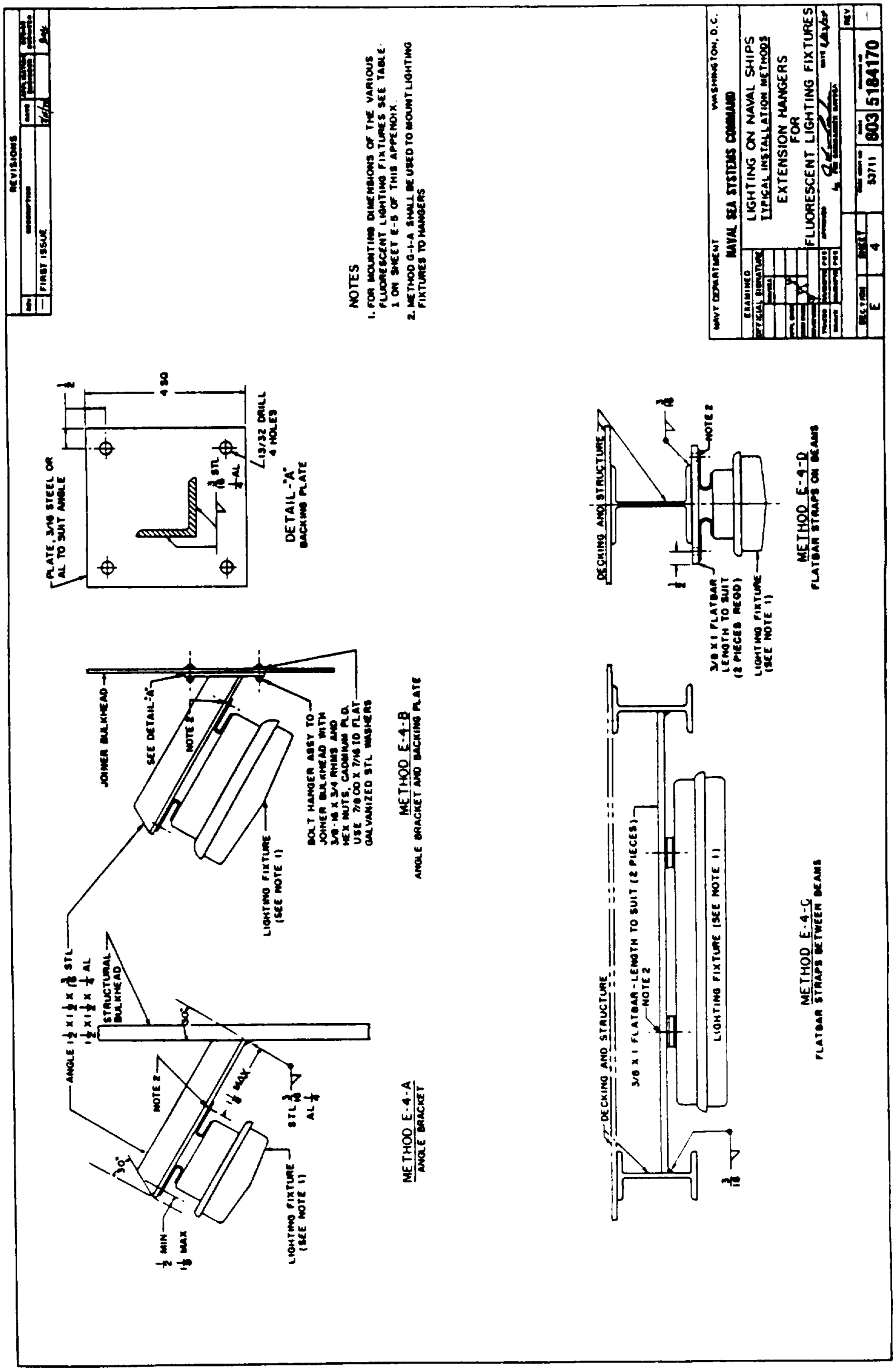
REV –


REVISIONS
FIRST ISSUE
NOTES
1. FOR MOUNTING DIMENSIONS OF THE VARIOUS FLUORESCENT LIGHTING FIXTURES SEE TABLE 1 ON SHEET E-5 OF THIS APPENDIX.
2. METHOD G-1-A SHALL BE USED TO MOUNT LIGHTING FIXTURES TO HANGERS
NAVY DEPARTMENT
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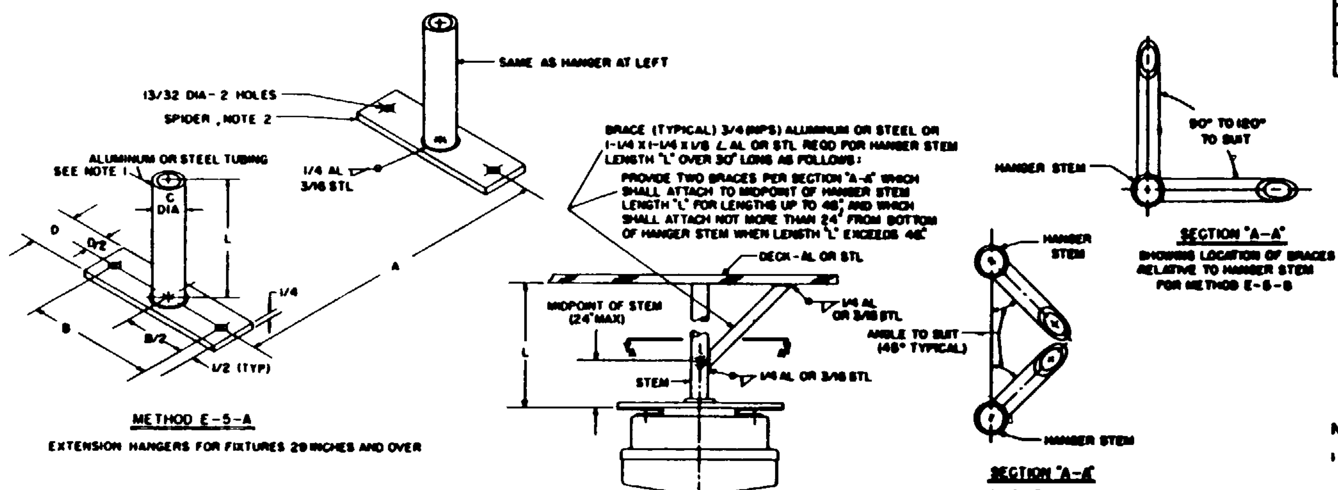
SHEET 4
PLATE, 3/16 STEEL OR AL TO SUIT ANGLE
4 SQ
13/32 DRILL 4 HOLES
DETAIL-"A"
BACKING PLATE
DECKING AND STRUCTURE
NOTE 2
3/8 X 1 FLATBAR LENGTH TO SUIT (2 PIECES REQD)
LIGHTING FIXTURE (SEE NOTE 1)
METHOD E-4-D
FLATBAR STRAPS ON BEAMS
JOINER BULKHEAD
SEE DETAIL "A"
BOLT HANGER ASSY TO JOINER BULKHEAD WITH 3/8-16 X 3/4 RHMS AND HEX NUTS, CADMIUM PLD. USE 7/8 OD X 7/16 ID FLAT GALVANIZED STL WASHERS
METHOD E-4-B
ANGLE BRACKET AND BACKING PLATE
3/8 X 1 FLATBAR-LENGTH TO SUIT (2 PIECES)
LIGHTING FIXTURE (SEE NOTE 1)
METHOD E-4-C
FLATBAR STRAPS BETWEEN BEAMS
STRUCTURAL BULKHEAD
30°
1 1/8 MAX
METHOD E-4-A
ANGLE BRACKET

REV	DESCRIPTION	DATE	APPROVED
—	FIRST ISSUE		
A	ADDED 30 & 46 WATT FIXTURES IN TABLE I		



METHOD E-5-A

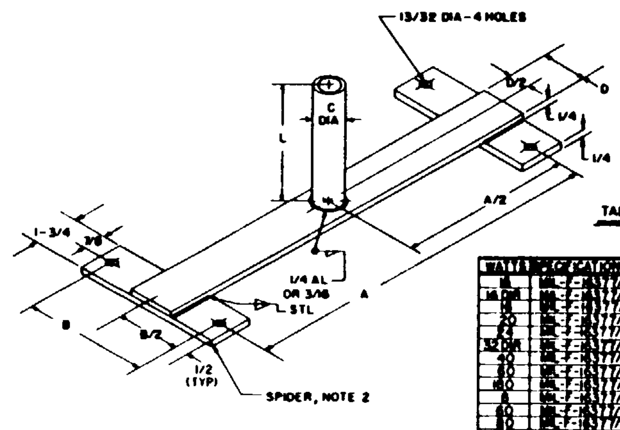
EXTENSION HANGERS FOR FIXTURES 29 INCHES AND OVER

SECTION "A-A"

SHOWING LOCATION OF BRACES RELATIVE TO HANGER STEM FOR METHOD E-5-A

SECTION "A-A"

SHOWING LOCATION OF BRACES RELATIVE TO HANGER STEM FOR METHOD E-5-B



METHOD E-5-B

EXTENSION HANGERS FOR FIXTURES 23 INCHES AND UNDER

NOTES

1 STEMS OF EXTENSION HANGERS MAY BE ANY DRAWN OR EXTRUDED SHAPE. THEIR STRENGTH SHALL BE EQUAL TO THAT OF THE TUBING SHOWN.

2 MOUNTING SPIDERS MAY BE FABRICATED, CUT FROM PLATE, OR CAST. THE STRENGTH SHALL BE EQUAL TO THAT OF THE SPIDERS SHOWN.

"C" NOMINAL PIPE SIZE	OUTSIDE DIAMETER	WALL THICKNESS ALUMINUM (SCHED 40)	WALL THICKNESS STEEL (STD)
3/4	1.050	0.113	0.113
1	1.315	0.133	0.133
1-1/4	1.660	0.140	0.140
1-1/2	1.900	0.145	0.145

TABLE I - DIMENSIONS

WATTS	SPECIFICATION NO	SYMBOL NO	A	B	"L" UP TO 24" AL C	AL D	STL C	STL D	"L" 24" TO 48" AL C	AL D	STL C	STL D	MTG MTHD
15	MIL-F-16377/6	336.1	10-7/8	6-3/4	1	1-3/8	3/4	1-3/8	1-1/2	2-1/2	1	1-3/8	[illegible]
14 DM	MIL-F-16377/6	141.3	11-1/4	7-1/4									[illegible]
15	MIL-F-16377/7	70.1	11-1/4	6-3/4									[illegible]
20	MIL-F-16377/8	336.1, 337	10-7/8	6-3/4									[illegible]
24	MIL-F-16377/9	73.1, 346	11-1/4	7-1/4									[illegible]
32 DM	MIL-F-16377/10	145.1	10-7/8	7-1/4									[illegible]
40	MIL-F-16377/11	77.4, 344	11-7/8	7-1/4									[illegible]
60	MIL-F-16377/12	333.1, 341.1, 342	11-7/8	8-1/4									[illegible]
160	MIL-F-16377/13	74, 75	28	13									[illegible]
8	MIL-F-16377/14	78.1, 80.1	9-1/4	4-3/4									[illegible]
60	MIL-F-16377/17	348	10-1/2	11									[illegible]
80	MIL-F-16377/17	349	23	8-1/2									[illegible]
120	MIL-F-16377/37	350	23	8-1/2									[illegible]
30	MIL-F-16377/45	81, 349.2	13-7/8	9-1/4									[illegible]
46	MIL-F-16377/46	82, 343.1	13-7/8	9-1/4									[illegible]

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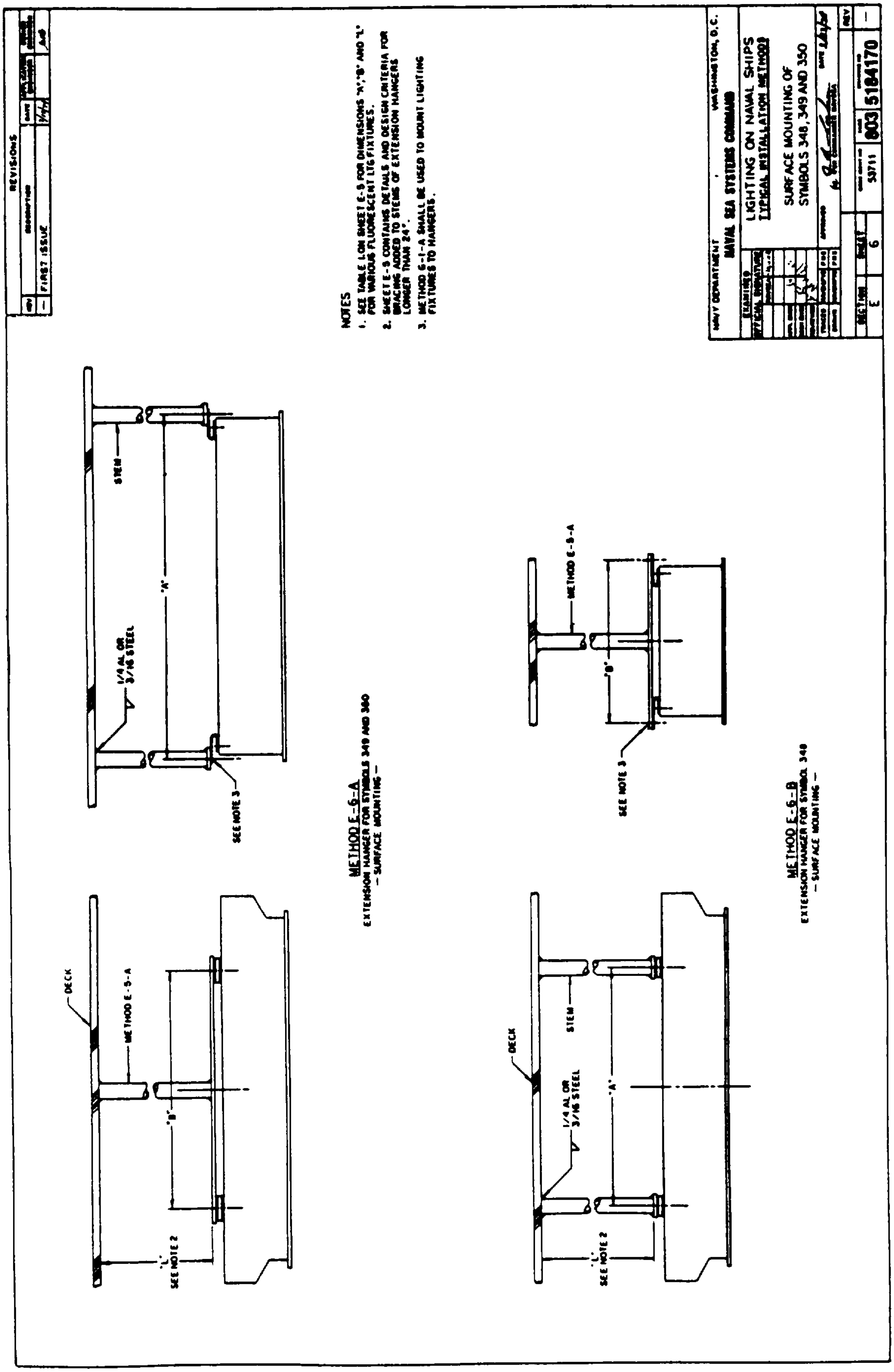
SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
E	5	53711	803	5184170	A


REVISIONS
FIRST ISSUE
NOTES
1. SEE TABLE I ON SHEET E-5 FOR DIMENSIONS "A","B" AND "L" FOR VARIOUS FLUORESCENT LTG FIXTURES.
2. SHEET E-5 CONTAINS DETAILS AND DESIGN CRITERIA FOR BRACING ADDED TO STEMS OF EXTENSION HANGERS LONGER THAN 24".
3. METHOD 6-1-A SHALL BE USED TO MOUNT LIGHTING FIXTURES TO HANGERS.
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SURFACE MOUNTING OF SYMBOLS 348, 349 AND 350
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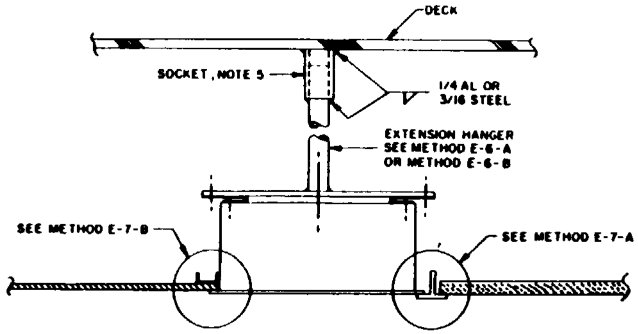
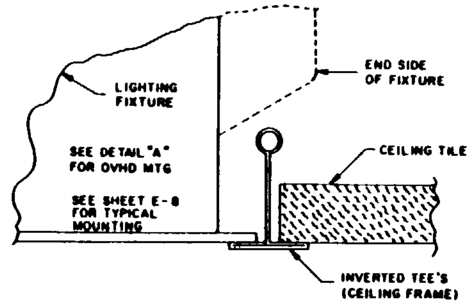
SECTION E
SHEET 6
REV -
STEM
'A'
1/4 AL OR 3/16 STEEL
SEE NOTE 3
DECK
METHOD E-5-A
'B'
'L' SEE NOTE 2
METHOD E-6-A
EXTENSION HANGER FOR SYMBOLS 349 AND 350
— SURFACE MOUNTING —
METHOD E-6-B
EXTENSION HANGER FOR SYMBOL 348
— SURFACE MOUNTING —

REVISIONS				
REV	DESCRIPTION	DATE		
—	FIRST ISSUE			
A	SPECIFIED TYPE OF CEILING FOR METHODS E-7-A & E-7-B			



DETAIL "A"

FLUSH MOUNTING OF SYMBOLS 348,349 AND 350

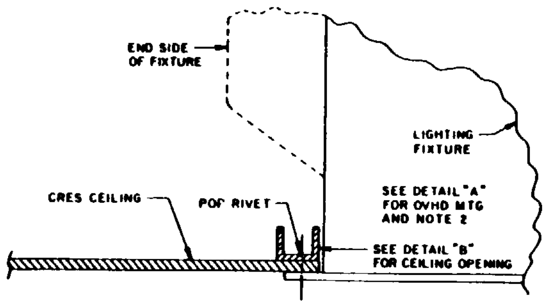


METHOD E-7-A

FIXTURE MOUNTING IN TYPE A & F CEILINGS OF DWG 804-5000994-SEE NOTE 1

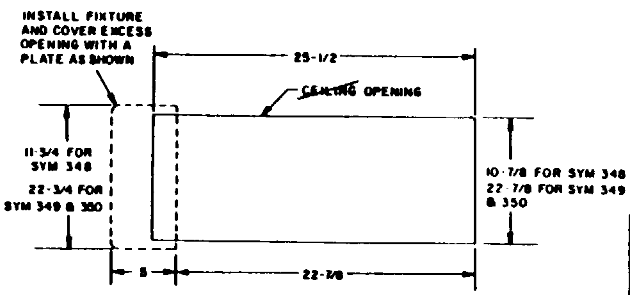
NOTES.

1. INSTALLATION PROCEDURES
   - A. REST LIGHTING FIXTURE ON THE INVERTED TEE'S.
   - B. INSTALL EXTENSION HANGERS ON FIXTURE WITH SOCKETS.
   - C. SLIDE SOCKET TO REACH DECK AND WELD IN PLACE.
   - D. WELD/BOLT SOCKET TO HANGER STEM.
2. EXTENSION HANGERS FOR LIGHTING FIXTURES MAY BE OMITTED IF STRUCTURE OF TYPE C&D CEILING IS ADEQUATE TO SUPPORT THE WEIGHT OF THE FIXTURES.
3. WHEN LIGHTING FIXTURES ARE RECESSED IN VENTILATION DUCTWORK, THE AIRTIGHT INTEGRITY OF THE DUCTWORK SHALL BE MAINTAINED BY USE OF A SUITABLE SEALING COMPOUND, WHICH SHALL BE APPLIED TO THE MATING SURFACES OF THE FIXTURE FLANGE AND THE STRUCTURE OF THE DUCTWORK.
4. WHERE CONDITIONS PERMIT CONNECTION BOXES FEEDING FIXTURES SHOULD BE INSTALLED TO BE ACCESSIBLE BY REMOVING THE LIGHTING FIXTURES
5. SOCKET SHALL BE ALUMINUM OR STEEL TUBING (6 INCHES LONG) OF AN I.D. TO SUIT O.D. OF STEM OF EXTENSION HANGER. SOCKET MAY BE OMITTED IF DESIRED



METHOD E-7-B

FIXTURE MOUNTING IN TYPE C&D CEILINGS OF DWG 804-5000994-SEE NOTE 3



DETAIL "B"

CEILING OPENING IN STRUCTURAL TYPE CEILINGS

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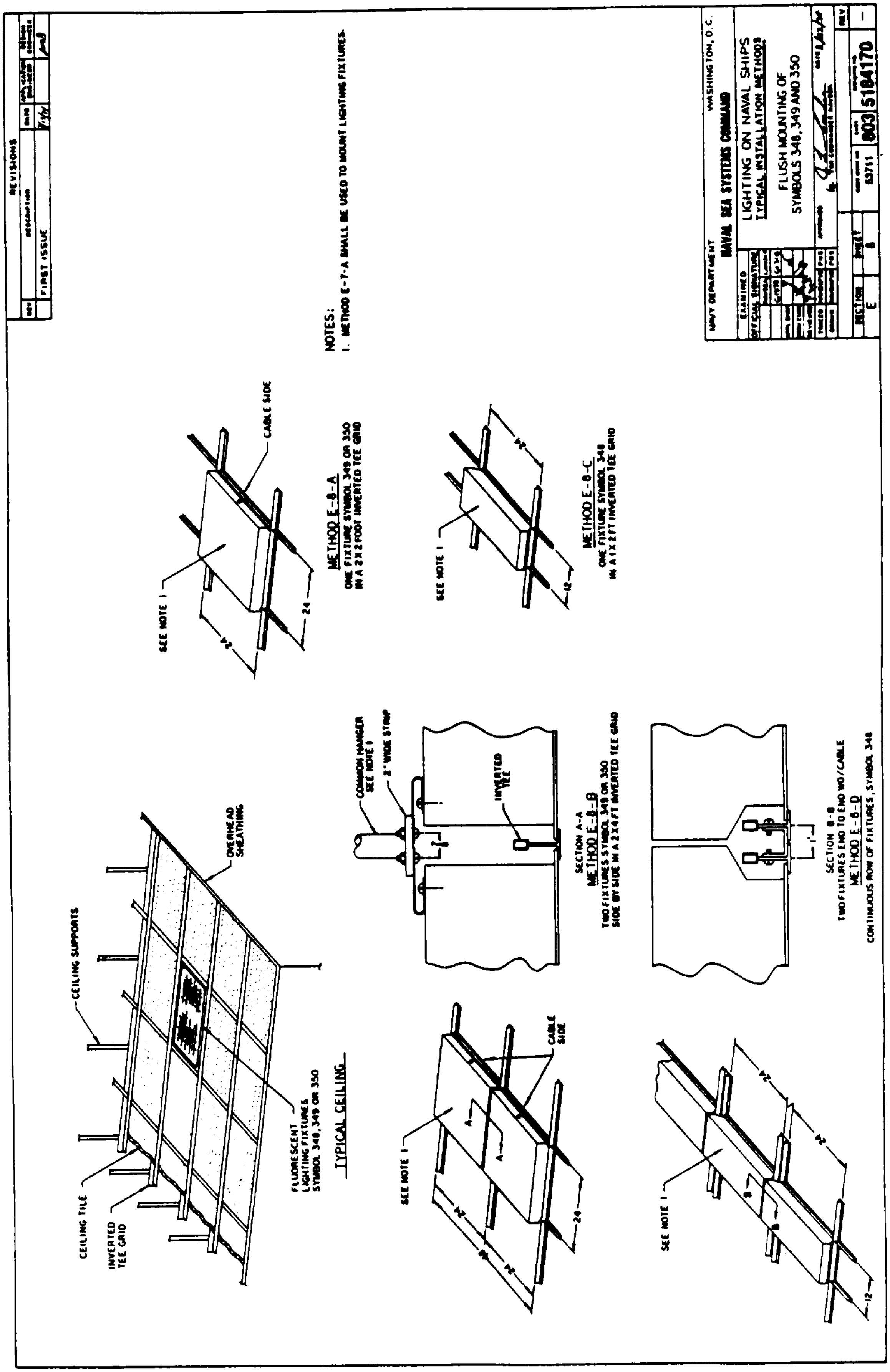
FLUSH MOUNTING OF
SYMBOLS 348,349 AND 350

SECTION	SHEET	CODE IDENT NO.	SIZE	DRAWING NO.	REV
E	7	53711	803	5184170	A


REVISIONS
FIRST ISSUE
NOTES:
1. METHOD E-7-A SHALL BE USED TO MOUNT LIGHTING FIXTURES.
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SYMBOLS 348, 349 AND 350
SECTION
E
SHEET
8
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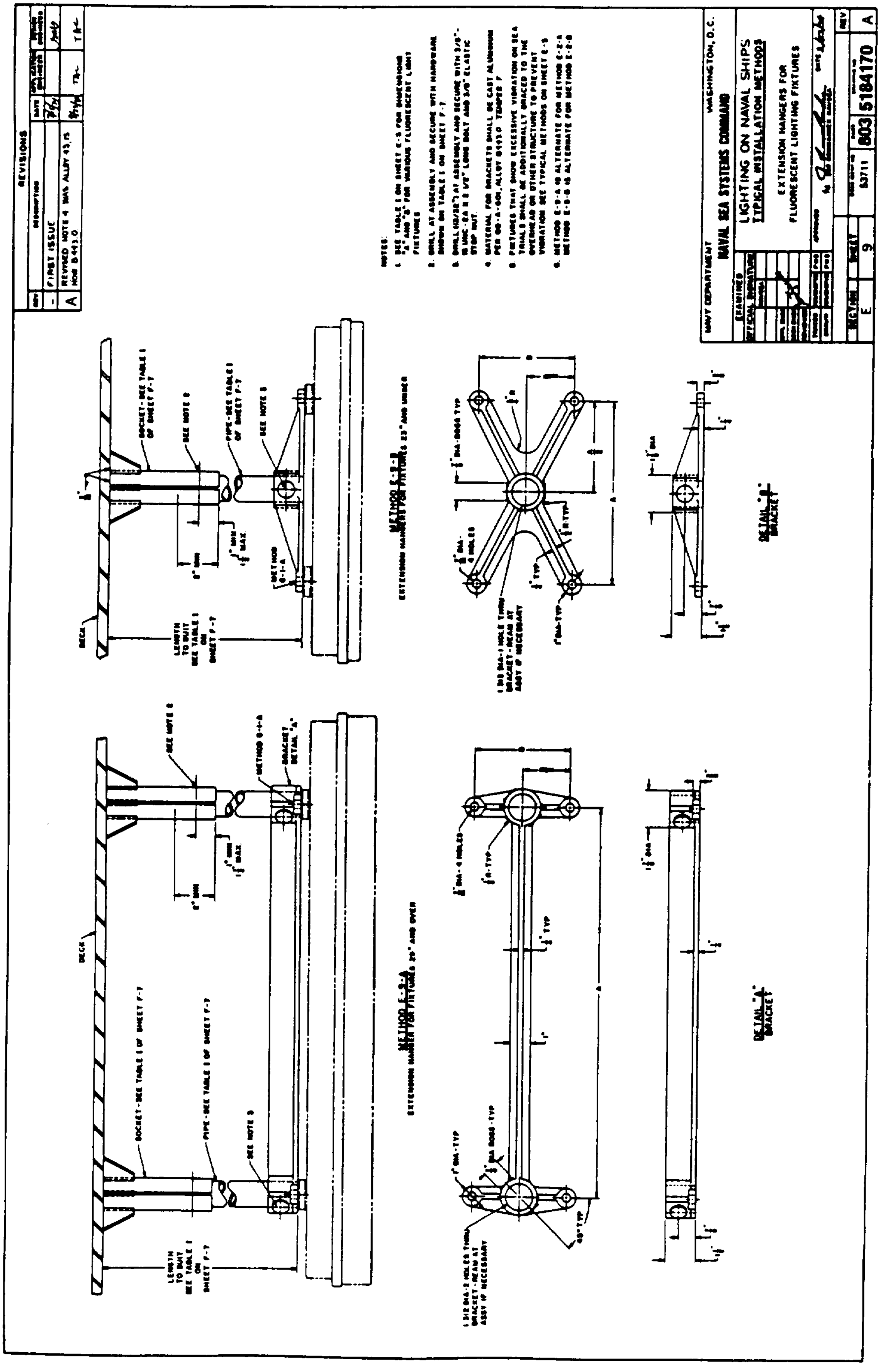
CEILING SUPPORTS
OVERHEAD SHEATHING
CEILING TILE
INVERTED TEE GRID
FLUORESCENT LIGHTING FIXTURES SYMBOL 348, 349 OR 350
TYPICAL CEILING
SEE NOTE 1
CABLE SIDE
METHOD E-8-A
ONE FIXTURE SYMBOL 349 OR 350 IN A 2 X 2 FOOT INVERTED TEE GRID
METHOD E-8-C
ONE FIXTURE SYMBOL 348 IN A 1 X 2 FT INVERTED TEE GRID
COMMON HANGER SEE NOTE 1
2" WIDE STRAP
INVERTED TEE
SECTION A-A
METHOD E-8-B
TWO FIXTURES SYMBOL 349 OR 350 SIDE BY SIDE IN A 2 X 4 FT INVERTED TEE GRID
SECTION B-B
METHOD E-8-D
TWO FIXTURES END TO END WO/CABLE
CONTINUOUS ROW OF FIXTURES, SYMBOL 348
24
12
48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METHOD E-9-A
METHOD E-9-B
DETAIL "A" BRACKET
DETAIL "B" BRACKET
DECK

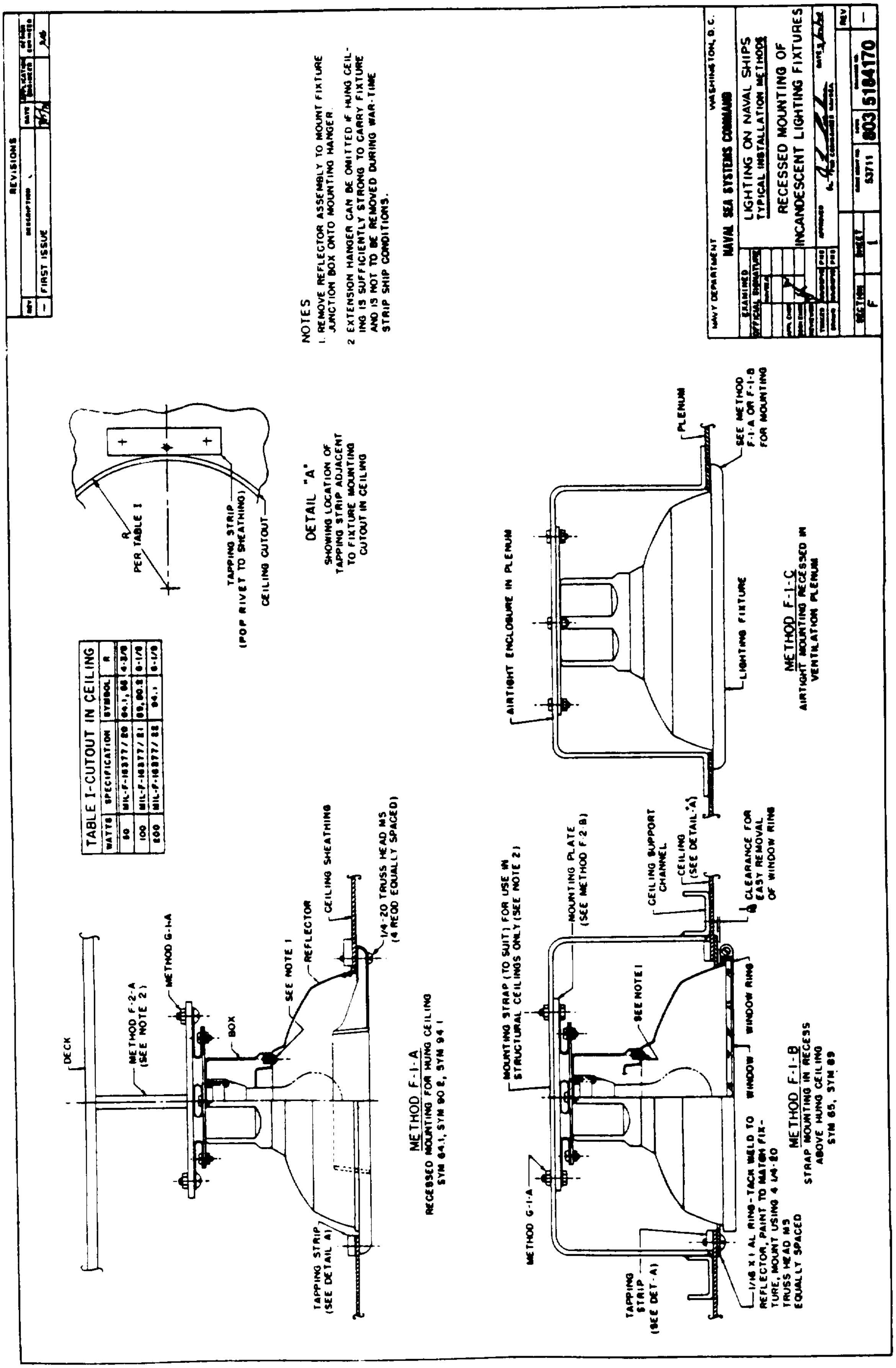
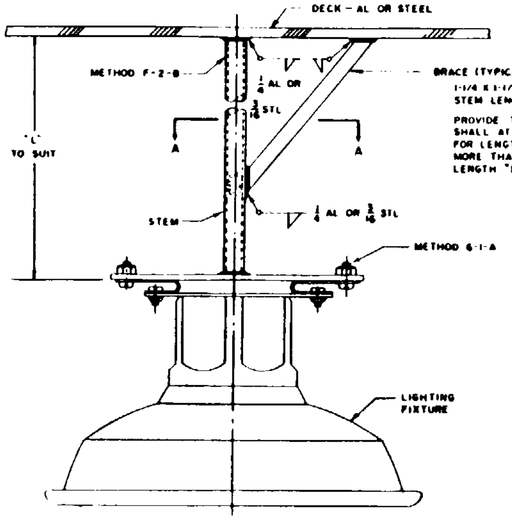


TABLE I-CUTOUT IN CEILING

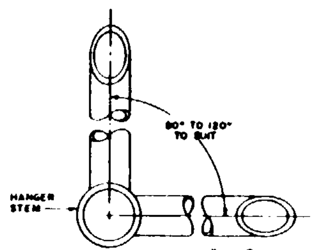
WATTS	SPECIFICATION	SYMBOL	R
50	MIL-F-16377/20	64.1, 65	4-3/8
100	MIL-F-16377/21	69, 90.2	6-1/8
200	MIL-F-16377/22	94.1	6-1/8

NOTES
1. REMOVE REFLECTOR ASSEMBLY TO MOUNT FIXTURE JUNCTION BOX ONTO MOUNTING HANGER.
2. EXTENSION HANGER CAN BE OMITTED IF HUNG CEILING IS SUFFICIENTLY STRONG TO CARRY FIXTURE AND IS NOT TO BE REMOVED DURING WAR-TIME STRIP SHIP CONDITIONS.

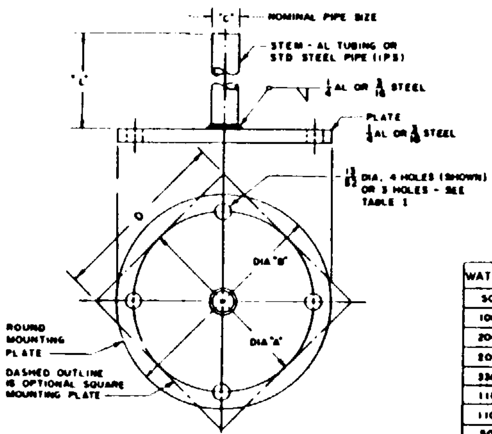
REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
—	FIRST ISSUE			
A	REVISED NOTE 3 WAS NAVSHIPS DWG 9000-S6202-73780 NOW PUBLICATION S9300-AW-EDG-010/EPI5M			



METHOD F-2-A
DECK MOUNTING FOR INCANDESCENT FIXTURES



SECTION "A-A"
SHOWING LOCATIONS RELATIVE TO HANGER



METHOD F-2-B
TYPICAL HANGER - ASSY DETAILS

TABLE 1.- DIMENSIONS

"C" NOMINAL PIPE SIZE	OUTSIDE DIAMETER	WALL THICKNESS ALUMINUM (SCHED 40)	WALL THICKNESS STEEL (STD)
3/4	1.050	0.113	0.113
1	1.315	0.113	0.113
1-1/2	1.900	0.145	0.145

WATTS	SPECIFICATION	SYMBOL	"A" DIA	"B" DIA	"L" DIM UP TO 24" AL "C"	"L" DIM UP TO 24" STL "C"	"L" DIM 24" TO 48" AL "C"	"L" DIM 24" TO 48" STL "C"	"D"	MTG HOLES
50	MIL-F-16377/20	841, 85	7-5/8	8-5/8	1	3/4	1-1/2	1	7	
100	MIL-F-16377/21	86, 862	7-5/8	8-5/8	1	3/4	1-1/2	1	7	4
200	MIL-F-16377/22	841	7-5/8	8-5/8	1	3/4	1-1/2	1	7	4
200	MIL-F-16377/23	87, 88	7-5/8	8-5/8	1	3/4	1-1/2	1	7	4
330	MIL-F-16377/24	862	11-1/4	12-1/4	1	3/4	1-1/2	1	9-1/2	4
110	MIL-F-16377/25	482, 882	7-3/4	8-5/8	1	3/4	1-1/2	1	7	4
110	MIL-F-16377/26	112, 113	7-5/8	8-5/8	1	3/4	1-1/2	1	7	4
50	MIL-F-16377/27	822, 938	METHOD F-4-A		1	3/4	1-1/2	1	3-1/2	3

NOTES

1 EXTENSION HANGERS MAY BE ANY DRAWN OR EXTRUDED SHAPE. THE STRENGTH SHALL BE EQUAL TO THAT OF THE TUBING SHOWN.

2 MOUNTING PLATES MAY BE CUT FROM FLAT OR CAST. THE STRENGTH OF CAST PLATES SHALL BE EQUAL TO THAT OF THE PLATE SHOWN. THE PLATES SHALL BE OF SUFFICIENT SIZE TO ACCOMMODATE THE LIGHTING FIXTURE.

3 LIGHTING CABLES SHALL BE SECURED TO THE SUPPORTS IN ACCORDANCE WITH PUBLICATION S9300-AW-EDG-010/EPI5M.

4 SHOULDER OF COLLAR STUD SHOULD BE FLUSH WITH, OR PROJECT SLIGHTLY FROM, SURFACE OF INSULATION. USE NEAREST APPROPRIATE LENGTH OF COLLAR STUD.

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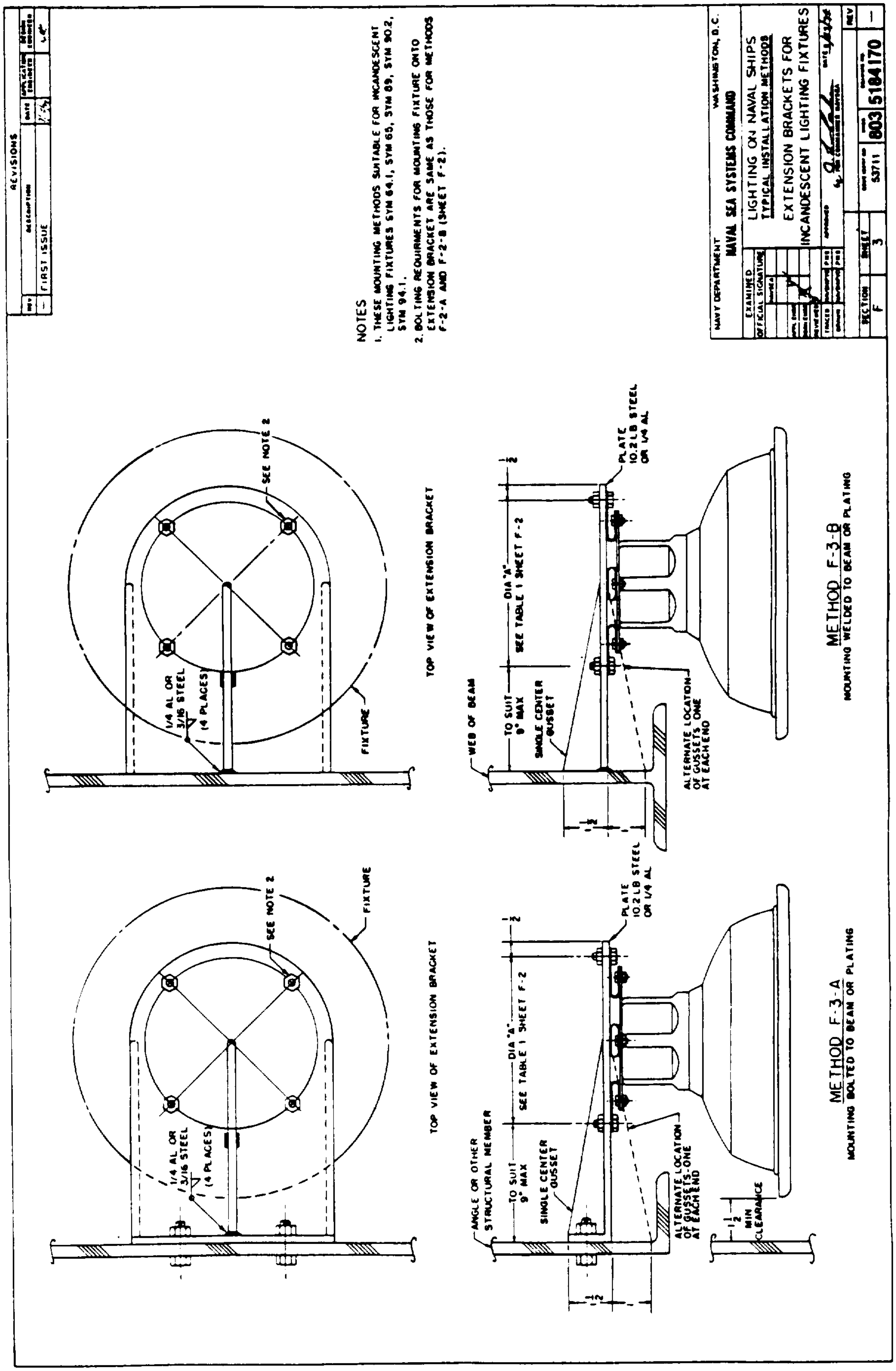
EXTENSION HANGERS FOR INCANDESCENT LIGHTING FIXTURES

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
F	2	53711	803	5184170	A


REVISIONS
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NOTES
1. THESE MOUNTING METHODS SUITABLE FOR INCANDESCENT LIGHTING FIXTURES SYM 64.1, SYM 65, SYM 89, SYM 90.2, SYM 94.1.
2. BOLTING REQUIREMENTS FOR MOUNTING FIXTURE ONTO EXTENSION BRACKET ARE SAME AS THOSE FOR METHODS F-2-A AND F-2-B (SHEET F-2).
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INCANDESCENT LIGHTING FIXTURES
SECTION F
SHEET 3
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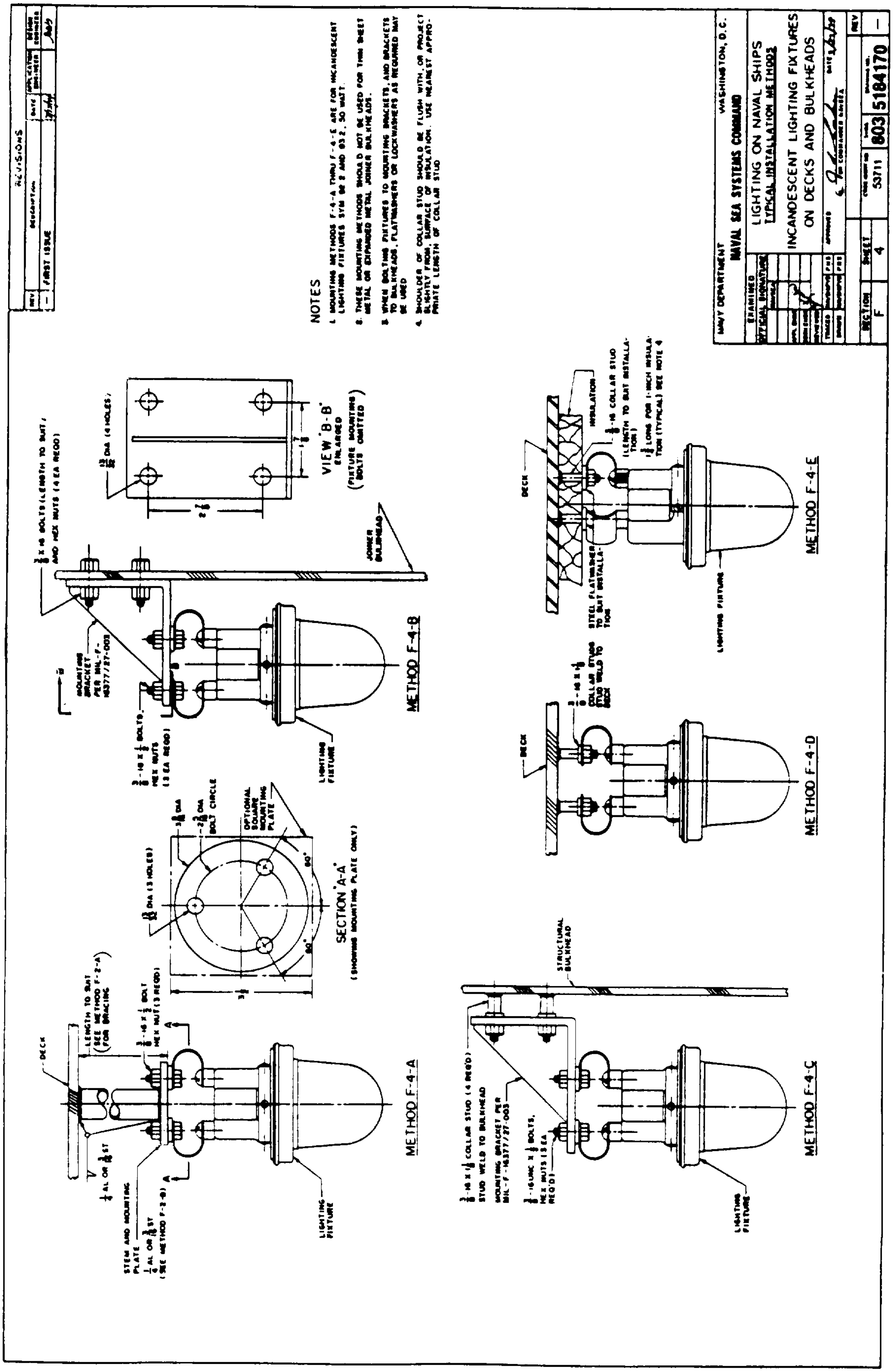
SEE NOTE 2
FIXTURE
1/4 AL OR 3/16 STEEL (4 PLACES)
TOP VIEW OF EXTENSION BRACKET
WEB OF BEAM
TO SUIT 9" MAX
SINGLE CENTER GUSSET
DIA "A" SEE TABLE 1 SHEET F-2
PLATE 10.2 LB STEEL OR 1/4 AL
ALTERNATE LOCATION OF GUSSETS ONE AT EACH END
METHOD F-3-B
MOUNTING WELDED TO BEAM OR PLATING
ANGLE OR OTHER STRUCTURAL MEMBER
MIN CLEARANCE
METHOD F-3-A
MOUNTING BOLTED TO BEAM OR PLATING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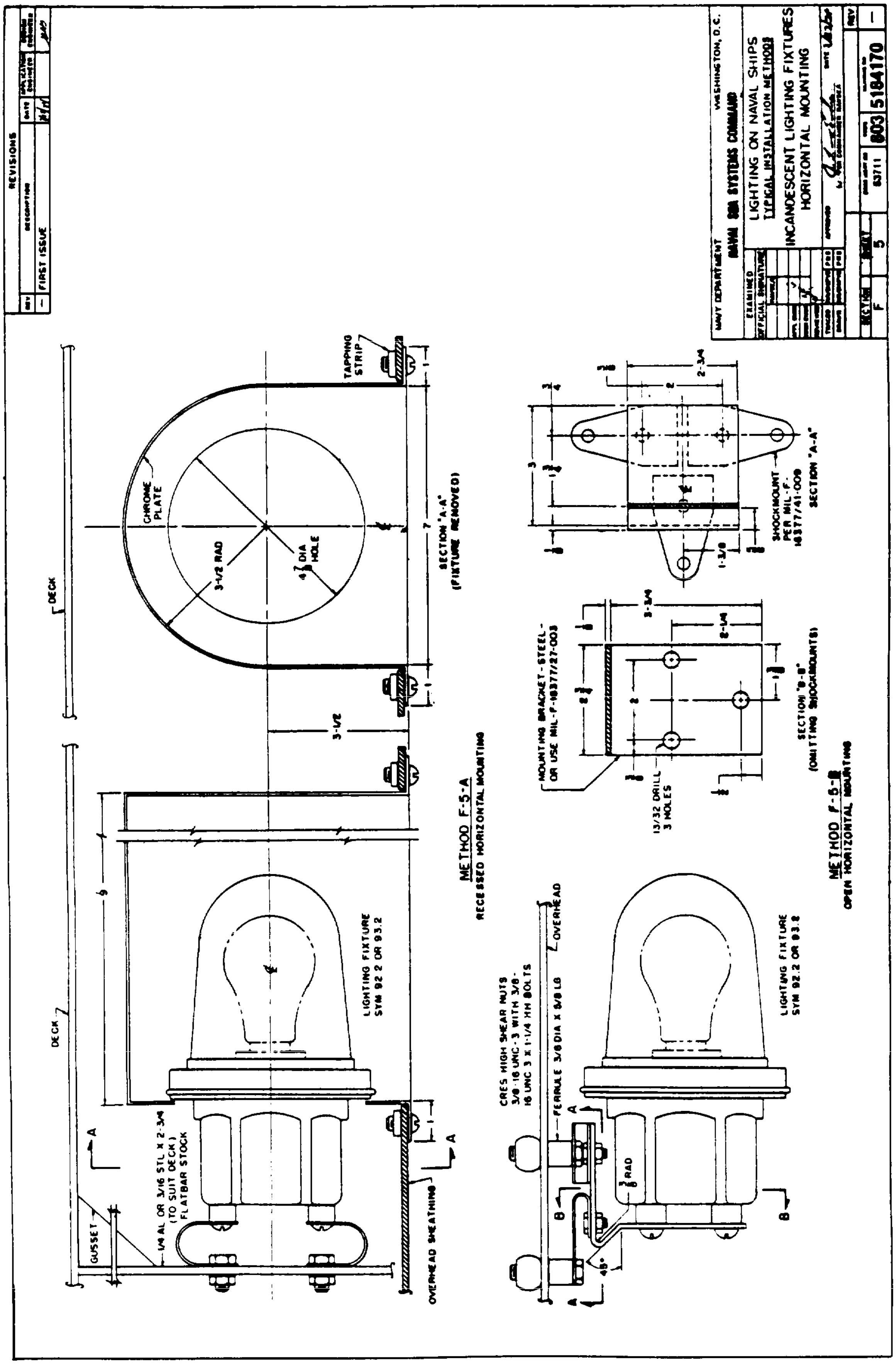
NOTES
METHOD F-4-A
METHOD F-4-B
METHOD F-4-C
METHOD F-4-D
METHOD F-4-E
SECTION 'A-A'
VIEW 'B-B'
LIGHTING FIXTURE
DECK
STRUCTURAL BULKHEAD
JOINER BULKHEAD
INSULATION


REVISIONS
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LIGHTING ON NAVAL SHIPS
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HORIZONTAL MOUNTING
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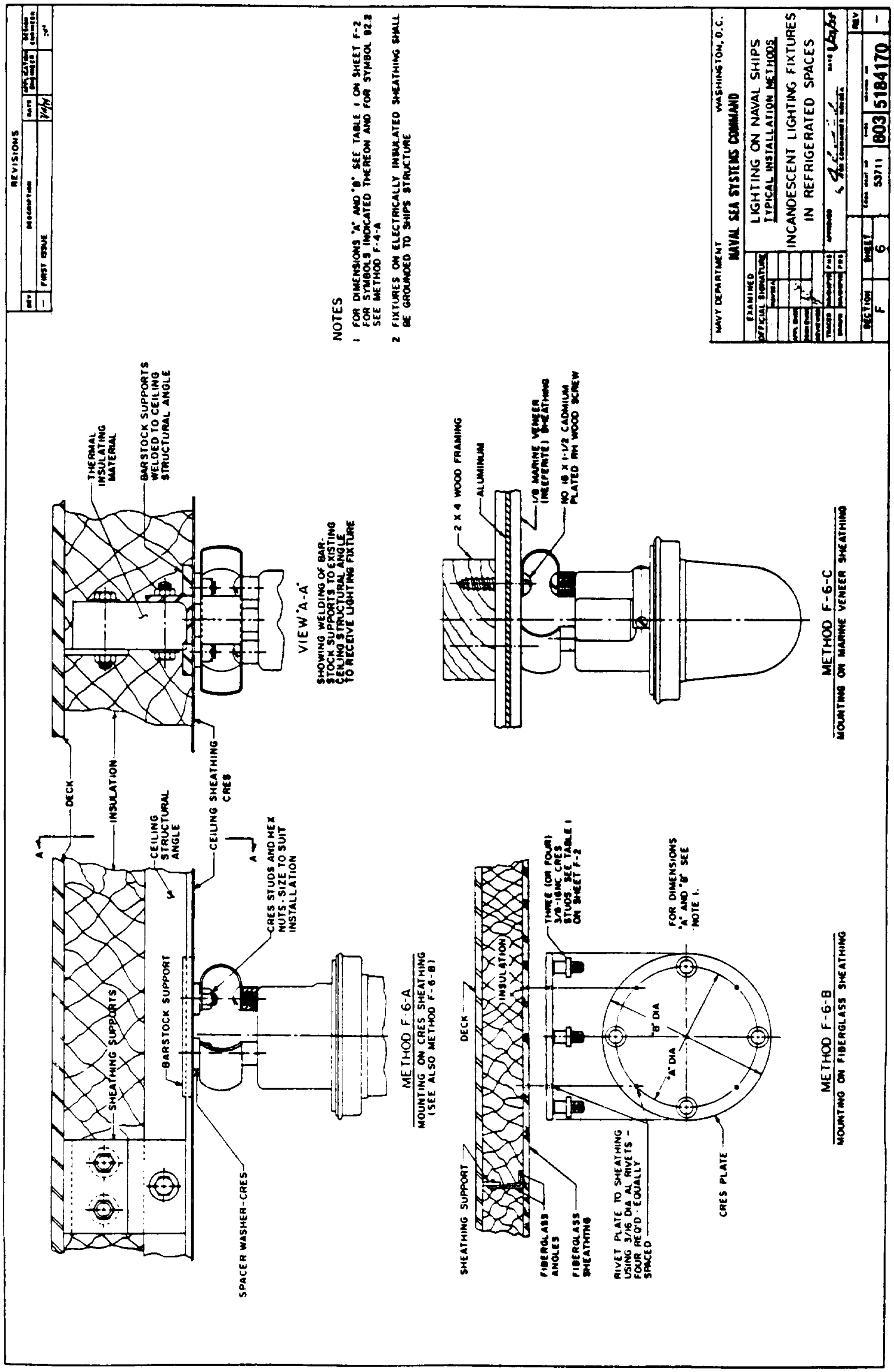
METHOD F-5-A
RECESSED HORIZONTAL MOUNTING
METHOD F-5-B
OPEN HORIZONTAL MOUNTING
SECTION "A-A" (FIXTURE REMOVED)
SECTION "A-A"
SECTION "B-B" (OMITTING SHOCKMOUNTS)
CHROME PLATE
3-1/2 RAD
TAPPING STRIP
DECK
OVERHEAD SHEATHING
GUSSET
1/4 AL OR 3/16 STL X 2-3/4 (TO SUIT DECK) FLATBAR STOCK
LIGHTING FIXTURE SYM 92.2 OR 93.2
OVERHEAD
FERRULE 3/8 DIA X 5/8 LG
CRES HIGH SHEAR NUTS 3/8-16 UNC-3 WITH 3/8-16 UNC 3 X 1-1/4 HH BOLTS
MOUNTING BRACKET-STEEL-OR USE MIL-F-16377/27-003
13/32 DRILL 3 HOLES
SHOCKMOUNT PER MIL-F-16377/41-009
45°


REVISIONS
FIRST ISSUE
NOTES
1 FOR DIMENSIONS 'A' AND 'B' SEE TABLE I ON SHEET F-2 FOR SYMBOLS INDICATED THEREON AND FOR SYMBOL 92.2 SEE METHOD F-4-A
2 FIXTURES ON ELECTRICALLY INSULATED SHEATHING SHALL BE GROUNDED TO SHIPS STRUCTURE
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IN REFRIGERATED SPACES
SECTION F
SHEET 6
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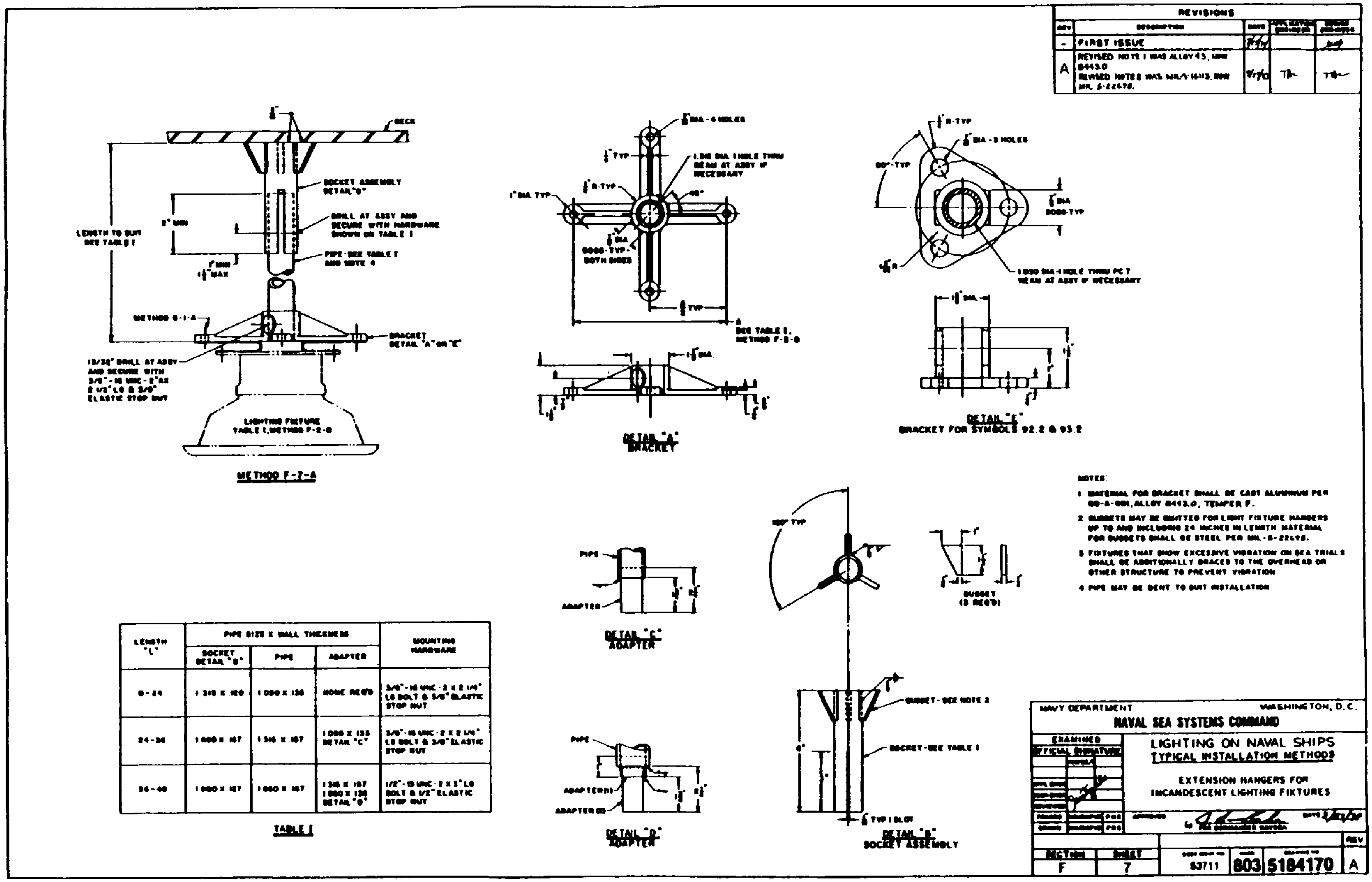
THERMAL INSULATING MATERIAL
BARSTOCK SUPPORTS WELDED TO CEILING STRUCTURAL ANGLE
DECK
INSULATION
CEILING STRUCTURAL ANGLE
CEILING SHEATHING CRES
CRES STUDS AND HEX NUTS-SIZE TO SUIT INSTALLATION
VIEW 'A-A'
SHOWING WELDING OF BAR-STOCK SUPPORTS TO EXISTING CEILING STRUCTURAL ANGLE TO RECEIVE LIGHTING FIXTURE
SHEATHING SUPPORTS
BARSTOCK SUPPORT
SPACER WASHER-CRES
METHOD F-6-A
MOUNTING ON CRES SHEATHING (SEE ALSO METHOD F-6-B)
2 X 4 WOOD FRAMING
ALUMINUM
1/8 MARINE VENEER (MEEFERITE) SHEATHING
NO 10 X 1-1/2 CADMIUM PLATED RH WOOD SCREW
METHOD F-6-C
MOUNTING ON MARINE VENEER SHEATHING
THREE (OR FOUR) 3/8-16NC CRES STUDS SEE TABLE I ON SHEET F-2
FOR DIMENSIONS 'A' AND 'B' SEE NOTE 1.
DECK
INSULATION
'B' DIA
'A' DIA
SHEATHING SUPPORT
FIBERGLASS ANGLES
FIBERGLASS SHEATHING
RIVET PLATE TO SHEATHING USING 3/16 DIA AL RIVETS - FOUR REQ'D - EQUALLY SPACED
CRES PLATE
METHOD F-6-B
MOUNTING ON FIBERGLASS SHEATHING

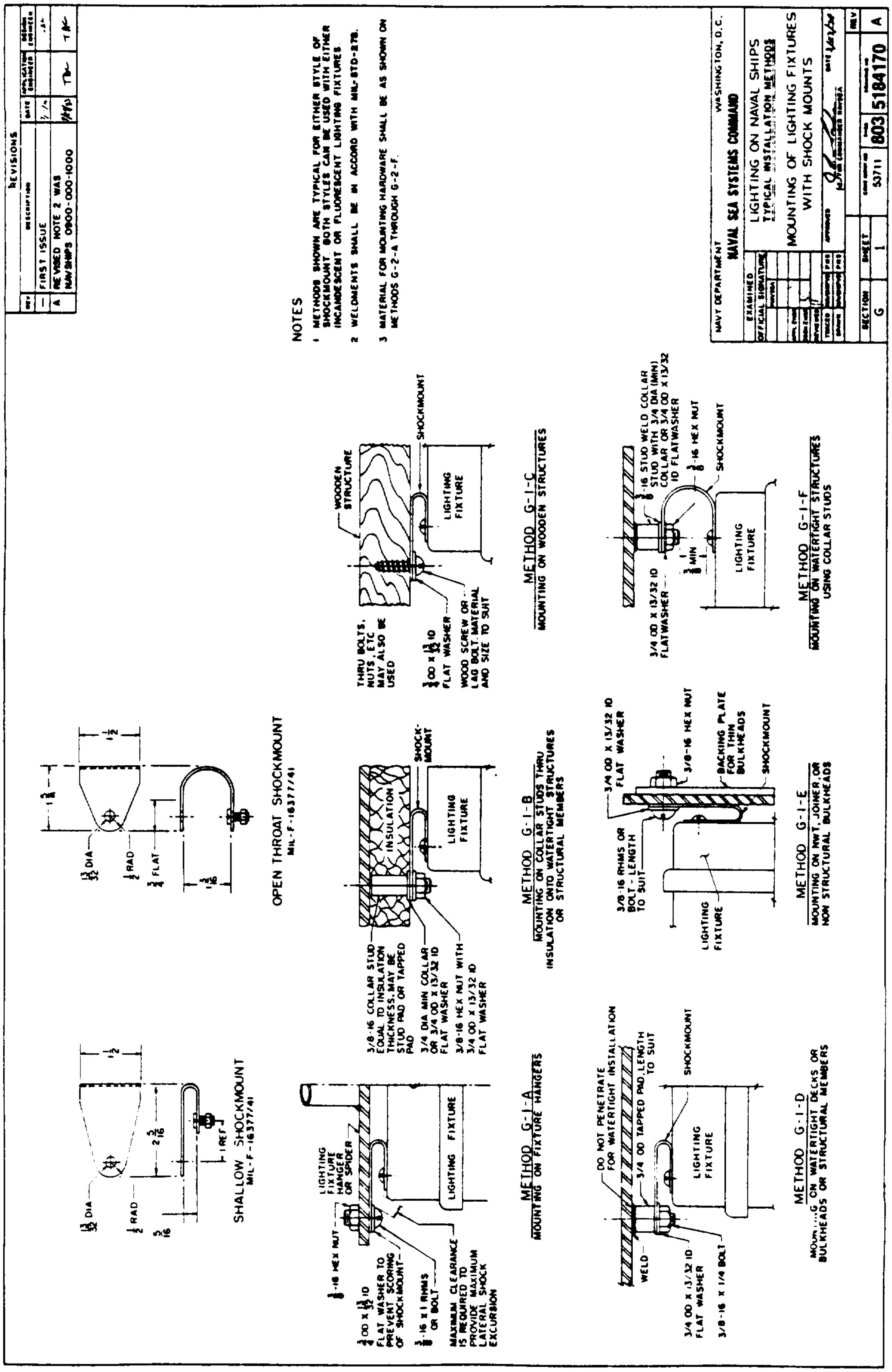


NOTES:

1 MATERIAL FOR BRACKET SHALL BE CAST ALUMINUM PER QQ-A-601, ALLOY B443.0, TEMPER F.
2 GUSSETS MAY BE OMITTED FOR LIGHT FIXTURE HANGERS UP TO AND INCLUDING 24 INCHES IN LENGTH MATERIAL FOR GUSSETS SHALL BE STEEL PER MIL-S-22698.
3 FIXTURES THAT SHOW EXCESSIVE VIBRATION ON SEA TRIALS SHALL BE ADDITIONALLY BRACED TO THE OVERHEAD OR OTHER STRUCTURE TO PREVENT VIBRATION
4 PIPE MAY BE BENT TO SUIT INSTALLATION

LENGTH "L"	PIPE SIZE X WALL THICKNESS			MOUNTING HARDWARE
	SOCKET DETAIL "B"	PIPE	ADAPTER	
0 - 24	1.315 X .120	1.050 X .133	NONE REQ'D	3/8"-16 UNC-2 X 2 1/4" LG BOLT & 3/8" ELASTIC STOP NUT
24 - 36	1.660 X .167	1.315 X .157	1.050 X .133 DETAIL "C"	3/8"-16 UNC-2 X 2 1/4" LG BOLT & 3/8" ELASTIC STOP NUT
36 - 48	1.900 X .127	1.660 X .167	1.315 X .157 1.050 X .133 DETAIL "D"	1/2"-13 UNC-2 X 3" LG BOLT & 1/2" ELASTIC STOP NUT

TABLE I


REVISIONS
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A REVISED NOTE 2 WAS NAVSHIPS 0900-000-1000
13/32 DIA
1/2 RAD
5/16
2 5/16
1 1/2
1 REF
SHALLOW SHOCKMOUNT
MIL-F-16377/41
1 3/4
3/4 FLAT
1 3/16
OPEN THROAT SHOCKMOUNT
MIL-F-16377/41
NOTES
1 METHODS SHOWN ARE TYPICAL FOR EITHER STYLE OF SHOCKMOUNT. BOTH STYLES CAN BE USED WITH EITHER INCANDESCENT OR FLUORESCENT LIGHTING FIXTURES.
2 WELDMENTS SHALL BE IN ACCORD WITH MIL-STD-278.
3 MATERIAL FOR MOUNTING HARDWARE SHALL BE AS SHOWN ON METHODS G-2-A THROUGH G-2-F.
3/8-16 HEX NUT
LIGHTING FIXTURE HANGER OR SPIDER
3/4 OD x 13/32 ID FLAT WASHER TO PREVENT SCORING OF SHOCKMOUNT
3/8-16 x 1 RHMS OR BOLT
MAXIMUM CLEARANCE IS REQUIRED TO PROVIDE MAXIMUM LATERAL SHOCK EXCURSION
LIGHTING FIXTURE
METHOD G-1-A
MOUNTING ON FIXTURE HANGERS
3/8-16 COLLAR STUD EQUAL TO INSULATION THICKNESS. MAY BE STUD PAD OR TAPPED PAD
3/4 DIA MIN COLLAR OR 3/4 OD X 13/32 ID FLAT WASHER
3/8-16 HEX NUT WITH 3/4 OD X 13/32 ID FLAT WASHER
INSULATION
SHOCK-MOUNT
LIGHTING FIXTURE
METHOD G-1-B
MOUNTING ON COLLAR STUDS THRU INSULATION ONTO WATERTIGHT STRUCTURES OR STRUCTURAL MEMBERS
THRU BOLTS, NUTS, ETC MAY ALSO BE USED
WOODEN STRUCTURE
3/4 OD x 13/32 ID FLAT WASHER
WOOD SCREW OR LAG BOLT. MATERIAL AND SIZE TO SUIT
SHOCKMOUNT
LIGHTING FIXTURE
METHOD G-1-C
MOUNTING ON WOODEN STRUCTURES
DO NOT PENETRATE FOR WATERTIGHT INSTALLATION
WELD
3/4 OD TAPPED PAD, LENGTH TO SUIT
3/4 OD X 13/32 ID FLAT WASHER
3/8-16 X 1/4 BOLT
SHOCKMOUNT
LIGHTING FIXTURE
METHOD G-1-D
MOUN…G ON WATERTIGHT DECKS OR BULKHEADS OR STRUCTURAL MEMBERS
3/8-16 RHMS OR BOLT - LENGTH TO SUIT
3/4 OD X 13/32 ID FLAT WASHER
3/8-16 HEX NUT
BACKING PLATE FOR THIN BULKHEADS
SHOCKMOUNT
LIGHTING FIXTURE
METHOD G-1-E
MOUNTING ON NWT, JOINER, OR NON STRUCTURAL BULKHEADS
3/4 OD X 13/32 ID FLATWASHER
3/8-16 STUD WELD COLLAR STUD WITH 3/4 DIA (MIN) COLLAR OR 3/4 OD X 13/32 ID FLATWASHER
3/8-16 HEX NUT
3/8 MIN
SHOCKMOUNT
LIGHTING FIXTURE
METHOD G-1-F
MOUNTING ON WATERTIGHT STRUCTURES USING COLLAR STUDS
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SECTION G
SHEET 1
53711
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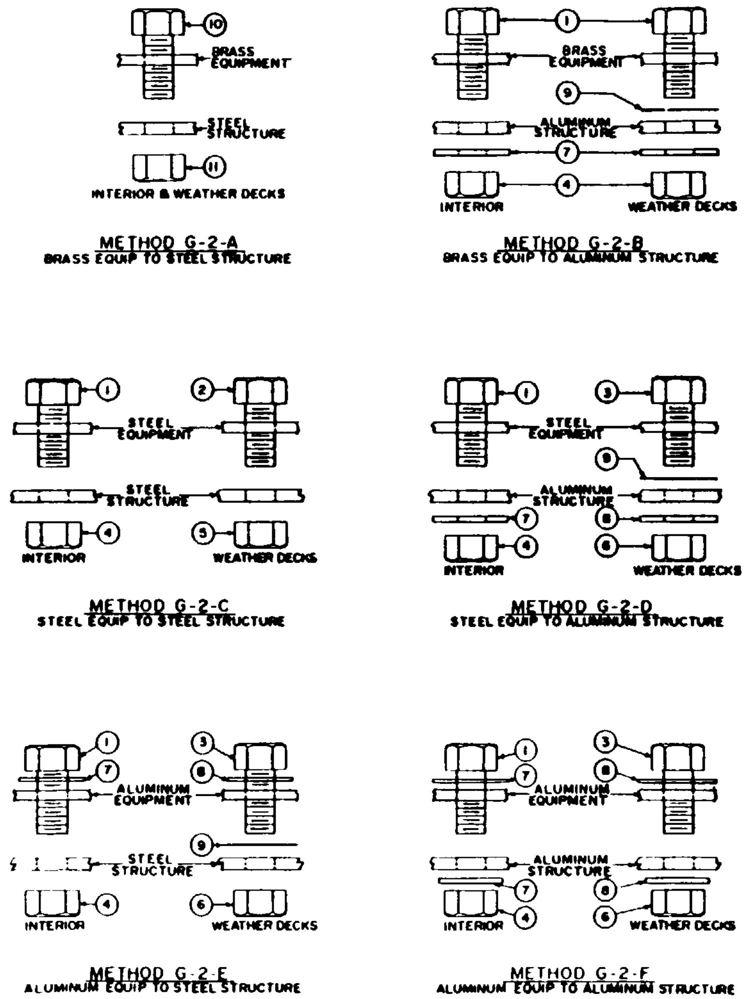
REV A

REVISIONS				
REV	DESCRIPTION	DATE	APPROVED	
—	FIRST ISSUE			
A	REVISED PC NO 1,2,3,4,5,6, 10 AND 11 WAS MIL-B-857A. REVISED PC9 WAS MIL-I-7798. REVISED NOTE 3 WAS MIL-B-23470.			



NOTES

1. ELECTRICAL EQUIPMENT IS GENERALLY FABRICATED OF STEEL, ALUMINUM OR BRASS AND IS USUALLY MOUNTED ON STEEL OR ALUMINUM STRUCTURES. MOUNTING METHODS SHOWN ARE RECOMMENDED AND SHALL BE USED WHENEVER POSSIBLE.
2. SCREW THREADS SHALL COMPLY WITH FEDERAL SERVICE HANDBOOK H-28. SCREW THREADS SHALL BE EITHER UNIFIED OR NATIONAL WITH UNIFIED PREFERRED. THE COARSE THREAD SERIES SHALL BE USED UNLESS DESIGN CONSIDERATIONS NECESSITATE THE USE OF FINE THREADS. UNIFIED 2A/2B OR NATIONAL 2A/2B FITS SHALL BE USED AS MUCH AS POSSIBLE.
3. SCREWS SHALL COMPLY WITH THE FOLLOWING FED & MIL SPECS:

CAP SCREWS-SLOTTED & HEX HEAD	FF-S-85
CAP SCREWS-SOCKET HEAD	FF-S-86
MACHINE SCREWS	FF-S-92
SET SCREWS	FF-S-200
	FF-S-210
TORQUE-CONTROLLED PRESTRESSED BOLTS & NUTS	MIL-P-23470

4. WHEN USING A THREADED FASTENER, NOT LESS THAN ONE THREAD, NOR MORE THAN FOUR, SHALL PROTRUDE BEYOND THE CROWN OF THE NUT.
5. THROUGH BOLTING SHALL BE USED WHENEVER POSSIBLE. WHERE NOT POSSIBLE, STUDS, TAP BOLTS OR MACHINE SCREWS MAY BE USED.
6. MATERIAL USED FOR FOUNDATION BRACKETS SHALL BE THE SAME AS THAT OF SURROUNDING SHIPS STRUCTURE.
7. ALL MOUNTING HOLES ON EQUIPMENT SHALL BE UTILIZED WHEN ATTACHING BRACKETS OR FOUNDATIONS.
8. FOUNDATION BOLT HOLES SHALL BE SAME DIAMETER AS EQUIPMENT MOUNTING HOLES.
9. NO SPRING TYPE LOCKWASHERS SHALL BE USED.
10. NON-MAGNETIC SCREW FASTENERS SHALL BE IN ACCORDANCE WITH MIL-F-19700
11. IN LIEU OF THE HEX HEAD BOLTS SPECIFIED, ROUND HEAD MACHINE SCREWS OF THE SAME SIZE MAY BE USED.

PC NO	LIST OF MATERIAL
11	NUT, STEEL, GRADE 5, MIL-S-1222 & MIL-N-25027, NO PLATING
10	BOLT, STEEL, GRADE 5, MIL-S-1222, NO PLATING
9	INSULATION TAPE, MIN THICKNESS 20 MILS, MIL-I-24391 (2 LAYERS)
8	WASHER, FLAT, CRES, CLASS 303, MS15795
7	WASHER, FLAT, STEEL, MS27183, CADMIUM PLATED
6	NUT, CRES, COND B, QQ-S-763, CLASS 303, MIL-N-25027 & MIL-S-1222
5	NUT, STEEL, GRADE 5, MIL-S-1222 & MIL-N-25027, DISTORTED TOP TYPE, GALV
4	NUT, STEEL, GRADE 5, MIL-S-1222 & MIL-N-25027, " , CAD PL
3	BOLT, CRES, CONDITION B, FED SPEC QQ-S-763, CLASS 303, MIL-S-1222
2	BOLT, STEEL, GRADE 5, MIL-S-1222, GALVANIZED
1	BOLT, STEEL, GRADE 5, MIL-S-1222, CADMIUM PLATED

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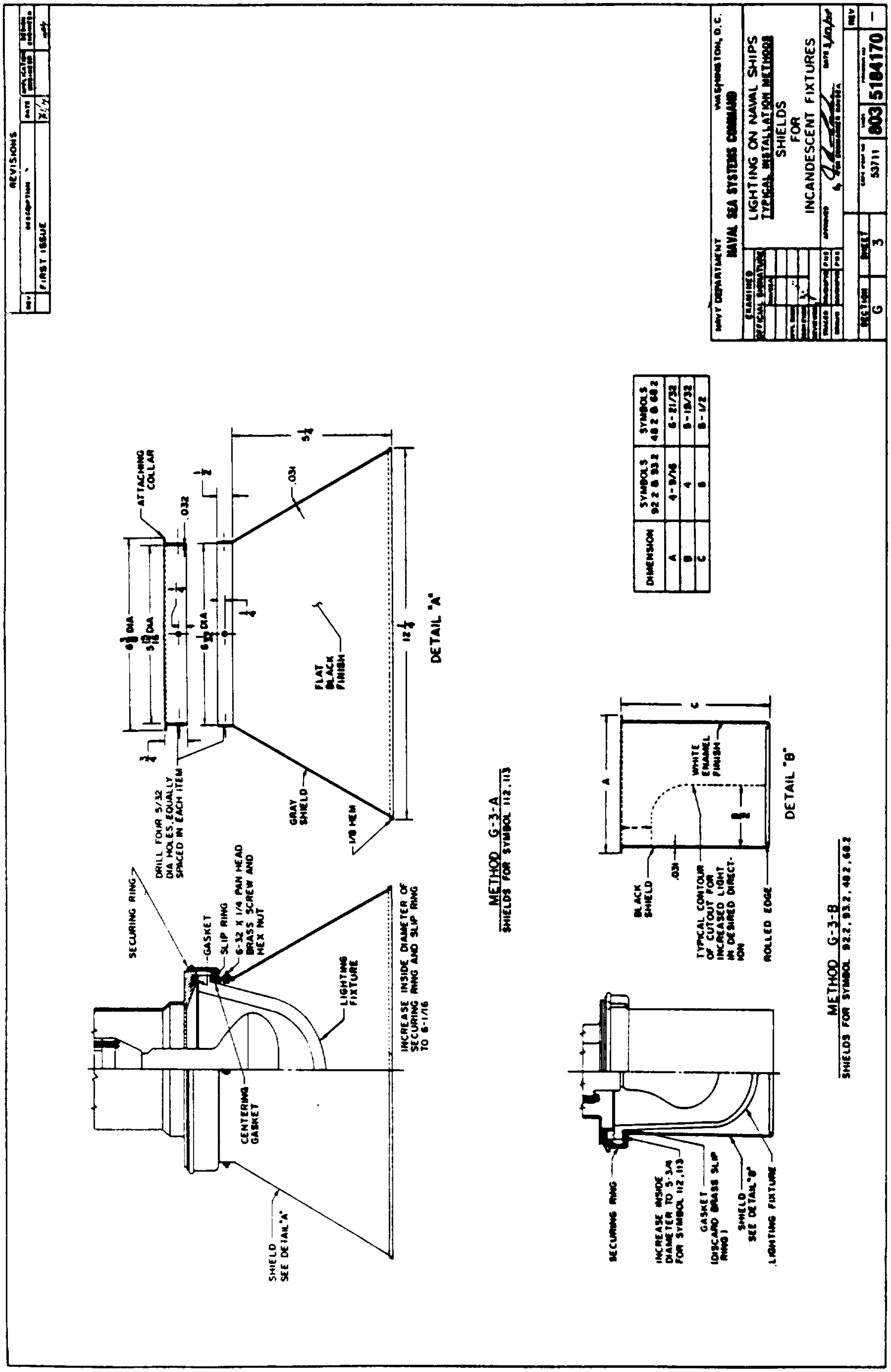
MOUNTING OF ELECTRICAL EQUIP
ON
STEEL OR ALUMINUM STRUCTURES

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
G	2	53711	803	5184170	A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FOR
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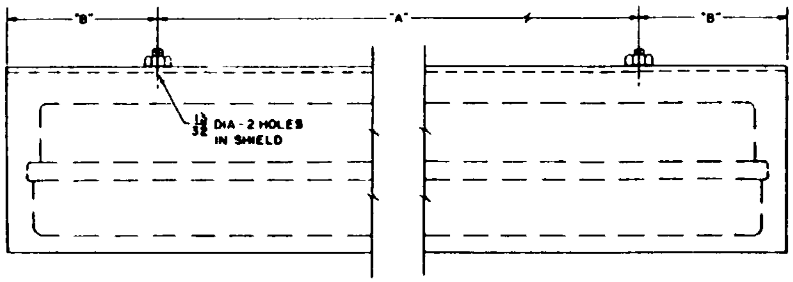
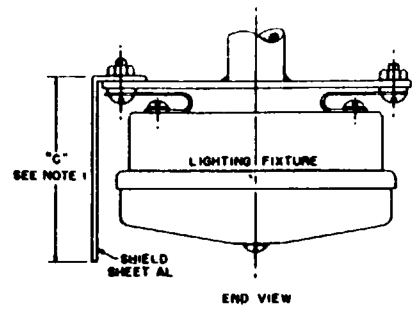
SECTION G
SHEET 3
DIMENSION
SYMBOLS 92.2 & 93.2
SYMBOLS 48.2 & 68.2
A
4-9/16
6-21/32
B
4
5-15/32
C
8
8-1/2
ATTACHING COLLAR
.032
.031
DRILL FOUR 5/32 DIA HOLES, EQUALLY SPACED IN EACH ITEM
FLAT BLACK FINISH
GRAY SHIELD
1/8 HEM
DETAIL "A"
METHOD G-3-A
SHIELDS FOR SYMBOL 112, 113
SECURING RING
GASKET
SLIP RING
6-32 X 1/4 PAN HEAD BRASS SCREW AND HEX NUT
LIGHTING FIXTURE
INCREASE INSIDE DIAMETER OF SECURING RING AND SLIP RING TO 6-1/16
CENTERING GASKET
SHIELD SEE DETAIL "A"
WHITE ENAMEL FINISH
BLACK SHIELD
TYPICAL CONTOUR OF CUTOUT FOR INCREASED LIGHT IN DESIRED DIRECTION
ROLLED EDGE
DETAIL "B"
METHOD G-3-B
SHIELDS FOR SYMBOL 92.2, 93.2, 48.2, 68.2
INCREASE INSIDE DIAMETER TO 5-3/4 FOR SYMBOL 112, 113
GASKET (DISCARD BRASS SLIP RING)
SHIELD SEE DETAIL "B"

REVISIONS				
REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
—	FIRST ISSUE			

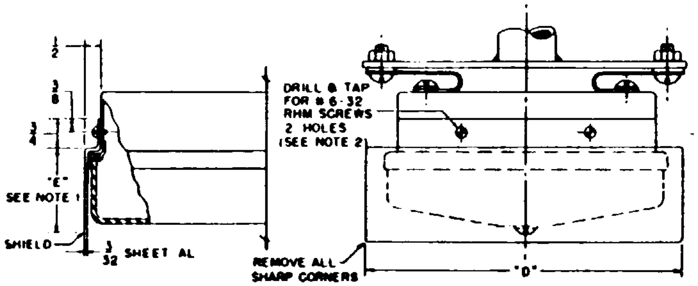




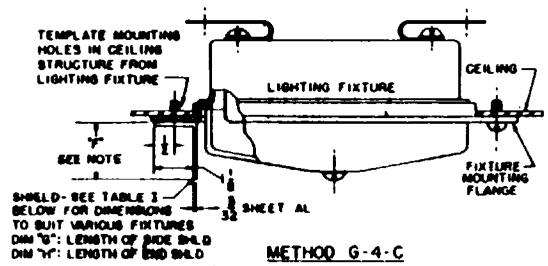
METHOD G-4-A
SIDE SHIELD ON OPEN MOUNTED STANDARD FLUORESCENT LIGHTING FIXTURE

NOTES

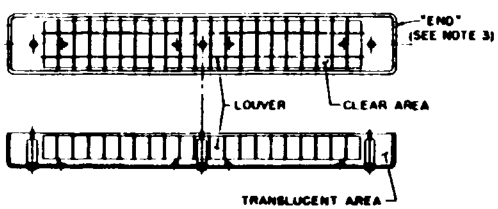
1. DEPTH OF SHIELD CAN BE VARIED TO SUIT INSTALLATION
2. WHENEVER A SHIELD IS ATTACHED TO THE ENCLOSURE OF A WATERTIGHT LIGHTING FIXTURE USING SCREWS THRU HOLES DRILLED IN ITS ENCLOSURE, THE WATERTIGHT INTEGRITY OF THE FIXTURE SHALL BE RESTORED BY A SUITABLE SEALING TECHNIQUE.
3. IF A DIFFUSING FLUORESCENT FIXTURE CAUSES GLARE, ITS DIFFUSING WINDOW CAN BE REPLACED WITH A LOUVERED TYPE. IF GLARE PERSISTS, THE TRANSLUCENT SIDES AND ENDS OF THE LOUVERED WINDOW, AND THE LOUVER ITSELF CAN BE PAINTED BLACK.



METHOD G-4-B
END SHIELD ON OPEN MOUNTED STANDARD FLUORESCENT LIGHTING FIXTURE



METHOD G-4-C
TYPICAL SHIELD ON FLUSH MOUNTED STANDARD FLUORESCENT LIGHTING FIXTURE



METHOD G-4-D
SUBSTITUTING LOUVERED WINDOW ASSEMBLIES (SEE NOTE 3)

TABLE I DIMENSIONS

WATTS	SPECIFICATION NO	SYMBOL NO	A	B	C	D	E	F	G	H
15	MIL-F-16377/5	338.1	13-7/8	8	4-3/4	5-3/4	2-1/4	1-1/8	25-3/16	6-7/8
16 DIR	MIL-F-16377/6	149.2	9-1/4	4-1/2	4-3/4	8-3/8	2-1/4	1-1/8	18-5/16	9-9/16
16	MIL-F-16377/7	70.3	9-1/4	4-1/2	3-3/4	5-3/4	1-5/8	1/2	19-7/32	6-7/8
20	MIL-F-16377/8	331.1, 347	19-7/8	8	8	5-3/4	2-1/4	1-1/8	31-3/16	6-7/8
24	MIL-F-16377/9	73.3, 346	9-1/4	4-1/2	4-3/4	8-3/8	2-1/4	1-1/8	18-5/16	9-9/16
32 DIR	MIL-F-16377/10	149.2	19-7/8	8	8	8-3/8	2-1/4	1-1/8	30-15/16	9-9/16
40	MIL F 16377/11	77.4, 344	19-7/8	8	8	8-3/8	2-3/4	1-5/8	30-15/16	9-9/16
60	MIL-F-16377/12	331.1, 342	19-7/8	8	8	9-1/4	3	2-7/8	31-1/4	11-1/2
8	MIL-F-16377/14	79.1, 80.1	9-1/4	4-1/2	4	3-1/2	2-1/4	1 1/8	18-1/2	4-7/8

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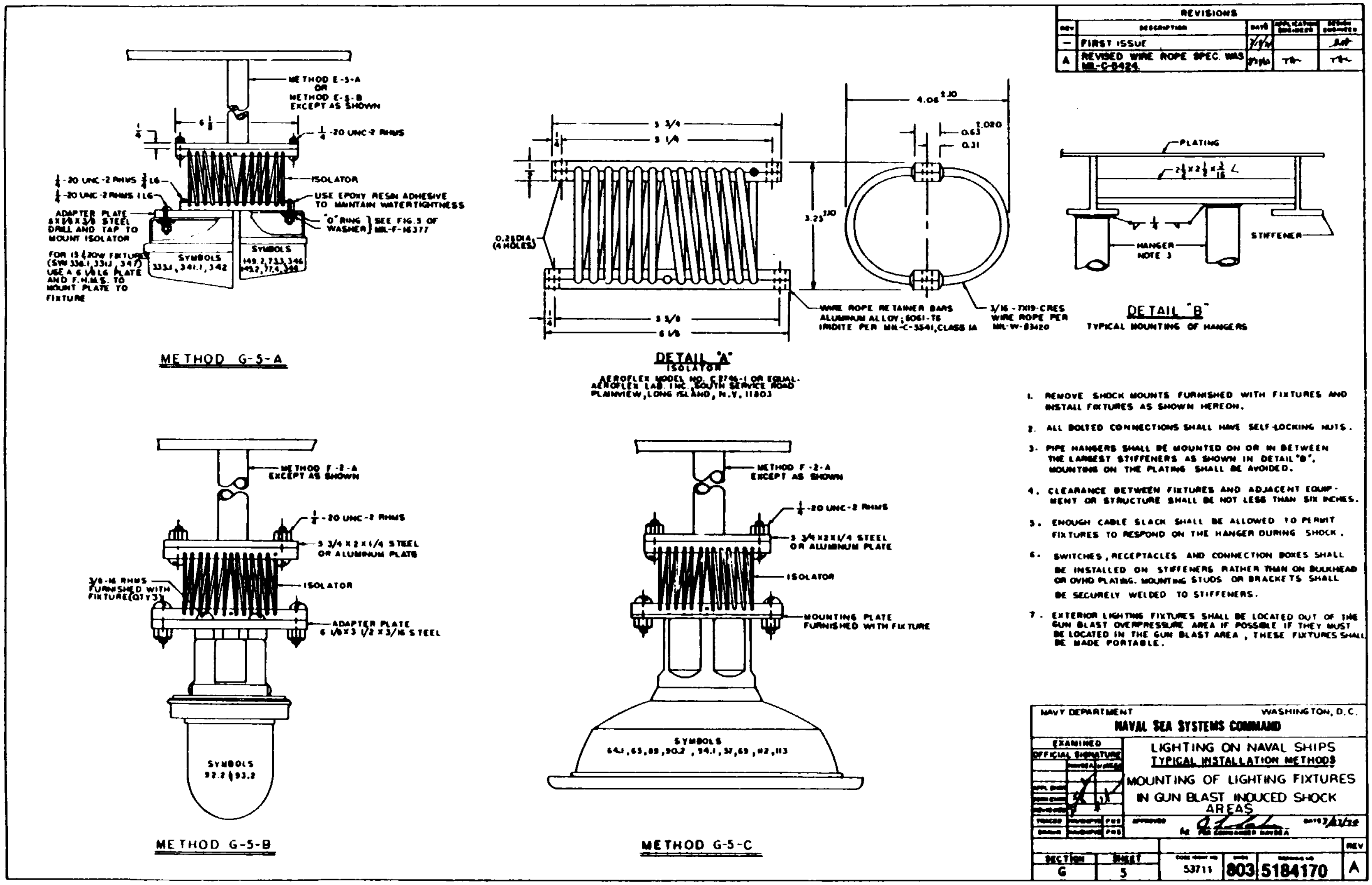
TYPICAL INSTALLATION METHODS

LIGHT SHIELDS FOR FLUORESCENT LIGHTING FIXTURES

SECTION G | SHEET 4 | 53711 | 803 | 5184170 | REV —


REVISIONS
REV | DESCRIPTION | DATE | APPLICATION ENGINEER | DESIGN ENGINEER
— | FIRST ISSUE
A | REVISED WIRE ROPE SPEC. WAS MIL-C-5424.
METHOD E-5-A OR METHOD E-5-B EXCEPT AS SHOWN
1/4-20 UNC-2 RHMS
ISOLATOR
USE EPOXY RESIN ADHESIVE TO MAINTAIN WATERTIGHTNESS
"O" RING } SEE FIG.5 OF WASHER } MIL-F-16377
1/4-20 UNC-2 RHMS 3/4 LG
1/4-20 UNC-2 RHMS 1 LG
ADAPTER PLATE 6X6X3/8 STEEL DRILL AND TAP TO MOUNT ISOLATOR
FOR 13 1/2OW FIXTURE (SYM 336.1, 336.1, 342) USE A 6 1/8 LG PLATE AND F.H.M.S. TO MOUNT PLATE TO FIXTURE
SYMBOLS 333.1, 341.1, 342
SYMBOLS 149.2, 153, 346, 152, 174, 348
METHOD G-5-A
3 3/4
3 1/4
3 5/8
6 1/8
0.28 DIA. (4 HOLES)
4.06 ±.10
3.25 ±.10
0.63 ±.020
0.31
WIRE ROPE RETAINER BARS ALUMINUM ALLOY; 6061-T6 IRIDITE PER MIL-C-5541, CLASS 1A
3/16-7X19-CRES WIRE ROPE PER MIL-W-83420
DETAIL "A"
ISOLATOR
AEROFLEX MODEL NO. C3796-1 OR EQUAL. AEROFLEX LAB. INC. SOUTH SERVICE ROAD PLAINVIEW, LONG ISLAND, N.Y. 11803
PLATING
2 1/2 x 2 1/2 x 3/16 L
HANGER NOTE 3
STIFFENER
DETAIL "B"
TYPICAL MOUNTING OF HANGERS
1. REMOVE SHOCK MOUNTS FURNISHED WITH FIXTURES AND INSTALL FIXTURES AS SHOWN HEREON.
2. ALL BOLTED CONNECTIONS SHALL HAVE SELF-LOCKING NUTS.
3. PIPE HANGERS SHALL BE MOUNTED ON OR IN BETWEEN THE LARGEST STIFFENERS AS SHOWN IN DETAIL "B". MOUNTING ON THE PLATING SHALL BE AVOIDED.
4. CLEARANCE BETWEEN FIXTURES AND ADJACENT EQUIPMENT OR STRUCTURE SHALL BE NOT LESS THAN SIX INCHES.
5. ENOUGH CABLE SLACK SHALL BE ALLOWED TO PERMIT FIXTURES TO RESPOND ON THE HANGER DURING SHOCK.
6. SWITCHES, RECEPTACLES AND CONNECTION BOXES SHALL BE INSTALLED ON STIFFENERS RATHER THAN ON BULKHEAD OR OVHD PLATING. MOUNTING STUDS OR BRACKETS SHALL BE SECURELY WELDED TO STIFFENERS.
7. EXTERIOR LIGHTING FIXTURES SHALL BE LOCATED OUT OF THE GUN BLAST OVERPRESSURE AREA IF POSSIBLE. IF THEY MUST BE LOCATED IN THE GUN BLAST AREA, THESE FIXTURES SHALL BE MADE PORTABLE.
METHOD F-2-A EXCEPT AS SHOWN
1/4-20 UNC-2 RHMS
3 3/4 X 2 X 1/4 STEEL OR ALUMINUM PLATE
ISOLATOR
3/8-16 RHMS FURNISHED WITH FIXTURE (QTY 3)
ADAPTER PLATE 6 1/8 X 3 1/2 X 3/16 STEEL
SYMBOLS 92.2 & 93.2
METHOD G-5-B
MOUNTING PLATE FURNISHED WITH FIXTURE
SYMBOLS 64.1, 65, 89, 90.2, 94.1, 57, 69, 112, 113
METHOD G-5-C
NAVY DEPARTMENT WASHINGTON, D.C.
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EXAMINED
OFFICIAL SIGNATURE
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MOUNTING OF LIGHTING FIXTURES IN GUN BLAST INDUCED SHOCK AREAS
APPROVED
SECTION G
SHEET 5
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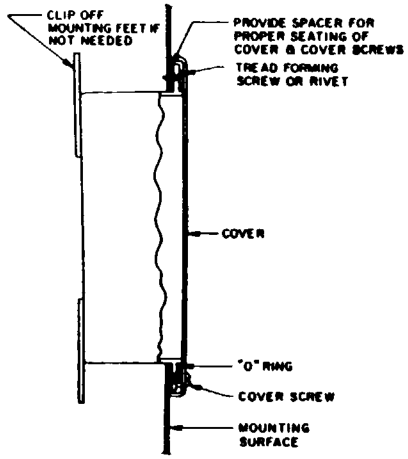
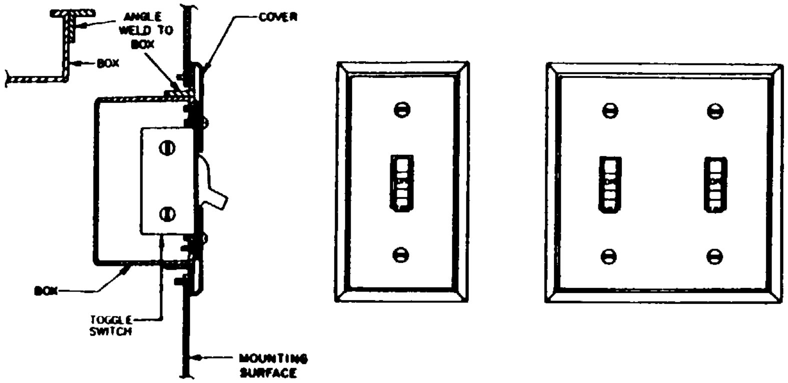
REV A



METHOD G-6-A

FLUSH MOUNTING OF WATER TIGHT & NAVY TYPE SWITCHES, RECEPTACLES OR CONNECTION BOXES



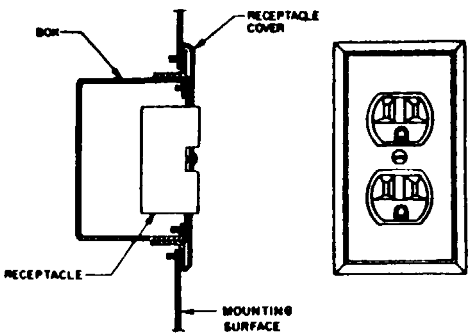
METHOD G-6-B

FLUSH MOUNTING OF COMMERCIAL SWITCHES

METHOD G-6-B	PART NUMBER-SEE NOTE 2			ACTION
	SWITCH	BOX	COVER	
1	503	103	302	ON-OFF
2	503-QTY2	107	308	ON-OFF

NOTE

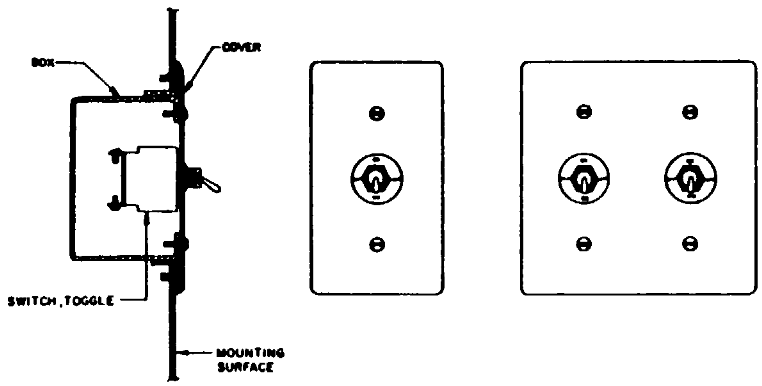
1. COLOR OF COVER PLATES SHALL BE SUCH AS TO MATCH THE DECOR OF THE SPACE.
2. PART NUMBERS AS SHOWN HEREON ARE THE SAME AS THOSE SHOWN ON SHEET G-8. OTHER COMBINATION OF PART NUMBERS, SELECTED FROM SHEET G-8, MAY BE FORMED AS DESIRED.
3. BOXES MAY BE MODIFIED FOR FLUSH MOUNTING AS SHOWN HEREON. ADDITIONAL METHODS ARE SHOWN ON SHEET G-7.
4. PLATES, IN ACCORDANCE WITH MIL-P-15024, SHALL BE PROVIDED FOR PROPER IDENTIFICATION OF EQUIPMENT AND CIRCUITS THEY SERVE.



METHOD G-6-C

FLUSH MOUNTING OF COMMERCIAL RECEPTACLES

METHOD G-6-C	PART NUMBER-SEE NOTE 2			RECEPTACLE TYPE
	RECEPTACLE	BOX	COVER	
1	702	103	402	ONE SINGLE
2	704	103	406	ONE DUPLEX
3	704-QTY 2	107	408	TWO DUPLEX



METHOD G-6-D

FLUSH MONTING OF COMMERCIAL SWITCHES

METHOD G-6-D	PART NUMBER-SEE NOTE 2			ACTION
	SWITCH	BOX	COVER	
1	601	103	STEEL-FOR FLUSH MTG	ON-OFF-ON
2	602	103	↓	ON-NONE-ON
3	602-QTY2	107	↓	ON-OFF-ON

REVISIONS

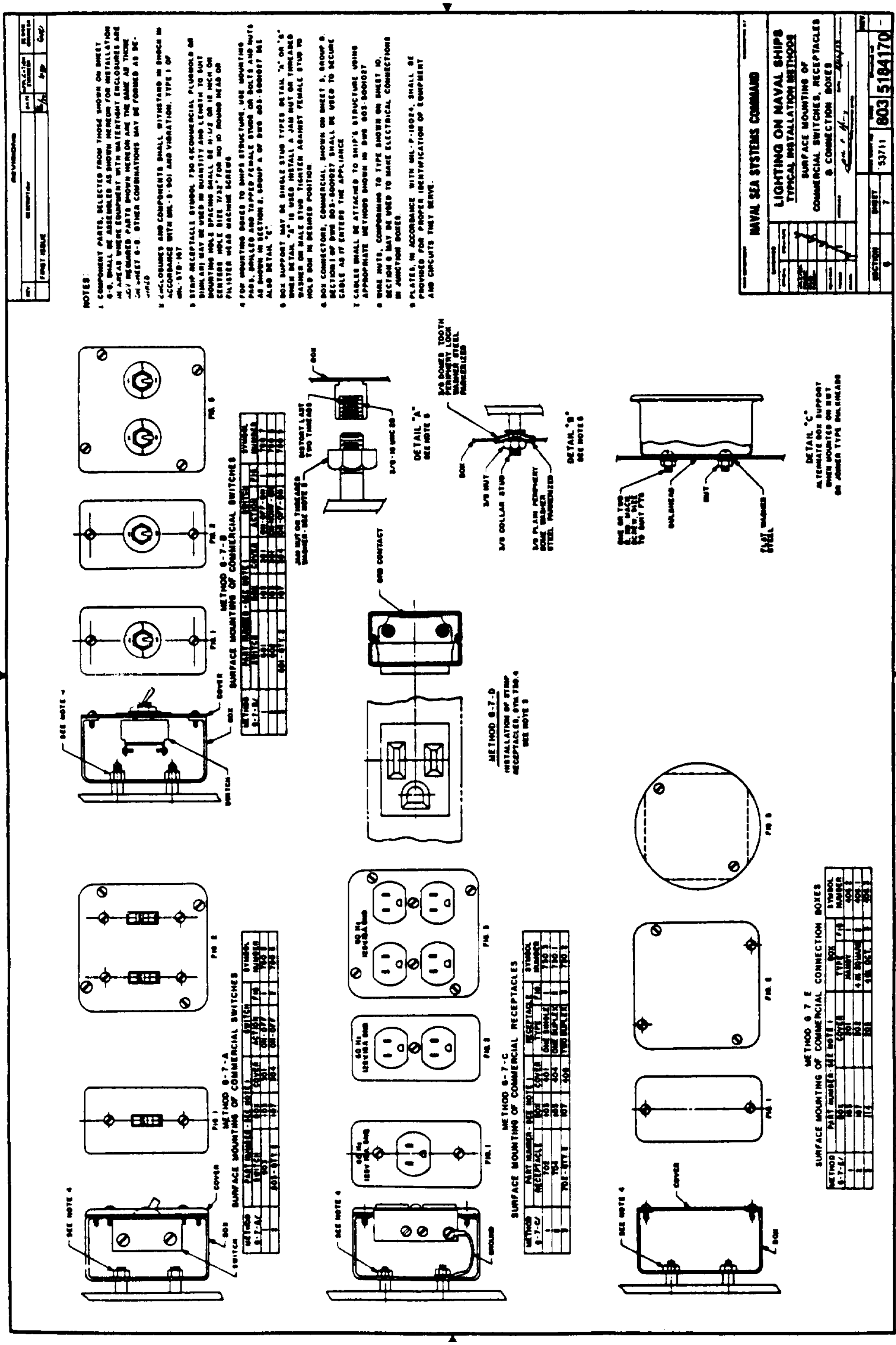
REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
—	FIRST ISSUE	7/1/77		
A	ADDED NOTES 2&3 AND TABLES FOR METHODS G-6-B, G-6-C AND G-6-D.	7/7/81		

NAVY DEPARTMENT WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

FLUSH MOUNTING OF SWITCHES, RECEPTACLES & CONNECTION BOXES

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
G	6	53711	803	5184170	A


NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
SURFACE MOUNTING OF COMMERCIAL SWITCHES, RECEPTACLES & CONNECTION BOXES
53711
803
5184170

USE OF COMMERCIAL ENCLOSURES AND COMPONENTS

REVISIONS				
REV	DESCRIPTION	DATE	APPROVED	
—	FIRST ISSUE			
A	REVISED NOTE 3 AND TABLE VI: TOGGLE SW WAS MS35058. REVISED PART NO'S AND NSN'S			

NOTES:

1 COMMERCIALLY AVAILABLE BOXES, STEEL, CADMIUM OR ZINC PLATED, CONFORMING TO FED-STD-120 OR TO W-J-800 MAY BE USED. BOXES MAY HAVE CONVENTIONAL OR REVERSE KNOCKOUTS. THE BOX KNOCKOUTS SHALL WITHSTAND THE REMOVAL FORCE SPECIFIED IN UNDERWRITERS LABORATORIES STANDARD UL-514

2 PLASTIC SWITCH & RECEPTACLE COVERS SHALL BE USED ONLY IN AREAS WHERE DECORATIVE BULKHEAD SHEATHING IS PROVIDED FOR FLUSH MOUNTING. SEE SHEET 6-6

3 THESE SWITCHES SHALL BE IN ACCORDANCE WITH MS 25307 EXCEPT SWITCH ACTUATING HANDLES SHALL BE PINNED TO THE NECK OF THE SWITCH BY A METAL PIN

4 RECEPTACLES SHALL BE IN ACCORDANCE WITH W-C-596/11B W-C-596/12 EXCEPT THAT THE GROUND CONTACT AND MOUNTING STRAP SHALL BE NICKEL-PLATED 0.0003 INCH THICK

1A 1B 1C

METHOD G-8-A
TABLE I - CONNECTION (JUNCTION) BOXES

PART NO	FIGURE	NAME	FED-STD-120 TYPE	FED-STD-120 SIZE	DIMENSIONS	KNOCKOUTS	NATIONAL STOCK NO 5975-
101	1A	HANDY	3	H	4 x 2-1/8 x 1-1/2	11 HOLES, 1/2 DIA	00-194-8871
102	1A		3	I	4 x 2-1/8 x 2-1/8	11 HOLES, 1/2 DIA	00-281-0090
103	1A		3	J	4 x 2-1/8 x 2-7/8	11 HOLES, 1/2 DIA	00-284-5827
104	1B	SQUARE	2	B	4 x 4 x 1-1/2	17 HOLES, 1/2 DIA	00-194-8878
105			2	B	4 x 4 x 1-1/2	11H-1/2D, 6H-3/4D	00-133-6398
106			2	B	4 x 4 x 1-1/2	3H-1/2D, 10H-3/4D	00-194-8884
107			2	C	4 x 4 x 2-1/8	17 HOLES, 1/2 DIA	00-194-8877
108			2	C	4 x 4 x 2-1/8	3H-1/2D, 10H-3/4D	00-194-8880
109			2	[illegible]	4 x 4 x 2-1/8	[illegible]	[illegible]
110			2	[illegible]	4-11/16 x 4-11/16 x 2-1/8	[illegible]	[illegible]
111	1C	OCTAGON	1	A	3-1/4 x 1-1/2	[illegible] HOLES, 1/2 DIA	[illegible]
112			1	B	4 x 1-1/2	[illegible] HOLES, 1/2 DIA	[illegible]
113			1	B	4 x 1-1/2	4H-1/2D, 8H-[illegible]	00-194-[illegible]
114			1	B	4 x 1-1/2	3H-1/2D, 6H-3/4D	[illegible]
115			1	C	4 x 1-1/8	8 HOLES, 1/2 DIA	00-133-[illegible]
116			1	C	4 x 1-1/8	3H-1/2D, 6H-3/4D	00-255-[illegible]

2A 2B 2C

METHOD G-8-B
TABLE II - BLANK COVERS

PART NO	FIGURE	FED-STD-120 SIZE	FED-STD-120 STYLE	USED WITH BOX	NATIONAL STOCK NO 5975-
201	2A	W	00	HANDY	00-200-7981
202	2B	V	61	4 IN SQUARE	00-281-0096
203	2B	T	80	4-11/16 IN SQUARE	00-280-7448
204	2C	R	42	3-1/4 IN OCTAGON	00-133-8773
205	2C	S	43	4 IN OCTAGON	00-133-8778

3A 3B 3C 3D

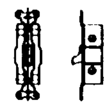
METHOD G-8-C
TABLE III - SWITCH COVERS, W-P-455, TYPE I

PART NO	FIG NO	NUMBER OF SWITCHES	USED WITH BOX	MATERIAL	COLOR	NATIONAL STOCK NO 5975-
301	3A	1	HANDY	STEEL	NATURAL	00-301-4924
302	3B	1	HANDY	PLASTIC	BROWN	00-243-1275
303	3B	1	HANDY	PLASTIC	IVORY	00-200-5311
304	3C	2	4 IN SQ	STEEL	NATURAL	00-284-8287
305	3D	2	4 IN SQ	PLASTIC	BROWN	00-494-0683
306	3D	2	4 IN SQ	PLASTIC	IVORY	–

4A 4B 4C 4D 4E 4F

METHOD G-8-D
TABLE IV - RECEPTACLE COVERS, W-P-455, TYPE 2

PART NO	FIGURE	NUMBER OF RECEPT	USED WITH BOX	MATERIAL	COLOR	NATIONAL STOCK NO 5975-
401	4A	1 SINGLE	HANDY	STEEL	NATURAL	00-280-3856
402	4B	1 SINGLE	HANDY	PLASTIC	BROWN	00-280-3518
403	4B	1 SINGLE	HANDY	PLASTIC	IVORY	–
404	4C	1 DUPLEX	HANDY	STEEL	NATURAL	00-188-1164
405	4C	1 DUPLEX	HANDY	STAINLESS STL	SATIN	00-682-0558
406	4D	1 DUPLEX	HANDY	PLASTIC	BROWN	00-176-9028
407	4D	1 DUPLEX	HANDY	PLASTIC	IVORY	00-583-6260
408	4E	2 DUPLEX	4 IN SQ	STEEL	NATURAL	00-281-0051
409	4F	2 DUPLEX	4 IN SQ	PLASTIC	BROWN	–
410	4F	2 DUPLEX	4 IN SQ	PLASTIC	IVORY	–

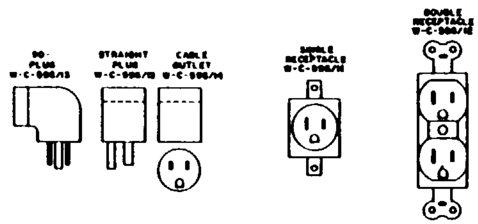


METHOD G-8-E
TABLE V - SWITCHES, TOGGLE, DPST, 120, W-S-896/2

PART NO	GOVERNMENT PART NO	CURRENT RATING (A)	COLOR OF HANDLE	NATIONAL STOCK NO 5930-
501	WS896/2-3A	20	BROWN	00-943-8260
502	WS896/2-3B	20	IVORY	–
503	[illegible]	[illegible]	BROWN	00-[illegible]
504	[illegible]	[illegible]	IVORY	–

METHOD G-8-F
TABLE VI - SWITCHES, TOGGLE, DPDT, 10A, 120V, MS25307 (SEE NOTE 3)

PART NO	MS PART NO	CIRCUIT W/ TOGGLE LEVER IN UP POSITION	CIRCUIT W/ TOGGLE LEVER IN CENTER POSITION	CIRCUIT W/ TOGGLE LEVER IN DOWN POSITION	NATIONAL STOCK NO 5930-
601	MS25307-[illegible]	ON	OFF	ON	00-701-[illegible]
602	MS25307-[illegible]	ON	NONE	ON	00-[illegible]
603	MS25307-[illegible]	ON	OFF	NONE	00-[illegible]



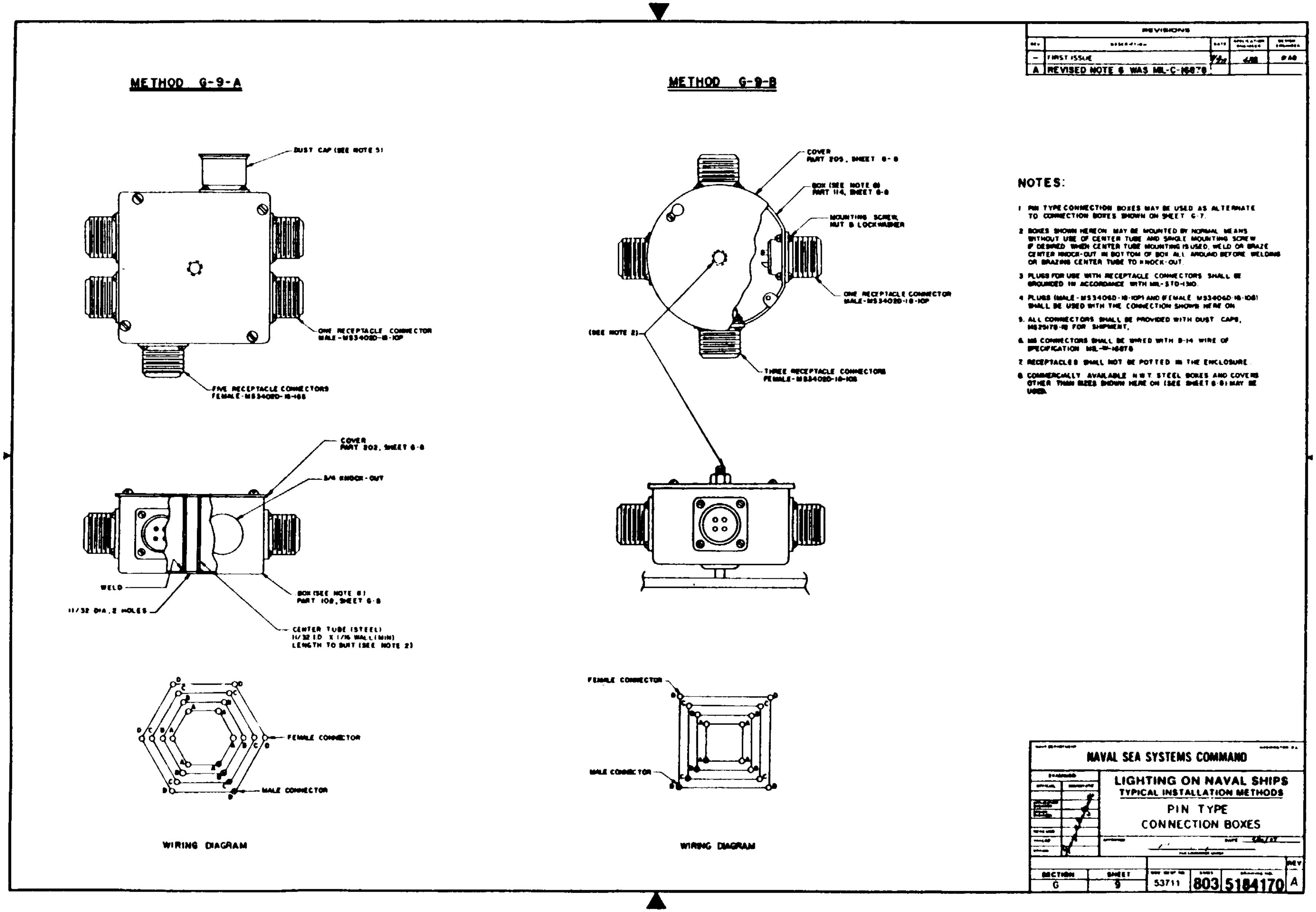
METHOD G-8-G
TABLE VII - PLUGS & RECEPTACLES, GROUNDED (SEE NOTE 4)

PART NO	GOVERNMENT PART NO	USE	COLOR	NATIONAL STOCK NO 5935-
701	WC596/11-1	GENERAL	IVORY	–
702	WC596/11-2	GENERAL	BROWN	01-012-3081
703	WC596/12-1	GENERAL	IVORY	01-017-3290
704	WC596/12-2	GENERAL	BROWN	01-[illegible]-4003
705	WC596/12-3	HOSPITAL	IVORY	01-017-3290
706	WC596/12-4	HOSPITAL	BROWN	01-012-3060
707	WC596/13-3	STRAIGHT	–	01-008-3878
708	WC596/13-4	90-ANGLE	–	01-023-8777
709	WC596/14-3	–	–	01-012-3066

NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
USE OF COMMERCIAL ENCLOSURES AND COMPONENTS

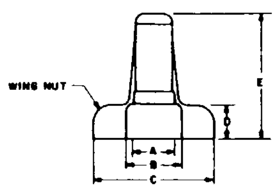
SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
6	8	53711	803	5184170	A


REVISIONS
- FIRST ISSUE
A REVISED NOTE 6 WAS MIL-C-16878
METHOD G-9-A
DUST CAP (SEE NOTE 5)
ONE RECEPTACLE CONNECTOR MALE-MS3402D-18-10P
FIVE RECEPTACLE CONNECTORS FEMALE-MS3402D-18-10S
COVER PART 202, SHEET 6-8
3/4 KNOCK-OUT
WELD
11/32 DIA. 2 HOLES
BOX (SEE NOTE 8) PART 108, SHEET 6-8
CENTER TUBE (STEEL) 11/32 I.D. X 1/16 WALL (MIN) LENGTH TO SUIT (SEE NOTE 2)
FEMALE CONNECTOR
MALE CONNECTOR
WIRING DIAGRAM
METHOD G-9-B
COVER PART 205, SHEET 6-8
BOX (SEE NOTE 8) PART 114, SHEET 6-8
MOUNTING SCREW, NUT & LOCKWASHER
ONE RECEPTACLE CONNECTOR MALE-MS3402D-18-10P
(SEE NOTE 2)
THREE RECEPTACLE CONNECTORS FEMALE-MS3402D-18-10S
FEMALE CONNECTOR
MALE CONNECTOR
WIRING DIAGRAM
NOTES:
1 PIN TYPE CONNECTION BOXES MAY BE USED AS ALTERNATE TO CONNECTION BOXES SHOWN ON SHEET G-7.
2 BOXES SHOWN HEREON MAY BE MOUNTED BY NORMAL MEANS WITHOUT USE OF CENTER TUBE AND SINGLE MOUNTING SCREW IF DESIRED. WHEN CENTER TUBE MOUNTING IS USED, WELD OR BRAZE CENTER KNOCK-OUT IN BOTTOM OF BOX ALL AROUND BEFORE WELDING OR BRAZING CENTER TUBE TO KNOCK-OUT.
3 PLUGS FOR USE WITH RECEPTACLE CONNECTORS SHALL BE GROUNDED IN ACCORDANCE WITH MIL-STD-1310.
4 PLUGS (MALE-MS3406D-18-10P) AND (FEMALE MS3406D-18-10S) SHALL BE USED WITH THE CONNECTION SHOWN HEREON
5. ALL CONNECTORS SHALL BE PROVIDED WITH DUST CAPS, MS25178-18 FOR SHIPMENT.
6. MS CONNECTORS SHALL BE WIRED WITH B-14 WIRE OF SPECIFICATION MIL-W-16878
7 RECEPTACLES SHALL NOT BE POTTED IN THE ENCLOSURE.
8 COMMERCIALLY AVAILABLE N.W.T. STEEL BOXES AND COVERS OTHER THAN SIZES SHOWN HEREON (SEE SHEET 6-8) MAY BE USED.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
PIN TYPE
CONNECTION BOXES
SECTION G
SHEET 9
53711
803
5184170
REV A

REVISIONS

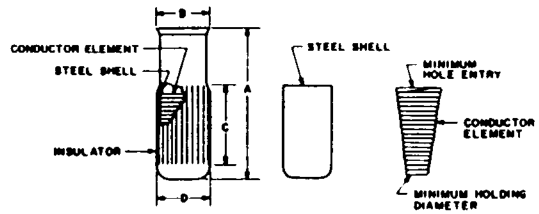
LTR	DESCRIPTION	DATE	APPROVED
—	FIRST ISSUE	[illegible]	[illegible]

METHOD G-10-A

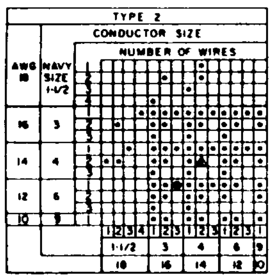


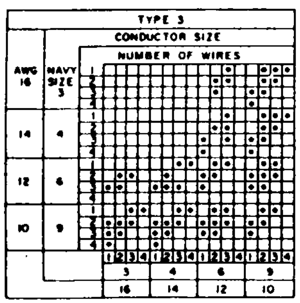
TYPE	A	B	C	D	E
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

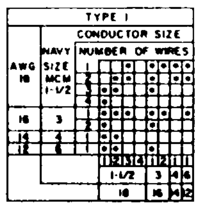
METHOD G-10-B

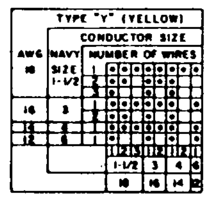


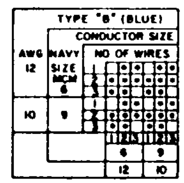
TYPE CONNECTOR	INSULATOR MATERIAL	MAX DIM A	MAX DIM B	DIM C	TAPER DIM D	MIN HOLE ENTRY	MINIMUM HOLDING DIA
Y	YEL VINYL	1-1/16"	3/8"	1/2"	.300 to .330	[illegible] ±.005	[illegible] ±.010
R	RED VINYL	1-1/8"	9/16"	5/8"	.390 to .425	.222 ±.005	[illegible] ±.010
B	BLUE VINYL	1-11/16"	5/8"	1"	.620 to .645	.345 ±.005	.292 ±.010

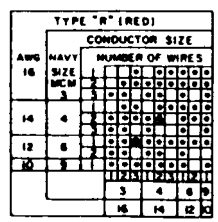












NOTES:

1 WIRE NUTS SHOWN HEREON MAY BE USED IN 120 AND 450 VOLT CIRCUITS ON CONDUCTORS UP THROUGH 9,000 CIRCULAR MILS FOR CONNECTING WIRE ENDS IN LIGHTING SYSTEMS (FIXTURES, CONNECTION BOXES, BRANCH BOXES AND DOOR SWITCHES) AND SMALL POWER APPLIANCES AND MOTORS (EXCEPT IC, FC AND ELECTRONIC SYSTEMS).

2 THE CONNECTOR TABLES INDICATE THE NUMBER AND SIZE OF WIRES PERMISSIBLE IN A SINGLE CONNECTOR. FOR EXAMPLE

A CIRCLED DOT ● INDICATES TYPE 2 OR TYPE R CONNECTOR CAN SPLICE ONE NAVY # 6 (OR AWG 12) CONDUCTOR TO THREE NAVY # 3 (OR AWG 16) CONDUCTORS

B FIND CORRECT SIZE CONNECTOR TO SPLICE TWO NAVY #4 TO TWO NAVY #4 CONDUCTORS. ANSWER IS FOUND IN TABLE TYPE 2 OR TABLE TYPE R AS INDICATED BY DOT ENCLOSED IN TRIANGLE ▲

TEST REQUIREMENT FOR
WIRE NUT CONNECTOR PLASTIC INSULATED TYPE

INSULATED SPRING WIRE CONNECTORS OF THE TYPES SHOWN SHALL HAVE SUCCESSFULLY PASSED THE FOLLOWING TESTS. CONNECTORS SHALL BE ASSEMBLED TO WIRE LENGTHS OF 18" OR MORE. A MINIMUM OF FIVE (5) SAMPLE CONNECTORS OF EACH SIZE CONTAINING THE SMALLEST NUMBER OF SMALLEST WIRES AND A MINIMUM OF FIVE SAMPLE CONNECTORS OF EACH SIZE CONTAINING THE LARGEST NUMBER OF SMALLEST WIRES SHALL BE TESTED AS FOLLOWS IN ACCORDANCE WITH MIL-E-16366

VIBRATION
VOLTAGE DROP
CURRENT OVERLOAD
PULL-OUT STRENGTH

THE AVERAGE VOLTAGE DROP AFTER VIBRATION, OVERLOAD TESTS SHALL NOT EXCEED 25 MILLIVOLTS.

DIELECTRIC STRENGTH - INSULATED CONNECTOR SHALL BE ABLE TO WITHSTAND DIELECTRIC TEST WITHOUT PUNCTURE OF THE INSULATION OR FLASHOVER. CONNECTOR SHALL BE EMBEDDED IN A VESSEL CONTAINING 12 LEAD SHOT (COMPRISING ONE ELECTRODE OF THE TEST) SO THAT THE OUTER SURFACE OF THE INSULATOR IS COVERED BY THE SHOT. SAMPLES SHALL CONFORM TO THE FOLLOWING.

RATING OF CONNECTOR IN VOLTS	60 CYCLE VOLTAGE FOR 1 MIN.	FLASHOVER VOLTAGE
450	1500	4000

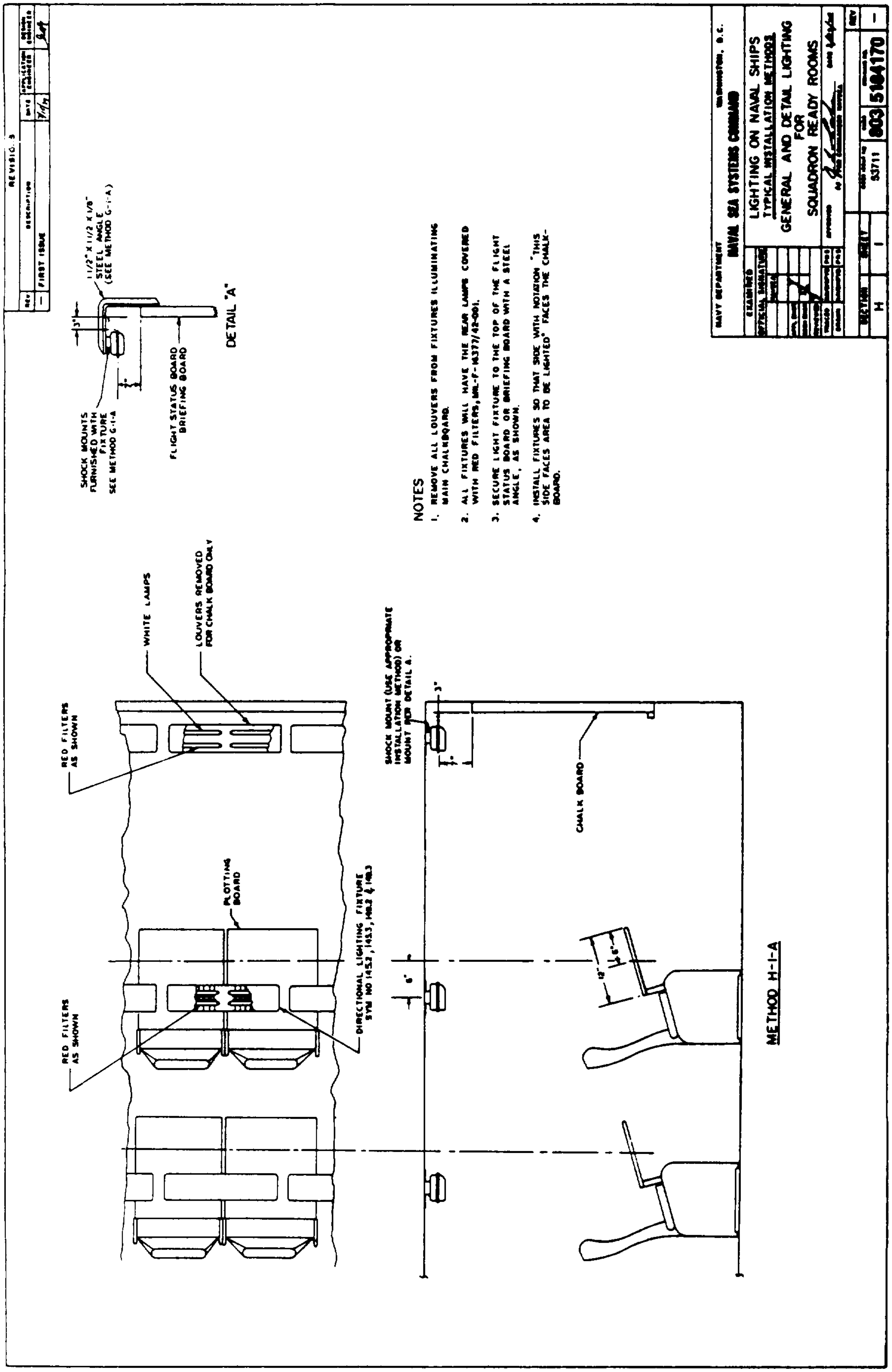
CONNECTORS SHALL BE GIVEN DIELECTRIC STRENGTH BEFORE AND AFTER WATER SOAK (SOAK IN ROOM TEMPERATURE WATER FOR 48 HOURS)

THIS SHEET SUPERSEDES SHEET 152 OF SECTION 4 OF NAVSEC DWG. 9000-S6202-73980.

NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
ELECTRIC PLANT INSTALLATION
STANDARD METHODS
USE OF WIRE NUTS TO
MAKE ELECTRICAL CONNECTIONS

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
6	10	53711	803	5184170	—


REVISIONS
REV
DESCRIPTION
DATE
APPLICATION ENGINEER
DESIGN ENGINEER
—
FIRST ISSUE
RED FILTERS AS SHOWN
RED FILTERS AS SHOWN
WHITE LAMPS
LOUVERS REMOVED FOR CHALK BOARD ONLY
PLOTTING BOARD
DIRECTIONAL LIGHTING FIXTURE SYM NO 145.2, 145.3, 148.2 & 148.3
SHOCK MOUNT (USE APPROPRIATE INSTALLATION METHOD) OR MOUNT PER DETAIL A.
6"
3"
7"
12"
6"
CHALK BOARD
METHOD H-I-A
SHOCK MOUNTS FURNISHED WITH FIXTURE SEE METHOD G-I-A
1 1/2" X 1 1/2 X 1/8" STEEL ANGLE (SEE METHOD G-I-A)
FLIGHT STATUS BOARD BRIEFING BOARD
DETAIL "A"
NOTES
1. REMOVE ALL LOUVERS FROM FIXTURES ILLUMINATING MAIN CHALKBOARD.
2. ALL FIXTURES WILL HAVE THE REAR LAMPS COVERED WITH RED FILTERS, MIL-F-16377/42-001.
3. SECURE LIGHT FIXTURE TO THE TOP OF THE FLIGHT STATUS BOARD OR BRIEFING BOARD WITH A STEEL ANGLE, AS SHOWN.
4. INSTALL FIXTURES SO THAT SIDE WITH NOTATION "THIS SIDE FACES AREA TO BE LIGHTED" FACES THE CHALKBOARD.
NAVY DEPARTMENT
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NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
GENERAL AND DETAIL LIGHTING FOR SQUADRON READY ROOMS
SECTION H
SHEET 1
53711
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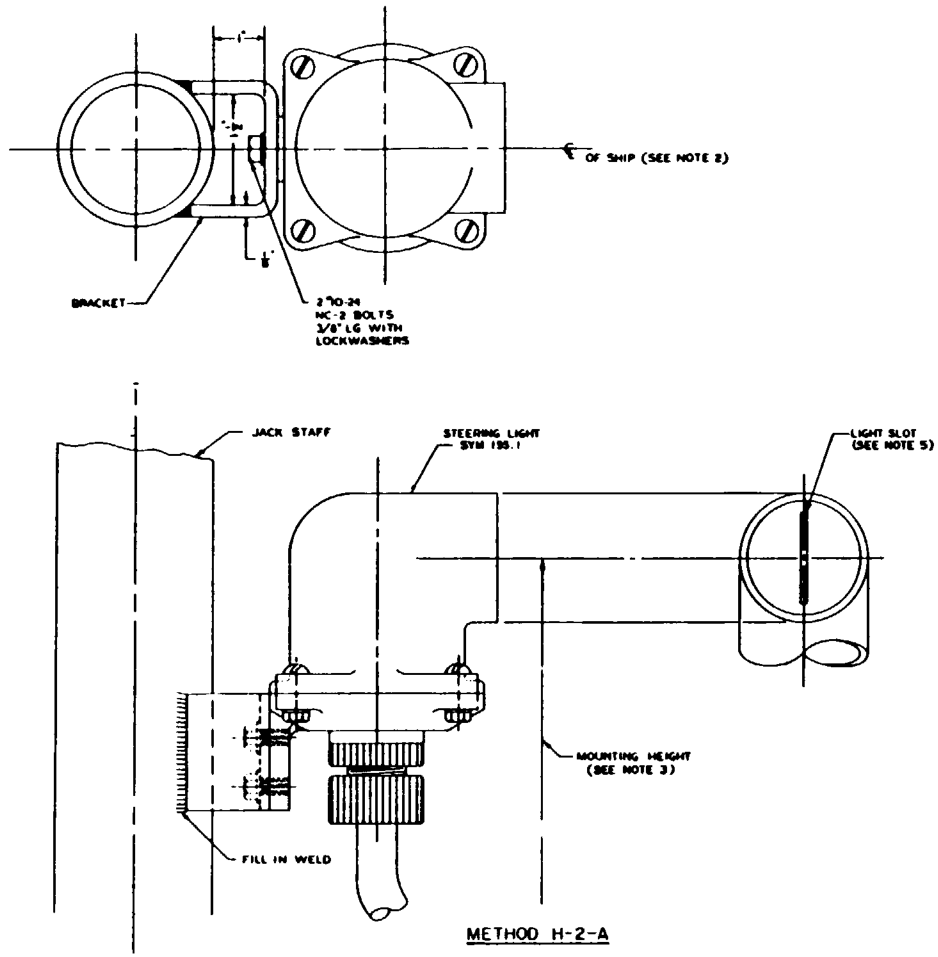
REV —

REVISIONS				
REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
–	FIRST ISSUE			



METHOD H-2-A

NOTES

1 STEERING LIGHT IS NOT REQUIRED FOR NEW CONSTRUCTION. IT MAY BE INSTALLED AT THE OPTION OF THE TYPE COMMANDER TO PROVIDE A GUIDE LIGHT TO ASSIST THE HELMSMAN IN STEERING.

2 THIS LINE TO BE CENTER LINE OF PILOT HOUSE. IF PILOT HOUSE IS NOT ON THE CENTER LINE OF SHIP THIS LINE SHALL BE PARALLEL TO KEEL.

3 HEIGHT FROM DECK TO BE SUCH AS TO PLACE LIGHT AS CLOSELY AS PRACTICABLE ON HORIZON TO VIEW OF SHIPS HELMSMAN.

4 STEERING LIGHT SHALL BE LOCATED ON THE JACKSTAFF OR OTHER STRUCTURE NEAR THE BOW, AND SHALL BE POSITIONED SO AS TO BE VISIBLE TO HELMSMAN IN PILOT HOUSE.

5 STEERING LIGHT (WHITE) SHALL BE SHIELDED ALL AROUND EXCEPT FOR THE NARROW VERTICAL SLOT, AS SHOWN.

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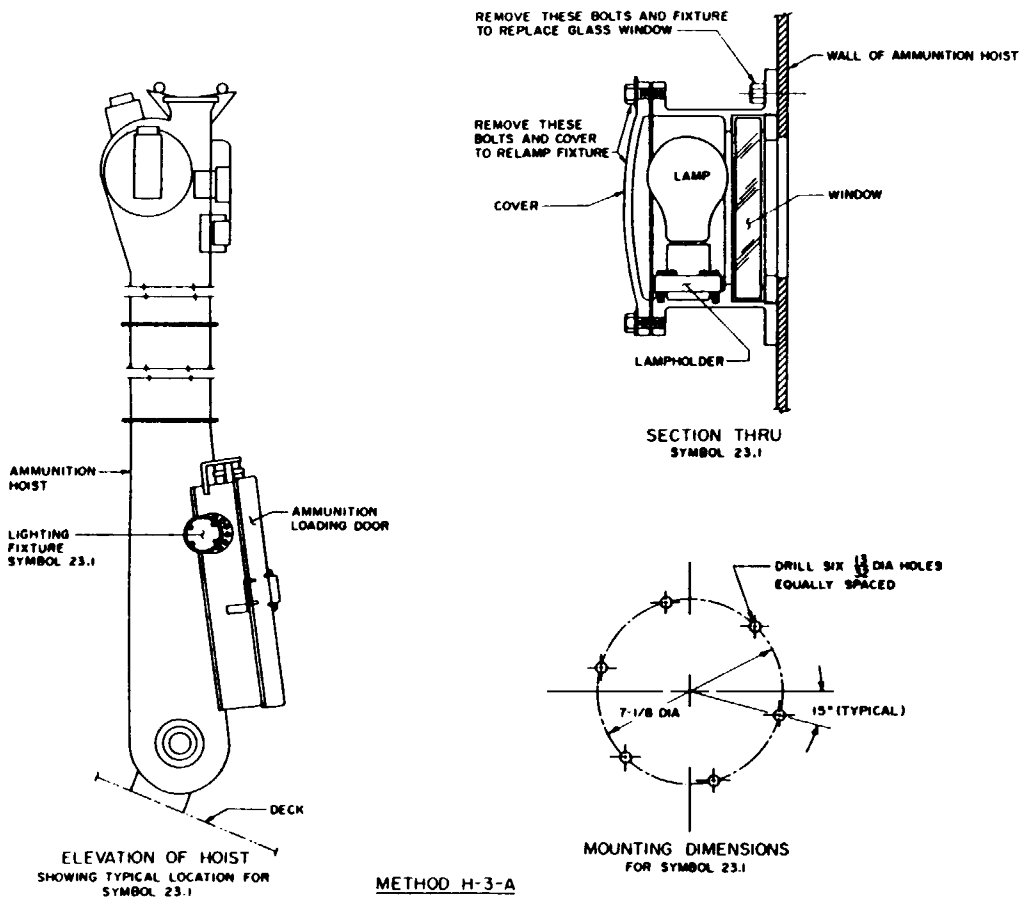
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

INCANDESCENT STEERING LIGHT

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
H	2	53711	803	5184170	–

REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
—	FIRST ISSUE	7/5/74		



METHOD H-3-A

NOTES

1 INSTALL LIGHT SO THAT LAMP WILL BURN WITH BASE (LAMPHOLDER) DOWN.

2 POSITION AND NUMBER OF LIGHTS TO BE INSTALLED SHALL BE AS REQUIRED BY THE DETAIL DRAWINGS FOR THE AMMUNITION HOIST.

3 CONNECT LIGHTS TO COMPARTMENT LIGHTING. COMPARTMENT LIGHTING SWITCH SHALL ALSO OPERATE THE AMMUNITION HOIST LIGHTS.

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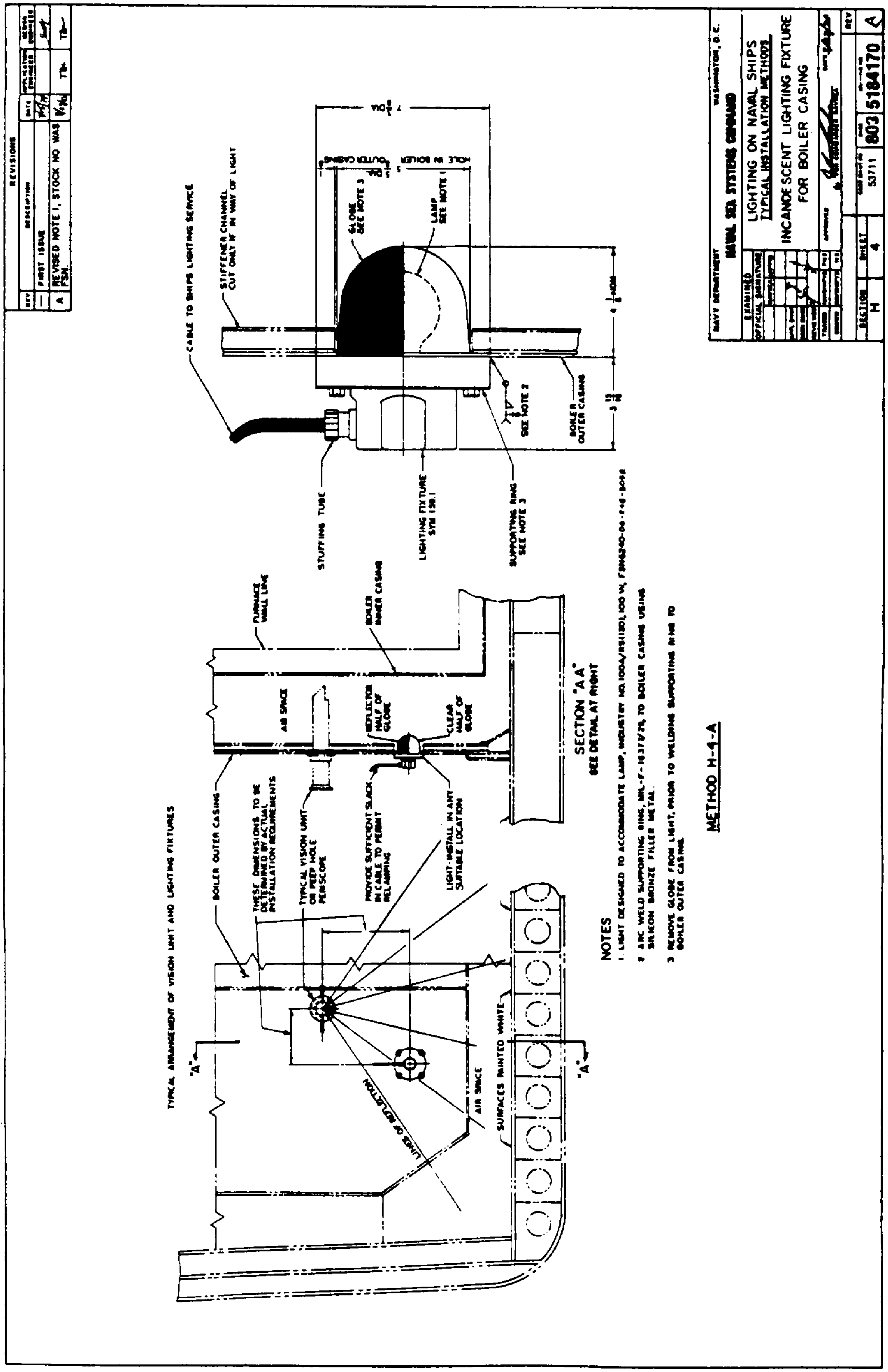
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

INSTALLATION OF AMMUNITION HOIST LIGHT, SYMBOL 23.1

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
H	3	53711	803	5184170	—


REVISIONS
— FIRST ISSUE
A REVISED NOTE 1, STOCK NO WAS FSN.
NAVY DEPARTMENT
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C.
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
INCANDESCENT LIGHTING FIXTURE FOR BOILER CASING
SECTION H
SHEET 4
53711
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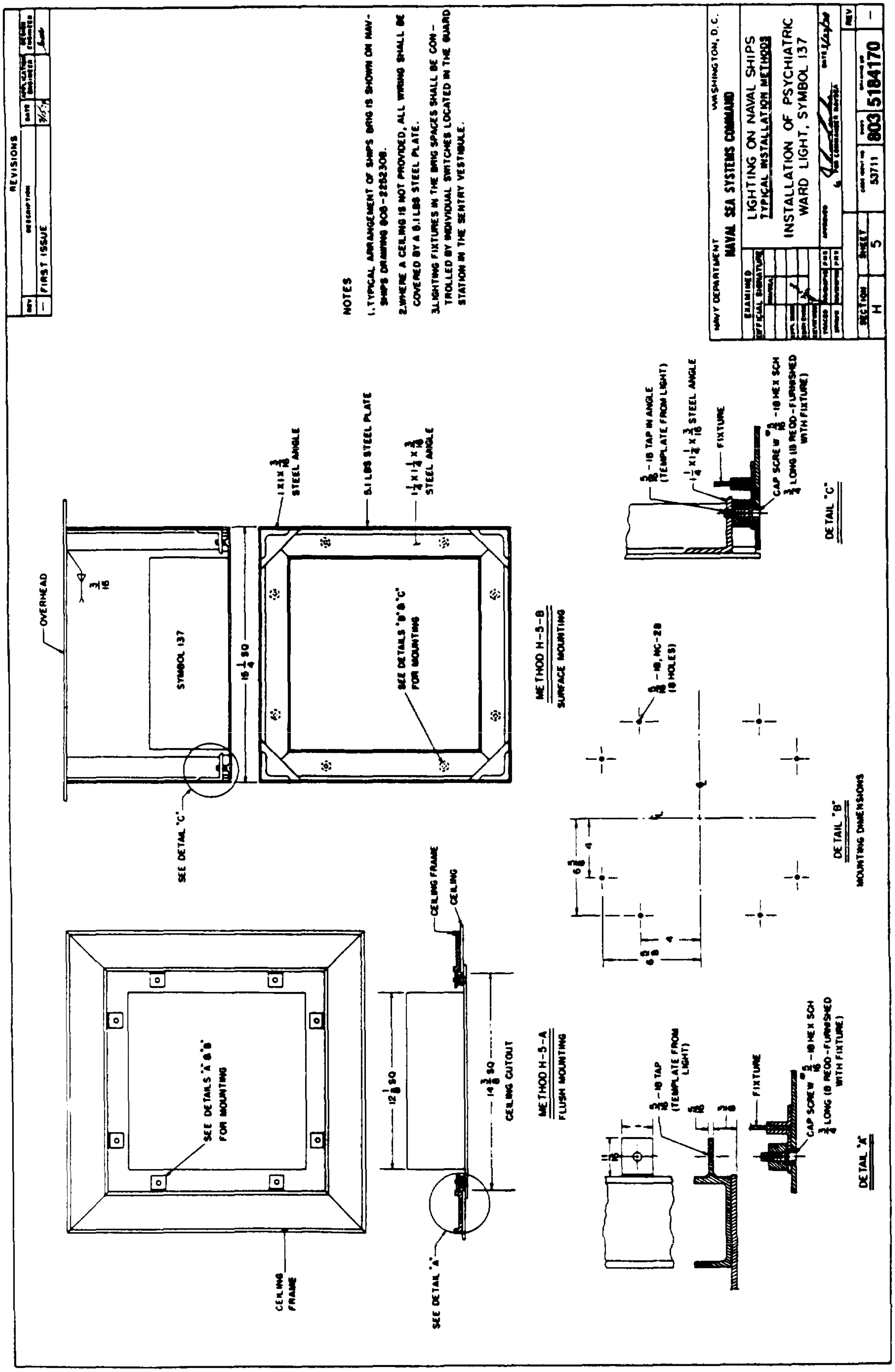
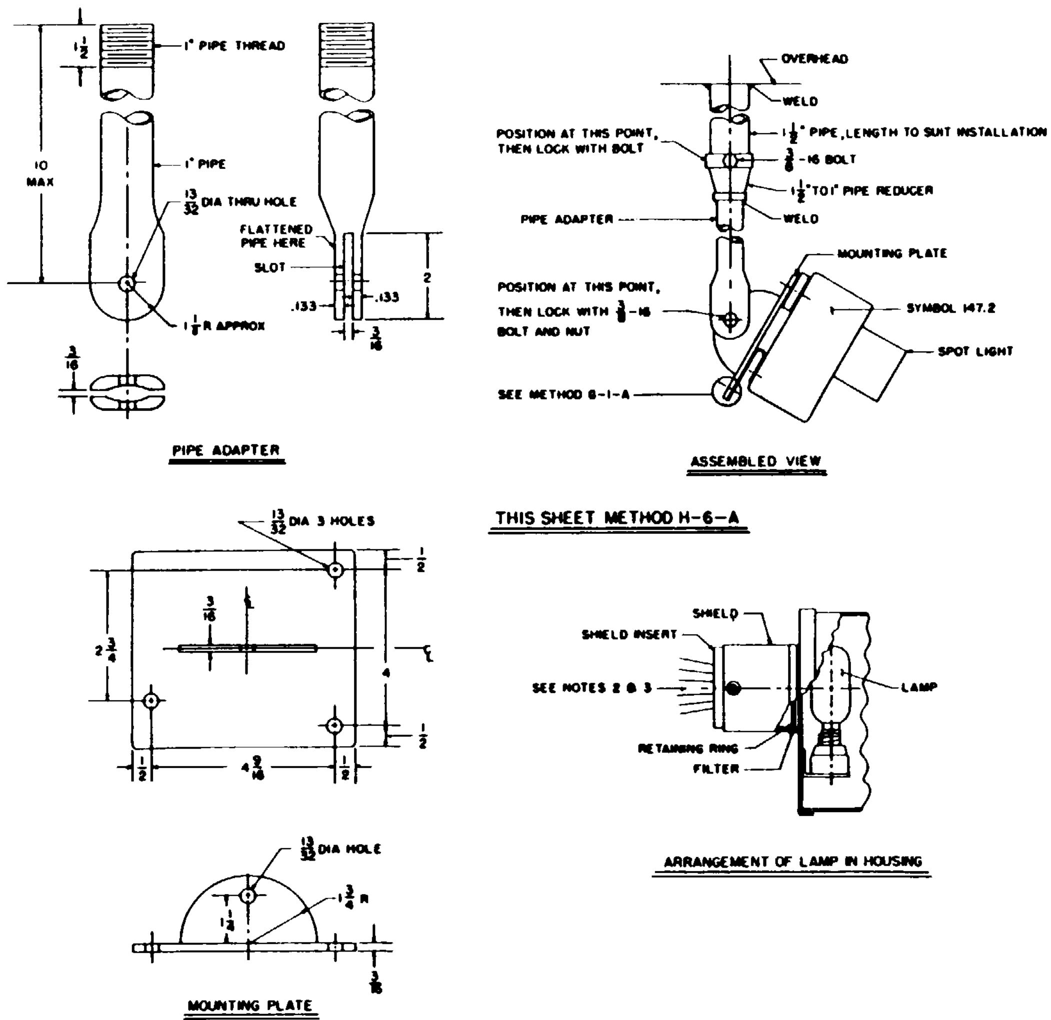
A
CABLE TO SHIPS LIGHTING SERVICE
STIFFENER CHANNEL CUT ONLY IF IN WAY OF LIGHT
GLOBE SEE NOTE 3
LAMP SEE NOTE 1
OUTER CASING
HOLE IN BOILER
STUFFING TUBE
LIGHTING FIXTURE SYM 130.1
SUPPORTING RING SEE NOTE 3
SEE NOTE 2
BOILER OUTER CASING
FURNACE WALL LINE
BOILER INNER CASING
AIR SPACE
REFLECTOR HALF OF GLOBE
CLEAR HALF OF GLOBE
SECTION "A A"
SEE DETAIL AT RIGHT
METHOD H-4-A
TYPICAL ARRANGEMENT OF VISION UNIT AND LIGHTING FIXTURES
BOILER OUTER CASING
THESE DIMENSIONS TO BE DETERMINED BY ACTUAL INSTALLATION REQUIREMENTS
TYPICAL VISION UNIT OR PEEP HOLE PERISCOPE
PROVIDE SUFFICIENT SLACK IN CABLE TO PERMIT RELAMPING
LIGHT-INSTALL IN ANY SUITABLE LOCATION
LINES OF REFLECTION
AIR SPACE
SURFACES PAINTED WHITE
"A"
NOTES
1 LIGHT DESIGNED TO ACCOMMODATE LAMP, INDUSTRY NO.100A/RS(120), 100 W, FSN6240-00-246-3002
2 ARC WELD SUPPORTING RING, MIL-F-18371/24, TO BOILER CASING USING SILICON BRONZE FILLER METAL.
3 REMOVE GLOBE FROM LIGHT, PRIOR TO WELDING SUPPORTING RING TO BOILER OUTER CASING


REVISIONS
REV
DESCRIPTION
DATE
APPLICATION ENGINEER
DESIGN ENGINEER
—
FIRST ISSUE
NOTES
1. TYPICAL ARRANGEMENT OF SHIPS BRIG IS SHOWN ON NAVSHIPS DRAWING 806-2252308.
2. WHERE A CEILING IS NOT PROVIDED, ALL WIRING SHALL BE COVERED BY A 5.1 LBS STEEL PLATE.
3. LIGHTING FIXTURES IN THE BRIG SPACES SHALL BE CONTROLLED BY INDIVIDUAL SWITCHES LOCATED IN THE GUARD STATION IN THE SENTRY VESTIBULE.
NAVY DEPARTMENT
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C.
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
INSTALLATION OF PSYCHIATRIC WARD LIGHT, SYMBOL 137
SECTION
H
SHEET
5
53711
803
5184170
OVERHEAD
SYMBOL 137
15 1/4 SQ
1 X 1 X 3/16 STEEL ANGLE
5.1 LBS STEEL PLATE
1 1/4 X 1 1/4 X 3/16 STEEL ANGLE
SEE DETAILS "B" & "C" FOR MOUNTING
SEE DETAIL "C"
METHOD H-5-B
SURFACE MOUNTING
5/16 - 18 TAP IN ANGLE (TEMPLATE FROM LIGHT)
1 1/4 X 1 1/4 X 3/16 STEEL ANGLE
FIXTURE
CAP SCREW #5/16 - 18 HEX SCH 3/4 LONG (8 REQD-FURNISHED WITH FIXTURE)
DETAIL "C"
5/16 - 18, NC-2B (8 HOLES)
DETAIL "B"
MOUNTING DIMENSIONS
CEILING FRAME
CEILING
SEE DETAILS "A" & "B" FOR MOUNTING
12 1/8 SQ
14 3/8 SQ CEILING CUTOUT
METHOD H-5-A
FLUSH MOUNTING
SEE DETAIL "A"
5/16 - 18 TAP (TEMPLATE FROM LIGHT)
FIXTURE
CAP SCREW #5/16 - 18 HEX SCH 3/4 LONG (8 REQD-FURNISHED WITH FIXTURE)
DETAIL "A"

REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
—	FIRST ISSUE	7/6/71		
A	REVISED STOCK NUMBERS. WAS FSN.			



NOTES

1. SPOT LIGHT, SYMBOL 147.2, IS PROVIDED WITH A RED AND A BLUE FILTER AND IT CAN BE USED FOR EITHER WHITE (NO FILTER), RED, OR BLUE ILLUMINATION.
2. ILLUMINATION COVERAGE CAN BE ADJUSTED BY MOVING THE SHIELD INSERTS IN OR OUT. A FLOOD LIGHT WILL RESULT IF POSITION OF SHIELD INSERT IS REVERSED.
3. ILLUMINATION INTENSITY CAN BE ADJUSTED BY USING ONE OF THE FOLLOWING 120 VOLT LAMPS:

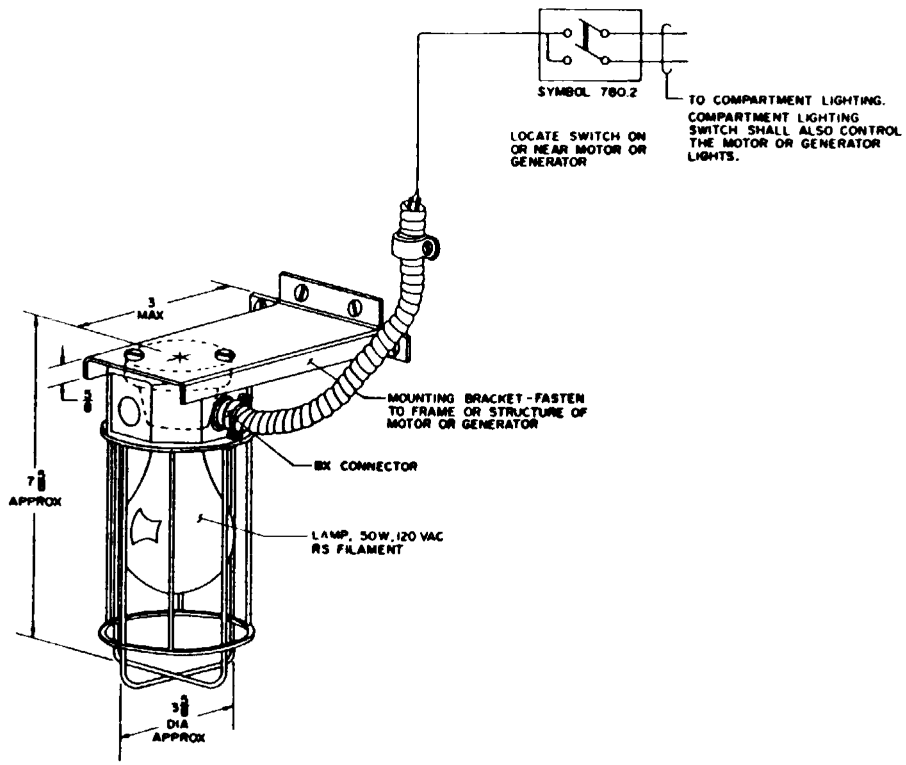
6 WATT, MS15579-4, IND NO. 636, NSN6240-00-143-3049
15 WATT, MS15574-1, IND NO. 15T7C, NSN6240-00-617-1719
25 WATT, MS15646, IND NO. 25T8C, NSN6240-00-143-3067

NAVY DEPARTMENT — WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
INSTALLATION OF SPOT LIGHT
SYMBOL 147.2

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
H	6	53711	803	5184170	A

REVISIONS				
REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
—	FIRST ISSUE			



METHOD H-7-A

NOTES

1 INSTALL FIXTURE IN LOCATION AND QUANTITIES AS REQUIRED BY THE DETAIL DRAWINGS FOR PROPULSION MOTORS AND GENERATORS.

2 SILICONE GASKETS OF ANY KIND ARE NOT PERMITTED IN THIS INSTALLATION.

NAVY DEPARTMENT WASHINGTON, D.C.

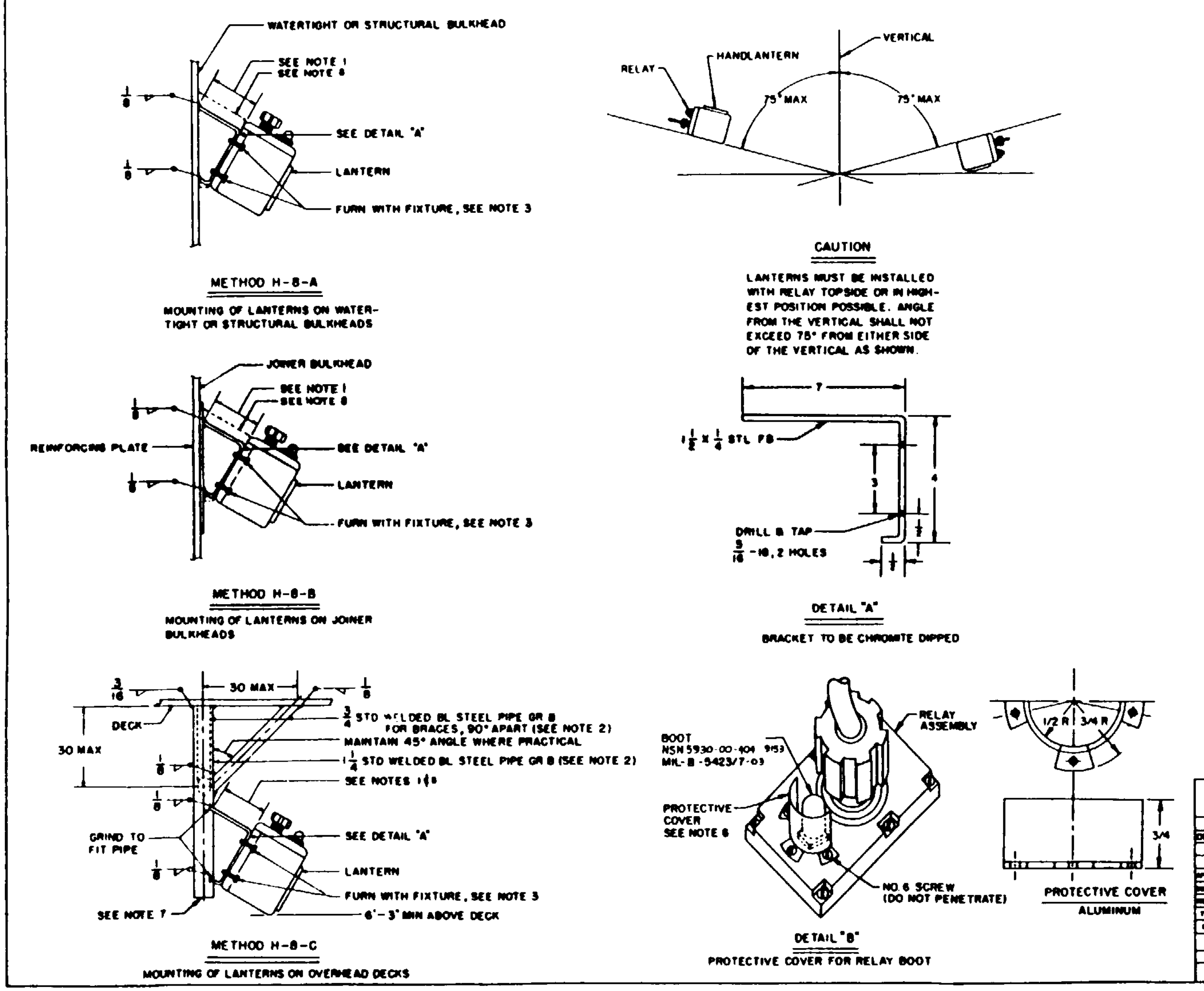
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
LIGHTING FIXTURE FOR PROPULSION MOTORS & GENERATORS
SYM NO 126.3

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
H	7	53711	803	5184170	—

REVISIONS

REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
—	FIRST ISSUE			
A	REVISED NSN OF SW BOOT WAS FSN 9G6230-681-4609. REVISED PART NO OF SW BOOT WAS /7, TYPE B, STYLE 2, SIZE 3.			



CAUTION

LANTERNS MUST BE INSTALLED WITH RELAY TOPSIDE OR IN HIGHEST POSITION POSSIBLE. ANGLE FROM THE VERTICAL SHALL NOT EXCEED 75° FROM EITHER SIDE OF THE VERTICAL AS SHOWN.

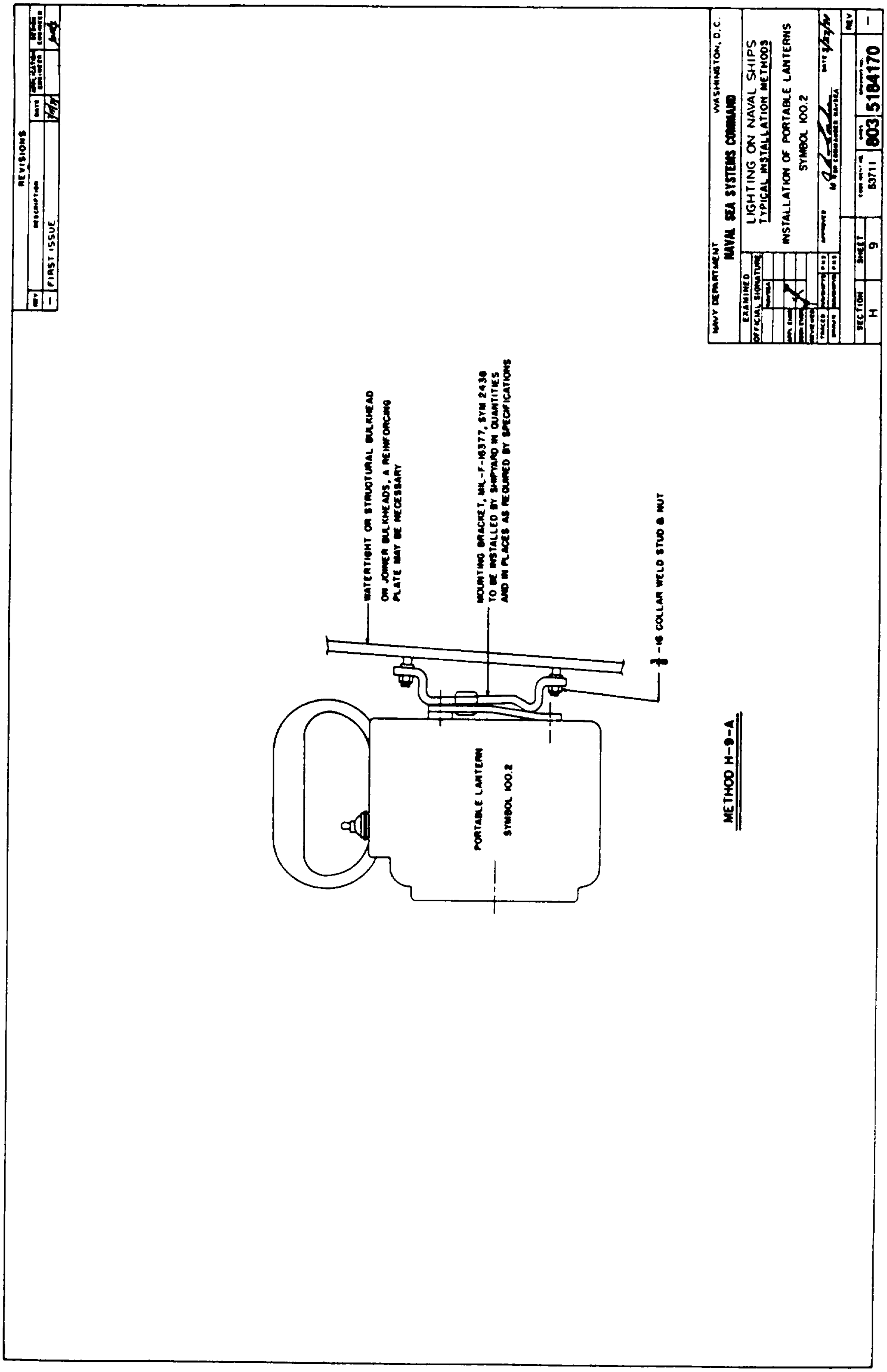
NOTES

1. CUT LONG LEG OF BRACKET TO SUIT DESIRED ANGLE (NOT TO EXCEED 75°) AND MAINTAIN 1/2" LENGTH ON THE SHORT LEG
2. MAXIMUM LENGTH IS 60" FOR ALL PIPE HANGERS. FOR PIPE HANGERS OVER 30" IN LENGTH, 2 BRACES MUST BE INSTALLED IN ACCORDANCE WITH THIS METHOD.
3. INSTALLING ACTIVITY SHALL MAKE LANTERN WATERTIGHT AT MOUNTING BOLTS.
4. COLOR OF LANTERN LIGHT MAY BE CHANGED AS REQUIRED BY THE INSTALLATION OF FILTERS IN ACCORDANCE WITH MIL-F-16377/43.
5. WHEN PLASTIC CASE LANTERNS ARE REPLACEMENTS FOR METAL CASE LANTERNS, THE RELAY BOXES MAY BE CONVERTED TO SERVE AS TERMINAL BOXES.
6. A PROTECTIVE COVER FOR RELAY BOOTS SHALL BE INSTALLED ON ALL RELAY LANTERNS SUBJECT TO FREQUENT TESTS BY SHIPS CREW WHILE WAITING ON MESS OR PAY LINES.
7. PLUG WITH PLASTIC SEALER WHEN LOCATED IN FOOD HANDLING SPACES.
8. BRACKET SHALL BE BOXED-IN IN AREAS, SUCH AS LIVING, COMMISSARY, MESSING AND MEDICAL SPACES, WHERE SHEATHING AND DECORATIVE TREATMENT ARE SPECIFIED.

NAVY DEPARTMENT — WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
INSTALLATION OF RELAY LANTERNS
SYMBOLS 101.2, 102.2, & 108

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
H	8	53711	803	5184170	A


REVISIONS
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DESCRIPTION
DATE
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FIRST ISSUE
NAVY DEPARTMENT
WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
INSTALLATION OF PORTABLE LANTERNS
SYMBOL 100.2
SECTION
H
SHEET
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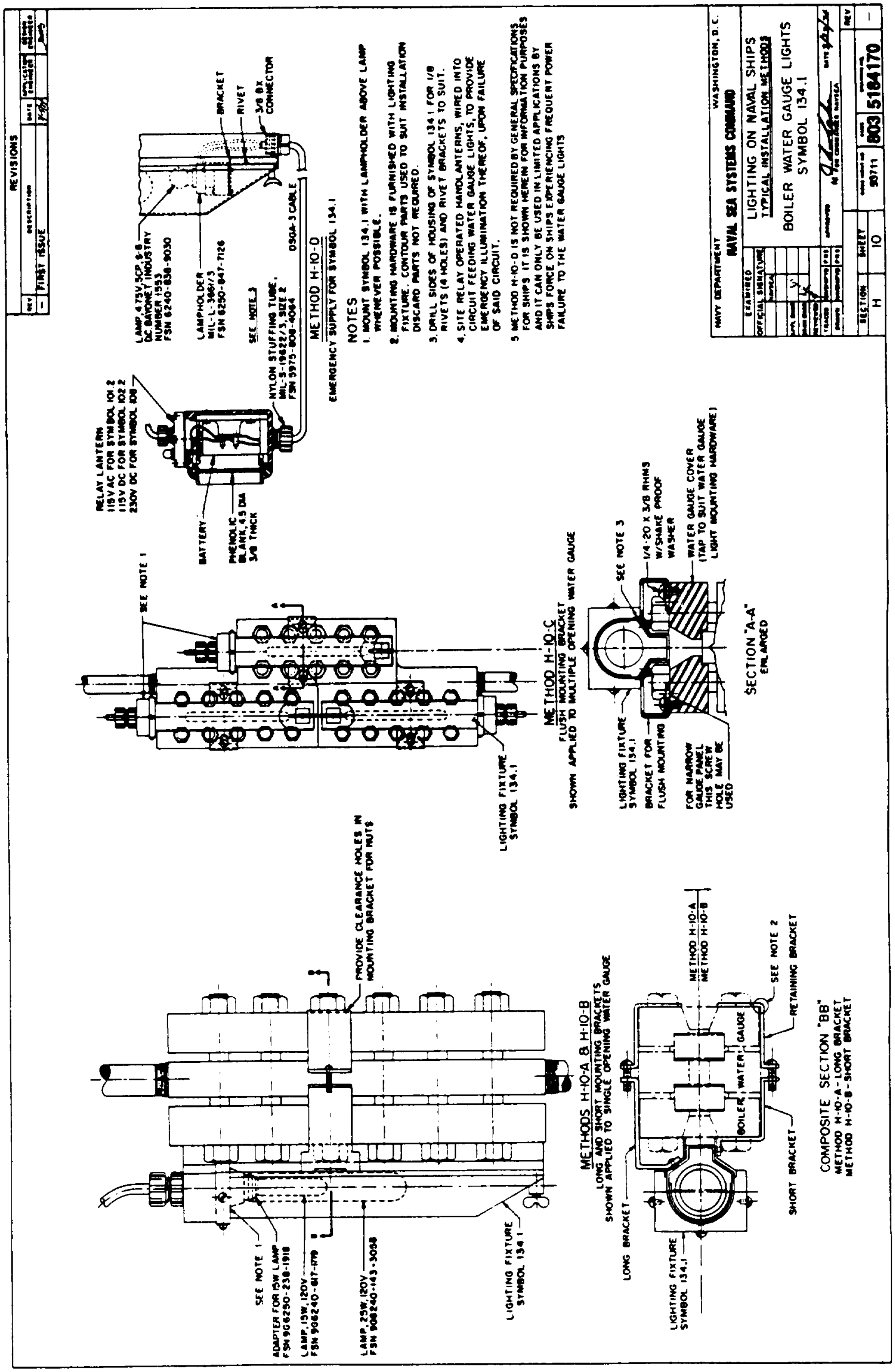
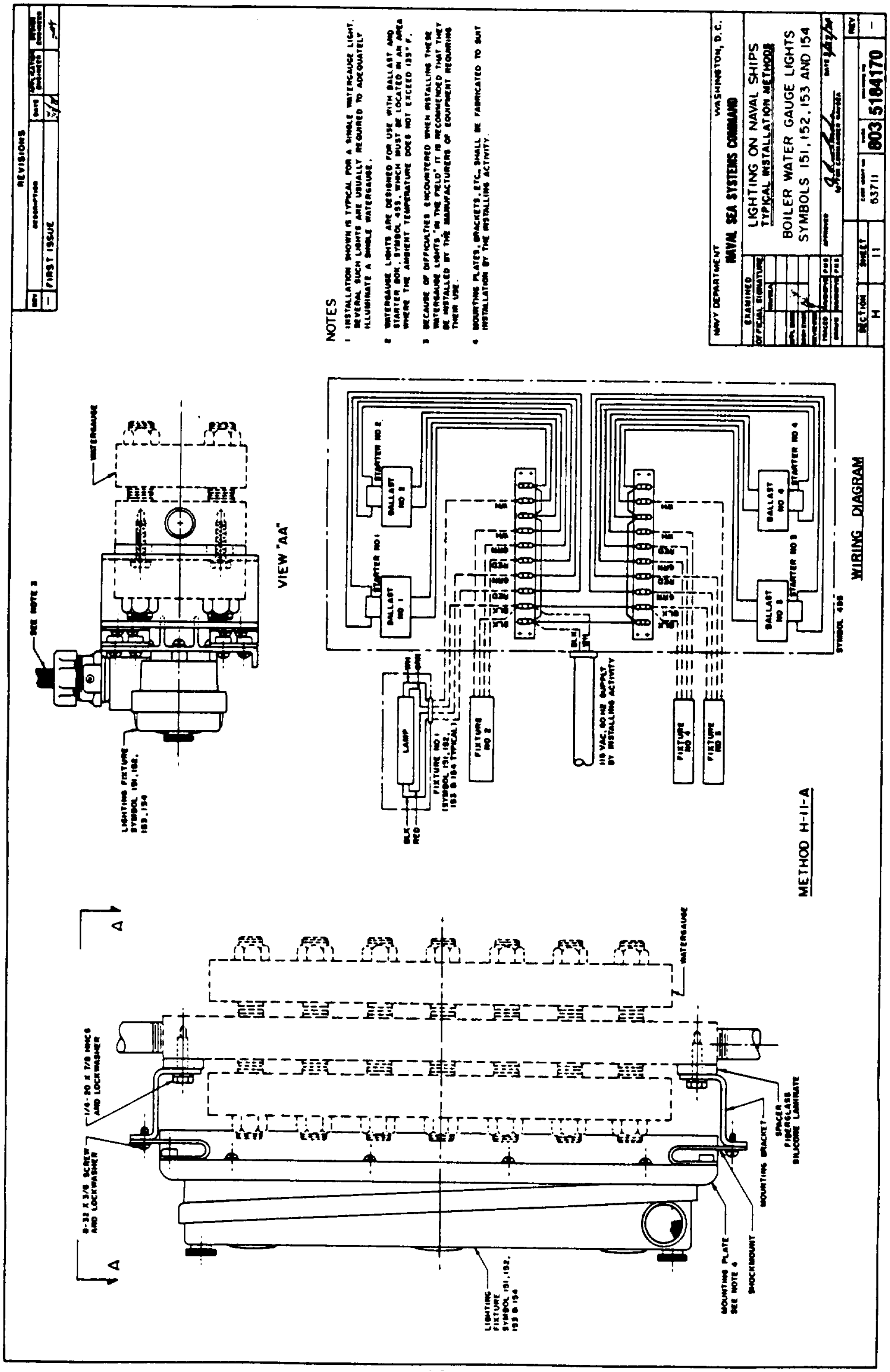
5184170
REV
-
WATERTIGHT OR STRUCTURAL BULKHEAD
OR JOINER BULKHEADS, A REINFORCING
PLATE MAY BE NECESSARY
MOUNTING BRACKET, MIL-F-16377, SYM 2436
TO BE INSTALLED BY SHIPYARD IN QUANTITIES
AND IN PLACES AS REQUIRED BY SPECIFICATIONS
-16 COLLAR WELD STUD & NUT
PORTABLE LANTERN
SYMBOL 100.2
METHOD H-9-A


REVISIONS
REV | DESCRIPTION | DATE | APPLICATION ENGINEER | DESIGN ENGINEER
– FIRST ISSUE
SEE NOTE 1
ADAPTER FOR 15W LAMP FSN 9G6250-238-1918
LAMP, 15W, 120V FSN 9G6240-617-1719
LAMP, 25W, 120V FSN 9G6240-143-3058
LIGHTING FIXTURE SYMBOL 134.1
PROVIDE CLEARANCE HOLES IN MOUNTING BRACKET FOR NUTS
METHODS H-10-A & H-10-B
LONG AND SHORT MOUNTING BRACKETS SHOWN APPLIED TO SINGLE OPENING WATER GAUGE
LONG BRACKET
LIGHTING FIXTURE SYMBOL 134.1
METHOD H-10-A
METHOD H-10-B
BOILER WATER GAUGE
SEE NOTE 2
SHORT BRACKET
RETAINING BRACKET
COMPOSITE SECTION "BB"
METHOD H-10-A - LONG BRACKET
METHOD H-10-B - SHORT BRACKET
SEE NOTE 1
LIGHTING FIXTURE SYMBOL 134.1
METHOD H-10-C
FLUSH MOUNTING BRACKET SHOWN APPLIED TO MULTIPLE OPENING WATER GAUGE
LIGHTING FIXTURE SYMBOL 134.1
BRACKET FOR FLUSH MOUNTING
FOR NARROW GAUGE PANEL THIS SCREW HOLE MAY BE USED
SEE NOTE 3
1/4-20 X 3/8 RHMS W/SHAKE PROOF WASHER
WATER GAUGE COVER (TAP TO SUIT WATER GAUGE LIGHT MOUNTING HARDWARE)
SECTION "A-A" ENLARGED
RELAY LANTERN
115V AC FOR SYMBOL 101.2
115V DC FOR SYMBOL 102.2
230V DC FOR SYMBOL 108
BATTERY
PHENOLIC BLANK, 4.5 DIA 3/8 THICK
LAMP, 4.75V, 5CP, S-8 DC BAYONET INDUSTRY NUMBER 1553 FSN 6240-838-9030
LAMPHOLDER MIL-L-3661/3 FSN 6250-847-7126
SEE NOTE 3
NYLON STUFFING TUBE, MIL-S-19622/3, SIZE 2 FSN 5975-808-4064
DSGA-3 CABLE
BRACKET
RIVET
3/8 BX CONNECTOR
METHOD H-10-D
EMERGENCY SUPPLY FOR SYMBOL 134.1
NOTES
1. MOUNT SYMBOL 134.1 WITH LAMPHOLDER ABOVE LAMP WHENEVER POSSIBLE.
2. MOUNTING HARDWARE IS FURNISHED WITH LIGHTING FIXTURE. CONTOUR PARTS USED TO SUIT INSTALLATION DISCARD PARTS NOT REQUIRED.
3. DRILL SIDES OF HOUSING OF SYMBOL 134.1 FOR 1/8 RIVETS (4 HOLES) AND RIVET BRACKETS TO SUIT.
4. SITE RELAY OPERATED HANDLANTERNS, WIRED INTO CIRCUIT FEEDING WATER GAUGE LIGHTS, TO PROVIDE EMERGENCY ILLUMINATION THEREOF, UPON FAILURE OF SAID CIRCUIT.
5. METHOD H-10-D IS NOT REQUIRED BY GENERAL SPECIFICATIONS FOR SHIPS. IT IS SHOWN HEREIN FOR INFORMATION PURPOSES AND IT CAN ONLY BE USED IN LIMITED APPLICATIONS BY SHIPS FORCE ON SHIPS EXPERIENCING FREQUENT POWER FAILURE TO THE WATER GAUGE LIGHTS
NAVY DEPARTMENT
WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
BOILER WATER GAUGE LIGHTS
SYMBOL 134.1
SECTION H
SHEET 10
53711
803
5184170
REV –


REVISIONS
— FIRST ISSUE
8-32 X 3/8 SCREW AND LOCKWASHER
1/4-20 X 7/8 HHCS AND LOCKWASHER
A
A
LIGHTING FIXTURE SYMBOL 151, 152, 153 & 154
MOUNTING PLATE SEE NOTE 4
SHOCKMOUNT
MOUNTING BRACKET
SPACER FIBERGLASS SILICONE LAMINATE
WATERGAUGE
SEE NOTE 3
LIGHTING FIXTURE SYMBOL 151, 152, 153, 154
WATERGAUGE
VIEW "AA"
LAMP
BLK
RED
WH
GRN
FIXTURE NO 1 (SYMBOL 151, 152, 153 & 154 TYPICAL)
FIXTURE NO 2
FIXTURE NO 4
FIXTURE NO 5
115 VAC, 60 HZ SUPPLY BY INSTALLING ACTIVITY
BALLAST NO 1
BALLAST NO 2
BALLAST NO 3
BALLAST NO 4
STARTER NO 1
STARTER NO 2
STARTER NO 3
STARTER NO 4
SYMBOL 495
WIRING DIAGRAM
METHOD H-11-A
NOTES
1 INSTALLATION SHOWN IS TYPICAL FOR A SINGLE WATERGAUGE LIGHT. SEVERAL SUCH LIGHTS ARE USUALLY REQUIRED TO ADEQUATELY ILLUMINATE A SINGLE WATERGAUGE.
2 WATERGAUGE LIGHTS ARE DESIGNED FOR USE WITH BALLAST AND STARTER BOX, SYMBOL 495, WHICH MUST BE LOCATED IN AN AREA WHERE THE AMBIENT TEMPERATURE DOES NOT EXCEED 135° F.
3 BECAUSE OF DIFFICULTIES ENCOUNTERED WHEN INSTALLING THESE WATERGAUGE LIGHTS "IN THE FIELD" IT IS RECOMMENDED THAT THEY BE INSTALLED BY THE MANUFACTURERS OF EQUIPMENT REQUIRING THEIR USE.
4 MOUNTING PLATES, BRACKETS, ETC., SHALL BE FABRICATED TO SUIT INSTALLATION BY THE INSTALLING ACTIVITY.
NAVY DEPARTMENT
WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
EXAMINED
OFFICIAL SIGNATURE
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
BOILER WATER GAUGE LIGHTS
SYMBOLS 151, 152, 153 AND 154
SECTION H
SHEET 11
53711
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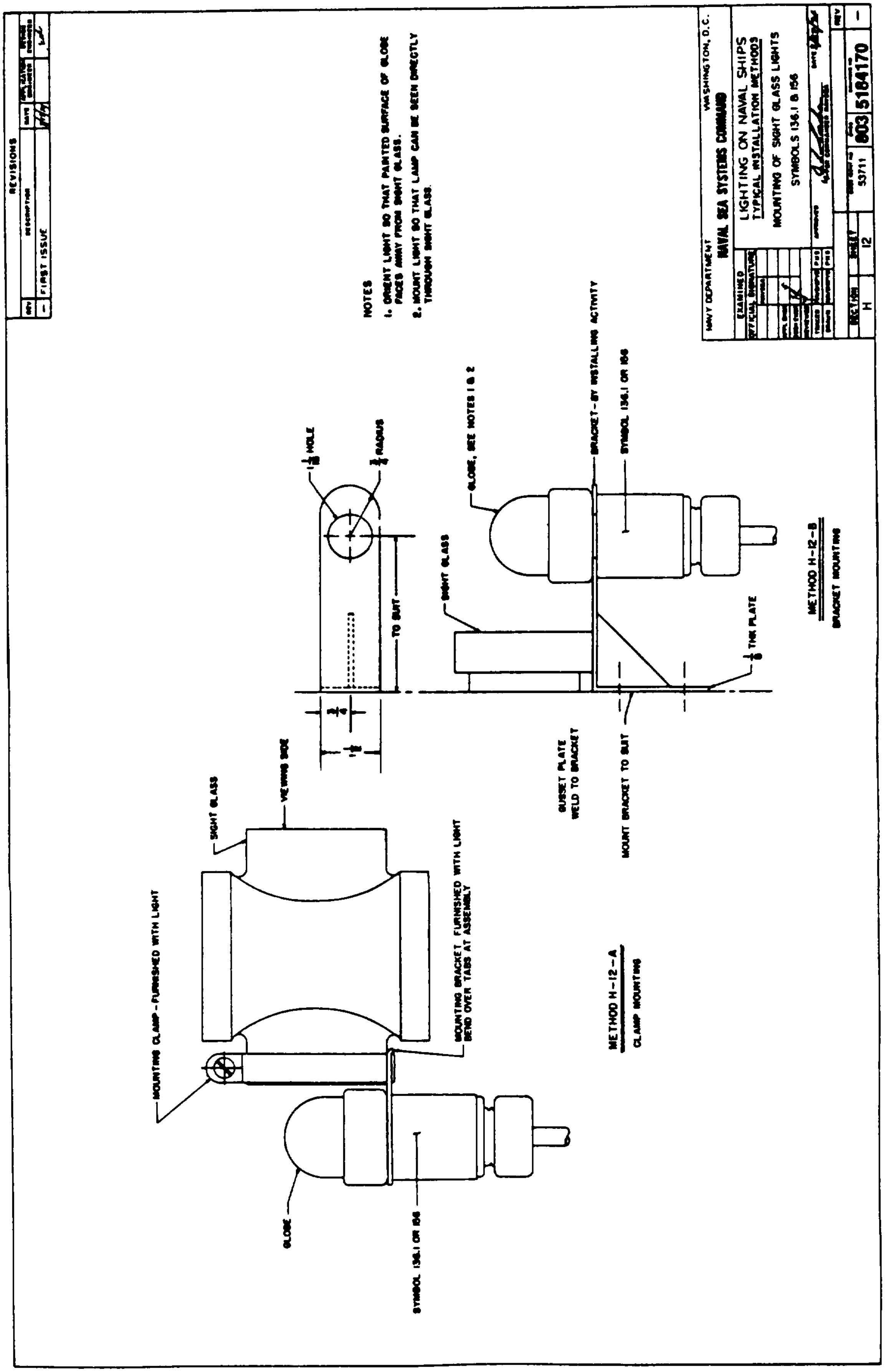
REV —


REVISIONS
FIRST ISSUE
NOTES
1. ORIENT LIGHT SO THAT PAINTED SURFACE OF GLOBE FACES AWAY FROM SIGHT GLASS.
2. MOUNT LIGHT SO THAT LAMP CAN BE SEEN DIRECTLY THROUGH SIGHT GLASS.
NAVY DEPARTMENT
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C.
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
MOUNTING OF SIGHT GLASS LIGHTS
SYMBOLS 136.1 & 156
53711
803
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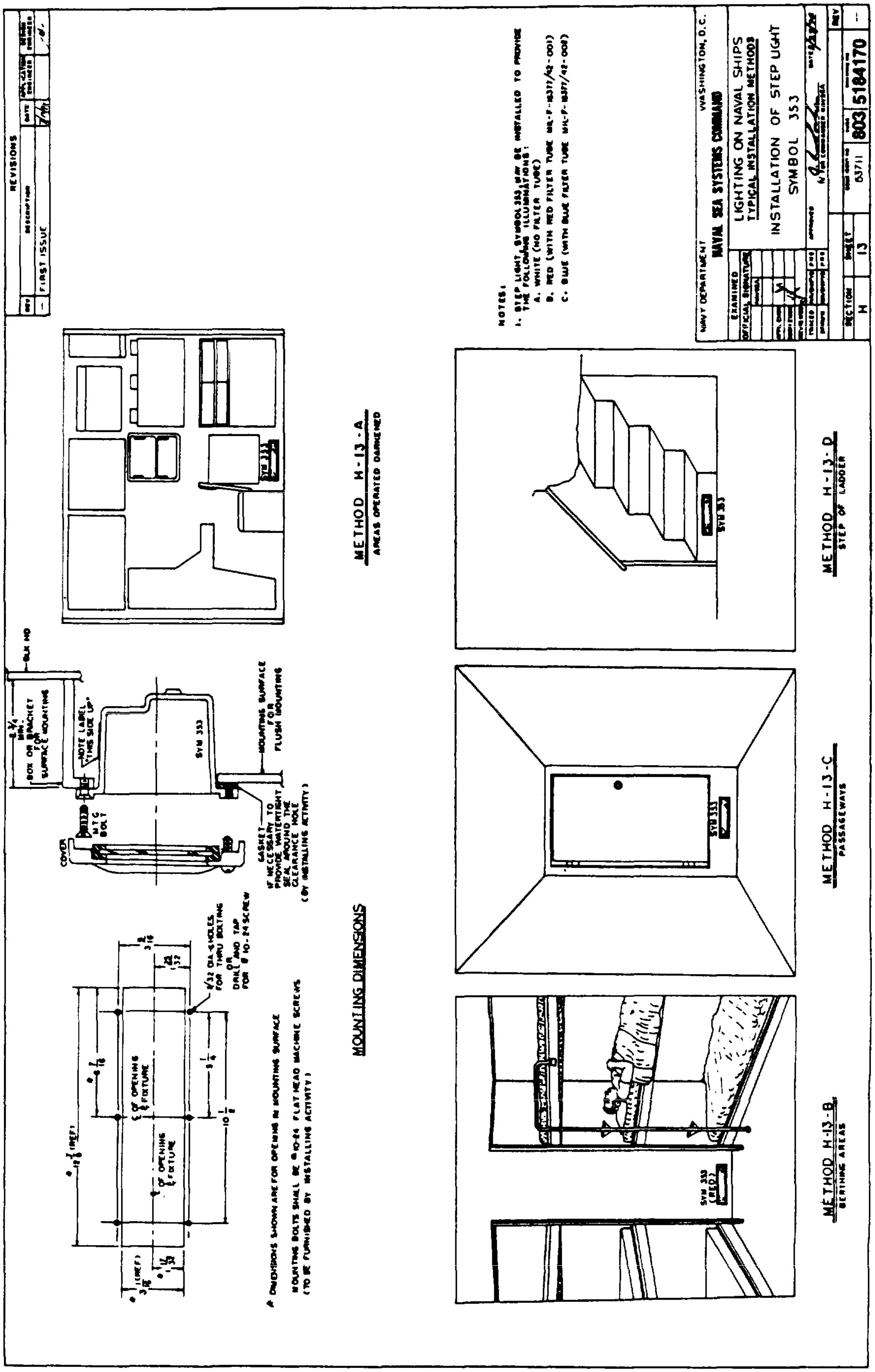
H
12
MOUNTING CLAMP - FURNISHED WITH LIGHT
SIGHT GLASS
VIEWING SIDE
MOUNTING BRACKET FURNISHED WITH LIGHT BEND OVER TABS AT ASSEMBLY
GLOBE
SYMBOL 136.1 OR 156
METHOD H-12-A
CLAMP MOUNTING
HOLE
RADIUS
TO SUIT
SIGHT GLASS
GLOBE, SEE NOTES 1 & 2
BRACKET - BY INSTALLING ACTIVITY
SYMBOL 136.1 OR 156
THK PLATE
GUSSET PLATE WELD TO BRACKET
MOUNT BRACKET TO SUIT
METHOD H-12-B
BRACKET MOUNTING


REVISIONS
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MOUNTING DIMENSIONS
OF OPENING
FIXTURE
COVER
MTG BOLT
NOTE LABEL "THIS SIDE UP"
BOX OR BRACKET FOR SURFACE MOUNTING
BLK HD
SYM 353
GASKET IF NECESSARY TO PROVIDE WATERTIGHT SEAL AROUND THE CLEARANCE HOLE (BY INSTALLING ACTIVITY)
MOUNTING SURFACE FOR FLUSH MOUNTING
FOR THRU BOLTING
OR
DRILL AND TAP
FOR # 10-24 SCREW
DIMENSIONS SHOWN ARE FOR OPENING IN MOUNTING SURFACE
MOUNTING BOLTS SHALL BE #10-24 FLAT HEAD MACHINE SCREWS (TO BE FURNISHED BY INSTALLING ACTIVITY)
METHOD H-13-A
AREAS OPERATED DARKENED
METHOD H-13-B
BERTHING AREAS
SYM 353 (RED)
METHOD H-13-C
PASSAGEWAYS
METHOD H-13-D
STEP OF LADDER
NOTES:
1. STEP LIGHT, SYMBOL 353, MAY BE INSTALLED TO PROVIDE THE FOLLOWING ILLUMINATIONS:
A. WHITE (NO FILTER TUBE)
B. RED (WITH RED FILTER TUBE MIL-F-16377/42-001)
C. BLUE (WITH BLUE FILTER TUBE MIL-F-16377/42-002)
NAVY DEPARTMENT
WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
EXAMINED
OFFICIAL SIGNATURE
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
INSTALLATION OF STEP LIGHT
SYMBOL 353
APPROVED
SECTION
H
SHEET
13
53711
803
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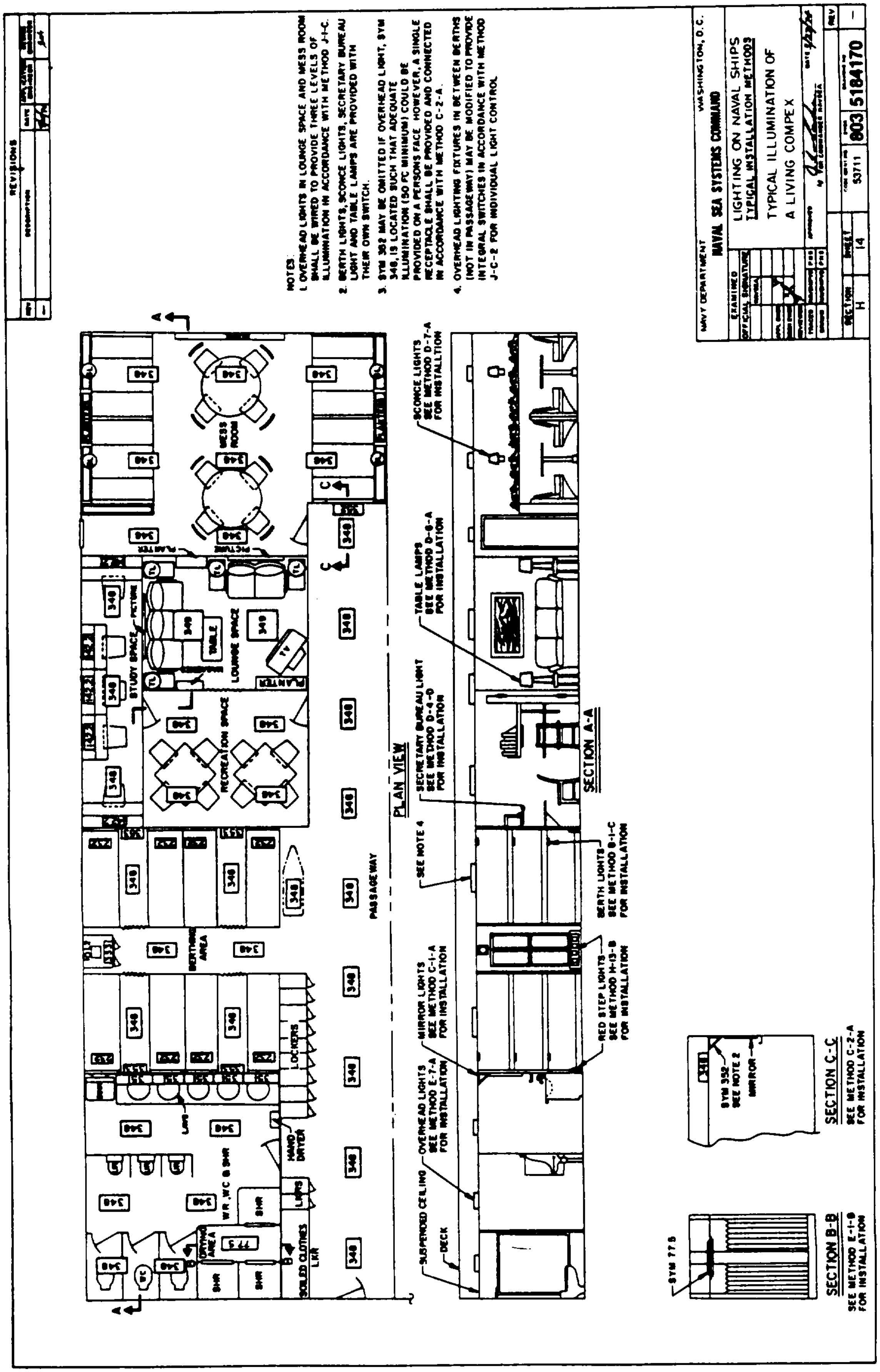
REVISIONS
NOTES:
1. OVERHEAD LIGHTS IN LOUNGE SPACE AND MESS ROOM SHALL BE WIRED TO PROVIDE THREE LEVELS OF ILLUMINATION IN ACCORDANCE WITH METHOD J-1-C.
2. BERTH LIGHTS, SCONCE LIGHTS, SECRETARY BUREAU LIGHT AND TABLE LAMPS ARE PROVIDED WITH THEIR OWN SWITCH.
3. SYM 352 MAY BE OMITTED IF OVERHEAD LIGHT, SYM 348, IS LOCATED SUCH THAT ADEQUATE ILLUMINATION (50 FC MINIMUM) COULD BE PROVIDED ON A PERSONS FACE. HOWEVER, A SINGLE RECEPTACLE SHALL BE PROVIDED AND CONNECTED IN ACCORDANCE WITH METHOD C-2-A.
4. OVERHEAD LIGHTING FIXTURES IN BETWEEN BERTHS (NOT IN PASSAGEWAY) MAY BE MODIFIED TO PROVIDE INTEGRAL SWITCHES IN ACCORDANCE WITH METHOD J-C-2 FOR INDIVIDUAL LIGHT CONTROL.
PLAN VIEW
MESS ROOM
LOUNGE SPACE
STUDY SPACE
RECREATION SPACE
BERTHING AREA
PASSAGEWAY
LOCKERS
WR, WC & SHR
SOILED CLOTHES LKR
HAND DRYER
DRYING AREA
SECTION A-A
SUSPENDED CEILING
DECK
OVERHEAD LIGHTS SEE METHOD E-7-A FOR INSTALLATION
MIRROR LIGHTS SEE METHOD C-1-A FOR INSTALLATION
SEE NOTE 4
SECRETARY BUREAU LIGHT SEE METHOD D-4-D FOR INSTALLATION
TABLE LAMPS SEE METHOD D-6-A FOR INSTALLATION
SCONCE LIGHTS SEE METHOD D-7-A FOR INSTALLTION
RED STEP LIGHTS SEE METHOD H-13-B FOR INSTALLATION
BERTH LIGHTS SEE METHOD B-1-C FOR INSTALLATION
SYM 77.5
SECTION B-B
SEE METHOD E-1-B FOR INSTALLATION
SYM 352 SEE NOTE 2
MIRROR
SECTION C-C
SEE METHOD C-2-A FOR INSTALLATION
NAVY DEPARTMENT
WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
TYPICAL ILLUMINATION OF
A LIVING COMPEX
SECTION H
SHEET 14
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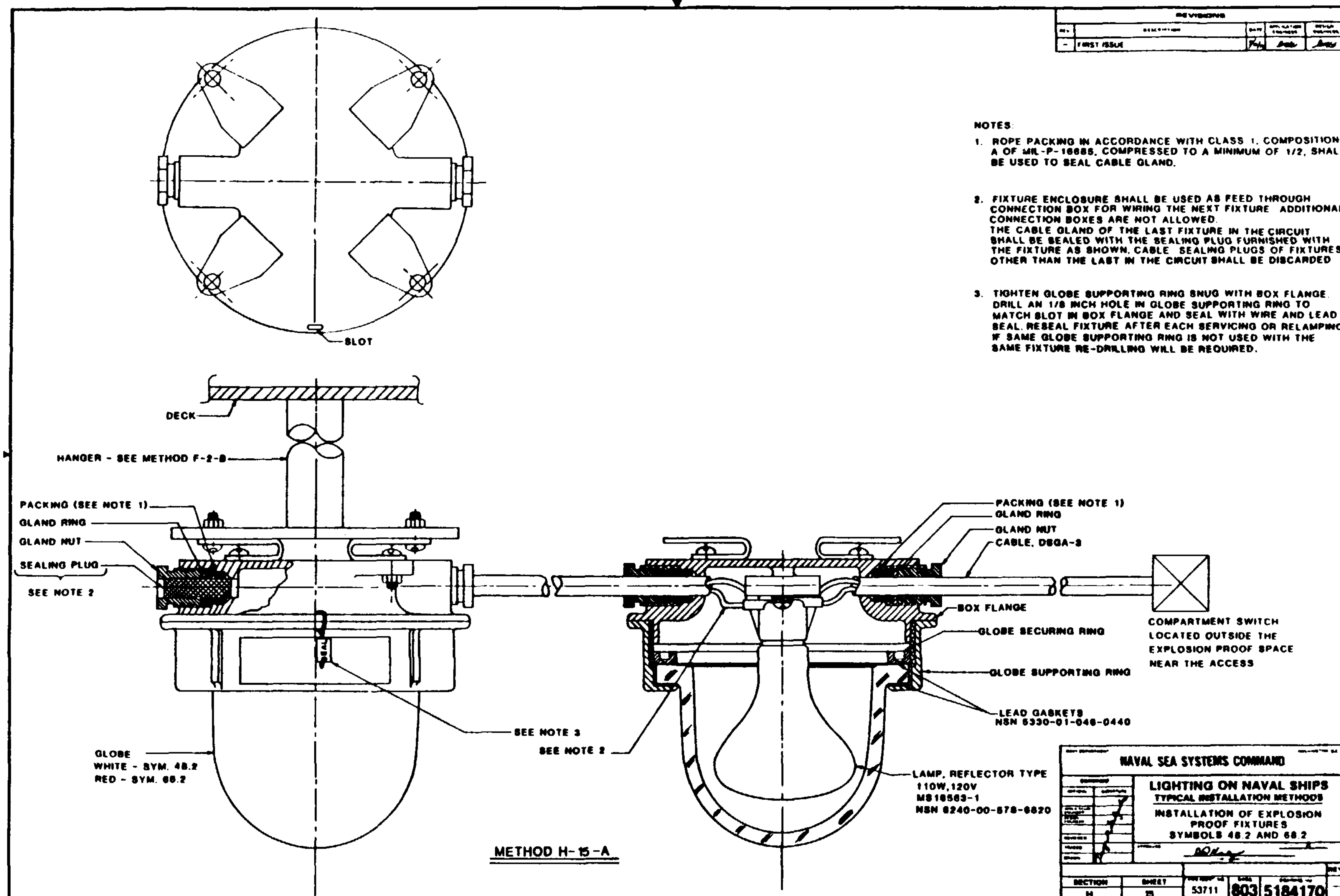
REVISIONS
FIRST ISSUE
NOTES:
1. ROPE PACKING IN ACCORDANCE WITH CLASS 1, COMPOSITION A OF MIL-P-16685, COMPRESSED TO A MINIMUM OF 1/2, SHALL BE USED TO SEAL CABLE GLAND.
2. FIXTURE ENCLOSURE SHALL BE USED AS FEED THROUGH CONNECTION BOX FOR WIRING THE NEXT FIXTURE. ADDITIONAL CONNECTION BOXES ARE NOT ALLOWED.
THE CABLE GLAND OF THE LAST FIXTURE IN THE CIRCUIT SHALL BE SEALED WITH THE SEALING PLUG FURNISHED WITH THE FIXTURE AS SHOWN. CABLE SEALING PLUGS OF FIXTURES OTHER THAN THE LAST IN THE CIRCUIT SHALL BE DISCARDED.
3. TIGHTEN GLOBE SUPPORTING RING SNUG WITH BOX FLANGE. DRILL AN 1/8 INCH HOLE IN GLOBE SUPPORTING RING TO MATCH SLOT IN BOX FLANGE AND SEAL WITH WIRE AND LEAD SEAL. RESEAL FIXTURE AFTER EACH SERVICING OR RELAMPING. IF SAME GLOBE SUPPORTING RING IS NOT USED WITH THE SAME FIXTURE RE-DRILLING WILL BE REQUIRED.
SLOT
DECK
HANGER - SEE METHOD F-2-B
PACKING (SEE NOTE 1)
GLAND RING
GLAND NUT
SEALING PLUG
SEE NOTE 2
SEAL
SEE NOTE 3
SEE NOTE 2
GLOBE
WHITE - SYM. 48.2
RED - SYM. 68.2
METHOD H-15-A
PACKING (SEE NOTE 1)
GLAND RING
GLAND NUT
CABLE, DSGA-3
BOX FLANGE
GLOBE SECURING RING
GLOBE SUPPORTING RING
LEAD GASKETS
NSN 5330-01-046-0440
COMPARTMENT SWITCH
LOCATED OUTSIDE THE
EXPLOSION PROOF SPACE
NEAR THE ACCESS
LAMP, REFLECTOR TYPE
110W,120V
MS18563-1
NSN 6240-00-578-6820
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
INSTALLATION OF EXPLOSION
PROOF FIXTURES
SYMBOLS 48.2 AND 68.2
SECTION
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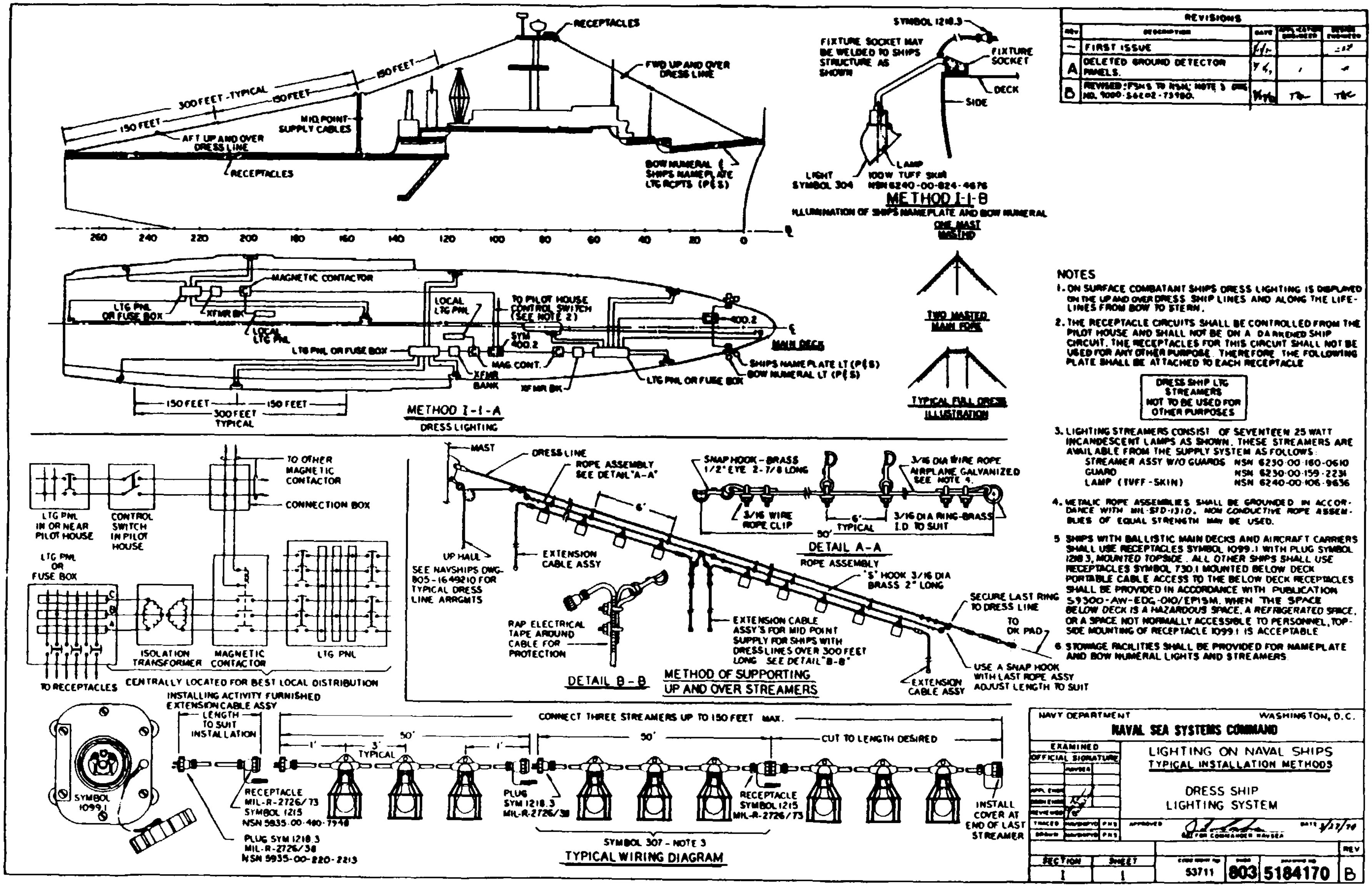
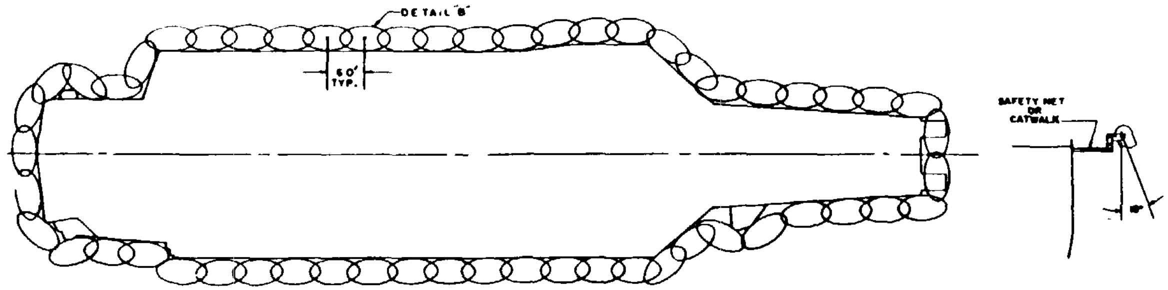
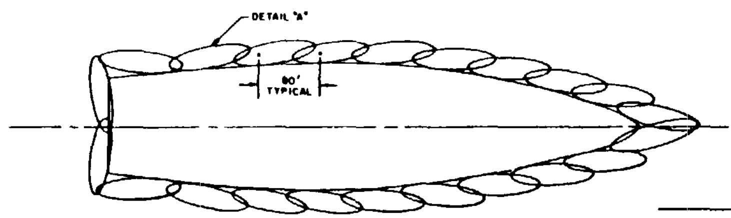

REVISIONS
— FIRST ISSUE
A DELETED GROUND DETECTOR PANELS.
B REVISED: FSN'S TO NSN; NOTE 5 DWG NO. 9000-S6202-73980.
RECEPTACLES
FWD UP AND OVER DRESS LINE
300 FEET -TYPICAL
150 FEET
MID POINT SUPPLY CABLES
AFT UP AND OVER DRESS LINE
BOW NUMERAL & SHIPS NAMEPLATE LTG RCPTS (P&S)
SYMBOL 1218.3
FIXTURE SOCKET MAY BE WELDED TO SHIPS STRUCTURE AS SHOWN
FIXTURE SOCKET
DECK
SIDE
LAMP
LIGHT SYMBOL 304
100W TUFF SKIN NSN 6240-00-824-4676
METHOD I-1-B
ILLUMINATION OF SHIPS NAMEPLATE AND BOW NUMERAL
ONE MAST MASTHD
TWO MASTED MAIN FORE
TYPICAL FULL DRESS ILLUSTRATION
MAGNETIC CONTACTOR
LTG PNL OR FUSE BOX
XFMR BK
LOCAL LTG PNL
TO PILOT HOUSE CONTROL SWITCH (SEE NOTE 2)
SYM 400.2
MAG CONT.
XFMR BANK
MAIN DECK
SHIPS NAMEPLATE LT (P&S)
BOW NUMERAL LT (P&S)
LTG PNL OR FUSE BOX
300 FEET TYPICAL
METHOD I-1-A
DRESS LIGHTING
NOTES
1. ON SURFACE COMBATANT SHIPS DRESS LIGHTING IS DISPLAYED ON THE UP AND OVER DRESS SHIP LINES AND ALONG THE LIFE-LINES FROM BOW TO STERN.
2. THE RECEPTACLE CIRCUITS SHALL BE CONTROLLED FROM THE PILOT HOUSE AND SHALL NOT BE ON A DARKENED SHIP CIRCUIT. THE RECEPTACLES FOR THIS CIRCUIT SHALL NOT BE USED FOR ANY OTHER PURPOSE. THEREFORE THE FOLLOWING PLATE SHALL BE ATTACHED TO EACH RECEPTACLE
DRESS SHIP LTG STREAMERS NOT TO BE USED FOR OTHER PURPOSES
3. LIGHTING STREAMERS CONSIST OF SEVENTEEN 25 WATT INCANDESCENT LAMPS AS SHOWN. THESE STREAMERS ARE AVAILABLE FROM THE SUPPLY SYSTEM AS FOLLOWS:
STREAMER ASSY W/O GUARDS NSN 6230-00-160-0610
GUARD NSN 6230-00-159-2231
LAMP (TUFF-SKIN) NSN 6240-00-106-9636
4. METALIC ROPE ASSEMBLIES SHALL BE GROUNDED IN ACCORDANCE WITH MIL-STD-1310. NON CONDUCTIVE ROPE ASSEMBLIES OF EQUAL STRENGTH MAY BE USED.
5 SHIPS WITH BALLISTIC MAIN DECKS AND AIRCRAFT CARRIERS SHALL USE RECEPTACLES SYMBOL 1099.1 WITH PLUG SYMBOL 1218.3, MOUNTED TOPSIDE. ALL OTHER SHIPS SHALL USE RECEPTACLES SYMBOL 730.1 MOUNTED BELOW DECK PORTABLE CABLE ACCESS TO THE BELOW DECK RECEPTACLES SHALL BE PROVIDED IN ACCORDANCE WITH PUBLICATION S9300-AW-EDG-010/EPISM. WHEN THE SPACE BELOW DECK IS A HAZARDOUS SPACE, A REFRIGERATED SPACE, OR A SPACE NOT NORMALLY ACCESSIBLE TO PERSONNEL, TOPSIDE MOUNTING OF RECEPTACLE 1099.1 IS ACCEPTABLE
6 STOWAGE FACILITIES SHALL BE PROVIDED FOR NAMEPLATE AND BOW NUMERAL LIGHTS AND STREAMERS
TO OTHER MAGNETIC CONTACTOR
CONNECTION BOX
LTG PNL IN OR NEAR PILOT HOUSE
CONTROL SWITCH IN PILOT HOUSE
LTG PNL OR FUSE BOX
ISOLATION TRANSFORMER
MAGNETIC CONTACTOR
LTG PNL
TO RECEPTACLES
CENTRALLY LOCATED FOR BEST LOCAL DISTRIBUTION
MAST
DRESS LINE
ROPE ASSEMBLY SEE DETAIL "A-A"
UP HAUL
SEE NAVSHIPS DWG-805-1649210 FOR TYPICAL DRESS LINE ARRGMTS
EXTENSION CABLE ASSY
SNAP HOOK - BRASS 1/2" EYE 2-7/8 LONG
3/16 DIA WIRE ROPE AIRPLANE GALVANIZED SEE NOTE 4
3/16 WIRE ROPE CLIP
6' TYPICAL
3/16 DIA RING-BRASS I.D TO SUIT
DETAIL A-A
ROPE ASSEMBLY
"S" HOOK 3/16 DIA BRASS 2" LONG
RAP ELECTRICAL TAPE AROUND CABLE FOR PROTECTION
EXTENSION CABLE ASSY'S FOR MID POINT SUPPLY FOR SHIPS WITH DRESS LINES OVER 300 FEET LONG SEE DETAIL "B-B"
DETAIL B-B
METHOD OF SUPPORTING UP AND OVER STREAMERS
SECURE LAST RING TO DRESS LINE
TO DK PAD
USE A SNAP HOOK WITH LAST ROPE ASSY ADJUST LENGTH TO SUIT
INSTALLING ACTIVITY FURNISHED EXTENSION CABLE ASSY
LENGTH TO SUIT INSTALLATION
CONNECT THREE STREAMERS UP TO 150 FEET MAX.
CUT TO LENGTH DESIRED
3' TYPICAL
SYMBOL 1099.1
RECEPTACLE MIL-R-2726/73 SYMBOL 1215 NSN 5935-00-480-7948
PLUG SYM 1218.3 MIL-R-2726/38 NSN 5935-00-220-2213
PLUG SYM 1218.3 MIL-R-2726/38
RECEPTACLE SYMBOL 1215 MIL-R-2726/73
INSTALL COVER AT END OF LAST STREAMER
SYMBOL 307 - NOTE 3
TYPICAL WIRING DIAGRAM
NAVY DEPARTMENT
WASHINGTON, D.C.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DRESS SHIP LIGHTING SYSTEM
SECTION I
SHEET 1
53711
803
5184170
B

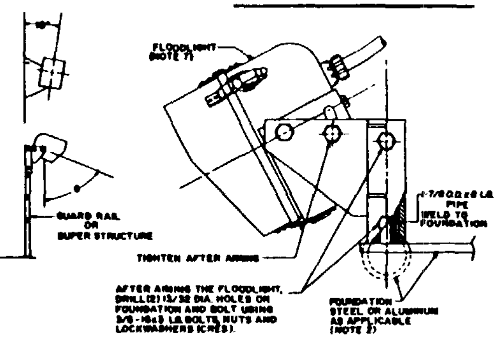
REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
—	FIRST ISSUE	[illegible]		[illegible]
A	DELETED FLOODLIGHT 300 2 & ADDED FLOODLIGHT 3034 & NOTE 7 CHANGED DWG 9000-S6202-73980 TO 803-5001027	[illegible]	[illegible]	[illegible]



METHOD 1-2-A
AIRCRAFT CARRIERS



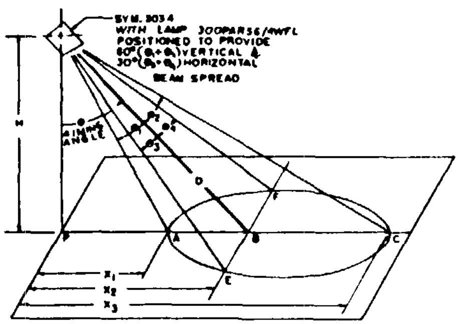
METHOD 1-2-B
OTHER SHIPS



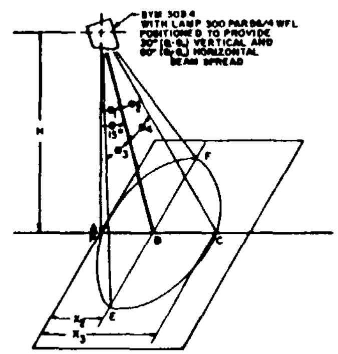
DETAIL "C"

TABLE 1.(NOTE 6)

H	θ	X_1	X_2	X_3	D	θF	E_A	E_B	E_C	E_F
		DETAIL "A"								
10	35	5	15	100	18	5		22		
15	35	7	22	120	26	7		9.7		
20	30	7	24	110	32	9	0.17	6	.024	[illegible]
25	30	9	30	120	39	11		5		
30	45	8	30	110	43	12		4.3		
35	45	9	35	120	49	13		3.3		
40	40	7	30	110	53	14	0.23	3.3	[illegible]	0.35
45	40	7	34	110	59	16		2.6		
50	35	5	35	110	61	17		2.5		
55	35	5	37	120	67	18		2.1		
60	30	0	35	110	69	19	[illegible]	2.1	.03	[illegible]
		DETAIL "B"								
30	15	0	14	30	32	31	0.62	4.2	[illegible]	[illegible]
35	15	0	15	32	37	33	[illegible]	[illegible]	[illegible]	[illegible]
60	15	0	16	35	62	36	[illegible]	[illegible]	0.31	[illegible]



DETAIL "A"



DETAIL "B"

NOTES:

1. SUFFICIENT PORTABLE FLOODLIGHTS, SYMBOL 303.4, SHALL BE INSTALLED ON ALL SURFACE COMBATANT AND AUXILIARY SHIPS TO GIVE COMPLETE COVERAGE AT ONE TIME WITH A SMALL OVERLAP OF THE LIGHT BEAM AT WATER SURFACE.
2. A MOUNTING BRACKET TO PERMIT AIMING THE FLOODLIGHT, AND READY MOUNTING AND REMOVAL, SHALL BE PROVIDED. PLACEMENT OR SHIELDING OF FLOODLIGHTS SHALL BE SUCH THAT MAIN SECURITY WATCHES CAN OBSERVE THE WATERLINE WITHOUT LOOKING INTO THE BEAM OF THE FLOODLIGHTS.
3. THE FLOODLIGHT CIRCUIT SHALL NOT BE ON A DARKENED SHIP CIRCUIT, AND SHALL BE CONTROLLED FROM THE PILOT HOUSE. THE RECEPTACLES FOR THIS CIRCUIT SHALL NOT BE USED FOR ANY OTHER PURPOSE.
4. SHIPS WITH BALLISTIC MAIN DECKS AND AIRCRAFT CARRIERS SHALL USE RECEPTACLES SYMBOL 1099.1 WITH PLUG SYMBOL 1218.3, MOUNTED TOPSIDE. ALL OTHER SHIPS SHALL USE RECEPTACLES SYMBOL 730.1 MOUNTED BELOW DECK. PORTABLE CABLE ACCESS TO THE BELOW DECK RECEPTACLES SHALL BE PROVIDED IN ACCORDANCE WITH DRAWING 803-5001027 METHOD 38401 OR 38402 WHEN THE SPACE BELOW DECK IS A HAZARDOUS SPACE, A REFRIGERATED SPACE, OR A SPACE NOT NORMALLY ACCESSIBLE TO PERSONNEL, TOPSIDE MOUNTING OF RECEPTACLE 1099.1 IS ACCEPTABLE
5. STOWAGE FACILITIES FOR THE PORTABLE FLOODLIGHTS SHALL BE PROVIDED.
6. SEE ARTICLE 6.3 OF CHAPTER 6 FOR FLOODLIGHT CALCULATIONS.
7. NARROW BEAM (SYM 303.2) AND MEDIUM BEAM (SYM 303.3) FLOODLIGHTS MAY ALSO BE USED, WHERE ADVANTAGEOUS, IN LIEU OF WIDE BEAM FLOODLIGHT, (SYM 303.4)

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LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

WATERLINE SECURITY LIGHTING

SECTION	SHEET	SIZE	CODE IDENT NO	DWG	DRAWING NO.	REV
I	2		53711	803	5184170	A

REV.	DESCRIPTION
—	FIRST ISSUE
A	DETAILS ON THIS SHEET DELETED

DETAILS ON THIS SHEET DELETED.

SEE 1972 REGULATIONS FOR PREVENTING COLLISIONS AT SEA.

NAVAL SEA SYSTEMS COMMAND

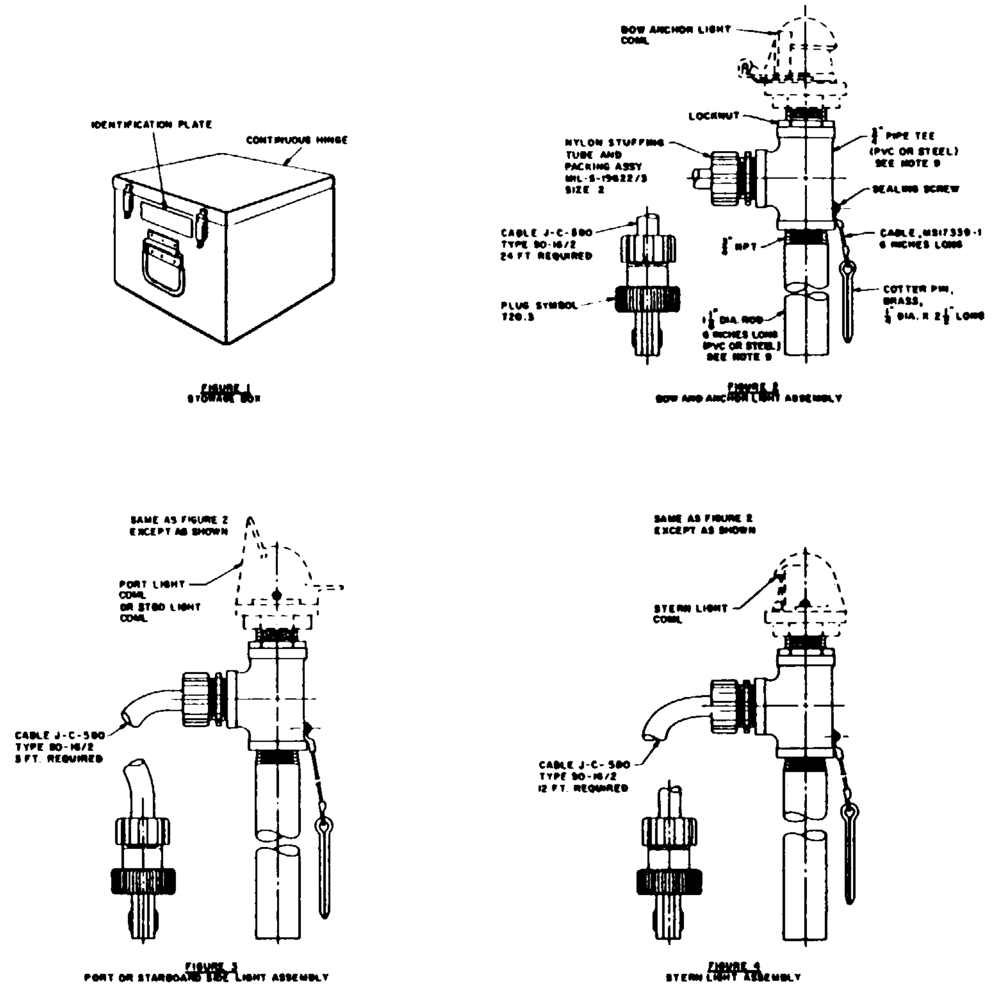
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

NAVIGATION LIGHTS REQUIRED BY INTERNATIONAL LAW

SECTION	SHEET	CODE IDENT NO.	SIZE	DRAWING NO.	REV.
I	3	53711	803	5184170	A

REVISIONS

REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
-	FIRST ISSUE			
A	REVISED NOTE 5, DELETED SYM 203, 207 2, 206 2 AND 211 REVISED ALL LIGHTS TO PHANTOM DELETED TABLE I		T R C	



METHOD I-4-A

NOTES:

1. THIS NAVIGATIONAL LIGHT KIT SHALL SERVICE LANDING CRAFT, TYPES LCVP, LCP-R, LCM-3, LCM-6, LCM-8 AND LCP-L.
2. EACH KIT SHALL CONSIST OF ONE (1) STOWAGE BOX CONTAINING ONE (1) BOW ANCHOR LIGHT ASSY, ONE (1) STERN LIGHT ASSY, ONE (1) PORT SIDE LIGHT ASSY, ONE (1) STARBOARD LIGHT ASSY AND 12 LAMPS (1 INSTALLED AND 2 SPARES).
3. THE KIT FURNISHED FOR EACH CRAFT SHALL HAVE ALL LIGHTS COMPLETELY ASSEMBLED AND READY FOR INSTALLATION LENGTH OF CABLE AS FURNISHED FOR EACH ASSEMBLY IS FOR CONNECTION TO RECEPTACLES OF EXISTING CRAFT.
4. STOWAGE BOX SHALL BE IN GENERAL AS SHOWN. A COMMERCIALLY AVAILABLE BOX ASSEMBLY MAY BE SUBSTITUTED, PROVIDING THAT THE DIMENSIONS DO NOT EXCEED THOSE SHOWN. A SEPARATE INTERIOR COMPARTMENT SHALL BE PROVIDED FOR STOWAGE OF SPARE LAMPS.
5. LIGHTS SHALL BE OF A COMMERCIAL GRADE AND MEET THE REQUIREMENTS OF THE 1972 REGULATIONS FOR PREVENTING COLLISIONS AT SEA
6. CHAIN SCREW AND TEE JOINTS SHALL BE SEALED WITH A PIPE JOINT ADHESIVE TO MAKE LIGHT ASSEMBLIES WATERTIGHT.
7. SPARE LAMPS SHALL BE PROPERLY PROTECTED TO PREVENT BREAKAGE UNDER CONDITIONS OF ROUGH HANDLING AND THE 10 AND 15 CANDLEPOWER LAMPS SHALL BE SEPARATELY IDENTIFIED AS TO THE ASSEMBLIES IN WHICH THEY ARE USED.
8. ALL STEEL PARTS SHALL BE ZINC OR CADMIUM PLATED.
9. IF STEEL PIPE TEE OR ROD IS USED, THE SUPPLY CABLE SHALL BE TYPE SO-16/3. THE THIRD CONDUCTOR IN THE CABLE SHALL BE USED TO GROUND THE PIPE TEE OR ROD.

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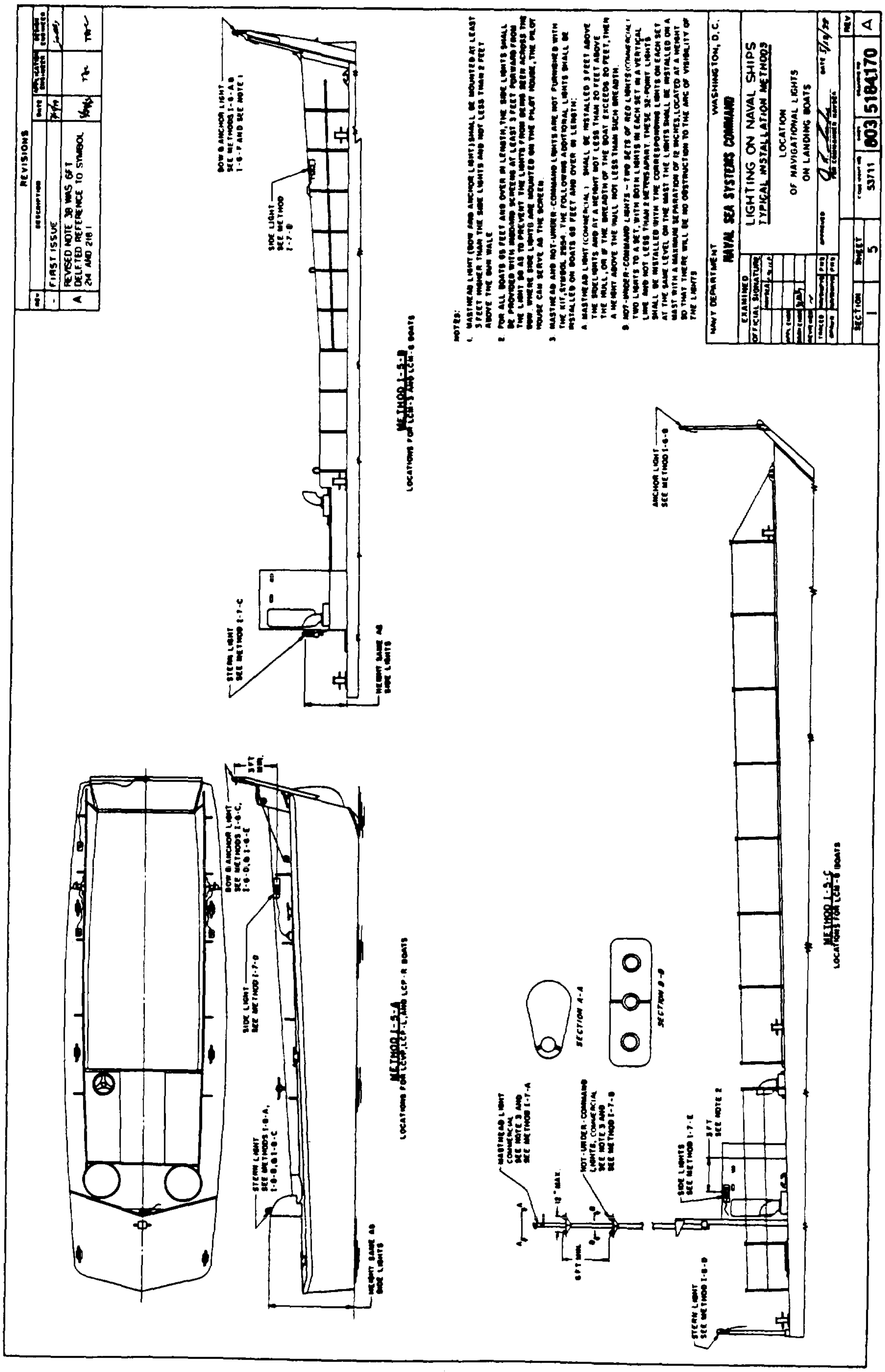
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

NAVIGATIONAL LIGHT KIT
FOR LANDING BOATS
SYMBOL 2554

SECTION	SHEET	CODE IDENT NO.	SIZE	DRAWING NO.	REV
I	4	53711	803	5184170	A


REVISIONS
REV | DESCRIPTION | DATE | APPLICATION ENGINEER | DESIGN ENGINEER
- FIRST ISSUE
A REVISED NOTE 3B WAS 6FT DELETED REFERENCE TO SYMBOL 214 AND 218 I
STERN LIGHT SEE METHODS I-8-A, I-8-B, & I-8-C
SIDE LIGHT SEE METHOD I-7-B
BOW & ANCHOR LIGHT SEE METHODS I-6-C, I-6-D, & I-6-E
3 FT MIN.
HEIGHT SAME AS SIDE LIGHTS
METHOD I-5-A
LOCATIONS FOR LCVP, LCP-L, AND LCP-R BOATS
STERN LIGHT SEE METHOD I-7-C
BOW & ANCHOR LIGHT SEE METHODS I-6-A & I-6-F AND SEE NOTE 1
SIDE LIGHT SEE METHOD I-7-B
HEIGHT SAME AS SIDE LIGHTS
METHOD I-5-B
LOCATIONS FOR LCM-3 AND LCM-6 BOATS
NOTES:
1. MASTHEAD LIGHT (BOW AND ANCHOR LIGHT) SHALL BE MOUNTED AT LEAST 3 FEET HIGHER THAN THE SIDE LIGHTS AND NOT LESS THAN 2 FEET ABOVE THE GUN WALE
2. FOR ALL BOATS 65 FEET AND OVER IN LENGTH, THE SIDE LIGHTS SHALL BE PROVIDED WITH INBOARD SCREENS AT LEAST 3 FEET FORWARD FROM THE LIGHT SO AS TO PREVENT THE LIGHTS FROM BEING SEEN ACROSS THE BOW. WHERE SIDE LIGHTS ARE MOUNTED ON THE PILOT HOUSE, THE PILOT HOUSE CAN SERVE AS THE SCREEN.
3. MASTHEAD AND NOT-UNDER-COMMAND LIGHTS ARE NOT FURNISHED WITH THE KIT, SYMBOL 2554. THE FOLLOWING ADDITIONAL LIGHTS SHALL BE INSTALLED ON BOATS 65 FEET AND OVER IN LENGTH:
A. MASTHEAD LIGHT (COMMERCIAL) SHALL BE INSTALLED 3 FEET ABOVE THE SIDELIGHTS AND AT A HEIGHT NOT LESS THAN 20 FEET ABOVE THE HULL, OR IF THE BREADTH OF THE BOAT EXCEEDS 20 FEET, THEN A HEIGHT ABOVE THE HULL NOT LESS THAN SUCH BREADTH.
B. NOT-UNDER-COMMAND LIGHTS – TWO SETS OF RED LIGHTS (COMMERCIAL) TWO LIGHTS TO A SET, WITH BOTH LIGHTS IN EACH SET IN A VERTICAL LINE AND NOT LESS THAN 2 METERS APART. THESE 32-POINT LIGHTS SHALL BE INSTALLED WITH THE CORRESPONDING LIGHTS ON EACH SET AT THE SAME LEVEL ON THE MAST. THE LIGHTS SHALL BE INSTALLED ON A MAST WITH A MAXIMUM SEPARATION OF 12 INCHES, LOCATED AT A HEIGHT SO THAT THERE WILL BE NO OBSTRUCTION TO THE ARC OF VISIBILITY OF THE LIGHTS
MASTHEAD LIGHT COMMERCIAL SEE NOTE 3 AND SEE METHOD I-7-A
12" MAX.
6 FT MIN.
NOT-UNDER-COMMAND LIGHTS, COMMERCIAL SEE NOTE 3 AND SEE METHOD I-7-B
SECTION A-A
SECTION B-B
STERN LIGHT SEE METHOD I-8-D
SIDE LIGHTS SEE METHOD I-7-E
3 FT SEE NOTE 2
ANCHOR LIGHT SEE METHOD I-6-B
METHOD I-5-C
LOCATIONS FOR LCM-8 BOATS
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TYPICAL INSTALLATION METHODS
LOCATION OF NAVIGATIONAL LIGHTS ON LANDING BOATS
SECTION I
SHEET 5
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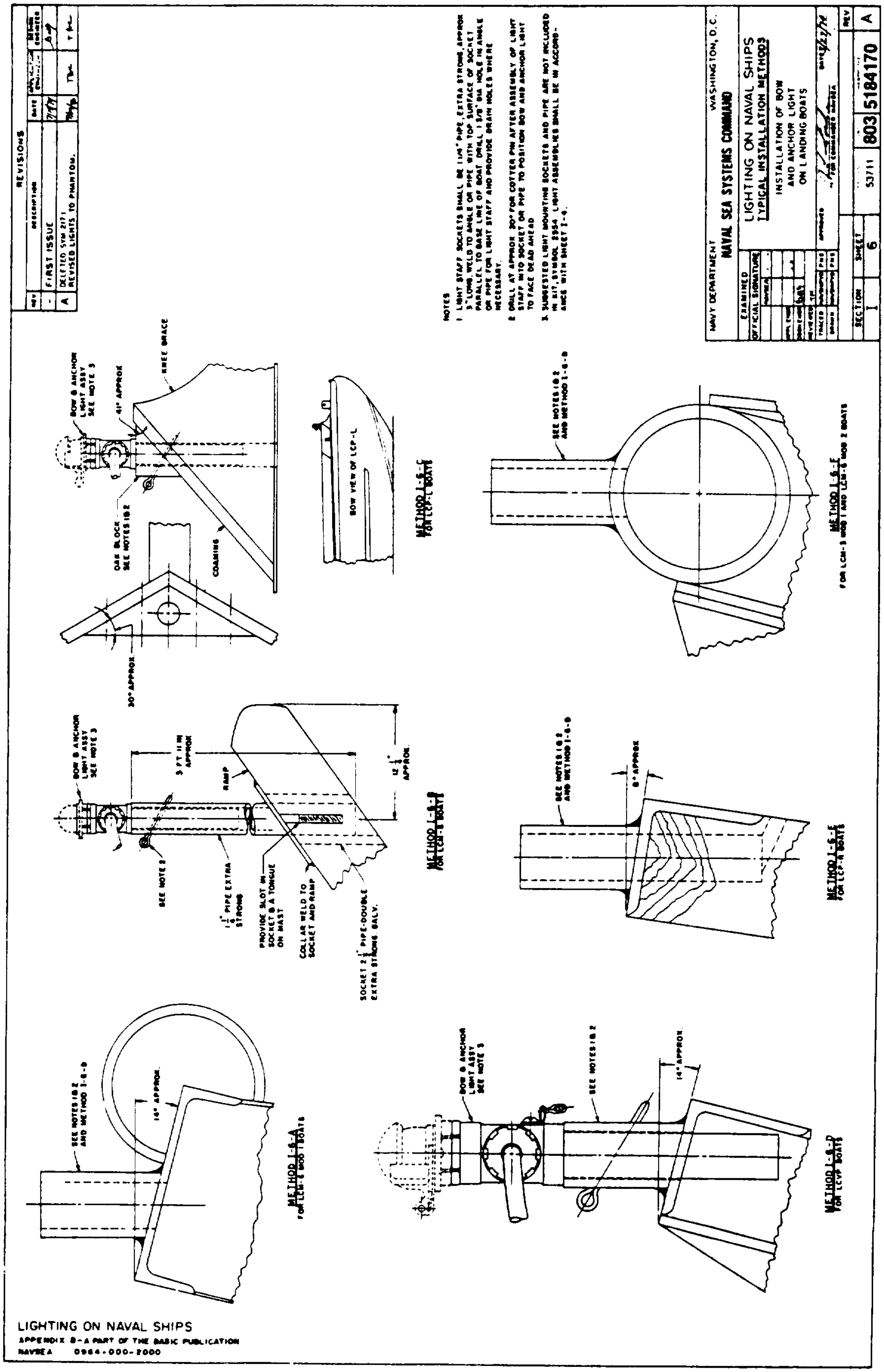
REV A


REVISIONS
REV | DESCRIPTION | DATE
- | FIRST ISSUE
A | DELETED SYM 2171 REVISED LIGHTS TO PHANTOM.
SEE NOTES 1 & 2 AND METHOD I-6-D
14° APPROX.
METHOD I-6-A
FOR LCM-6 MOD 1 BOATS
BOW & ANCHOR LIGHT ASSY SEE NOTE 3
SEE NOTE 2
5 FT 11 IN APPROX
1 1/4" PIPE EXTRA STRONG
RAMP
PROVIDE SLOT IN SOCKET & A TONGUE ON MAST
COLLAR WELD TO SOCKET AND RAMP
SOCKET 2 1/2" PIPE-DOUBLE EXTRA STRONG GALV.
12 1/4" APPROX.
METHOD I-6-B
FOR LCM-8 BOATS
30° APPROX.
OAK BLOCK SEE NOTES 1 & 2
41° APPROX
KNEE BRACE
COAMING
BOW VIEW OF LCP-L
METHOD I-6-C
FOR LCP-L BOATS
SEE NOTES 1 & 2
METHOD I-6-D
FOR LCVP BOATS
8° APPROX
METHOD I-6-E
FOR LCP-R BOATS
METHOD I-6-F
FOR LCM-3 MOD 1 AND LCM-6 MOD 2 BOATS
NOTES
1 LIGHT STAFF SOCKETS SHALL BE 1 1/4" PIPE, EXTRA STRONG, APPROX 5" LONG. WELD TO ANGLE OR PIPE WITH TOP SURFACE OF SOCKET PARALLEL TO BASE LINE OF BOAT. DRILL 1 3/8" DIA HOLE IN ANGLE OR PIPE FOR LIGHT STAFF AND PROVIDE DRAIN HOLES WHERE NECESSARY.
2 DRILL AT APPROX 30° FOR COTTER PIN AFTER ASSEMBLY OF LIGHT STAFF INTO SOCKET OR PIPE TO POSITION BOW AND ANCHOR LIGHT TO FACE DEAD AHEAD.
3 SUGGESTED LIGHT MOUNTING SOCKETS AND PIPE ARE NOT INCLUDED IN KIT, SYMBOL 2954. LIGHT ASSEMBLIES SHALL BE IN ACCORDANCE WITH SHEET I-4.
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NAVAL SEA SYSTEMS COMMAND
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TYPICAL INSTALLATION METHODS
INSTALLATION OF BOW AND ANCHOR LIGHT ON LANDING BOATS
FOR COMMANDER NAVSEA
SECTION I
SHEET 6
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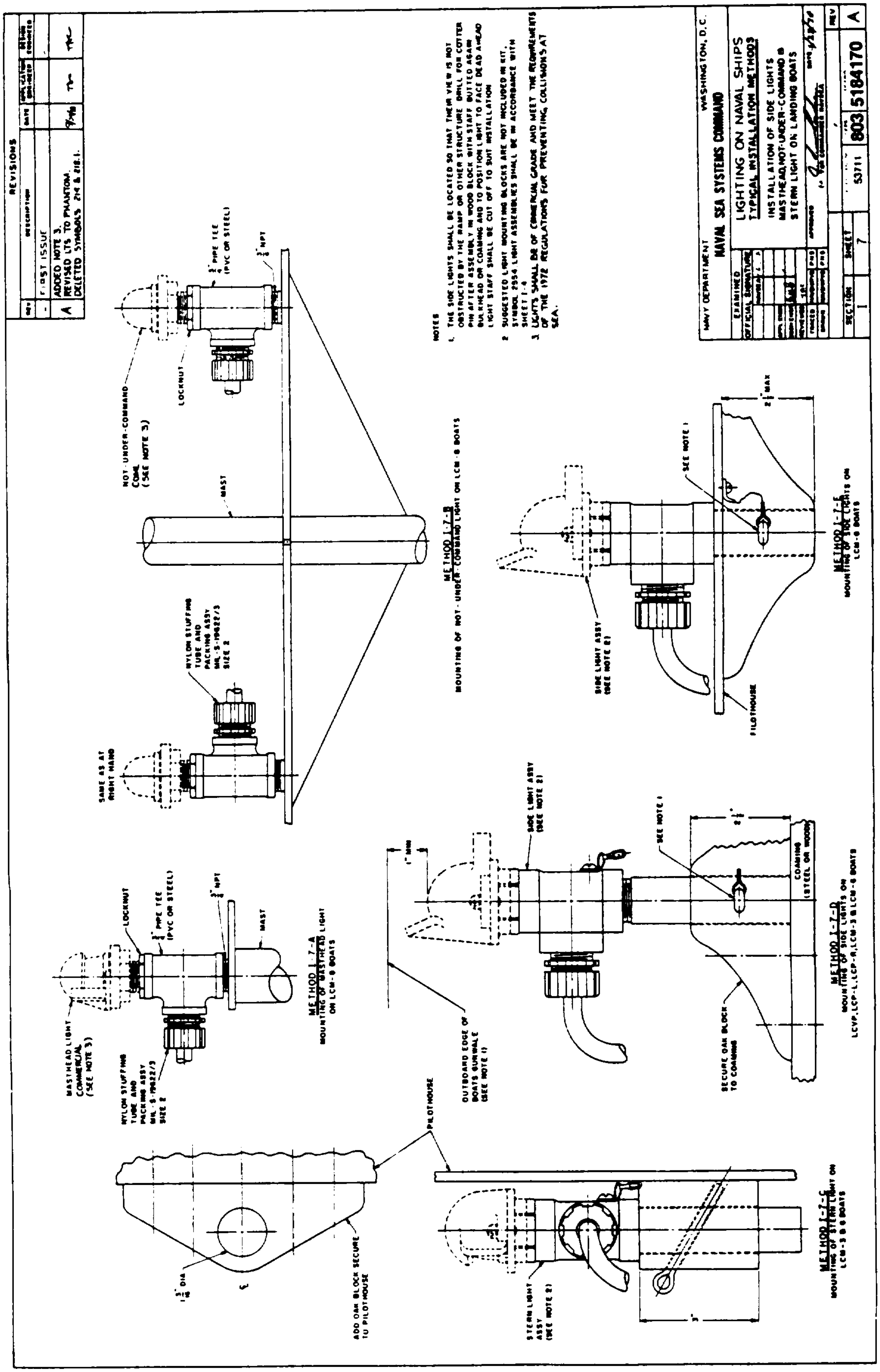
REV A
LIGHTING ON NAVAL SHIPS
APPENDIX B - A PART OF THE BASIC PUBLICATION
NAVSEA 0964-000-2000


REVISIONS
REV
DESCRIPTION
DATE
FIRST ISSUE
A
ADDED NOTE 3.
REVISED LTS TO PHANTOM.
DELETED SYMBOLS 214 & 218.1.
MASTHEAD LIGHT COMMERCIAL (SEE NOTE 3)
NYLON STUFFING TUBE AND PACKING ASSY MIL-S-19622/3 SIZE 2
LOCKNUT
3/4" PIPE TEE (PVC OR STEEL)
3/4" NPT
MAST
METHOD I-7-A
MOUNTING OF MASTHEAD LIGHT ON LCM-8 BOATS
SAME AS AT RIGHT HAND
NOT-UNDER-COMMAND COML (SEE NOTE 3)
METHOD I-7-B
MOUNTING OF NOT-UNDER-COMMAND LIGHT ON LCM-8 BOATS
ADD OAK BLOCK SECURE TO PILOTHOUSE
PILOTHOUSE
STERN LIGHT ASSY (SEE NOTE 2)
METHOD I-7-C
MOUNTING OF STERN LIGHT ON LCM-3 & 6 BOATS
OUTBOARD EDGE OF BOATS GUNWALE (SEE NOTE 1)
1" MIN
SIDE LIGHT ASSY (SEE NOTE 2)
SEE NOTE 1
SECURE OAK BLOCK TO COAMING
COAMING (STEEL OR WOOD)
METHOD I-7-D
MOUNTING OF SIDE LIGHTS ON LCVP, LCP-L, LCP-R, LCM-3 & LCM-6 BOATS
METHOD I-7-E
MOUNTING OF SIDE LIGHTS ON LCM-8 BOATS
NOTES
1. THE SIDE LIGHTS SHALL BE LOCATED SO THAT THEIR VIEW IS NOT OBSTRUCTED BY THE RAMP OR OTHER STRUCTURE. DRILL FOR COTTER PIN AFTER ASSEMBLY IN WOOD BLOCK WITH STAFF BUTTED AGAIN BULKHEAD OR COAMING AND TO POSITION LIGHT TO FACE DEAD AHEAD LIGHT STAFF SHALL BE CUT OFF TO SUIT INSTALLATION
2. SUGGESTED LIGHT MOUNTING BLOCKS ARE NOT INCLUDED IN KIT. SYMBOL 2954 LIGHT ASSEMBLIES SHALL BE IN ACCORDANCE WITH SHEET I-4
3. LIGHTS SHALL BE OF COMMERCIAL GRADE AND MEET THE REQUIREMENTS OF THE 1972 REGULATIONS FOR PREVENTING COLLISIONS AT SEA.
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INSTALLATION OF SIDE LIGHTS MASTHEAD, NOT-UNDER-COMMAND & STERN LIGHT ON LANDING BOATS
SECTION
I
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7
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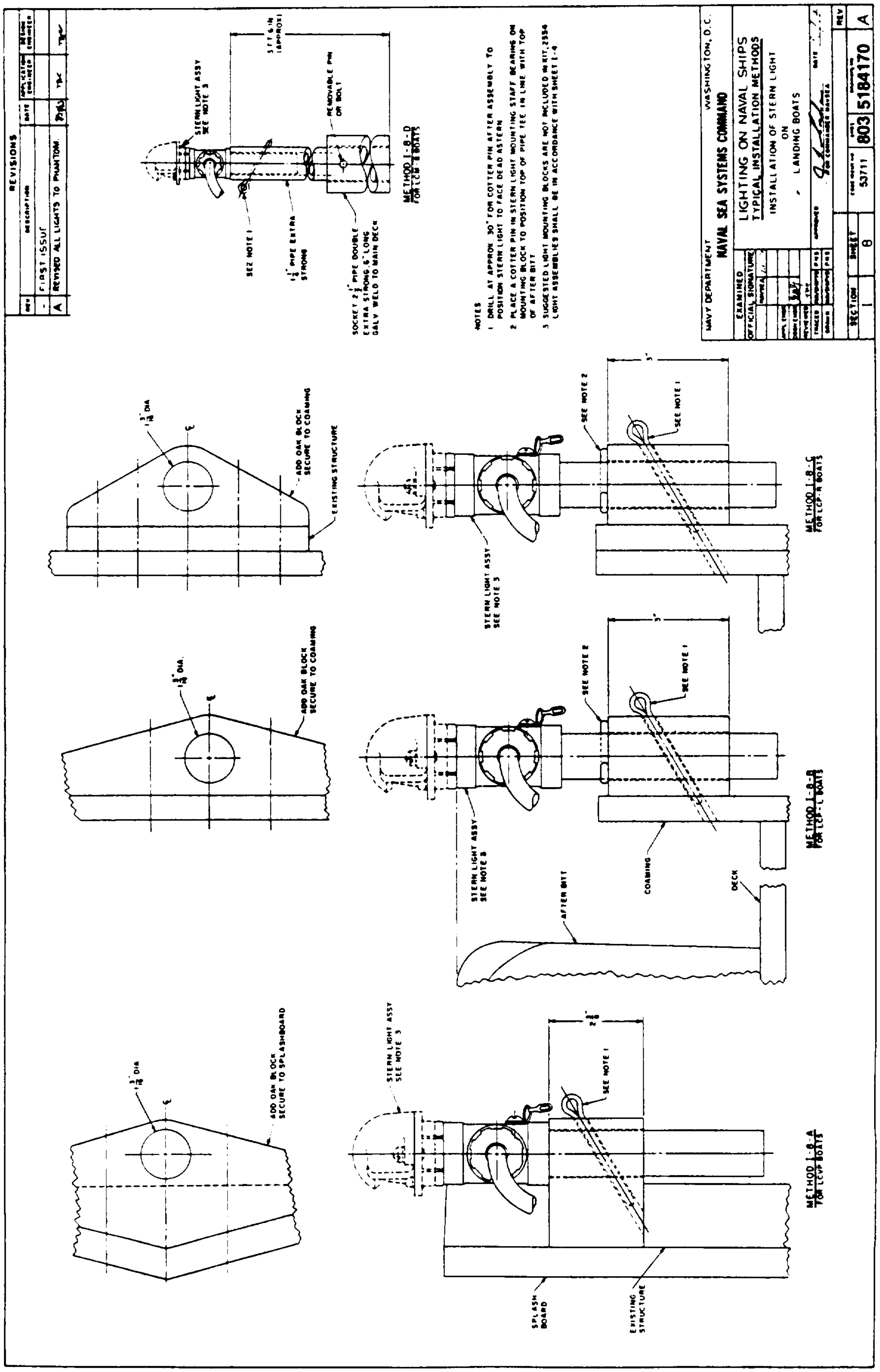
REV
A


REVISIONS
FIRST ISSUE
REVISED ALL LIGHTS TO PHANTOM
NAVY DEPARTMENT
NAVAL SEA SYSTEMS COMMAND
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TYPICAL INSTALLATION METHODS
INSTALLATION OF STERN LIGHT
ON
LANDING BOATS
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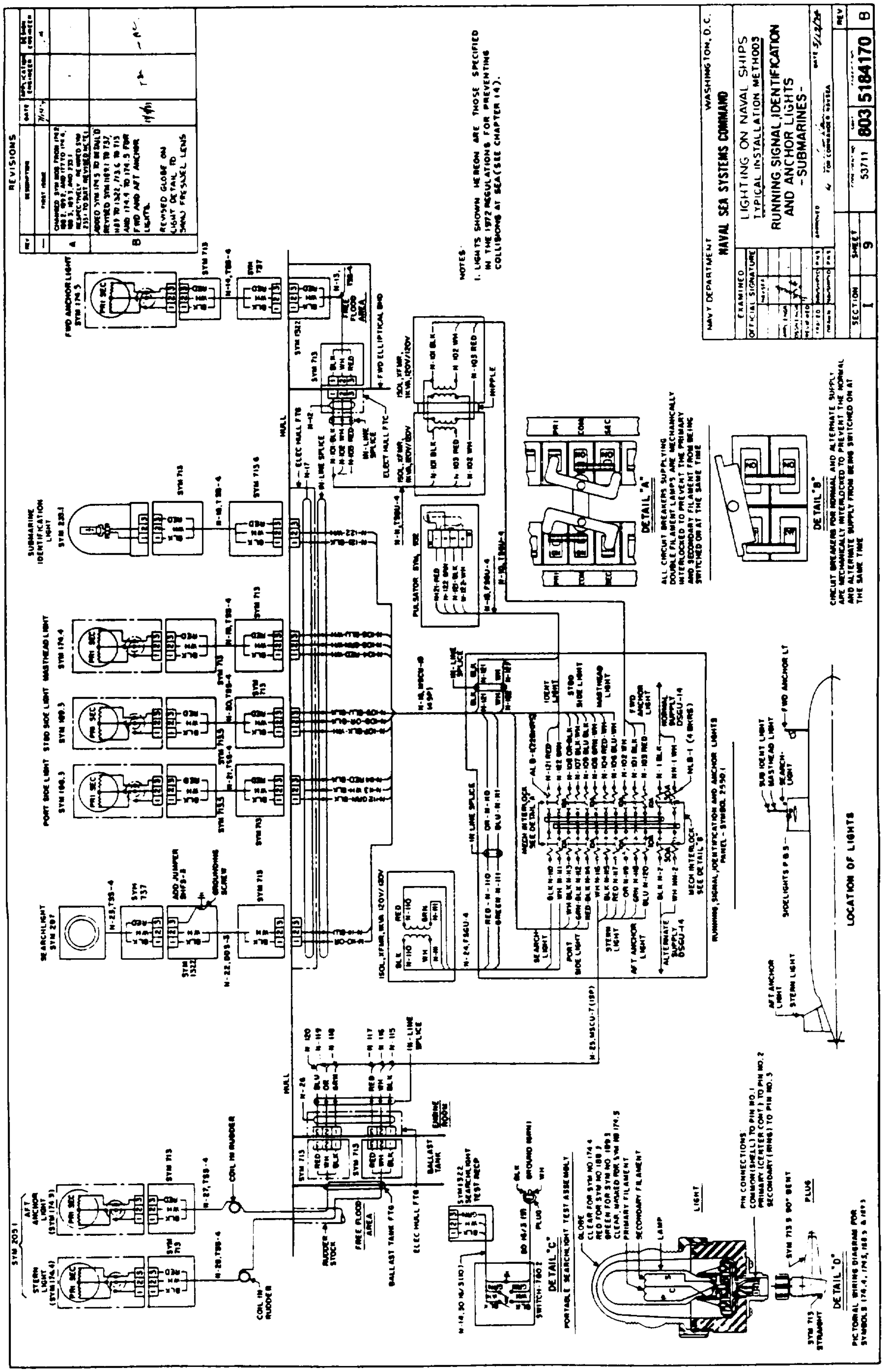
NOTES
1 DRILL AT APPROX. 30° FOR COTTER PIN AFTER ASSEMBLY TO POSITION STERN LIGHT TO FACE DEAD ASTERN
2 PLACE A COTTER PIN IN STERN LIGHT MOUNTING STAFF BEARING ON MOUNTING BLOCK TO POSITION TOP OF PIPE TEE IN LINE WITH TOP OF AFTER BITT
3 SUGGESTED LIGHT MOUNTING BLOCKS ARE NOT INCLUDED IN KIT, 2394 LIGHT ASSEMBLIES SHALL BE IN ACCORDANCE WITH SHEET I-4
METHOD I-8-A FOR LCVP BOATS
METHOD I-8-B FOR LCP-L BOATS
METHOD I-8-C FOR LCP-R BOATS
METHOD I-8-D FOR LCM BOATS
STERN LIGHT ASSY SEE NOTE 3
ADD OAK BLOCK SECURE TO SPLASHBOARD
ADD OAK BLOCK SECURE TO COAMING
EXISTING STRUCTURE
SPLASH BOARD
COAMING
DECK
AFTER BITT
SEE NOTE 1
SEE NOTE 2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RUNNING, SIGNAL, IDENTIFICATION AND ANCHOR LIGHTS
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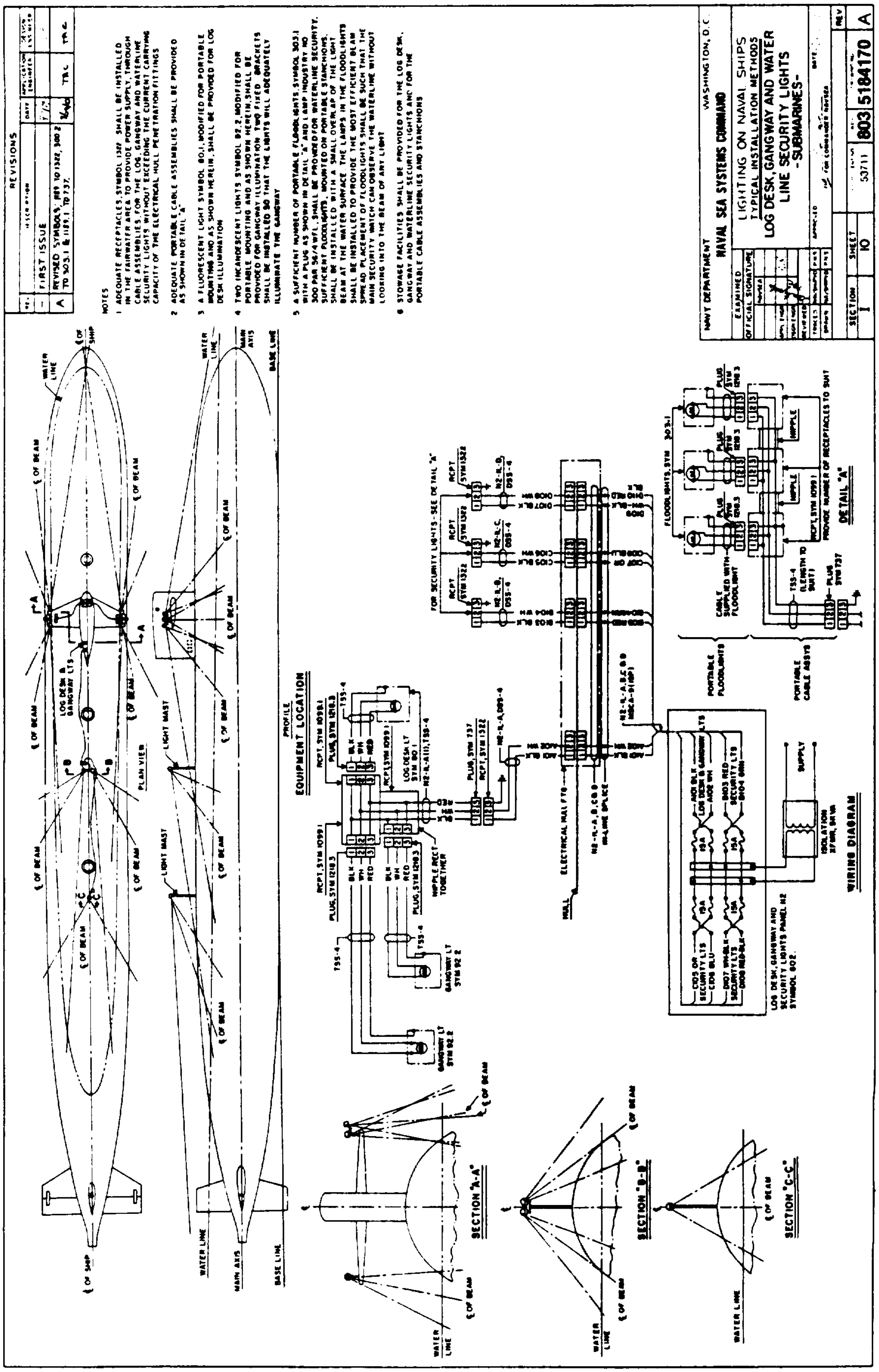
B
REVISIONS
LOCATION OF LIGHTS
DETAIL "A"
DETAIL "B"
DETAIL "C"
DETAIL "D"


REVISIONS
FIRST ISSUE
A REVISED SYMBOLS; 1189 TO 1322, 300.2 TO 303.1 & 1189.1 TO 737.
TRC
NOTES
1 ADEQUATE RECEPTACLES, SYMBOL 1322 SHALL BE INSTALLED IN THE FAIRWATER AREA TO PROVIDE POWER SUPPLY, THROUGH CABLE ASSEMBLIES, FOR THE LOG, GANGWAY AND WATERLINE SECURITY LIGHTS WITHOUT EXCEEDING THE CURRENT CARRYING CAPACITY OF THE ELECTRICAL HULL PENETRATION FITTINGS
2 ADEQUATE PORTABLE CABLE ASSEMBLIES SHALL BE PROVIDED AS SHOWN IN DETAIL "A"
3 A FLUORESCENT LIGHT SYMBOL 80.1, MODIFIED FOR PORTABLE MOUNTING AND AS SHOWN HEREIN, SHALL BE PROVIDED FOR LOG DESK ILLUMINATION
4 TWO INCANDESCENT LIGHTS SYMBOL 92.2, MODIFIED FOR PORTABLE MOUNTING AND AS SHOWN HEREIN, SHALL BE PROVIDED FOR GANGWAY ILLUMINATION. TWO FIXED BRACKETS SHALL BE INSTALLED SO THAT THE LIGHTS WILL ADEQUATELY ILLUMINATE THE GANGWAY
5 A SUFFICIENT NUMBER OF PORTABLE FLOODLIGHTS, SYMBOL 303.1 WITH A PLUG AS SHOWN IN DETAIL "A" AND LAMP INDUSTRY NO 300 PAR 56/4 WFL, SHALL BE PROVIDED FOR WATERLINE SECURITY. SUFFICIENT FLOODLIGHTS, MOUNTED ON PORTABLE STANCHIONS, SHALL BE INSTALLED WITH A SMALL OVERLAP OF THE LIGHT BEAM AT THE WATER SURFACE. THE LAMPS IN THE FLOODLIGHTS SHALL BE INSTALLED TO PROVIDE THE MOST EFFICIENT BEAM SPREAD. PLACEMENT OF FLOODLIGHTS SHALL BE SUCH THAT THE MAIN SECURITY WATCH CAN OBSERVE THE WATERLINE WITHOUT LOOKING INTO THE BEAM OF ANY LIGHT
6 STOWAGE FACILITIES SHALL BE PROVIDED FOR THE LOG DESK, GANGWAY AND WATERLINE SECURITY LIGHTS AND FOR THE PORTABLE CABLE ASSEMBLIES AND STANCHIONS
PLAN VIEW
PROFILE
EQUIPMENT LOCATION
SECTION "A-A"
SECTION "B-B"
SECTION "C-C"
WIRING DIAGRAM
DETAIL "A"
LOG DESK, GANGWAY AND SECURITY LIGHTS PANEL N2 SYMBOL 602.
PORTABLE FLOODLIGHTS
PORTABLE CABLE ASSYS
FLOODLIGHTS, SYM 303.1
PROVIDE NUMBER OF RECEPTACLES TO SUIT
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LOG DESK, GANGWAY AND WATER LINE SECURITY LIGHTS
-SUBMARINES-
SECTION I
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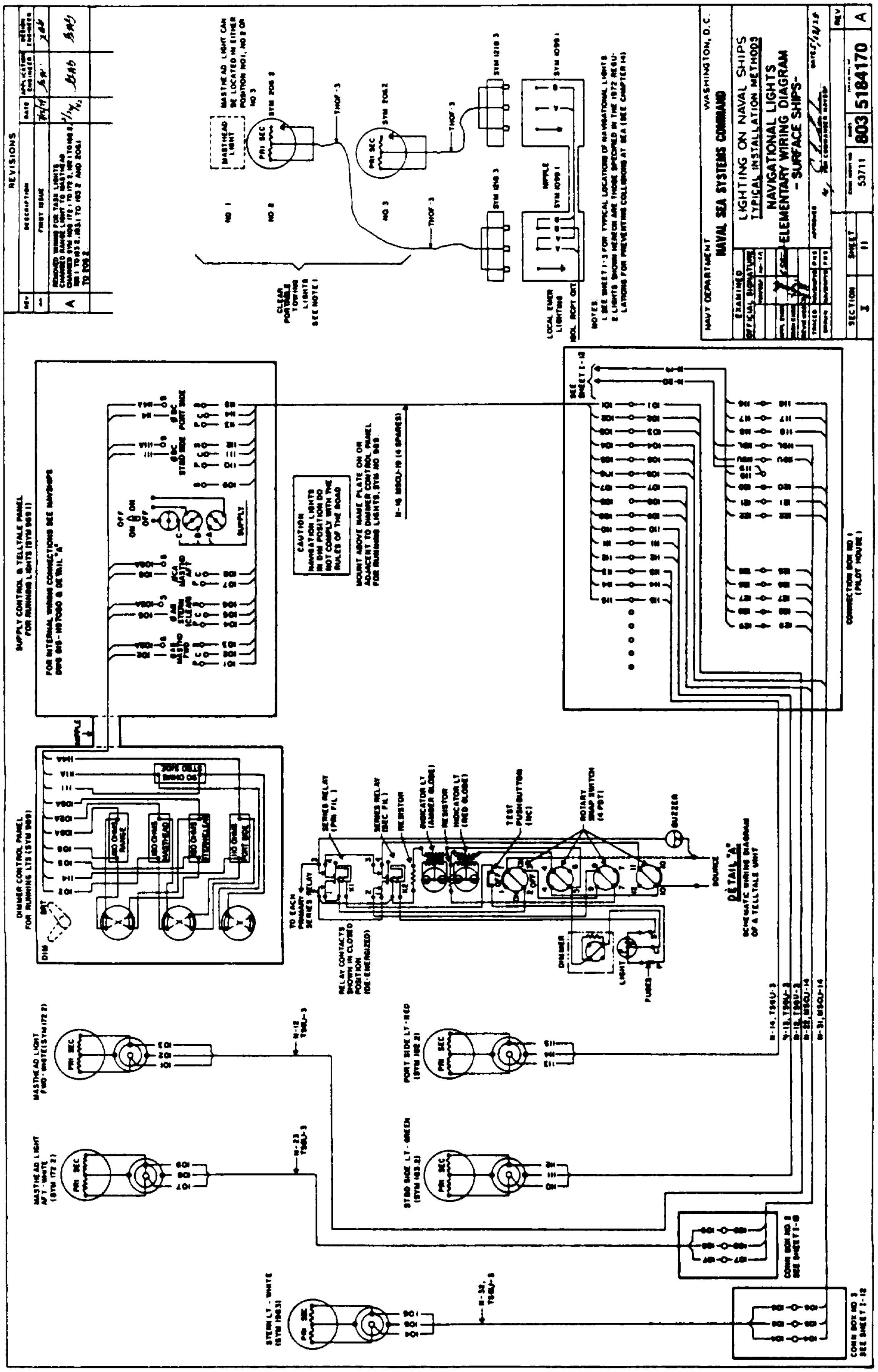
REV A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NAVIGATIONAL LIGHTS
ELEMENTARY WIRING DIAGRAM
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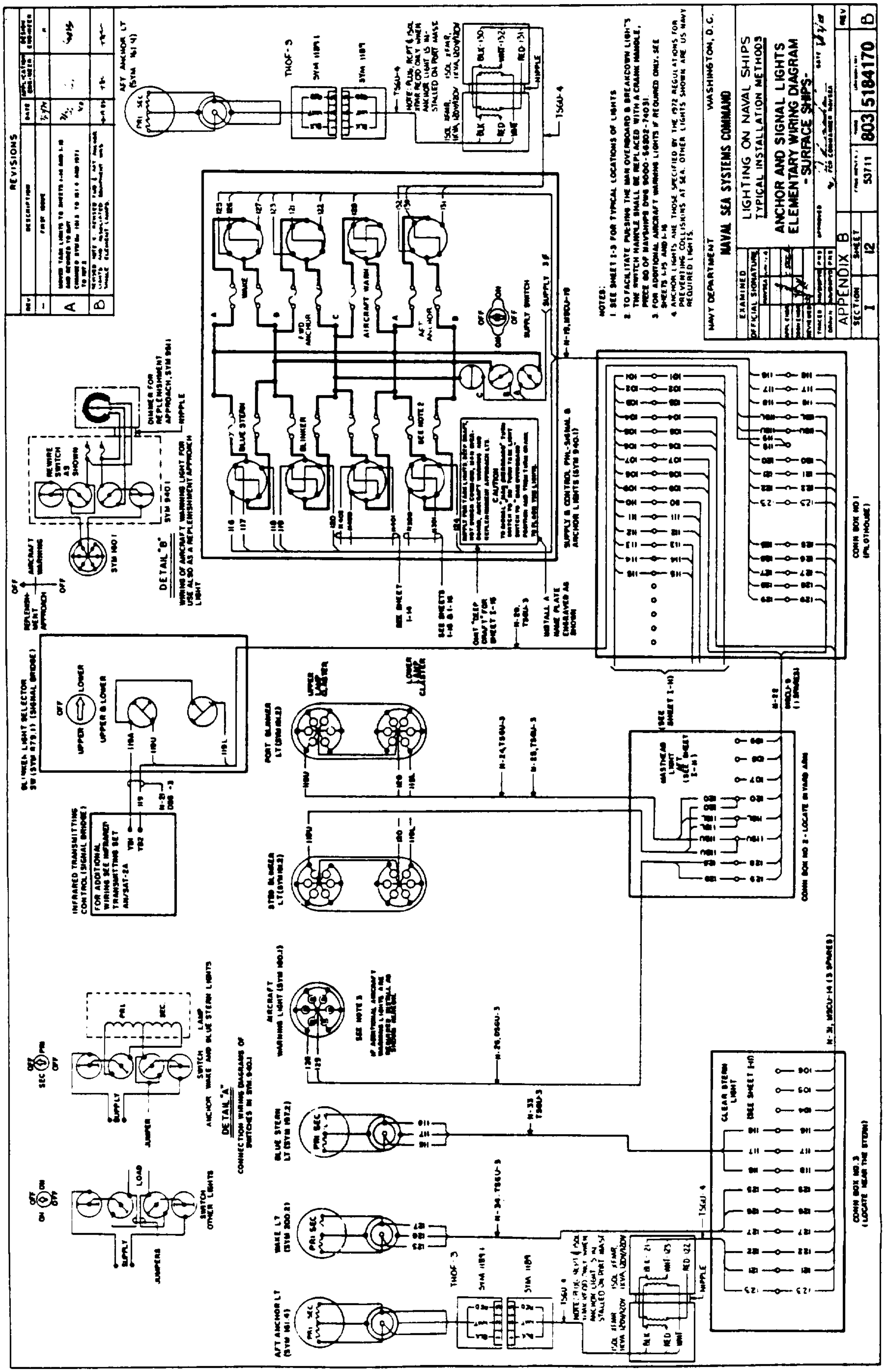
A
REVISIONS
CAUTION
SUPPLY CONTROL & TELLTALE PANEL FOR RUNNING LIGHTS
DIMMER CONTROL PANEL FOR RUNNING LTS
CONNECTION BOX NO 1 (PILOT HOUSE)
DETAIL "A"
SCHEMATIC WIRING DIAGRAM OF A TELLTALE UNIT
BUZZER
SOURCE
DIMMER
FUSES
STERN LT - WHITE
MASTHEAD LIGHT FWD - WHITE
MASTHEAD LIGHT AFT - WHITE
PORT SIDE LT - RED
STBD SIDE LT - GREEN
NOTES: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TYPICAL INSTALLATION METHODS
ANCHOR AND SIGNAL LIGHTS
ELEMENTARY WIRING DIAGRAM
- SURFACE SHIPS -
APPENDIX B
SECTION I
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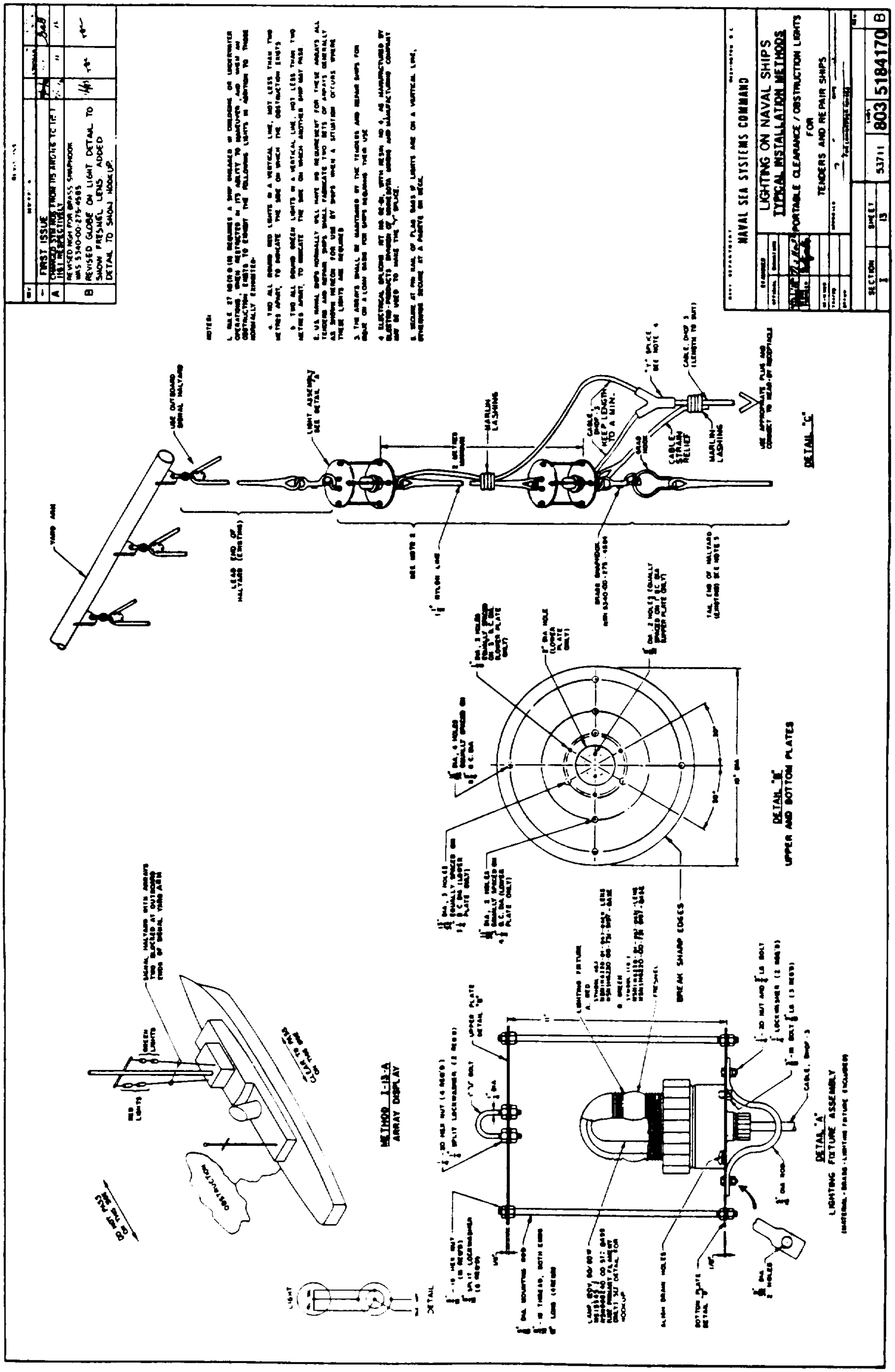
REVISIONS


NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
PORTABLE CLEARANCE / OBSTRUCTION LIGHTS
FOR
TENDERS AND REPAIR SHIPS
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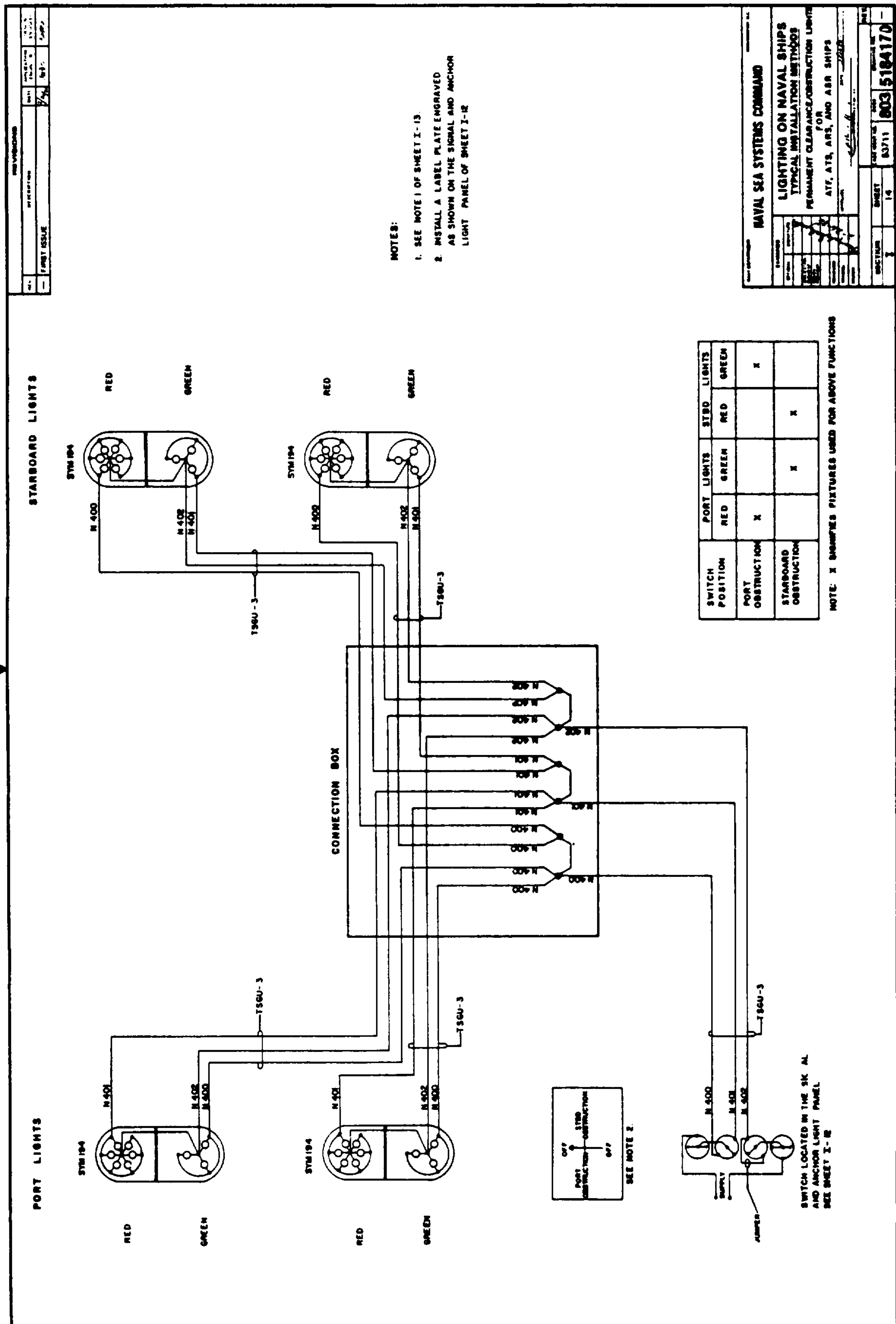
DETAIL "C"
DETAIL "B"
UPPER AND BOTTOM PLATES
DETAIL "A"
LIGHTING FIXTURE ASSEMBLY
METHOD 1-13-A
ARRAY DISPLAY
BREAK SHARP EDGES


NAVAL SEA SYSTEMS COMMAND
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PERMANENT CLEARANCE/OBSTRUCTION LIGHTS
FOR
ATF, ATS, ARS, AND ASR SHIPS
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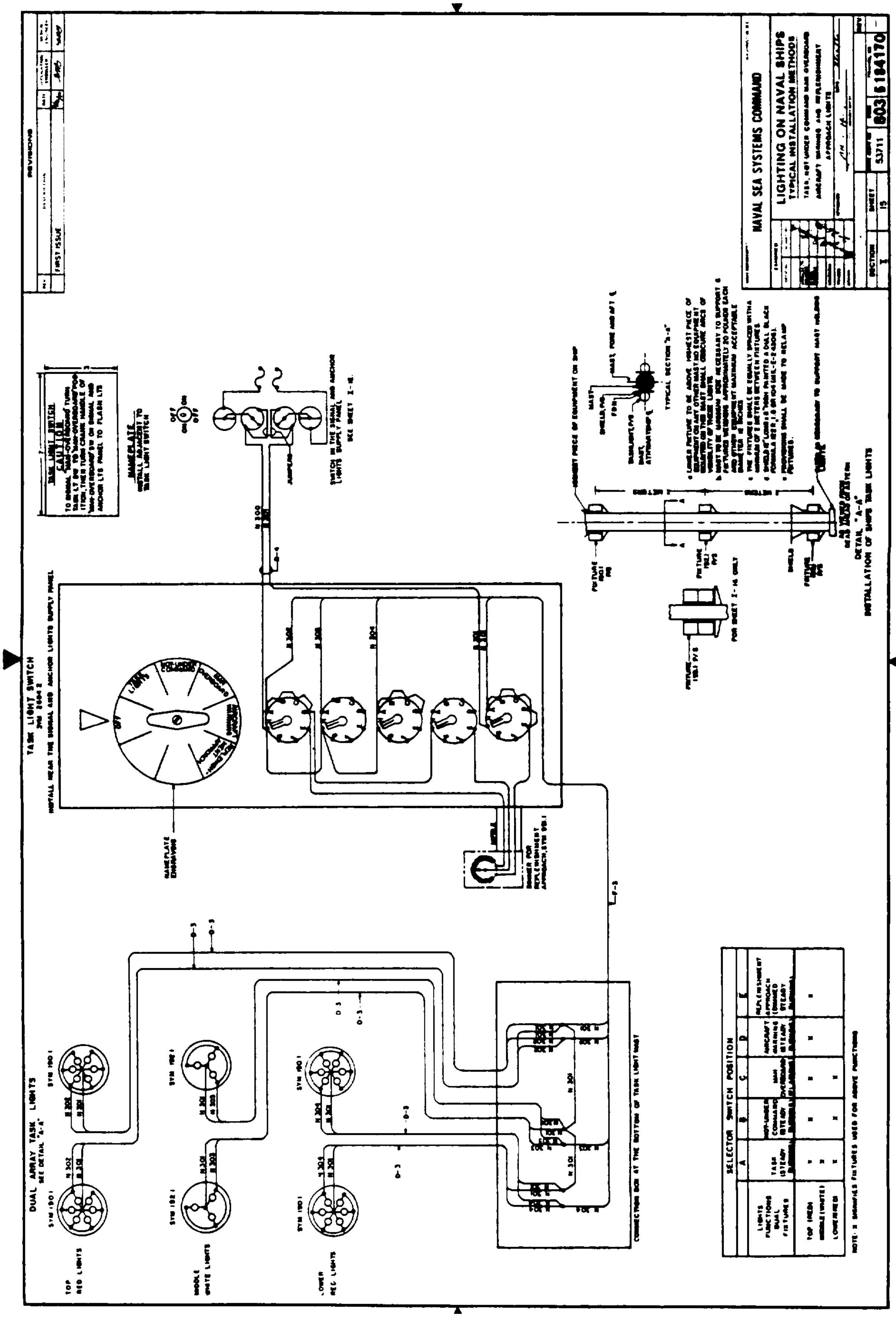
NOTES:
1. SEE NOTE 1 OF SHEET I-13.
2. INSTALL A LABEL PLATE ENGRAVED AS SHOWN ON THE SIGNAL AND ANCHOR LIGHT PANEL OF SHEET I-12
STARBOARD LIGHTS
PORT LIGHTS
RED
GREEN
SYM 194
N 400
N 401
N 402
TSGU-3
CONNECTION BOX
SWITCH POSITION
PORT LIGHTS
STBD LIGHTS
RED
GREEN
PORT OBSTRUCTION
STARBOARD OBSTRUCTION
X
NOTE: X SIGNIFIES FIXTURES USED FOR ABOVE FUNCTIONS
OFF
PORT OBSTRUCTION
STBD OBSTRUCTION
SEE NOTE 2.
SUPPLY
JUMPER
SWITCH LOCATED IN THE SIGNAL AND ANCHOR LIGHT PANEL SEE SHEET I-12


NAVAL SEA SYSTEMS COMMAND
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TASK LIGHT SWITCH
DUAL ARRAY TASK LIGHTS
SELECTOR SWITCH POSITION
DETAIL "A-A"
INSTALLATION OF SHIPS TASK LIGHTS
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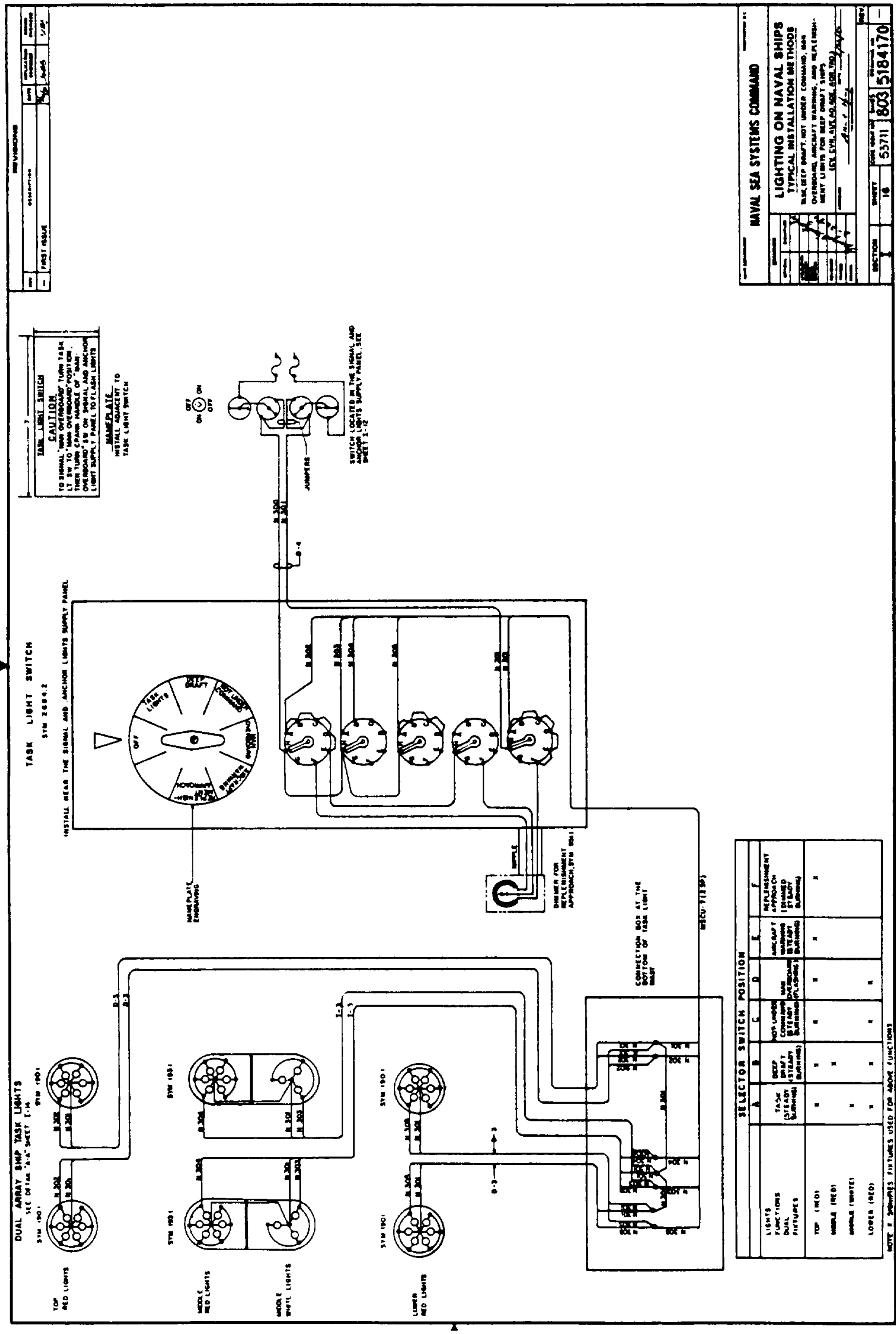
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TASK LIGHT SWITCH
CAUTION
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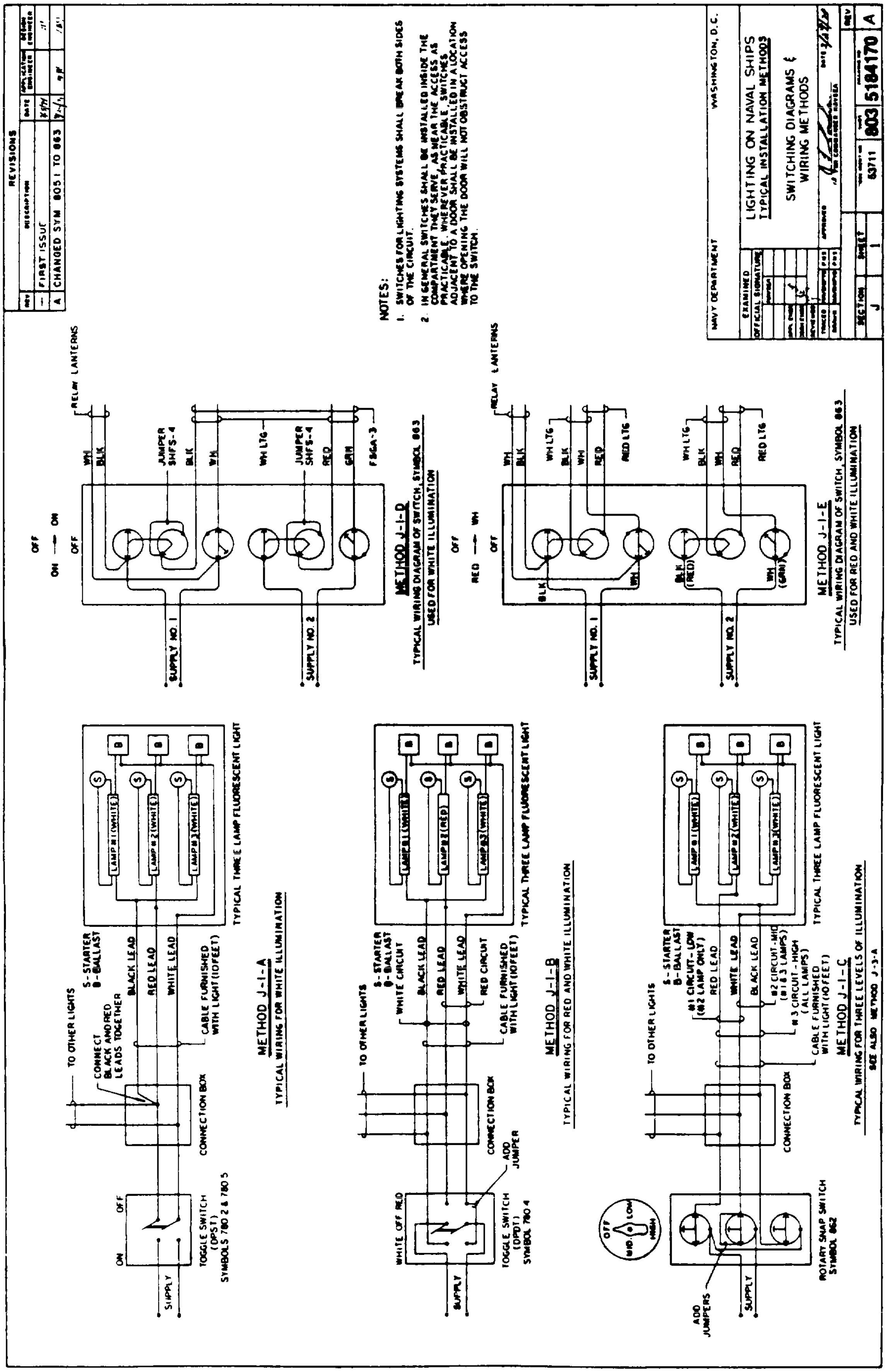
REVISIONS
FIRST ISSUE
CHANGED SYM 805 I TO 863
NOTES:
1. SWITCHES FOR LIGHTING SYSTEMS SHALL BREAK BOTH SIDES OF THE CIRCUIT.
2. IN GENERAL SWITCHES SHALL BE INSTALLED INSIDE THE COMPARTMENT THEY SERVE, AS NEAR THE ACCESS AS PRACTICABLE. WHEREVER PRACTICABLE, SWITCHES ADJACENT TO A DOOR SHALL BE INSTALLED IN A LOCATION WHERE OPENING THE DOOR WILL NOT OBSTRUCT ACCESS TO THE SWITCH.
NAVY DEPARTMENT
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TYPICAL INSTALLATION METHODS
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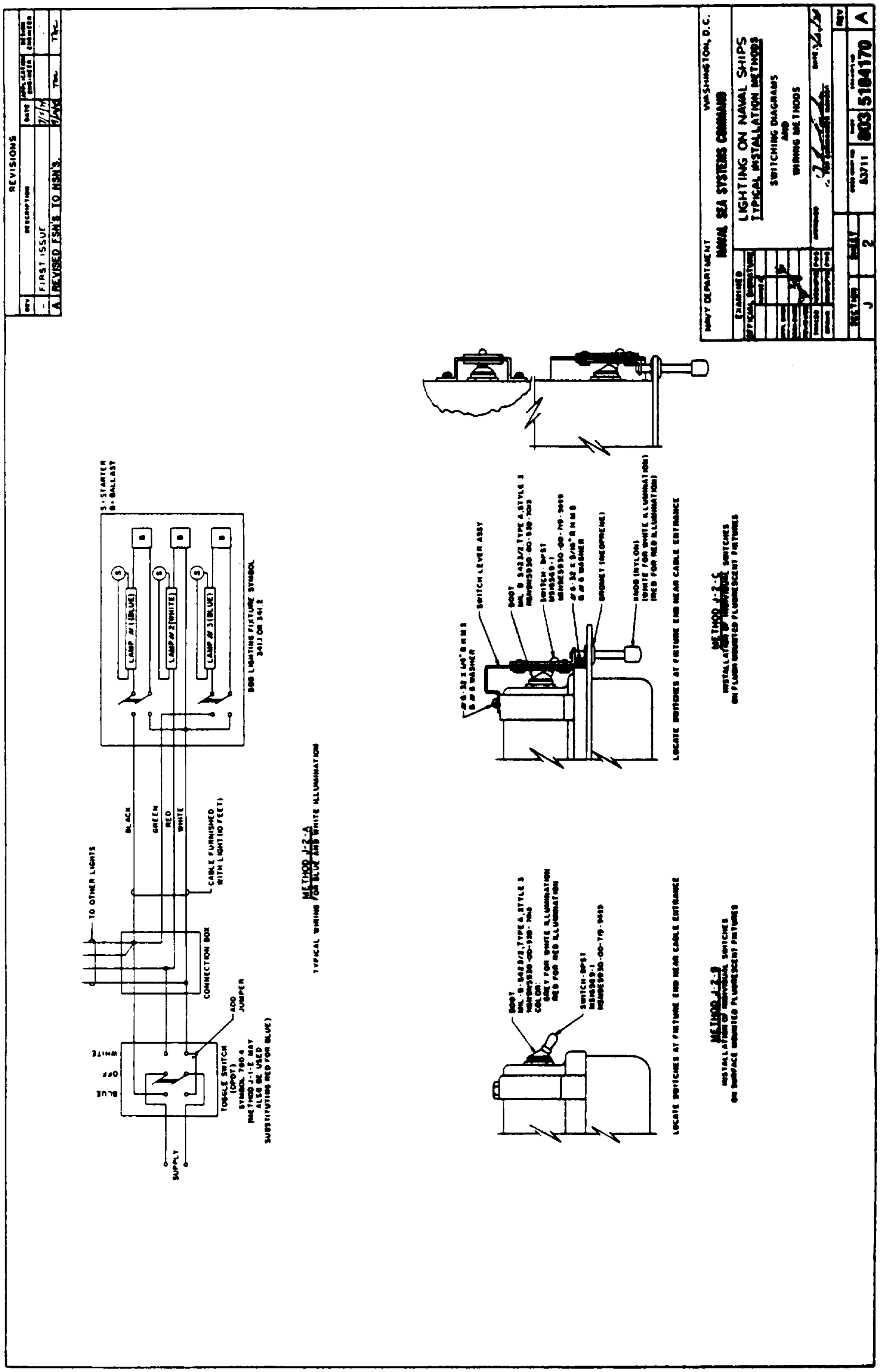
METHOD J-1-A
TYPICAL WIRING FOR WHITE ILLUMINATION
METHOD J-1-B
TYPICAL WIRING FOR RED AND WHITE ILLUMINATION
METHOD J-1-C
TYPICAL WIRING FOR THREE LEVELS OF ILLUMINATION
SEE ALSO METHOD J-3-A
METHOD J-1-D
TYPICAL WIRING DIAGRAM OF SWITCH, SYMBOL 863
USED FOR WHITE ILLUMINATION
METHOD J-1-E
TYPICAL WIRING DIAGRAM OF SWITCH, SYMBOL 863
USED FOR RED AND WHITE ILLUMINATION
TYPICAL THREE LAMP FLUORESCENT LIGHT
S-STARTER
B-BALLAST
BLACK LEAD
RED LEAD
WHITE LEAD
CABLE FURNISHED WITH LIGHT (10 FEET)
CONNECTION BOX
TO OTHER LIGHTS
CONNECT BLACK AND RED LEADS TOGETHER
TOGGLE SWITCH (DPST) SYMBOLS 780 2 & 780 5
TOGGLE SWITCH (DPDT) SYMBOL 780 4
ROTARY SNAP SWITCH SYMBOL 862
ADD JUMPER
ADD JUMPERS
SUPPLY
SUPPLY NO. 1
SUPPLY NO. 2
RELAY LANTERNS
JUMPER SHFS-4
FSGA-3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METHOD J-2-A
TYPICAL WIRING FOR BLUE AND WHITE ILLUMINATION
CONNECTION BOX
TO OTHER LIGHTS
BLACK
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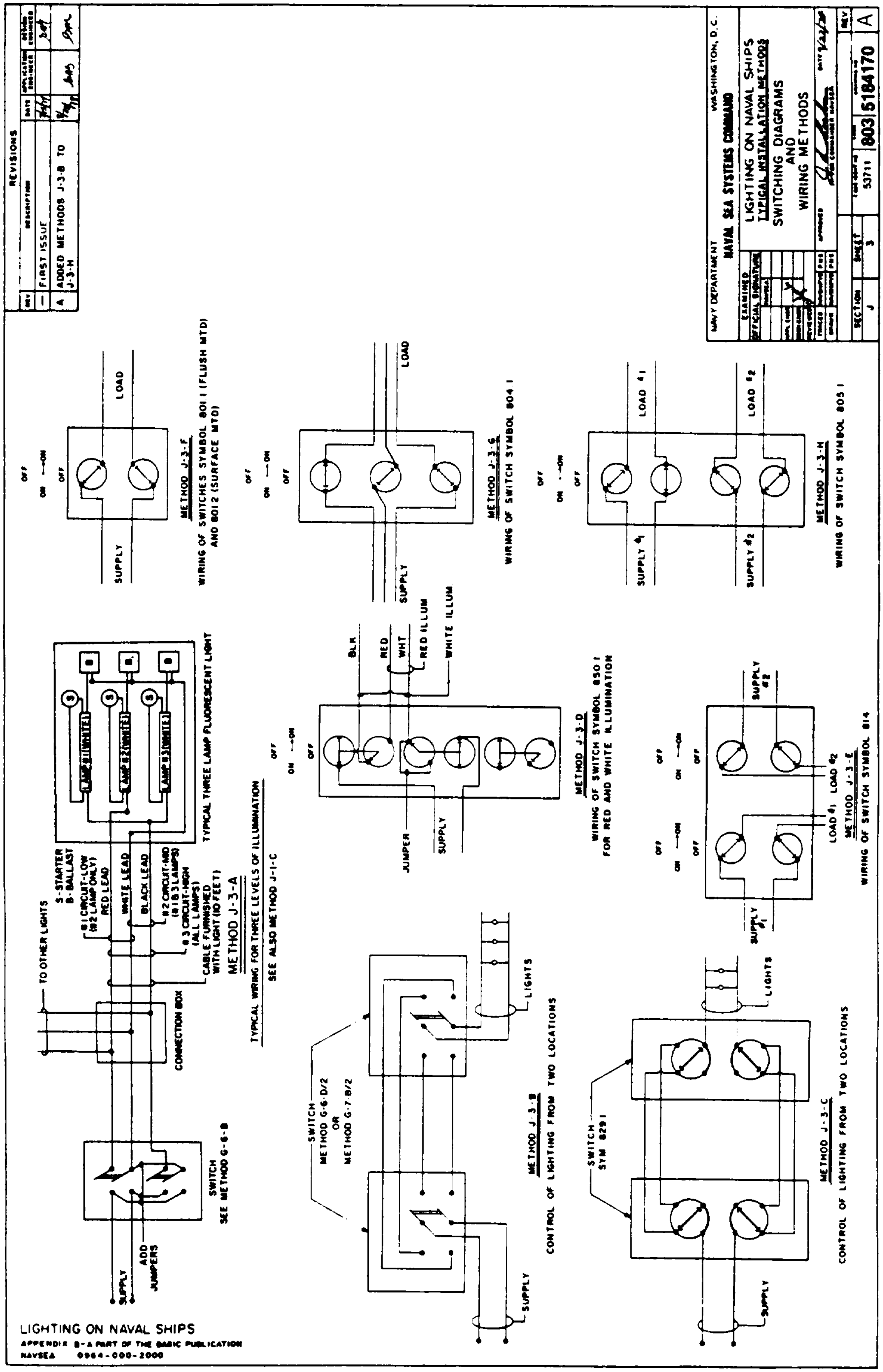
SUPPLY
METHOD J-2-B
METHOD J-2-C
LOCATE SWITCHES AT FIXTURE END NEAR CABLE ENTRANCE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A ADDED METHODS J-3-B TO J-3-H
NAVY DEPARTMENT
NAVAL SEA SYSTEMS COMMAND
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METHOD J-3-F
WIRING OF SWITCHES SYMBOL 801 I (FLUSH MTD) AND 801 2 (SURFACE MTD)
METHOD J-3-G
WIRING OF SWITCH SYMBOL 804 I
METHOD J-3-H
WIRING OF SWITCH SYMBOL 805 I
SUPPLY
LOAD
SUPPLY #1
SUPPLY #2
LOAD #1
LOAD #2
OFF
ON
TYPICAL THREE LAMP FLUORESCENT LIGHT
S-STARTER
B-BALLAST
WHITE LEAD
BLACK LEAD
CABLE FURNISHED WITH LIGHT (10 FEET)
METHOD J-3-A
TYPICAL WIRING FOR THREE LEVELS OF ILLUMINATION
SEE ALSO METHOD J-1-C
TO OTHER LIGHTS
CONNECTION BOX
SWITCH
SEE METHOD G-6-B
ADD JUMPERS
BLK
RED
WHT
RED ILLUM
WHITE ILLUM
JUMPER
METHOD J-3-D
WIRING OF SWITCH SYMBOL 830 I FOR RED AND WHITE ILLUMINATION
METHOD J-3-E
WIRING OF SWITCH SYMBOL 814
LIGHTS
SWITCH
METHOD G-6-D/2
OR
METHOD G-7-B/2
METHOD J-3-B
CONTROL OF LIGHTING FROM TWO LOCATIONS
SWITCH
SYM 829 I
METHOD J-3-C
CONTROL OF LIGHTING FROM TWO LOCATIONS
LIGHTING ON NAVAL SHIPS
APPENDIX B - A PART OF THE BASIC PUBLICATION
NAVSEA 0964-000-2000

SWBD OR LTG LOAD CENTER	FEEDER	LIGHTING EQUIPMENT SERVED	AREA SERVED	CABLE TYPE AND SIZE	RESULTANT LINE CURRENT	DEMAND FACTOR	ASSUMED LINE CURRENT	CIRCUIT BREAKER SIZE	CIRCUIT BREAKER ELEMENT RATING	FEEDER AND MAINS DRAWING NO
			SHIP'S SERVICE LIGHTING							
1S	1S-4P-1SB	LTG TF 2 (3-26-1)		T23	42	0.76	37			
1S	1S-1L-1SB	LTG LOAD CENTER 1SB (3-22-1)		T190	157	0.76	119			
1SB	1SB-1L-(4-31-1)	LTG PNL (4-31-1)	4TH AND BELOW,							
	1SB-1L-(2-40-1)	LTG PNL (2-40-1)	CREW AND CPO QTRS, FR 30-50							
	1SB-1L-SPARE									
	1SB-1L-(3-57-2)	LTG PNL (3-57-2)	1-C, F-C AND WARDROOM, FR 45-60	T30	53	0.89	48			
2S										
ETC										
			EMERGENCY LIGHTING							
1E										
ETC										
2E										
ETC										

REV	DESCRIPTION	DATE	APPLICATION ENGINEER	DESIGN ENGINEER
	FIRST ISSUE			
A	CORRECTED NOTE 7A AND CURRENT VALUES FOR LINE NOS 5-12 AND 14-15 OF LOAD TABLE			

NOTES

1. THIS DRAWING IS TYPICAL ONLY AND SHOULD BE ARRANGED TO SUIT THE PARTICULAR SHIP
2. LIST FEEDERS IN ORDER SHOWN HERE ON
3. ADD DATA REGARDING FUSE AND CIRCUIT BREAKER ELEMENT SIZES BASED ON THE REQUIREMENTS OF GENERAL SPECIFICATIONS FOR SHIPS
4. A SCHEMATIC DIAGRAM OF EACH CIRCUIT SHALL BE SHOWN AS INDICATED ON SHEET J-5 OF APPENDIX B
5. WATTAGE OF FIXTURES AND APPLIANCES SHALL BE AS FOLLOWS
   - A. LAMPS RATED AT 115 VOLTS
   - B. 100 WATTS PER OUTLET IN ALL RECEPTACLE BOXES UNLESS THE DECK DRWG SHOWS AN APPLIANCE OR LAMP CONNECTED TO RECEPTACLE, IN WHICH CASE THE RATED WATTAGE OF APPLIANCE OR LAMP SHALL BE USED
   - C. WHERE A FAN AND HEATER ARE SHOWN CONNECTED TO A DOUBLE RECEPTACLE, ONLY THE CURRENT RATING OF THE HEATER SHALL BE USED
   - D. FRACTIONAL H P MOTORS ARE ASSUMED TO HAVE AN AVERAGE LAGGING POWER FACTOR OF 0.55
   - E. ONLY THE MAXIMUM LOAD CONNECTED AT ONE TIME SHALL BE CONSIDERED THAT IS, ONLY THE 2-20 WATT LAMPS OF A 60 WATT FLUORESCENT FIXTURE SHALL BE CONSIDERED FOR LOAD CALCULATIONS IF THE THIRD 20 WATT LAMP IS USED FOR RED ILLUMINATION
6. LOAD TABLE HERE ON AND ARTICLE 10.4.1.10.2 OF CHAPTER 10 PROVIDE ADDITIONAL INFORMATION FOR LOAD CALCULATIONS
7. PHASE CURRENTS REFERRED TO THEIR RESPECTIVE PHASE VOLTAGES ARE AS FOLLOWS
   - A. CURRENT X AT $\angle 0°$ (P F = 1.0)

     $I_{AB} = X\angle 0° - 0° = X\angle 0 = X \cos 0° + jX \sin 0° = X(1) + jX(0)$

     $I_{BC} = X\angle -120° - 0° = X\angle -120 = X \cos(-120) + jX \sin(-120) = X(-.5) + jX(-.866)$

     $I_{CA} = X\angle 120° - 0° = X\angle 120 = X \cos(120) + jX \sin(120) = X(-.5) + jX(+.866)$
   - B. CURRENT X AT $\angle 56.6°$ (P F = .55)

     $I_{AB} = X\angle 0° - 56.6° = X\angle -56.6 = X \cos(-56.6) + jX \sin(-56.6) = X(+.55) + jX(-.83)$

     $I_{BC} = X\angle -120° - 56.6° = X\angle -176.6 = X \cos(-176.6) + jX \sin(-176.6) = X(-.998) + jX(-.059)$

     $I_{CA} = X\angle 120° - 56.6° = X\angle 63.4 = X \cos(63.4) + jX \sin(63.4) = X(+.448) + jX(+.894)$

LIST OF DECK DRAWINGS SHOWING LATEST ALTERATIONS ON WHICH CABLE SIZES ARE CALCULATED				TABLE SHOWING LATEST ALTERATION OF EACH SHEET			
DECK	DRAWING NO CONTR	DRAWING NO NAVSHIPS	ALT NO	SHEET NO	ALT NO	SHEET NO	ALT NO

LOAD TABLE SHOWING UNIT VALUES USED FOR CABLE SIZE CALCULATIONS ALL FEATURES RATED AT 115 V

LINE NO	LAMPS AND APPLIANCES	WATTS	VARS	PF	CURRENT	PHASE CURRENTS (SEE NOTE 7) I_{AB}	I_{BC}	I_{CA}	REMARKS
1	8-WATT FLUORESCENT LAMP	11.0	16.7	0.55	0.17	+.094-j.141	-.170-j.010	+.076+j.152	
2	15-	26.0	39.5	0.55	0.40	+.220-j.332	-.399-j.024	+.179+j.356	
3	20-	25.0	37.4	0.55	0.38	+.209-j.315	-.379-j.022	+.170+j.340	
4	60(QTY3)-	198.0	44.4	0.97	1.70	+1.65-j.428	-1.18-j1.22	-.469+j1.63	
5	25-WATT INCANDESCENT LAMP	25.0	0.0	1.00	0.22	+0.0-j.22	-.11-j.191	-.11+j.191	
6	50-	50.0	0.0	1.00	0.43	+0.0-j.43	-.22-j.372	-.22+j.372	
7	100-	100.0	0.0	1.00	0.87	+0.0-j.87	-.44-j.753	-.44+j.753	
8	110-	110.0	0.0	1.00	0.96	+0.0-j.96	-.48-j.831	-.48+j.831	
9	150-	150.0	0.0	1.00	1.30	+0.0-j1.30	-.65-j1.126	-.65+j1.126	
10	200-	200.0	0.0	1.00	1.70	+0.0-j1.70	-.85-j1.472	-.85+j1.472	
11	300-	300.0	0.0	1.00	2.60	+0.0-j2.60	-1.30-j2.252	-1.30+j2.252	
12	500-	500.0	0.0	1.00	4.34	+0.0-j4.34	-2.17-j3.758	-2.17+j3.758	
13	RELAY LANTERN	NEG	—	—	—				
14	SINGLE RECEPTACLE	100.00	152	0.55	1.58	+0.84-j1.31	-1.58-j0.08	-0.71+j1.41	
15	DUPLEX RECEPTACLE	200.00	304	0.55	3.16	+1.74-j2.62	-3.15-j0.19	+1.42+j2.83	
16	X-RAY FILM DEVELOPING UNIT	150.00	240	0.54	1.38	+.74-j1.16	-1.37-j0.07	+.62+j1.25	
17	ETC								

SUPERSEDES NAVSHIPS DWG S6400-1449014

NAVY DEPARTMENT WASHINGTON, D.C.

NAVAL SEA SYSTEMS COMMAND

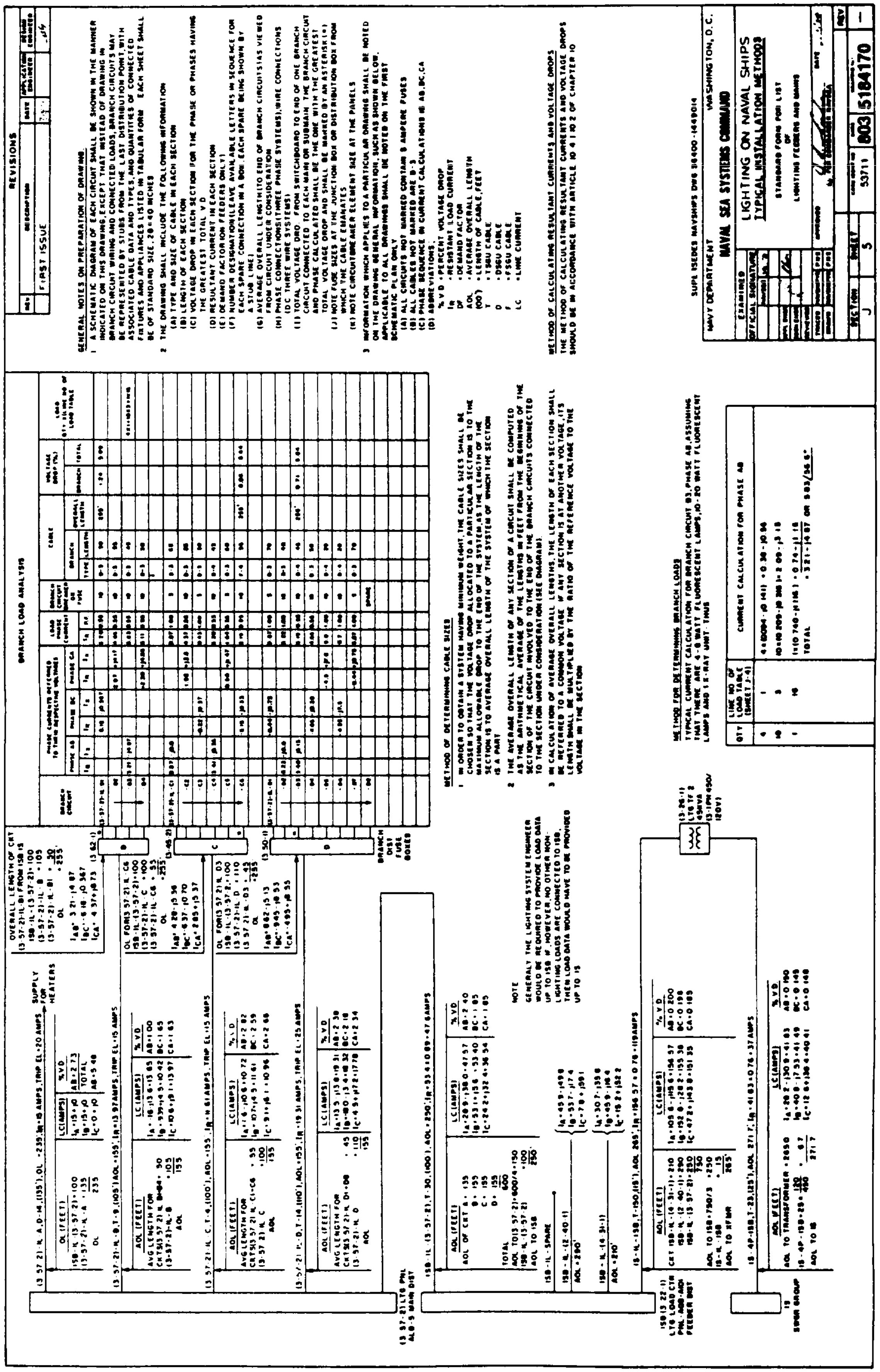
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

STANDARD FORM FOR LIST OF LIGHTING FEEDERS AND MAINS

EXAMINED OFFICIAL SIGNATURE

APPROVED FOR COMMANDER NAVSEA

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
J	4	53711	803	5184170	A


REVISIONS
FIRST ISSUE
BRANCH LOAD ANALYSIS
GENERAL NOTES ON PREPARATION OF DRAWING
METHOD OF CALCULATING RESULTANT CURRENTS AND VOLTAGE DROPS
METHOD OF DETERMINING CABLE SIZES
METHOD FOR DETERMINING BRANCH LOADS
CURRENT CALCULATION FOR PHASE AB
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LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
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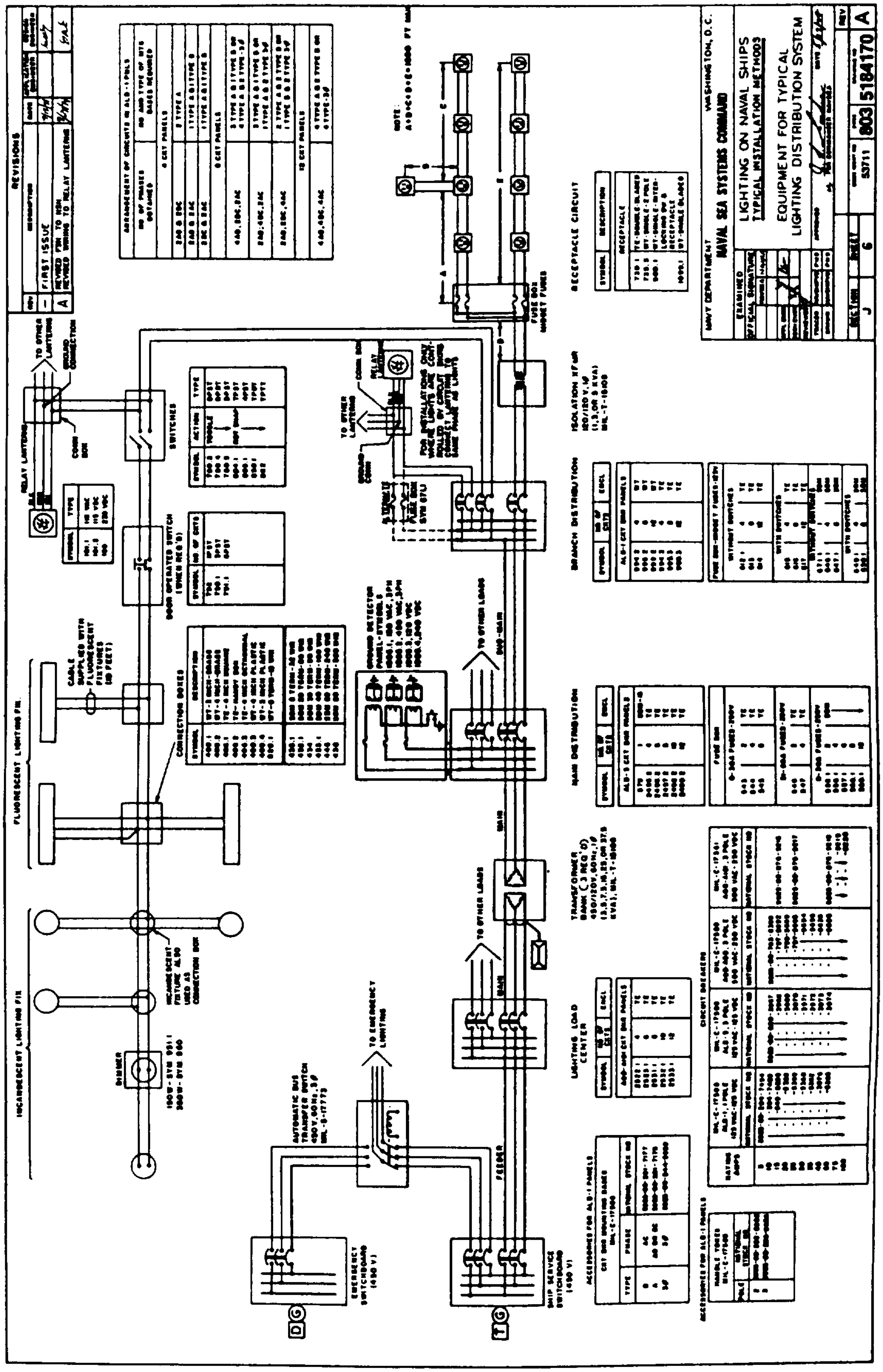
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EQUIPMENT FOR TYPICAL
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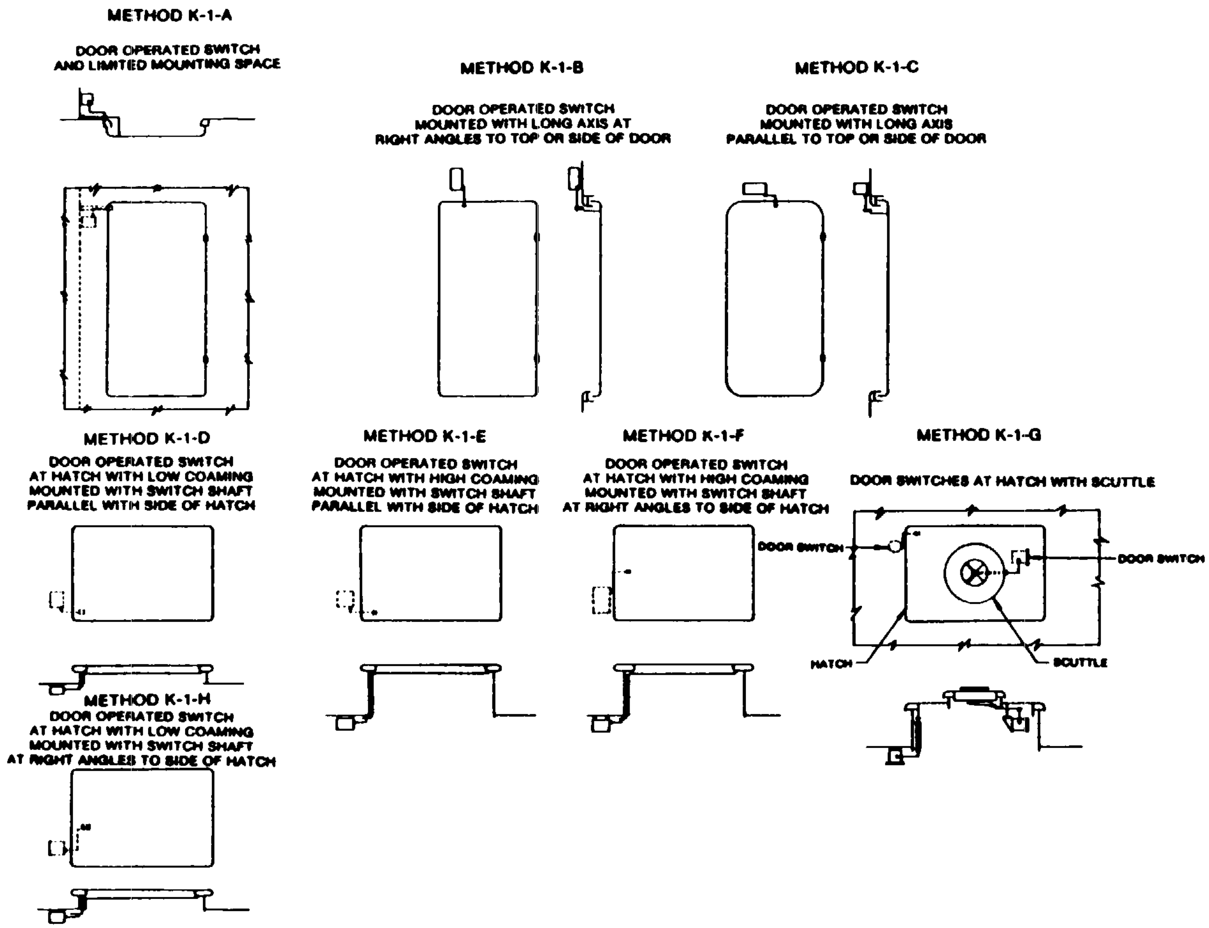


NOTES:

1. THIS DRAWING IS FOR INFORMATION AND GUIDANCE FOR THE INSTALLATION OF DOOR OPERATED SWITCHES. SYMBOLS 790 1, 791 1 AND 792

2. SHEETS K-6, K-7 & K-8 SHOW THE SIMPLEST ARRANGEMENTS FOR DOOR OPERATING AND SHOULD BE USED WHEREVER PRACTICABLE. THE INSTALLATION AND ADJUSTMENT INSTRUCTIONS ARE APPLICABLE TO ALL METHODS

3. SHEET K-9, K-10, K-13 & K-14 SHOW TYPICAL ARRANGEMENT FOR THE USE OF THE VARIOUS OPERATING ACCESSORIES FOR DOOR OPERATION. IT IS THE INTENT OF THESE METHODS TO INDICATE METHODS OF SURMOUNTING OBSTACLES SUCH AS STRUCTURAL MEMBERS, CABLE RUNS ETC., WHICH INTERFERE WITH THE USE OF ARRANGEMENTS SHOWN ON SHEETS K-6, K-7 & K-8.

4. SHEETS K-15 AND K-16 SHOW TYPICAL ARRANGEMENTS FOR HATCH MOUNTING AND THE USE OF THE OPERATING ACCESSORIES

5. SHEET K-17 SHOWS ARRANGEMENTS OF SHEETS K-15 & K-16 EXPANDED TO PROVIDE FOR OPERATION OF THE SWITCH BY BOTH THE HATCH AND SCUTTLE COVERS

6. SHEETS K-12 & K-18 SHOW TYPICAL ARRANGEMENTS FOR MOUNTING SYMBOL 792 SWITCH FOR OPERATION WITH RAISED WATERTIGHT (R.W.T.) HATCH AND SCUTTLE COVERS AND THE USE OF OPERATING ACCESSORIES

7. SHEET K-20 SHOWS METHOD OF COUPLING SYMBOLS 790 1 AND 791.1

8. IN ORDER TO PREVENT FAILURE DUE TO ICING, SWITCHES SHALL NOT BE MOUNTED IN OPEN WEATHER.

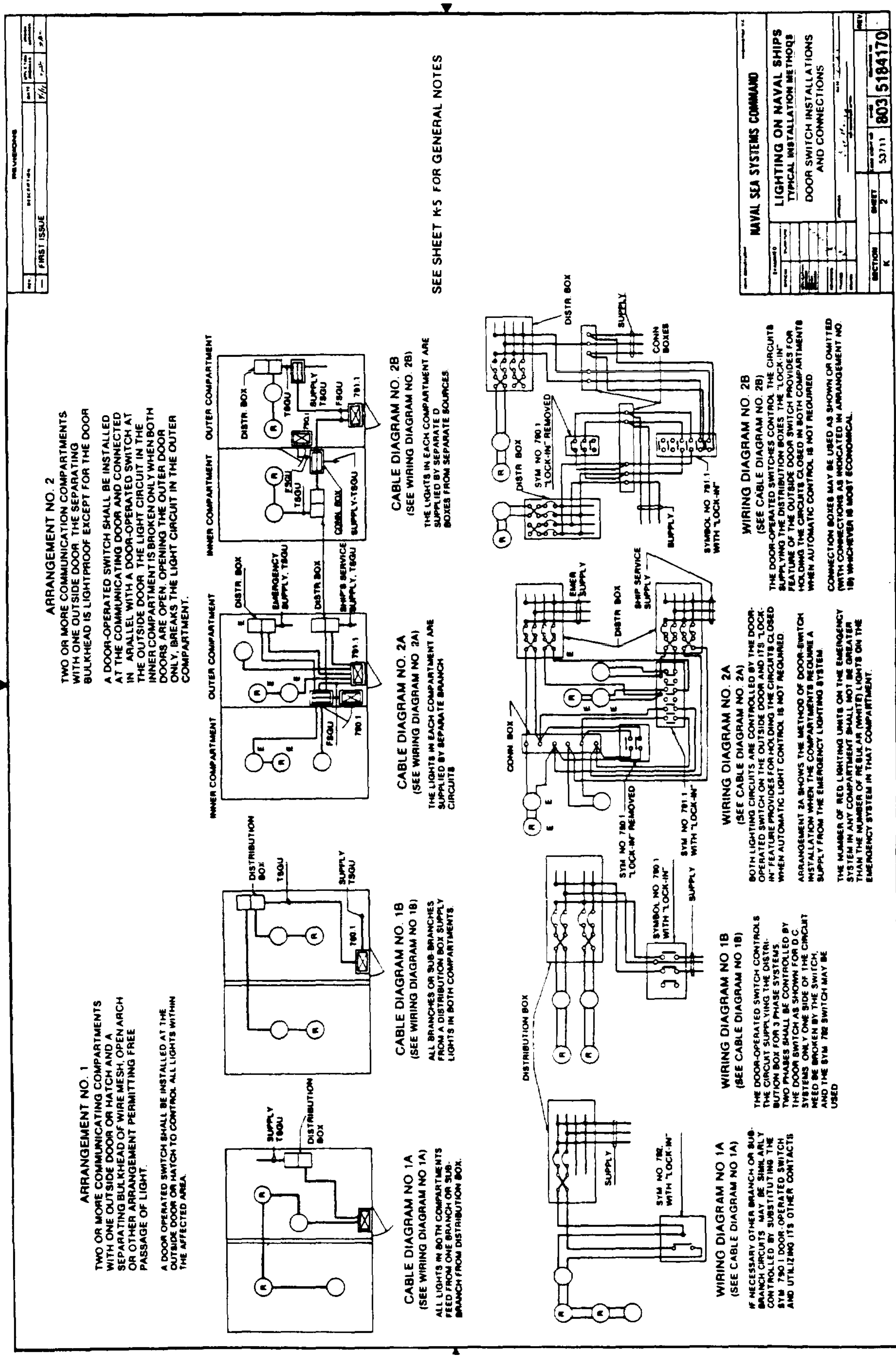
THIS SHEET SUPERSEDES SECTION 3, SHEET 89, OF DRAWING, NAVSEC NO. 9000-S6202-73980.

NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

DOOR OPERATED SWITCHES
APPLICATION DIAGRAMS

SECTION	SHEET				REV
K	1	53711	803	5184170	-


REVISIONS
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ARRANGEMENT NO. 1
TWO OR MORE COMMUNICATING COMPARTMENTS WITH ONE OUTSIDE DOOR OR HATCH AND A SEPARATING BULKHEAD OF WIRE MESH, OPEN ARCH OR OTHER ARRANGEMENT PERMITTING FREE PASSAGE OF LIGHT.
A DOOR OPERATED SWITCH SHALL BE INSTALLED AT THE OUTSIDE DOOR OR HATCH TO CONTROL ALL LIGHTS WITHIN THE AFFECTED AREA.
ARRANGEMENT NO. 2
TWO OR MORE COMMUNICATION COMPARTMENTS WITH ONE OUTSIDE DOOR. THE SEPARATING BULKHEAD IS LIGHTPROOF EXCEPT FOR THE DOOR
A DOOR-OPERATED SWITCH SHALL BE INSTALLED AT THE COMMUNICATING DOOR AND CONNECTED IN ARALLEL WITH A DOOR-OPERATED SWITCH AT THE OUTSIDE DOOR. THE LIGHT CIRCUIT IN THE INNER COMPARTMENT IS BROKEN ONLY WHEN BOTH DOORS ARE OPEN. OPENING THE OUTER DOOR ONLY, BREAKS THE LIGHT CIRCUIT IN THE OUTER COMPARTMENT.
SUPPLY TSGU
DISTRIBUTION BOX
INNER COMPARTMENT
OUTER COMPARTMENT
DISTR BOX
EMERGENCY SUPPLY, TSGU
SHIP'S SERVICE SUPPLY, TSGU
FSGU
790.1
791.1
CONN BOX
SUPPLY-TSGU
CABLE DIAGRAM NO 1A
(SEE WIRING DIAGRAM NO 1A)
ALL LIGHTS IN BOTH COMPARTMENTS FEED FROM ONE BRANCH OR SUB-BRANCH FROM DISTRIBUTION BOX.
CABLE DIAGRAM NO. 1B
(SEE WIRING DIAGRAM NO 1B)
ALL BRANCHES OR SUB-BRANCHES FROM A DISTRIBUTION BOX SUPPLY LIGHTS IN BOTH COMPARTMENTS.
CABLE DIAGRAM NO. 2A
(SEE WIRING DIAGRAM NO 2A)
THE LIGHTS IN EACH COMPARTMENT ARE SUPPLIED BY SEPARATE BRANCH CIRCUITS
CABLE DIAGRAM NO. 2B
(SEE WIRING DIAGRAM NO. 2B)
THE LIGHTS IN EACH COMPARTMENT ARE SUPPLIED BY SEPARATE D BOXES FROM SEPARATE SOURCES
SEE SHEET K-5 FOR GENERAL NOTES
SYM NO 792, WITH "LOCK-IN"
SYMBOL NO 790.1 WITH "LOCK-IN"
SYM NO 790.1 "LOCK-IN" REMOVED
SYM NO 791.1 WITH "LOCK-IN"
EMER SUPPLY
SHIP SERVICE SUPPLY
CONN BOXES
SYMBOL NO 791.1 WITH "LOCK-IN"
WIRING DIAGRAM NO 1A
(SEE CABLE DIAGRAM NO 1A)
IF NECESSARY OTHER BRANCH OR SUB-BRANCH CIRCUITS MAY BE SIMILARLY CONTROLLED BY SUBSTITUTING THE SYM 790.1 DOOR-OPERATED SWITCH AND UTILIZING ITS OTHER CONTACTS
WIRING DIAGRAM NO 1B
(SEE CABLE DIAGRAM NO 1B)
THE DOOR-OPERATED SWITCH CONTROLS THE CIRCUIT SUPPLYING THE DISTRIBUTION BOX FOR 3 PHASE SYSTEMS. TWO PHASES SHALL BE CONTROLLED BY THE DOOR SWITCH AS SHOWN FOR D.C. SYSTEMS ONLY ONE SIDE OF THE CIRCUIT NEED BE BROKEN BY THE SWITCH, AND THE SYM 792 SWITCH MAY BE USED
WIRING DIAGRAM NO. 2A
(SEE CABLE DIAGRAM NO. 2A)
BOTH LIGHTING CIRCUITS ARE CONTROLLED BY THE DOOR-OPERATED SWITCH ON THE OUTSIDE DOOR AND ITS "LOCK-IN" FEATURE PROVIDES FOR HOLDING THE CIRCUITS CLOSED WHEN AUTOMATIC LIGHT CONTROL IS NOT REQUIRED.
ARRANGEMENT 2A SHOWS THE METHOD OF DOOR-SWITCH INSTALLATION WHEN THE COMPARTMENTS REQUIRE A SUPPLY FROM THE EMERGENCY LIGHTING SYSTEM.
THE NUMBER OF RED LIGHTING UNITS ON THE EMERGENCY SYSTEM IN ANY COMPARTMENT SHALL NOT BE GREATER THAN THE NUMBER OF REGULAR (WHITE) LIGHTS ON THE EMERGENCY SYSTEM IN THAT COMPARTMENT.
WIRING DIAGRAM NO. 2B
(SEE CABLE DIAGRAM NO. 2B)
THE DOOR-OPERATED SWITCHES CONTROL THE CIRCUITS SUPPLYING THE DISTRIBUTION BOXES. THE "LOCK-IN" FEATURE OF THE OUTSIDE DOOR SWITCH PROVIDES FOR HOLDING THE CIRCUITS CLOSED IN BOTH COMPARTMENTS WHEN AUTOMATIC CONTROL IS NOT REQUIRED.
CONNECTION BOXES MAY BE USED AS SHOWN OR OMITTED (WITH CONNECTIONS AS INDICATED IN ARRANGEMENT NO. 1B) WHICHEVER IS MOST ECONOMICAL.
NAVAL SEA SYSTEMS COMMAND
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TYPICAL INSTALLATION METHODS
DOOR SWITCH INSTALLATIONS AND CONNECTIONS
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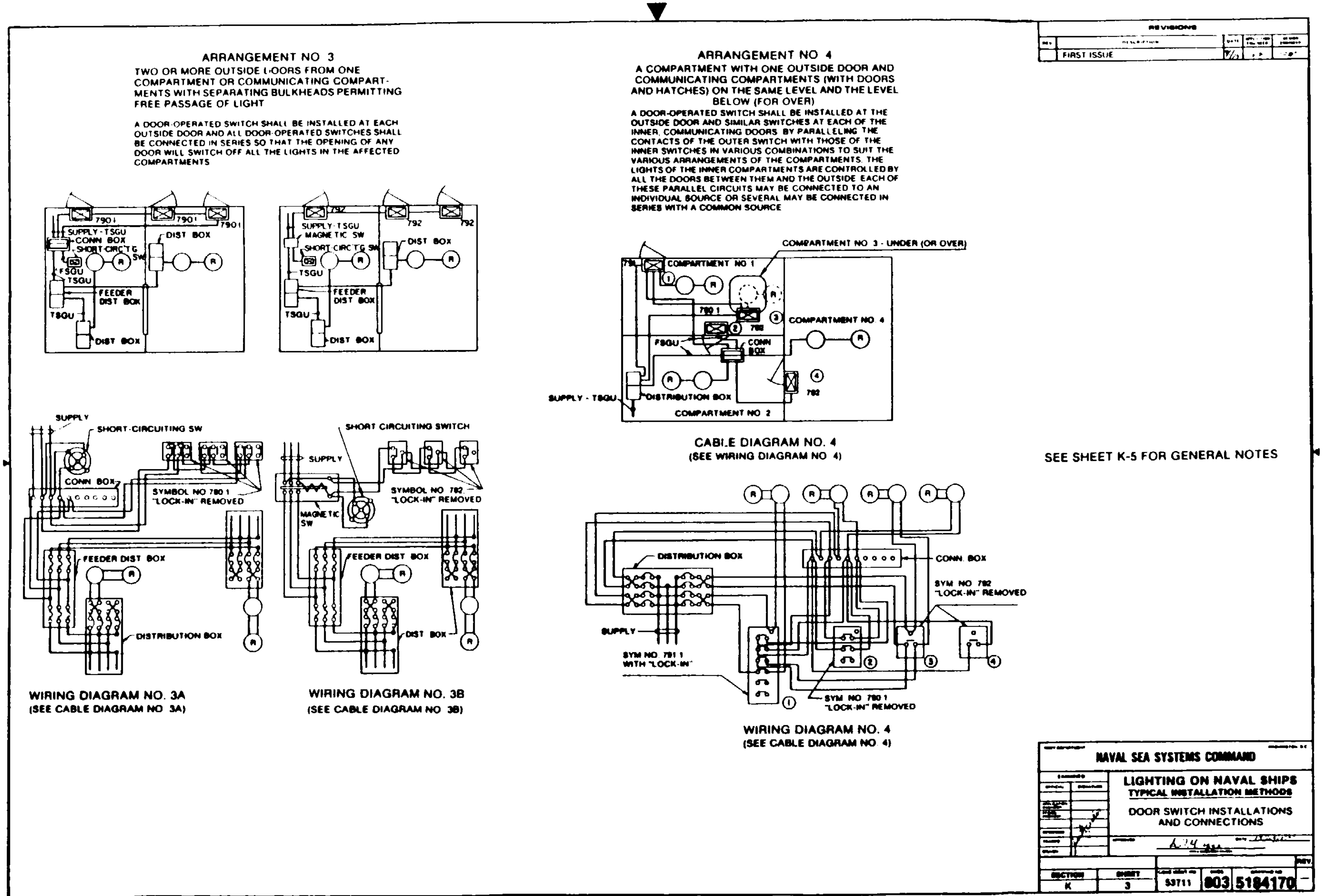
REVISIONS
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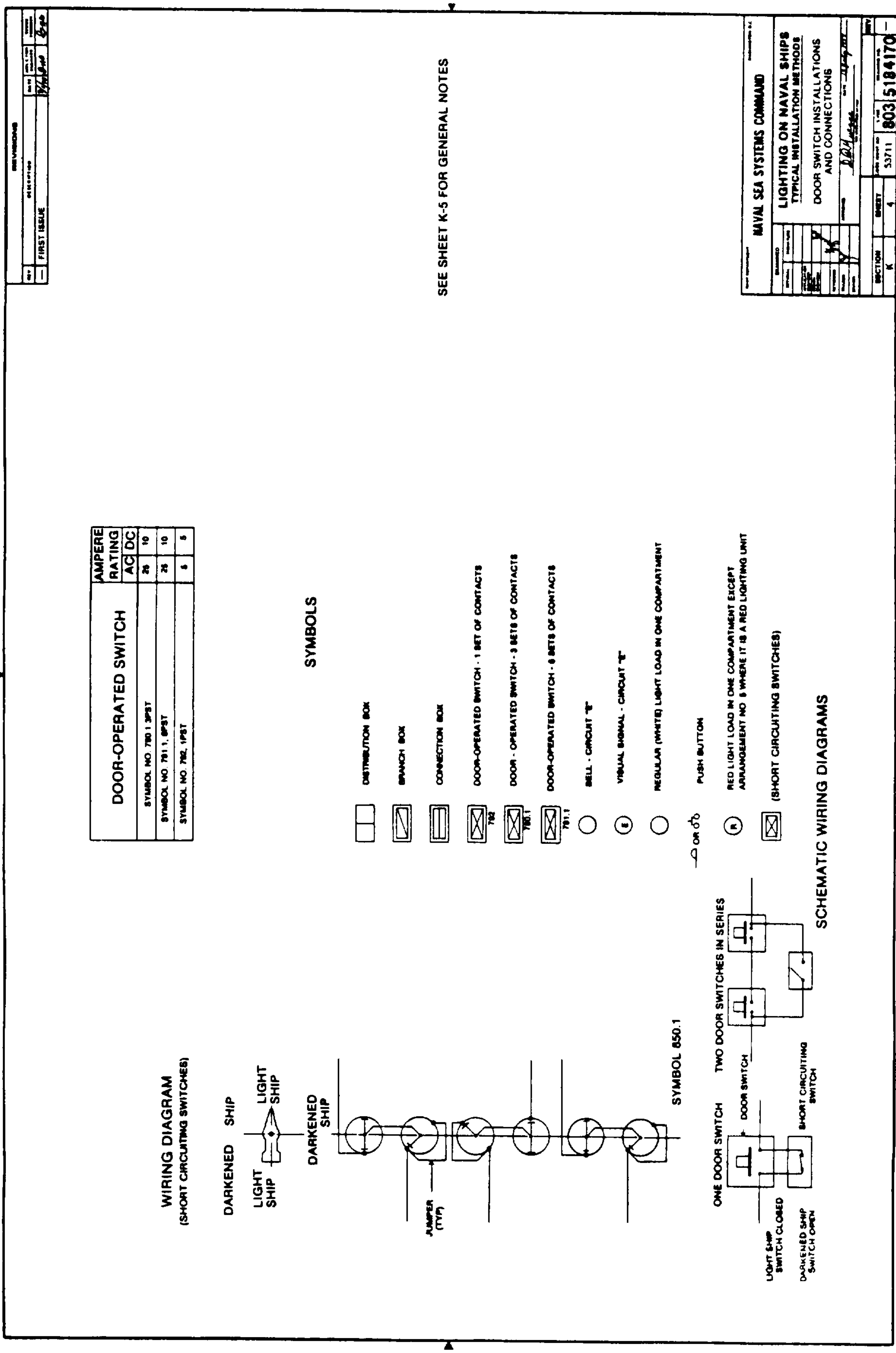
ARRANGEMENT NO 3
TWO OR MORE OUTSIDE DOORS FROM ONE COMPARTMENT OR COMMUNICATING COMPARTMENTS WITH SEPARATING BULKHEADS PERMITTING FREE PASSAGE OF LIGHT
A DOOR-OPERATED SWITCH SHALL BE INSTALLED AT EACH OUTSIDE DOOR AND ALL DOOR-OPERATED SWITCHES SHALL BE CONNECTED IN SERIES SO THAT THE OPENING OF ANY DOOR WILL SWITCH OFF ALL THE LIGHTS IN THE AFFECTED COMPARTMENTS
SUPPLY-TSGU
CONN BOX
SHORT CIRC'TG SW
FSGU
TSGU
FEEDER DIST BOX
DIST BOX
MAGNETIC SW
ARRANGEMENT NO 4
A COMPARTMENT WITH ONE OUTSIDE DOOR AND COMMUNICATING COMPARTMENTS (WITH DOORS AND HATCHES) ON THE SAME LEVEL AND THE LEVEL BELOW (FOR OVER)
A DOOR-OPERATED SWITCH SHALL BE INSTALLED AT THE OUTSIDE DOOR AND SIMILAR SWITCHES AT EACH OF THE INNER, COMMUNICATING DOORS. BY PARALLELING THE CONTACTS OF THE OUTER SWITCH WITH THOSE OF THE INNER SWITCHES IN VARIOUS COMBINATIONS TO SUIT THE VARIOUS ARRANGEMENTS OF THE COMPARTMENTS, THE LIGHTS OF THE INNER COMPARTMENTS ARE CONTROLLED BY ALL THE DOORS BETWEEN THEM AND THE OUTSIDE. EACH OF THESE PARALLEL CIRCUITS MAY BE CONNECTED TO AN INDIVIDUAL SOURCE OR SEVERAL MAY BE CONNECTED IN SERIES WITH A COMMON SOURCE
COMPARTMENT NO 3 - UNDER (OR OVER)
COMPARTMENT NO 1
COMPARTMENT NO 4
COMPARTMENT NO 2
SUPPLY - TSGU
DISTRIBUTION BOX
CABLE DIAGRAM NO. 4
(SEE WIRING DIAGRAM NO 4)
SEE SHEET K-5 FOR GENERAL NOTES
SUPPLY
SHORT-CIRCUITING SW
SYMBOL NO 790 1 "LOCK-IN" REMOVED
FEEDER DIST BOX
DISTRIBUTION BOX
WIRING DIAGRAM NO. 3A
(SEE CABLE DIAGRAM NO 3A)
SHORT CIRCUITING SWITCH
SYMBOL NO 792 "LOCK-IN" REMOVED
WIRING DIAGRAM NO. 3B
(SEE CABLE DIAGRAM NO 3B)
CONN BOX
SYM NO 792 "LOCK-IN" REMOVED
SYM NO 791 1 WITH "LOCK-IN"
SYM NO 790 1 "LOCK-IN" REMOVED
WIRING DIAGRAM NO. 4
(SEE CABLE DIAGRAM NO 4)
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR SWITCH INSTALLATIONS AND CONNECTIONS
SECTION K
SHEET 3
53711
803
5184170


REVISIONS
— FIRST ISSUE
DOOR-OPERATED SWITCH
AMPERE RATING
AC DC
SYMBOL NO. 780 1 3PST 25 10
SYMBOL NO. 781 1, 6PST 25 10
SYMBOL NO. 782, 1PST 5 5
SEE SHEET K-5 FOR GENERAL NOTES
WIRING DIAGRAM
(SHORT CIRCUITING SWITCHES)
DARKENED SHIP
LIGHT SHIP
LIGHT SHIP
DARKENED SHIP
JUMPER (TYP)
SYMBOL 850.1
SYMBOLS
DISTRIBUTION BOX
BRANCH BOX
CONNECTION BOX
DOOR-OPERATED SWITCH - 1 SET OF CONTACTS
DOOR - OPERATED SWITCH - 3 SETS OF CONTACTS
DOOR-OPERATED SWITCH - 6 SETS OF CONTACTS
BELL - CIRCUIT "E"
VISUAL SIGNAL - CIRCUIT "E"
REGULAR (WHITE) LIGHT LOAD IN ONE COMPARTMENT
PUSH BUTTON
RED LIGHT LOAD IN ONE COMPARTMENT EXCEPT ARRANGEMENT NO 5 WHERE IT IS A RED LIGHTING UNIT
(SHORT CIRCUITING SWITCHES)
ONE DOOR SWITCH
TWO DOOR SWITCHES IN SERIES
DOOR SWITCH
LIGHT SHIP SWITCH CLOSED
DARKENED SHIP SWITCH OPEN
SHORT CIRCUITING SWITCH
SCHEMATIC WIRING DIAGRAMS
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR SWITCH INSTALLATIONS AND CONNECTIONS
SECTION K
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REVISIONS

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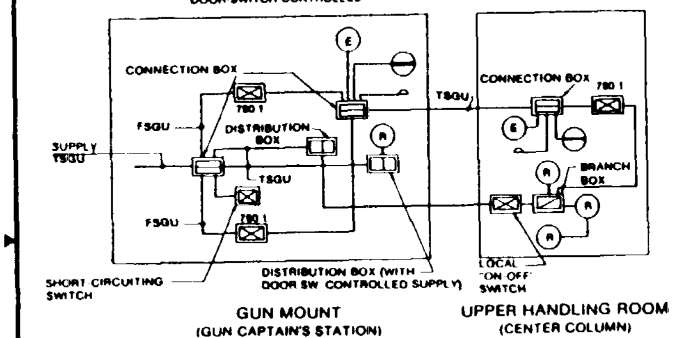
	FIRST ISSUE		

ARRANGEMENT NO 5

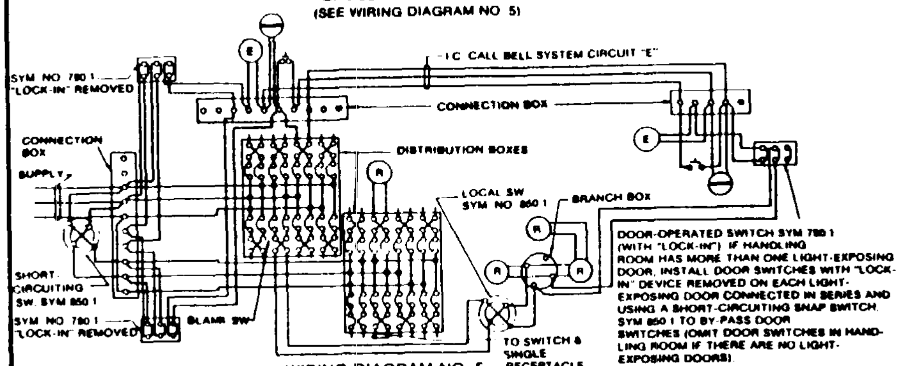
GUN MOUNTS - TWO OR MORE DIFFERENT CIRCUITS ON THE SAME DOOR SWITCHES

TWO DOOR-OPERATED SWITCHES IN THE MOUNT CONTROL THE SUPPLY TO ONE DISTRIBUTION BOX (WHICH SUPPLIES THE LIGHTING IN THE MOUNT) ANOTHER DISTRIBUTION BOX IS FED DIRECT (WITHOUT DOOR SWITCH CONTROL) AND SUPPLIES THE DIAL AND SIGHT LIGHTING, ETC. OF ORDANCE AND FIRE CONTROL EQUIPMENT THE SAME TWO DOOR-OPERATED SWITCHES ALSO CONTROL THE VISUAL (LIGHT) PORTION OF THE CALL BELL CIRCUIT (CIRCUIT E) WHICH IS TAKEN FROM THE DISTRIBUTION BOX WITHOUT DOOR SWITCH CONTROL IN ORDER TO PROVIDE THE AUDIBLE (BELL) PORTION OF CIRCUIT E WITH CURRENT THAT IS NOT DOOR SWITCH CONTROLLED

WHEN THE UPPER HANDLING ROOM CONTAINS A LIGHT-EXPOSING HATCH OR DOOR, A DOOR-OPERATED SWITCH IS REQUIRED TO CONTROL CIRCUIT "E" (VISUAL PORTION) AND THE LOCAL LIGHTS ON THE CENTER COLUMN. BOTH CIRCUITS BEING FED FROM THE DISTRIBUTION BOX WHICH IS NOT DOOR-SWITCH CONTROLLED



CABLE DIAGRAM NO 5
(SEE WIRING DIAGRAM NO 5)



WIRING DIAGRAM NO. 5
(SEE CABLE DIAGRAM NO 5)

(FOR COMPLETE LIGHTING ARRANGEMENT OF 5" GUN MOUNTS (ENCLOSED) SEE BU DWG 9-S-5421-L)

GENERAL NOTES

1 LIMIT THE CABLES ENTERING THE DOOR SWITCH ENCLOSURE TO A MAX OF 4407 C M (SGA CABLE)

2 LIMIT THE TERMINAL TUBES TO SIZES C, E, F AND G

3 IN THE SYM 780 1 AND SYM 782 DOOR SWITCHES, LIMIT THE NUMBER OF TERMINAL TUBES TO 3 LIMIT THE NUMBER OF ENTERING WIRES TO 6 AND THE CONNECTION TERMINALS TO 1

4 IN THE SYM 781 1 DOOR SWITCH, LIMIT THE NUMBER OF TERMINAL TUBES TO 6. LIMIT THE NUMBER OF ENTERING WIRES TO 12 AND THE CONNECTION TERMINALS TO 2

5 IN ORDER TO AVOID CONFUSION AS TO WHEN TO USE THE DOOR SWITCH "WITH LOCK-IN" AND WHEN TO USE THE DOOR SWITCH WITH "LOCK-IN REMOVED" AND ALSO WHEN TO USE THE SEPARATE "SHORT CIRCUITING SWITCH" IT SHOULD BE CLEARLY UNDERSTOOD WHAT IS TO BE ACCOMPLISHED IT IS ESSENTIAL, IN ANY DOOR SWITCH INSTALLATION INVOLVING THE USE OF TWO OR MORE DOOR SWITCHES CONNECTED IN SERIES OR PARALLEL, THAT THE CHANGE-OVER FROM AUTOMATIC TO MANUAL CONTROL BE ACCOMPLISHED AT ONE POINT ONLY IN ORDER TO AVOID THE POSSIBILITY OF OVERLOOKING ANY OF THE CHANGE-OVER DEVICES TO DO THIS EFFECTIVELY AND IN THE SIMPLEST MANNER THE FOLLOWING RULES SHOULD BE OBSERVED

(A) WHEN ONLY ONE DOOR SWITCH IS USED (ARRANGEMENT 1) IT IS NECESSARY TO USE THE TYPE "WITH LOCK-IN"

(B) WHEN TWO OR MORE DOOR SWITCHES ARE CONNECTED IN PARALLEL (ARRANGEMENT 2) THE SWITCH ON THE OUTSIDE DOOR (WHICH INCLUDES THE CIRCUITS OF ALL THE INNER DOORS) SHOULD BE THE TYPE "WITH LOCK-IN" ALL THE SWITCHES ON THE INNER DOORS SHOULD BE THE TYPE WITH "LOCK-IN REMOVED"

(C) WHEN TWO OR MORE DOOR SWITCHES ARE CONNECTED IN SERIES (ARRANGEMENT 3) ALL OF THEM SHOULD BE THE TYPE WITH "LOCK-IN REMOVED" IN THIS CASE A "SHORT-CIRCUITING SWITCH" IS REQUIRED TO SHORT CIRCUIT THE ENTIRE SERIES GROUP OF DOOR SWITCHES

(D) WHEN DOOR SWITCHES ARE CONNECTED IN SERIES-PARALLEL (ARRANGEMENT 4) THE CONNECTIONS OF THE DOOR SWITCHES AT THE OUTSIDE DOORS WILL DETERMINE WHAT TO USE IF THERE ARE SEVERAL OUTSIDE DOORS WITH SWITCHES CONNECTED IN SERIES, THESE WILL TAKE DOOR SWITCHES WITH "LOCK-IN REMOVED" AND A "SHORT-CIRCUITING SWITCH" MUST BE USED IF THERE IS BUT ONE OUTSIDE DOOR, THEN IT WILL TAKE A DOOR SWITCH "WITH LOCK-IN" AND NO SHORT-CIRCUITING SWITCH WILL BE USED. IN EITHER EVENT, ALL THE INNER DOORS WILL TAKE SWITCHES WITH "LOCK-IN REMOVED"

DOOR-SWITCH "LOCK-IN" REMOVED

THE REMOVAL OF THE LOCK-IN FEATURE IS ACCOMPLISHED BY REMOVING PC'S NO S 8000-S6202-74304-50, -51, -52, -53, -54 & -56 FROM DOOR SWITCH SYM NO 780 1 AND PC'S NO'S 8000-S6202-74052-15, -16, & -17 UPON INSTALLATION SHIP'S WIRING DWGS SHALL BEAR NOTATIONS FOR THE REMOVAL OF THE LOCK-IN FEATURE WHERE REQUIRED

6 THIS DWG IS TO BE USED AS A GUIDE ONLY AND IS NOT INTENDED TO COVER ALL POSSIBLE ARRANGEMENTS ITS PURPOSE IS TO ILLUSTRATE TYPICAL APPLICATIONS OF NAVSEA STANDARD DOOR-OPERATED SWITCHES

7 EACH POINT OF POSSIBLE LIGHT EXPOSURE SHALL BE GIVEN SPECIAL ATTENTION TO INSURE THAT THE MEANS PROVIDED WILL ADEQUATELY PREVENT THE EXPOSURE OF ANY LIGHT, EITHER DIRECT LIGHT OR LIGHT REFLECTED FROM DECKS AND BULKHEADS, TO THE EXTERIOR OF THE VESSEL CONSIDERATION SHOULD BE GIVEN TO DOORS AND HATCHES NORMALLY DOGGED AND NOT IN USE DURING DARKENED SHIP CONDITION ADVANTAGE SHOULD ALSO BE TAKEN OF LABYRINTHS PROVIDED BY THE STRUCTURAL ARRANGEMENT AT THE POINT OF POSSIBLE LIGHT EXPOSURE WHERE NEITHER OF THE ABOVE CONDITIONS APPLY THE LIGHT INTEGRITY OF THE SHIP SHALL BE OBTAINED BY INSTALLING EITHER LIGHT TRAPS OR DOOR-OPERATED SWITCHES FOR CONTROLLING THE LIGHTS

8 IN CERTAIN INSTANCES THE DOOR SWITCH INSTALLATIONS SHOWN IN ARRANGEMENT NO 2 MAY BE SIMPLIFIED BY CONTROLLING THE LIGHTS IN BOTH COMPARTMENTS BY THE SWITCH ON THE OUTSIDE DOOR ALONE IF THE NUMBER OF PROBABLE LIGHT INTERRUPTIONS IS NEGLIGIBLE THIS WILL ELIMINATE THE SWITCH ON THE INSIDE DOOR AND SIMPLIFY THE CONTROL WIRING

9 ALL CABLES SHOWN ARE DSGU EXCEPT AS OTHERWISE NOTED

10 RED LIGHTING UNITS SHOWN IN EACH COMPARTMENT IN THE ABOVE ARRANGEMENTS DOES NOT NECESSARILY MEAN THAT EACH OF THESE COMPARTMENTS WILL HAVE RED-LIGHT THE COMPARTMENTS WHICH WILL HAVE RED LIGHTING UNITS SHALL BE DETERMINED FROM THE SHIP SPECIFICATIONS

11 THESE ARRANGEMENTS SHOW THAT BOTH RED AND WHITE LIGHTING UNITS MAY BE CONTROLLED FROM THE SAME DOOR SWITCH AND THAT LIGHTING UNITS FROM BOTH THE SHIP'S SERVICE AND EMERGENCY SYSTEMS MAY BE CONTROLLED FROM THE SAME DOOR SWITCH

NAVAL SEA SYSTEMS COMMAND

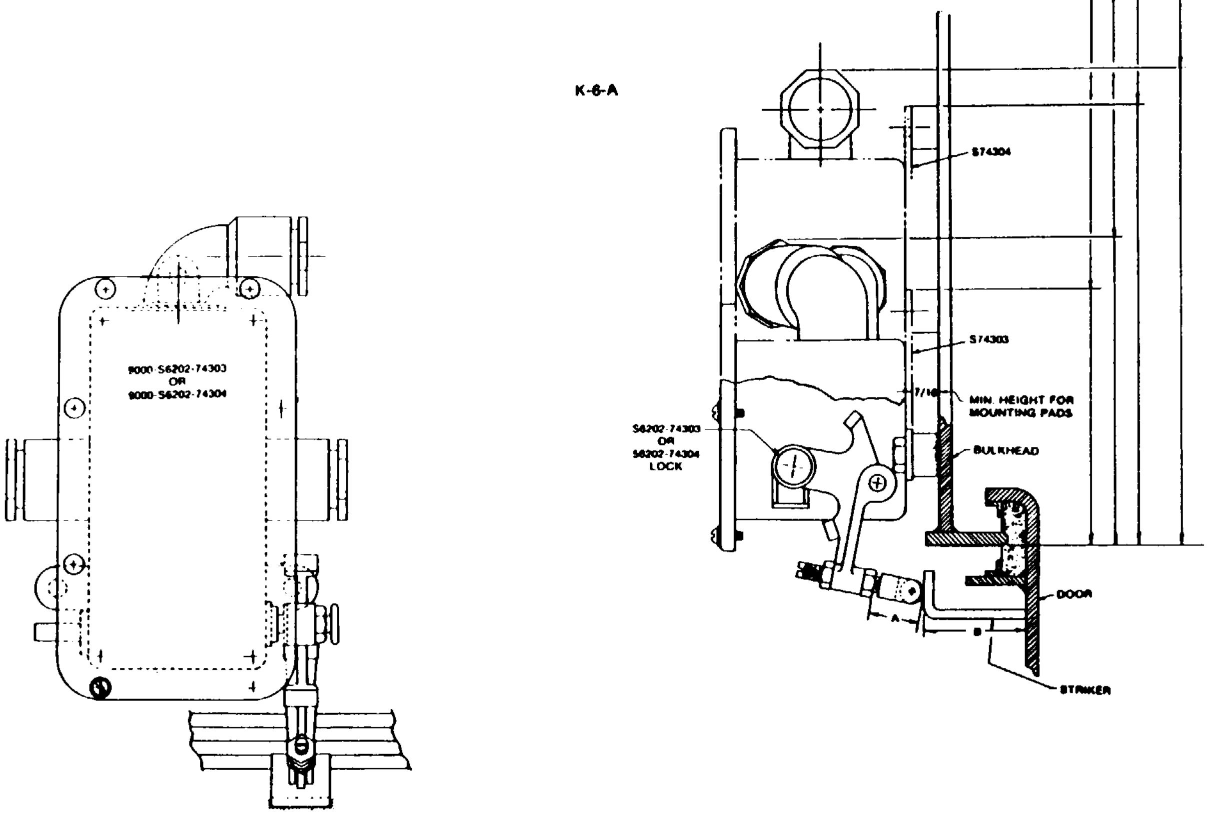
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

DOOR SWITCH INSTALLATIONS AND CONNECTIONS

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
K	5	53711	803	5184170	—

REV	DESCRIPTION	DATE
—	FIRST ISSUE	

K-6-A



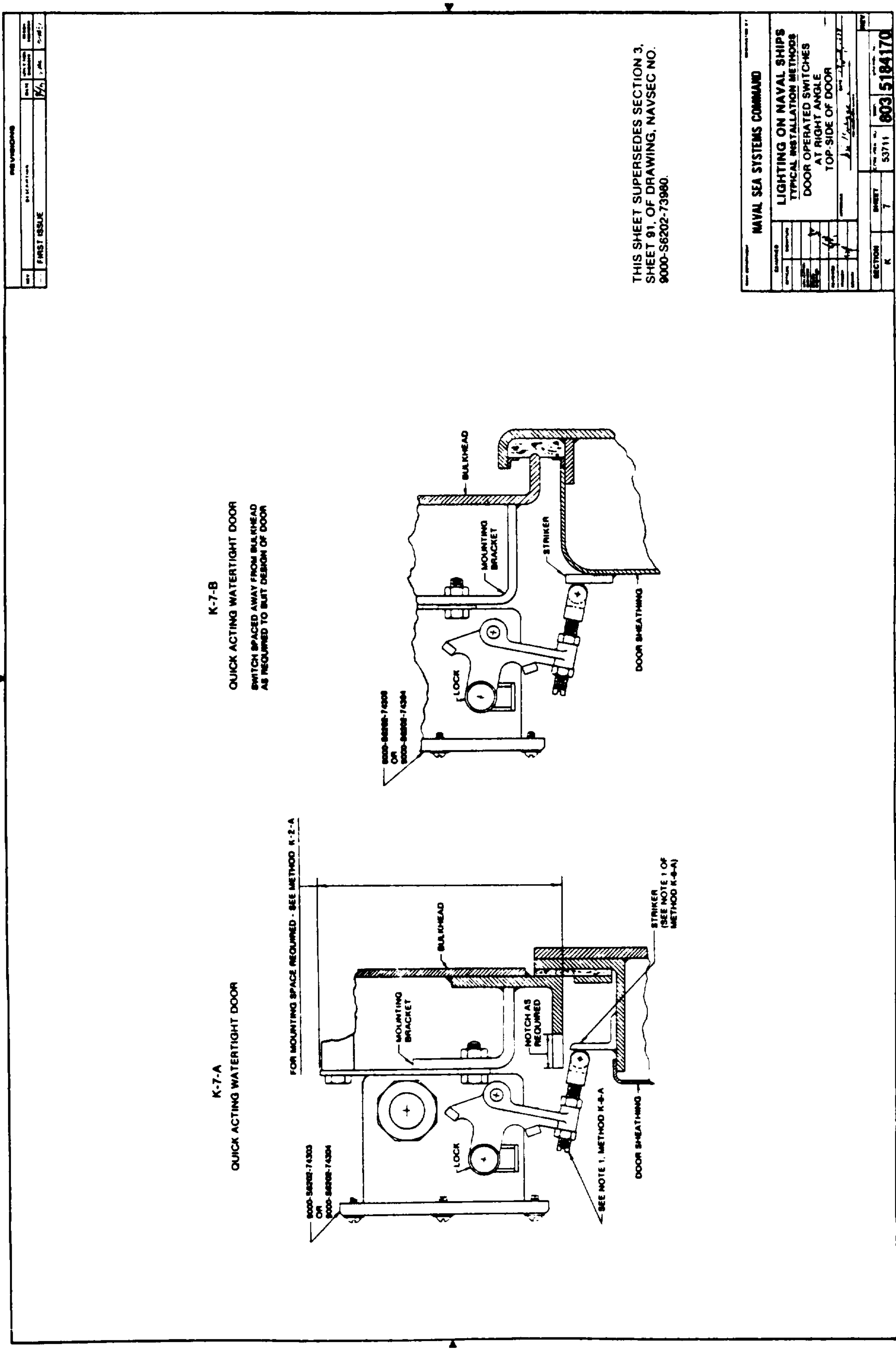
NOTES:
1 A STRIKER OF SUITABLE DESIGN FOR ACTUATING THE SWITCH SHALL BE FURNISHED AND INSTALLED BY THE INSTALLING ACTIVITY FOR EACH DOOR OPERATED SWITCH
2 IT IS IMPORTANT THAT DIMENSION "A" BE AS SHORT AS PRACTICABLE. LENGTH OF STRIKER, DIMENSION "B" SHALL BE DETERMINED ACCORDINGLY.
3 TO ADJUST SWITCH FOR PROPER OPERATION SEE NOTE 1 METHOD K-6-A

THIS SHEET SUPERSEDES SECTION 3, SHEET 90, OF DRAWING, NAVSEC NO. 9000-S6202-73980.

NAVAL SEA SYSTEMS COMMAND

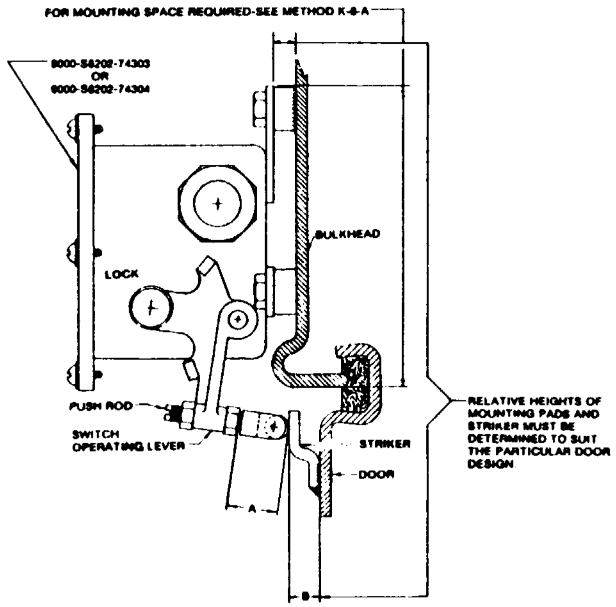
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES
LONG AXIS RIGHT ANGLE
TO TOP OR SIDE OF DOOR

SECTION	SHEET				REV.
K	6	53711	803	5184170	—

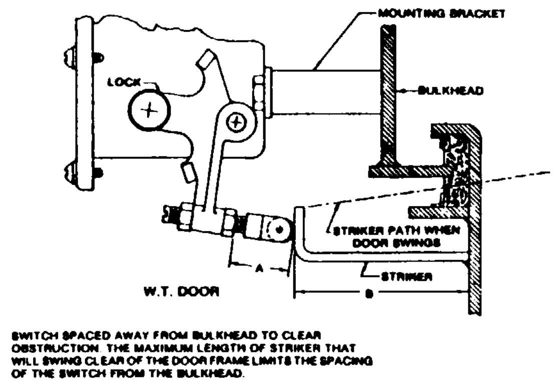

REVISIONS
FIRST ISSUE
K-7-A
QUICK ACTING WATERTIGHT DOOR
FOR MOUNTING SPACE REQUIRED - SEE METHOD K-2-A
9000-S6202-74303
OR
9000-S6202-74304
MOUNTING BRACKET
BULKHEAD
LOCK
NOTCH AS REQUIRED
SEE NOTE 1, METHOD K-8-A
DOOR SHEATHING
STRIKER (SEE NOTE 1 OF METHOD K-8-A)
K-7-B
QUICK ACTING WATERTIGHT DOOR
SWITCH SPACED AWAY FROM BULKHEAD AS REQUIRED TO SUIT DESIGN OF DOOR
9000-S6202-74303
OR
9000-S6202-74304
LOCK
BULKHEAD
MOUNTING BRACKET
STRIKER
DOOR SHEATHING
THIS SHEET SUPERSEDES SECTION 3, SHEET 91, OF DRAWING, NAVSEC NO. 9000-S6202-73980.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES
AT RIGHT ANGLE
TOP-SIDE OF DOOR
SECTION K
SHEET 7
53711
803 5184170

REV	DESCRIPTION	DATE	APPROVED
—	FIRST ISSUE		

K-8-A



K-8-B



NOTES:

1 TO ADJUST SWITCH FOR PROPER OPERATION ENGAGE LOCK. THEN, WITH DOOR CLOSED AND DOGGED ADJUST PUSH ROD TO MEET STRIKER WHEN THE LOCK IS OMITTED FROM THE SWITCH REMOVE THE COVER AND CAREFULLY ADJUST PUSH ROD IN THE SWITCH CLOSING DIRECTION UNTIL THE INTERNAL QUICK-BREAK LATCH DROPS INTO PLACE. THEN TURN PUSH ROD AN ADDITIONAL 3/4 TURN

FOR BEST OPERATION OF THE SWITCH IT IS IMPORTANT THAT THE FINAL ADJUSTMENT OF THE PUSH ROD BRINGS THE END OF THE SWITCH OPERATING LEVER AS CLOSE TO THE DOOR STRIKER AS IS PRACTICABLE

2 SEE NOTES 1 AND 2 OF METHOD K-8-A

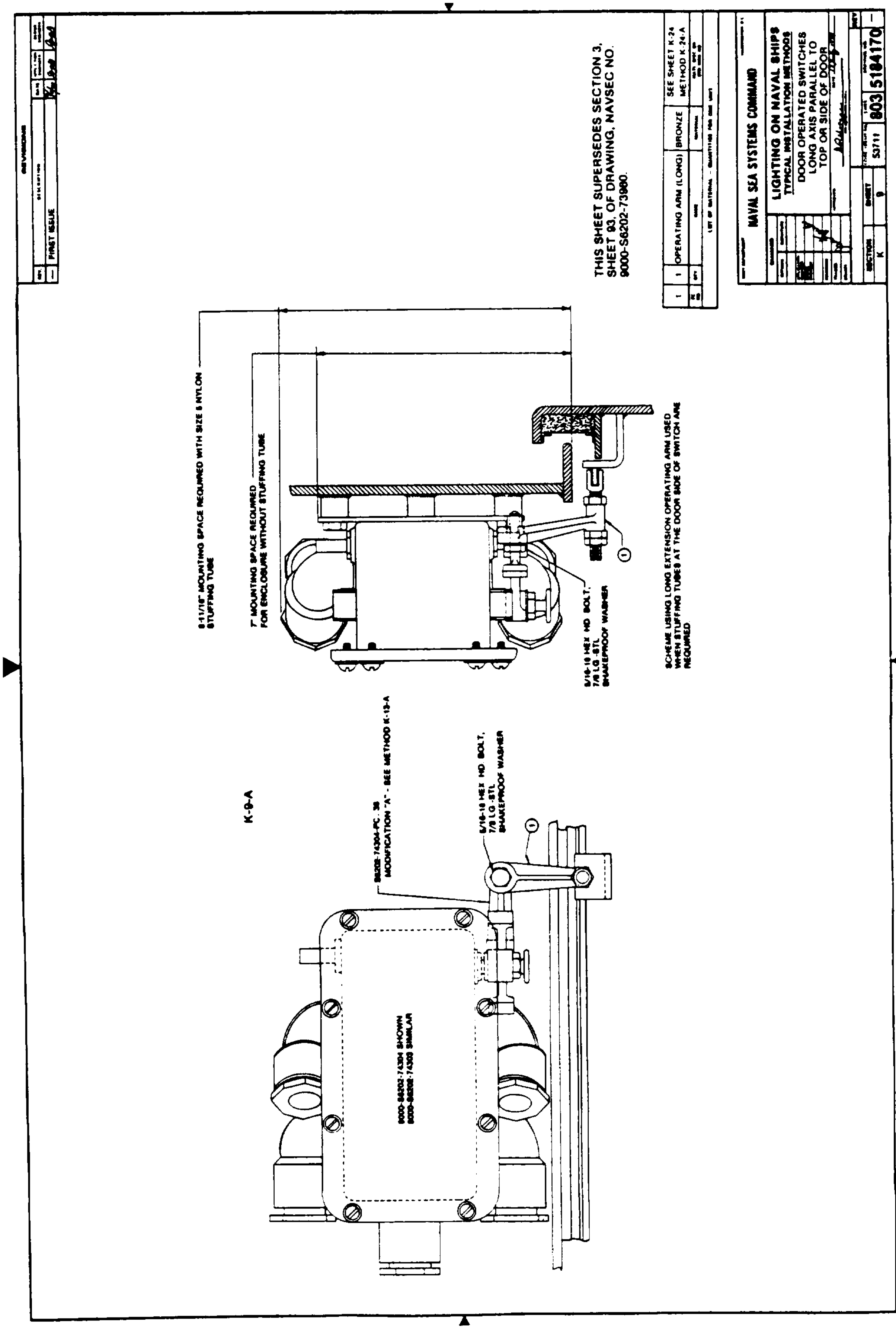
THIS SHEET SUPERSEDES SECTION 3, SHEET 92, OF DRAWING, NAVSEC NO. 9000-S6202-73980.

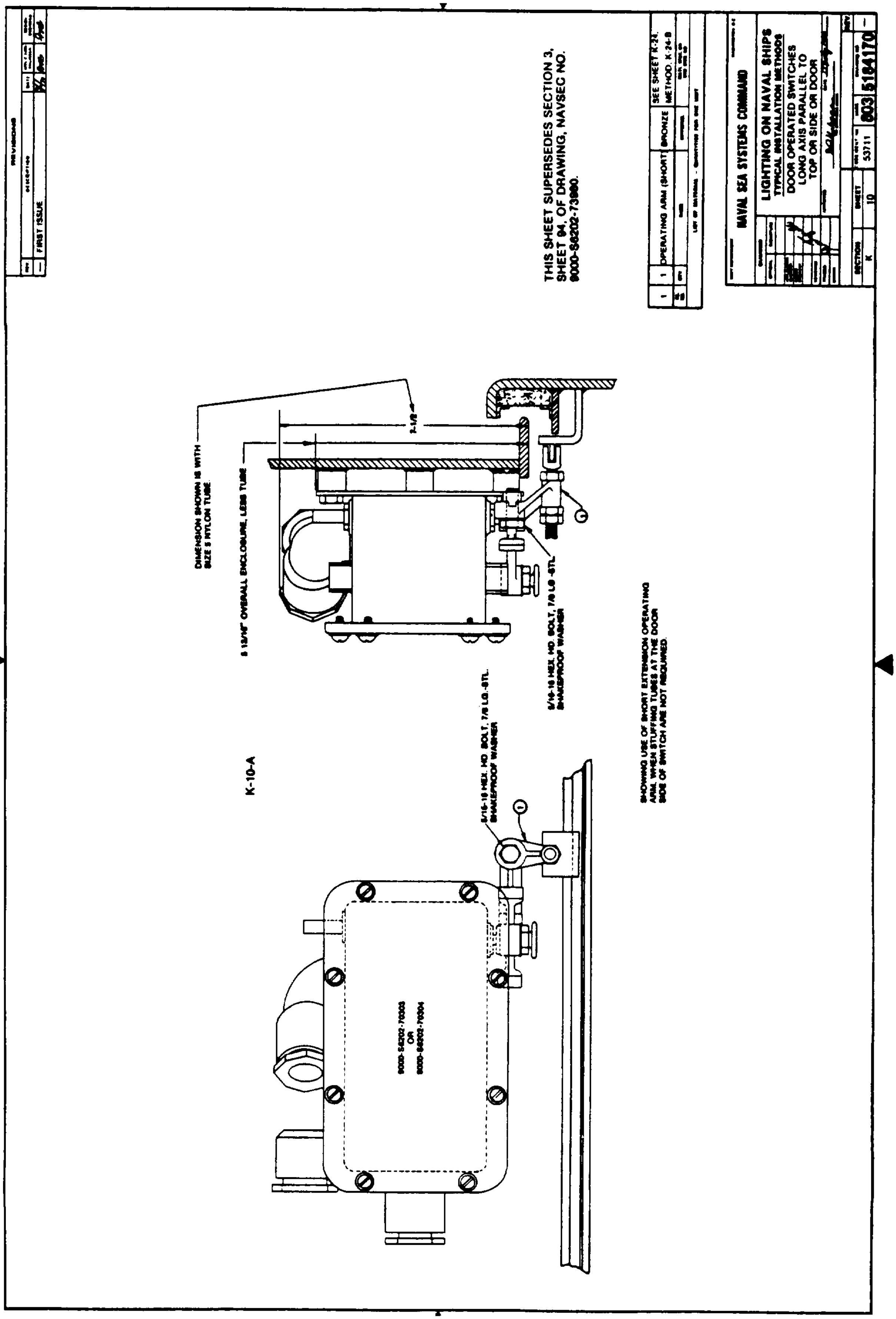
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

DOOR OPERATED SWITCHES
LONG AXIS RIGHT ANGLE TO
TOP OR SIDE OR DOOR

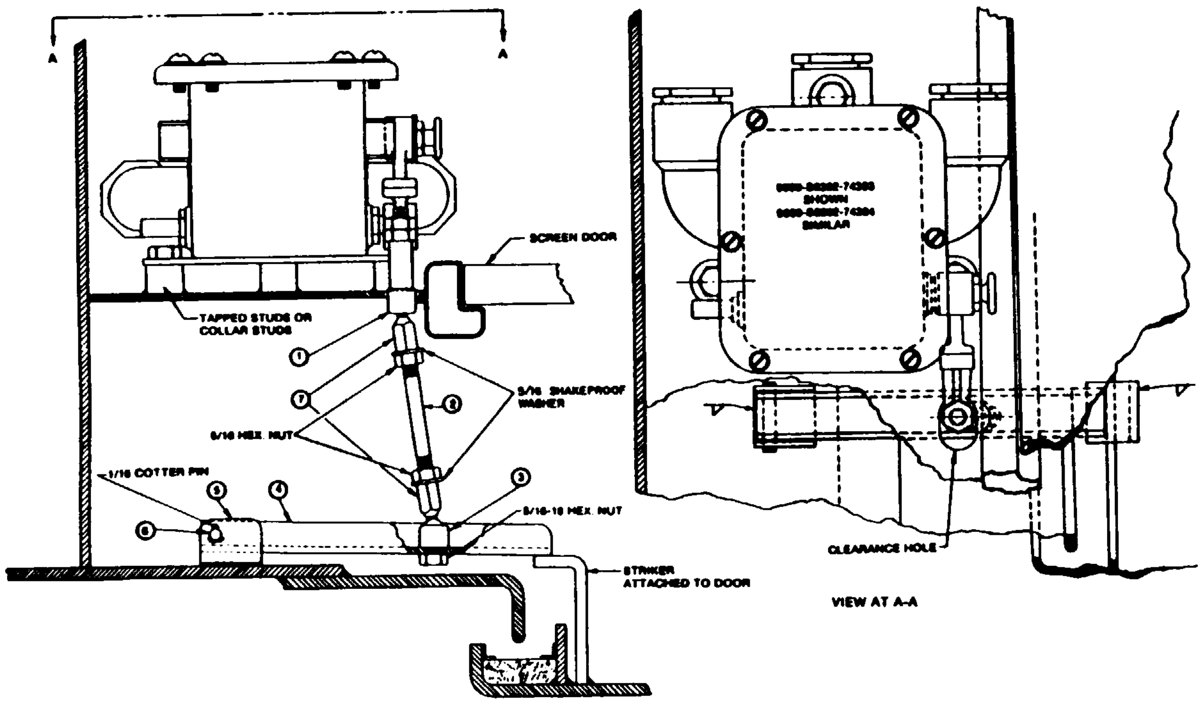
SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
K	8	53711	803	5184170	—


REVISIONS
— FIRST ISSUE
K-9-A
9000-S6202-74304 SHOWN
9000-S6202-74303 SIMILAR
S6202-74304-PC. 38
MODIFICATION "A" - SEE METHOD K-13-A
5/16-18 HEX HD BOLT,
7/8 LG -STL
SHAKEPROOF WASHER
1
8-11/16" MOUNTING SPACE REQUIRED WITH SIZE 5 NYLON
STUFFING TUBE
7" MOUNTING SPACE REQUIRED
FOR ENCLOSURE WITHOUT STUFFING TUBE
SCHEME USING LONG EXTENSION OPERATING ARM USED
WHEN STUFFING TUBES AT THE DOOR SIDE OF SWITCH ARE
REQUIRED
THIS SHEET SUPERSEDES SECTION 3,
SHEET 93, OF DRAWING, NAVSEC NO.
9000-S6202-73980.
1 1 OPERATING ARM (LONG) BRONZE SEE SHEET K-24
METHOD K-24-A
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES
LONG AXIS PARALLEL TO
TOP OR SIDE OF DOOR
SECTION K
SHEET 9
53711
803
5184170


FIRST ISSUE
K-10-A
DIMENSION SHOWN IS WITH SIZE 5 NYLON TUBE.
5 13/16" OVERALL ENCLOSURE, LESS TUBE
7-1/2
9000-S6202-70303
OR
9000-S6202-70304
5/16-18 HEX. HD. BOLT, 7/8 LG.-STL.
SHAKEPROOF WASHER
5/16-18 HEX. HD. BOLT, 7/8 LG.-STL.
SHAKEPROOF WASHER
SHOWING USE OF SHORT EXTENSION OPERATING ARM, WHEN STUFFING TUBES AT THE DOOR SIDE OF SWITCH ARE NOT REQUIRED.
THIS SHEET SUPERSEDES SECTION 3, SHEET 94, OF DRAWING, NAVSEC NO. 9000-S6202-73980.
1 1 OPERATING ARM (SHORT) BRONZE SEE SHEET K-24, METHOD. K-24-B
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES
LONG AXIS PARALLEL TO
TOP OR SIDE OR DOOR
SECTION K
SHEET 10
53711
803 5184170
—

REV	DESCRIPTION	DATE	APPROVED
-	FIRST ISSUE		

K-11-A



VIEW AT A-A

THIS SHEET SUPERSEDES SECTION 3, SHEET 95, OF DRAWING , NAVSEC NO. 9000-S6202-73980.

PC NO	QTY	NAME	MATERIAL	
7	2	BALL JOINER	STEEL	SEE SHEET K-22 METHOD K-22-A
6	1	PIN	STEEL	SEE SHEET K-23 METHOD K-23-F
5	1	HINGE BRACKET	STEEL	SEE SHEET K-24 METHOD K-24-E
4	1	HINGE LEVER	STEEL	SEE SHEET K-24 METHOD K-24-D
3	1	SOCKET (SHORT)	STEEL	SEE SHEET K-24 METHOD K-24-F
2	1	EXTENSION, THREADED	STEEL	SEE SHEET K-23 METHOD K-23-E
1	1	SOCKET (LONG)	STEEL	SEE SHEET K-23 METHOD K-23-D

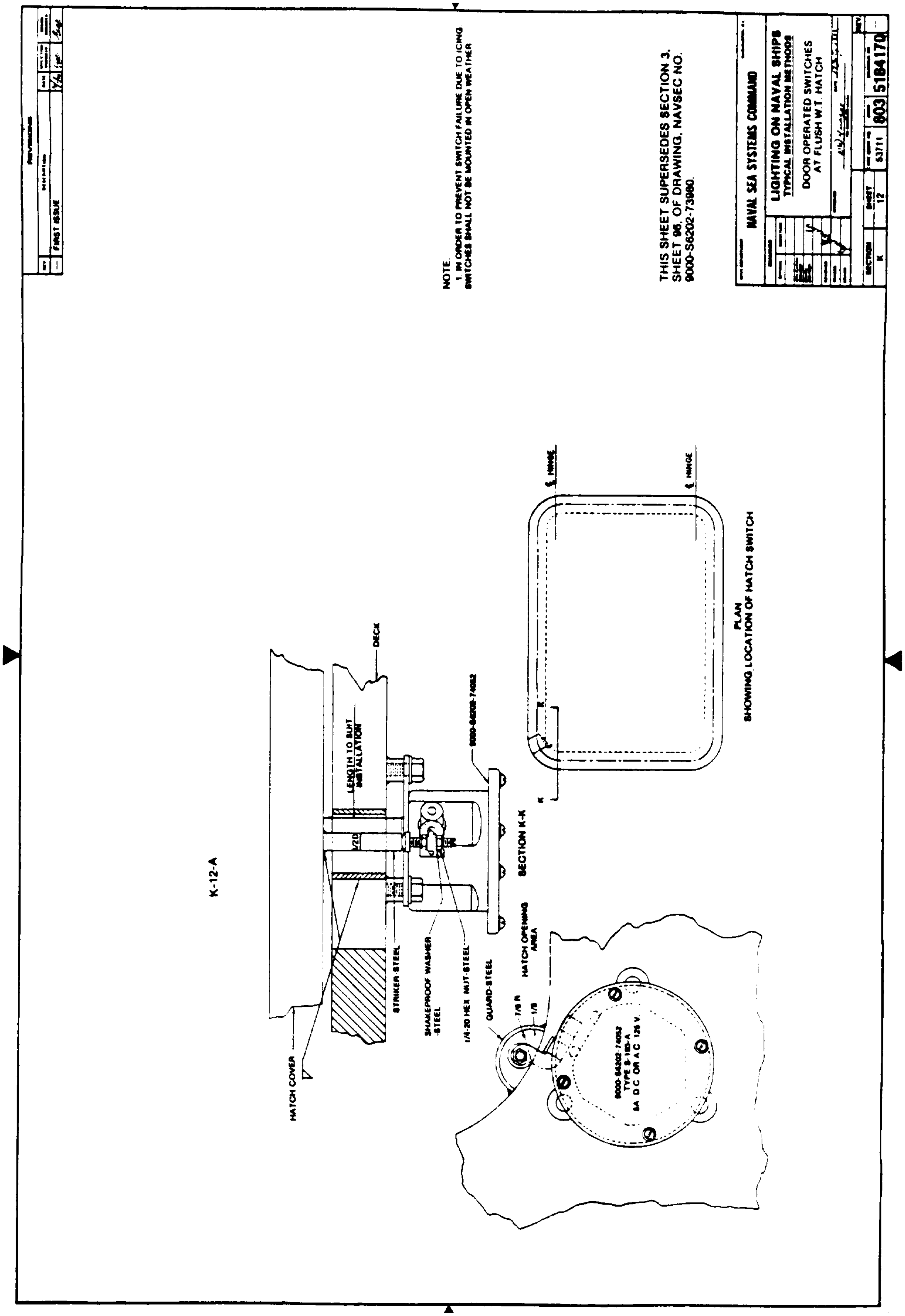
LIST OF MATERIAL - QUANTITIES FOR ONE UNIT

NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

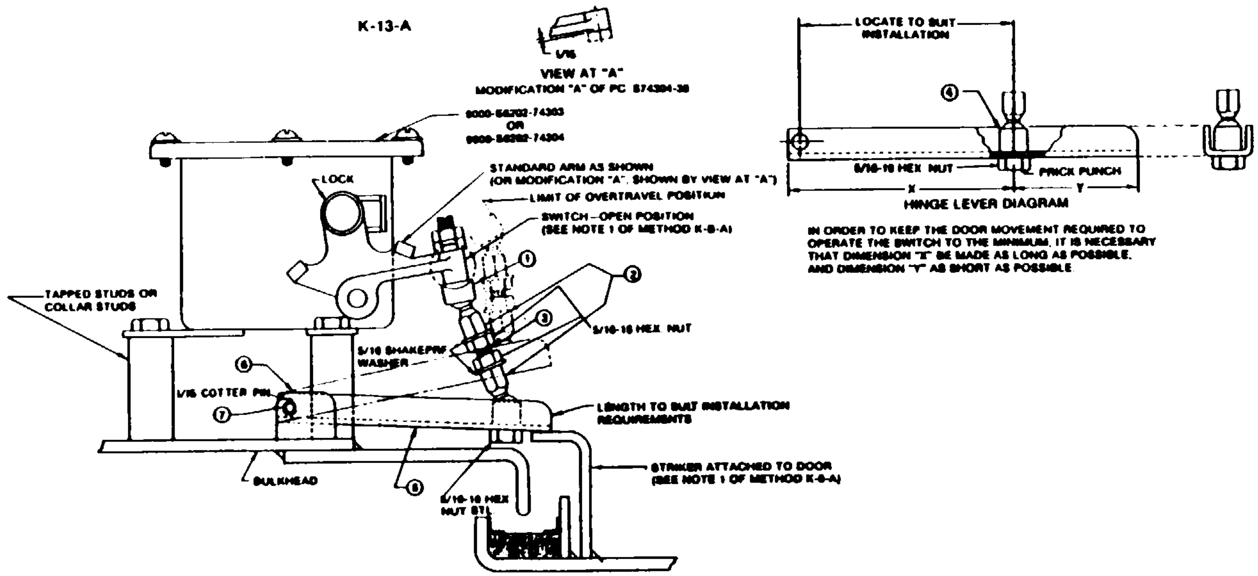
DOOR OPERATED SWITCHES
MOUNTED TO CLEAR SCREEN DOOR

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO.	REV
K	11	53711	803	5184170	—


NOTE.
1 IN ORDER TO PREVENT SWITCH FAILURE DUE TO ICING SWITCHES SHALL NOT BE MOUNTED IN OPEN WEATHER
THIS SHEET SUPERSEDES SECTION 3, SHEET 96, OF DRAWING, NAVSEC NO. 9000-S6202-73980.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES AT FLUSH W.T. HATCH
53711
803
5184170
SECTION K
SHEET 12
REVISIONS
FIRST ISSUE
PLAN
SHOWING LOCATION OF HATCH SWITCH
SECTION K-K
K-12-A
DECK
LENGTH TO SUIT INSTALLATION
STRIKER-STEEL
SHAKEPROOF WASHER -STEEL
1/4-20 HEX NUT-STEEL
GUARD-STEEL
HATCH OPENING AREA
HATCH COVER
9000-S6202-74052
TYPE S-185-A
5A DC OR AC 125 V

REV	DESCRIPTION	DATE		
—	FIRST ISSUE			

K-13-A



IN ORDER TO KEEP THE DOOR MOVEMENT REQUIRED TO OPERATE THE SWITCH TO THE MINIMUM, IT IS NECESSARY THAT DIMENSION "X" BE MADE AS LONG AS POSSIBLE, AND DIMENSION "Y" AS SHORT AS POSSIBLE.

THIS SHEET SUPERSEDES SECTION 3, SHEET 97, OF DRAWING, NAVSEC NO 9000-S6202-73980.

7	1	PIN	STEEL	SEE SHEET K-23 METHOD K-23-F
6	1	HINGE BRACKET	STEEL	SEE SHEET K-24, METHOD K-24-E
5	1	HINGE LEVER	STEEL	SEE SHEET K-24, METHOD K-24-D
4	1	SOCKET (SHORT)	STEEL	SEE SHEET K-24, METHOD K 24-F
3	1	EXTENSION THREADED	STEEL	SEE SHEET K-23, METHOD K 23-E
2	2	BALL JOINER	STEEL	SEE SHEET K-22, METHOD K-22-E
1	1	SOCKET (LONG)	STEEL	SEE SHEET K-23, METHOD K-23-D
ITEM NO.	QTY	NAME	MATERIAL	

LIST OF MATERIAL — QUANTITIES FOR ONE UNIT

NAVAL SEA SYSTEMS COMMAND

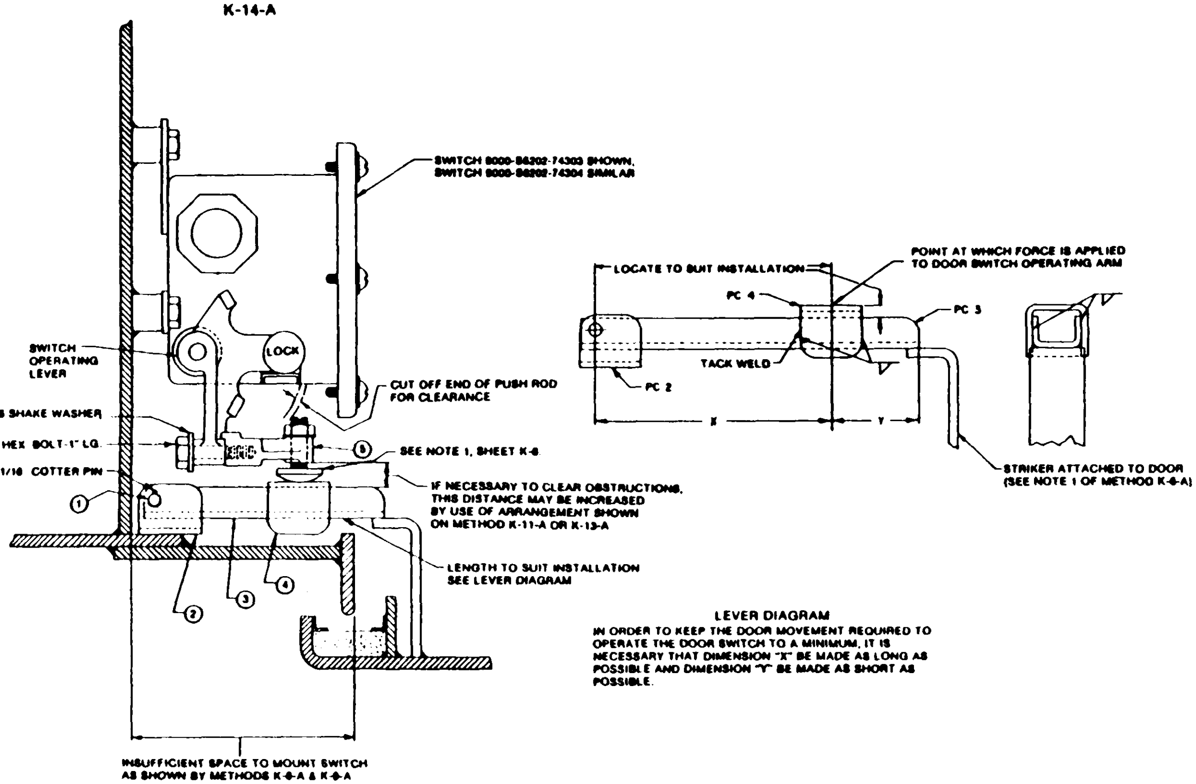
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

DOOR OPERATED SWITCHES
MOUNTED TO CLEAR OBSTRUCTION

SECTION	SHEET				REV
K	13	53711	803	5184170	

REV	DESCRIPTION	DATE		
—	FIRST ISSUE			

K-14-A



LEVER DIAGRAM

IN ORDER TO KEEP THE DOOR MOVEMENT REQUIRED TO OPERATE THE DOOR SWITCH TO A MINIMUM, IT IS NECESSARY THAT DIMENSION "X" BE MADE AS LONG AS POSSIBLE AND DIMENSION "Y" BE MADE AS SHORT AS POSSIBLE.

THIS SHEET SUPERSEDES SECTION 3, SHEET 98, OF DRAWING, NAVSEC NO. 9000-S6202-73980.

PC NO	QTY	NAME	MATERIAL	
5	1	OPERATING ARM EXTENSION	BRONZE	SEE SHEET K-24, METHOD K-24-C
4	1	STRIKE PAD	STEEL	SEE SHEET K-24, METHOD K-24-E
3	1	HINGE LEVER	STEEL	SEE SHEET K-24, METHOD K-24-D
2	1	HINGE BRACKET	STEEL	SEE SHEET K-22, METHOD K-22-C
1	1	PIN	STEEL	SEE SHEET K-23, METHOD K-23-F

LIST OF MATERIAL - QUANTITIES FOR ONE UNIT

NAVAL SEA SYSTEMS COMMAND

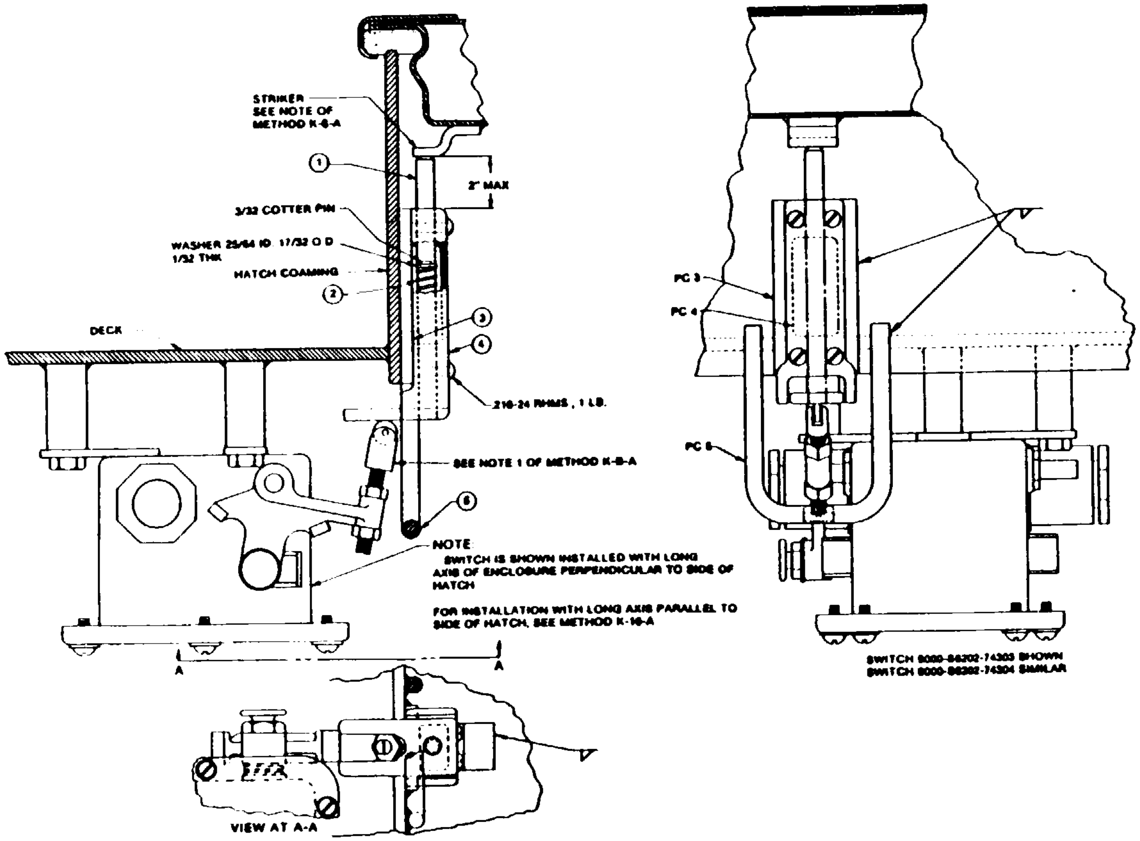
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS

DOOR OPERATED SWITCHES
LIMITED MOUNTING SPACE

SECTION	SHEET				REV
K	14	53711	803	5184170	—

REV	DESCRIPTION	DATE		
	FIRST ISSUE			

K-15-A



THIS SHEET SUPERSEDES SECTION 3, SHEET 99, OF DRAWING NAVSEC NO. 9000-S6202-73980.

PC NO	QTY	NAME	MATERIAL	
5	1	GUARD	STEEL	SEE SHEET K-23, METHOD K 23 C
4	1	PLUNGER HOUSING	BRONZE	SEE SHEET K-24, METHOD K 24-G
3	1	PLUNGER HOUSING BASE PLANT	STEEL	SEE SHEET K-23 METHOD K 23-H
2	1	SPRING	STEEL	SEE SHEET K-23, METHOD K 23-G
1	1	PLUNGER	STEEL	SEE SHEET K-23, METHOD K 23-B

LIST OF MATERIAL

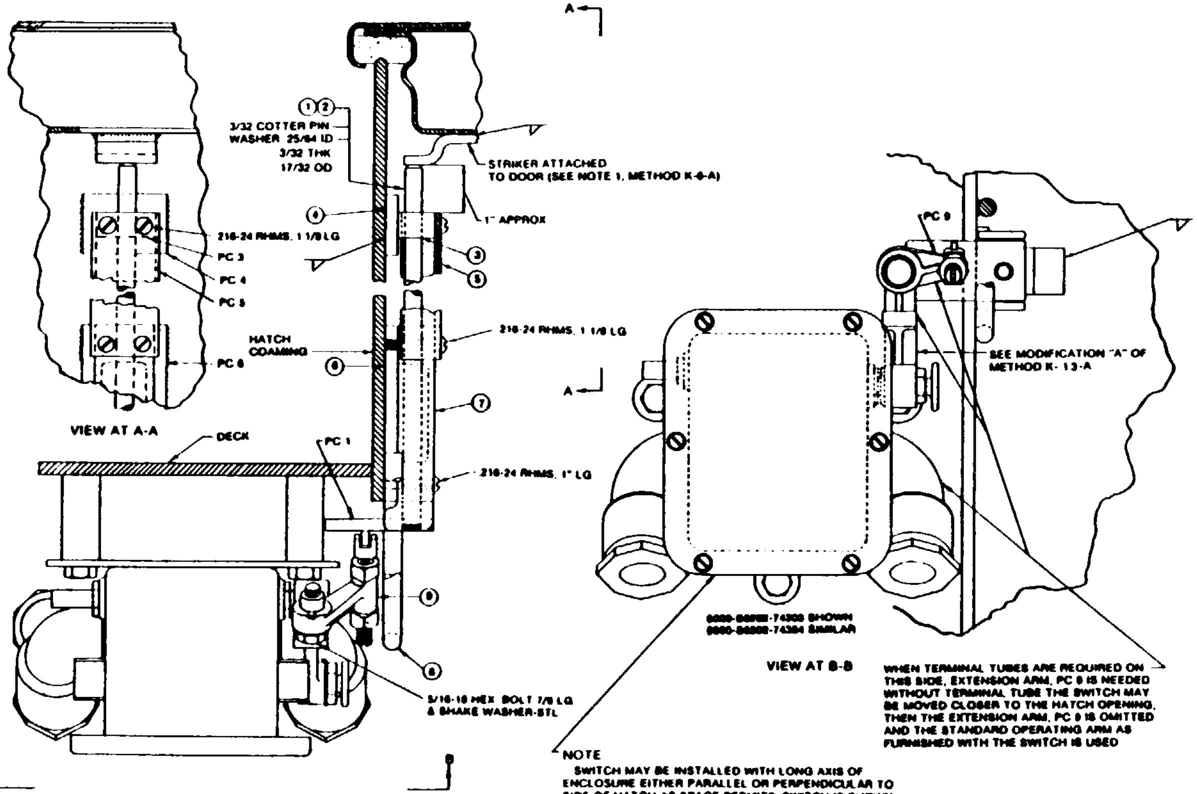
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES AT HATCH WITH LOW COAMING

SECTION	SHEET				REV
K	15	53711	803	5184170	—

REV	DESCRIPTION	DATE	APPROVED
—	FIRST ISSUE		

K-16-A



WHEN TERMINAL TUBES ARE REQUIRED ON THIS SIDE, EXTENSION ARM, PC 9 IS NEEDED WITHOUT TERMINAL TUBE THE SWITCH MAY BE MOVED CLOSER TO THE HATCH OPENING, THEN THE EXTENSION ARM, PC 9 IS OMITTED AND THE STANDARD OPERATING ARM AS FURNISHED WITH THE SWITCH IS USED

NOTE
SWITCH MAY BE INSTALLED WITH LONG AXIS OF ENCLOSURE EITHER PARALLEL OR PERPENDICULAR TO SIDE OF HATCH AS SPACE PERMITS. SWITCH IS SHOWN IN THIS CASE WITH LONG AXIS PARALLEL TO SIDE OF HATCH
SEE METHOD K-16-A FOR INSTALLING SWITCH PERPENDICULAR TO SIDE OF HATCH.

THIS SHEET SUPERSEDES SECTION 3, SHEET 101, OF DRAWING NAVSEC NO. 9000-S6202-73980.

PC NO.	QTY	NAME	MATERIAL	REMARKS
9	1	OPERATING ARM (SHORT)	BRONZE	SEE SHEET K-24, METHOD K-24-B
8	1	GUARD	STEEL	SEE SHEET K-23, METHOD K-23-C
7	1	PLUNGER HOUSING	BRONZE	SEE SHEET K-24, METHOD K-24-G
6	1	PLUNGER HOUSING BASE PLATE	STEEL	SEE SHEET K-23, METHOD K-23-H
5	1	PLUNGER HOUSING EXTENSION	STEEL	SEE SHEET K-23, METHOD K-23-A
4	1	GUIDE MOUNTING PLATE	STEEL	SEE SHEET K-22, METHOD K-22-D
3	1	PLUNGER GUIDE	BRONZE	SEE SHEET K-23, METHOD K-23-J
2	1	SPRING	STEEL	SEE SHEET K-23, METHOD K-23-G
1	1	PLUNGER	STEEL	SEE SHEET K-23, METHOD K-23-B

LIST OF MATERIAL   QUANTITIES FOR ONE UNIT

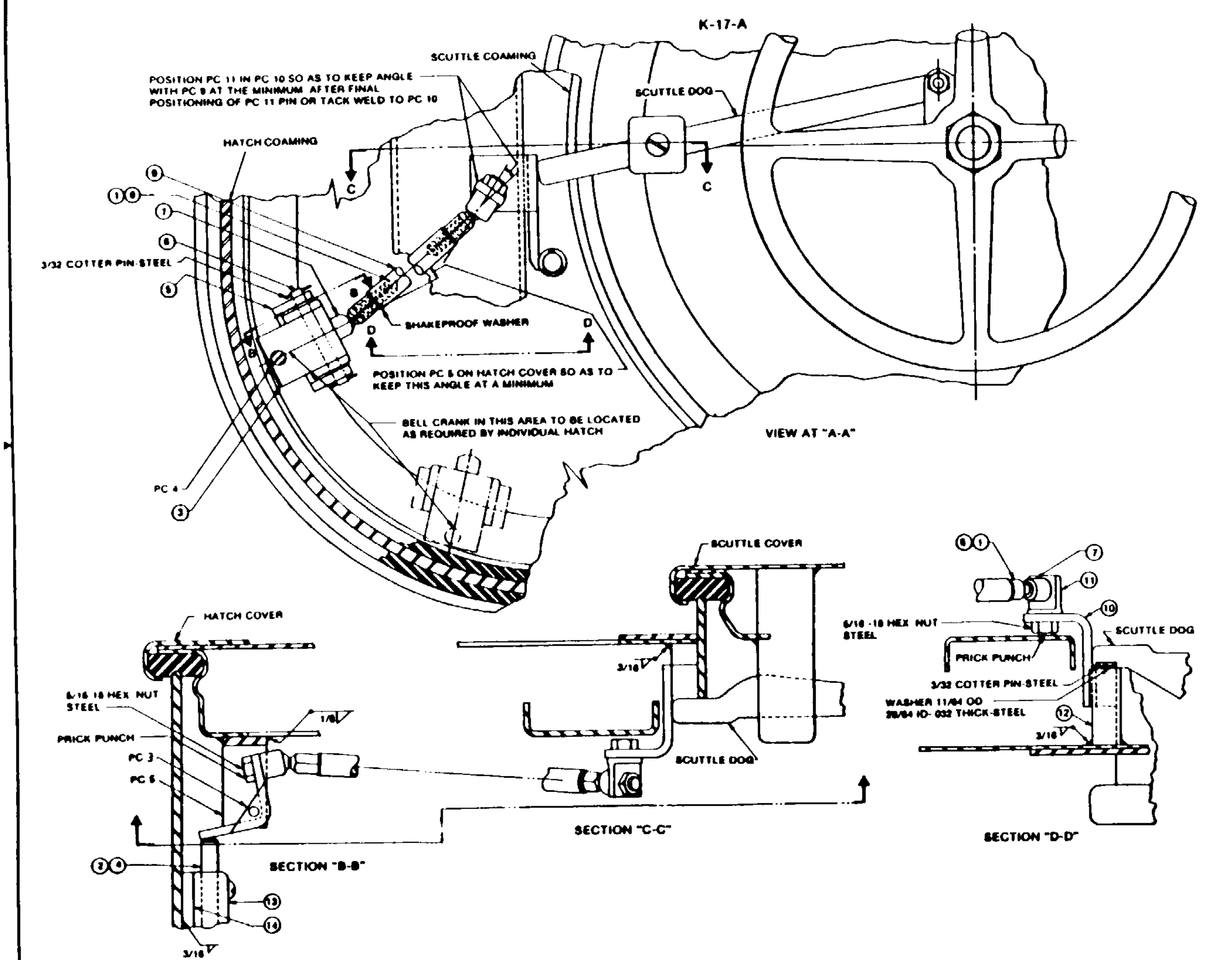
NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES
AT HATCH WITH HIGH COAMING

SECTION	SHEET				REV
K	16	53711	803	5184170	—

REV	DESCRIPTION
—	FIRST ISSUE

K-17-A



THIS SHEET SUPERSEDES SECTION 3, SHEET 103, OF DRAWING, NAVSEC NO. 9000-S6202-73980.

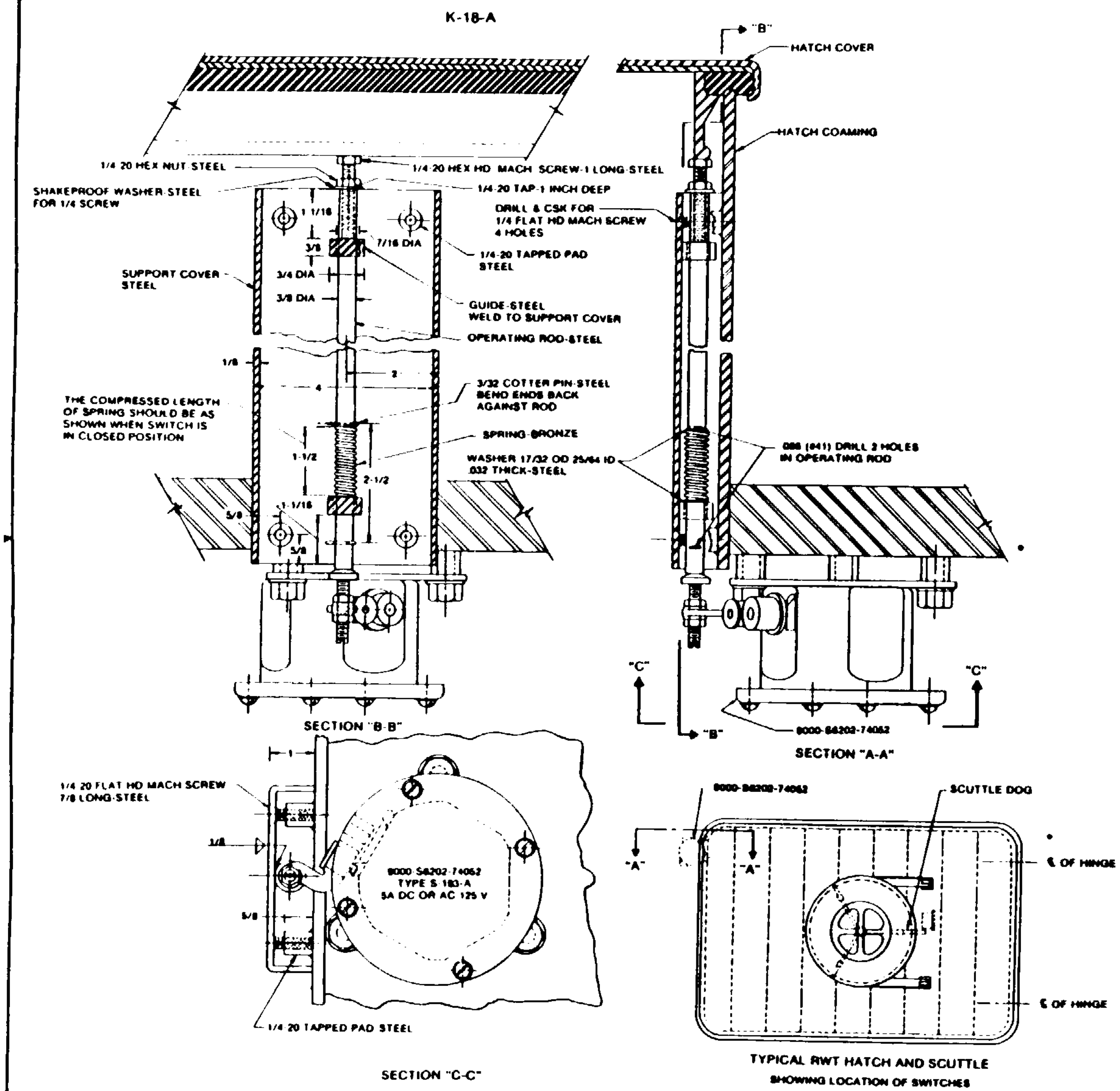
PC NO	QTY	NAME	MATERIAL	NAVY SPEC OR DWG NO
14	1	PLUNGER HOUSING BASE PLATE	STEEL	SEE SHEET K-23, MEHTOD K-23-H
13	1	PLUNGER HOUSING	BRONZE	SEE SHEET K-24, METHOD K-24-G
12	1	MOUNTING PIN	STEEL	SEE SHEET K-21, METHOD K-21-C
11	1	CONNECTING STUD	STEEL	SEE SHEET K-21, METHOD K-21-A
10	1	ANGLED HINGE	STEEL	SEE SHEET K-21, METHOD K-21-B
9	1	EXTENSION ROD (TAPPED)	STEEL	SEE SHEET K-21, METHOD K-21-H
8	2	THREADED ROD	STEEL	SEE SHEET K-21, METHOD K-21-D
7	2	SOCKET (SHORT)	STEEL	SEE SHEET K-24, METHOD K-24-F
6	8	PIN (LONG)	STEEL	SEE SHEET K-21, METHOD K-21-G
5	1	BASE	STEEL	SEE SHEET K-21, METHOD K-21-F
4	1	PLUNGER	STEEL	SEE SHEET K-23, METHOD K-23-B
3	1	HINGE	STEEL	SEE SHEET K-21, METHOD K-21-E
2	1	SPRING	STEEL	SEE SHEET K-23, METHOD K-23-G
1	2	BALL JOINER	STEEL	SEE SHEET K-22, METHOD K-22-E

LIST OF MATERIAL — QUANTITIES FOR ONE UNIT

NAVAL SEA SYSTEMS COMMAND

LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES INSTALLATION METHODS AND ACCESSORIES

SECTION	SHEET	CODE IDENT NO	SIZE	DRAWING NO	REV
K	17	53711	803	5184170	—



REVISIONS

REV	DESCRIPTION
—	FIRST ISSUE

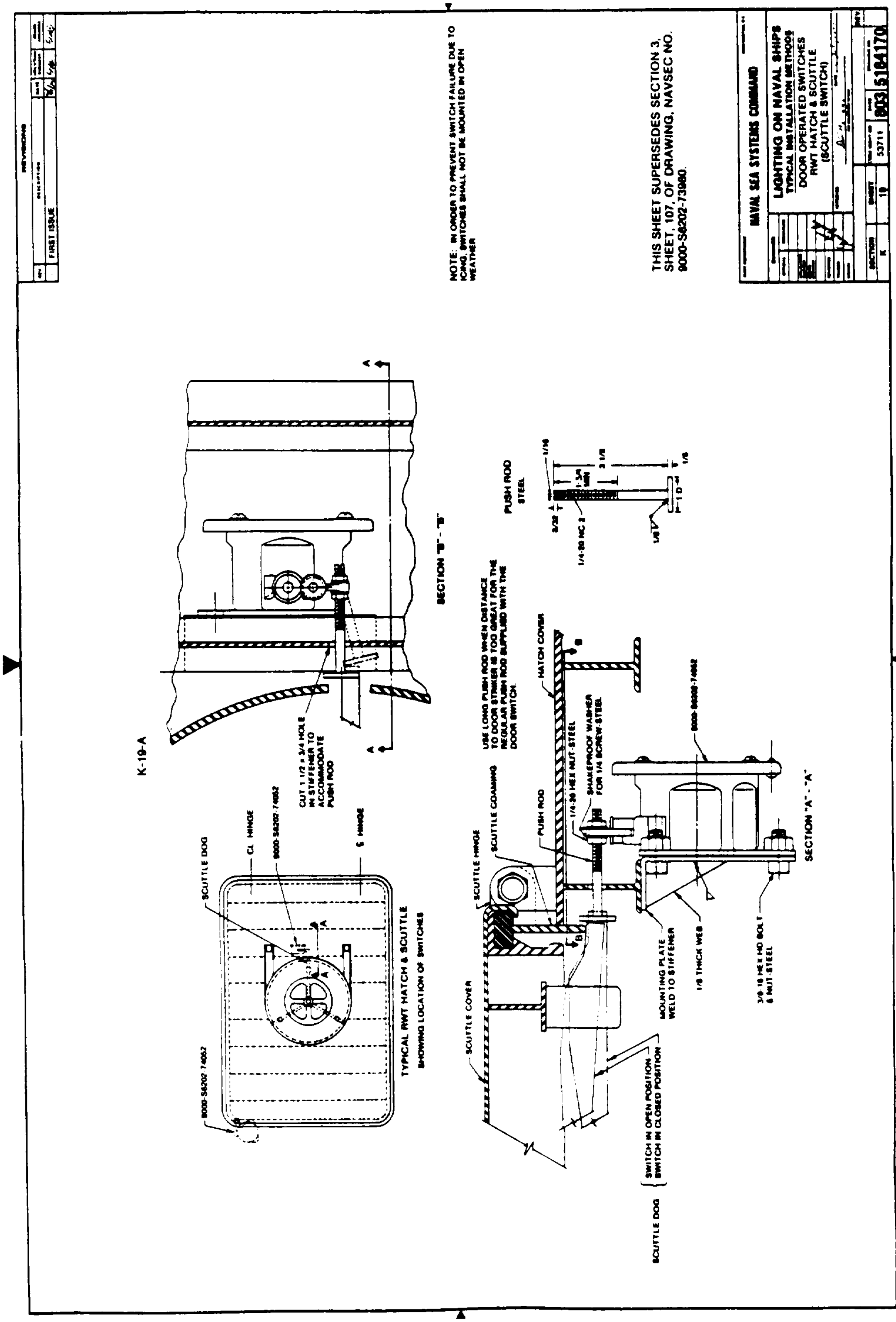
NOTE.
IN ORDER TO PREVENT SWITCH FAILURE DUE TO ICING, SWITCHES SHALL NOT BE MOUNTED IN OPEN WEATHER.

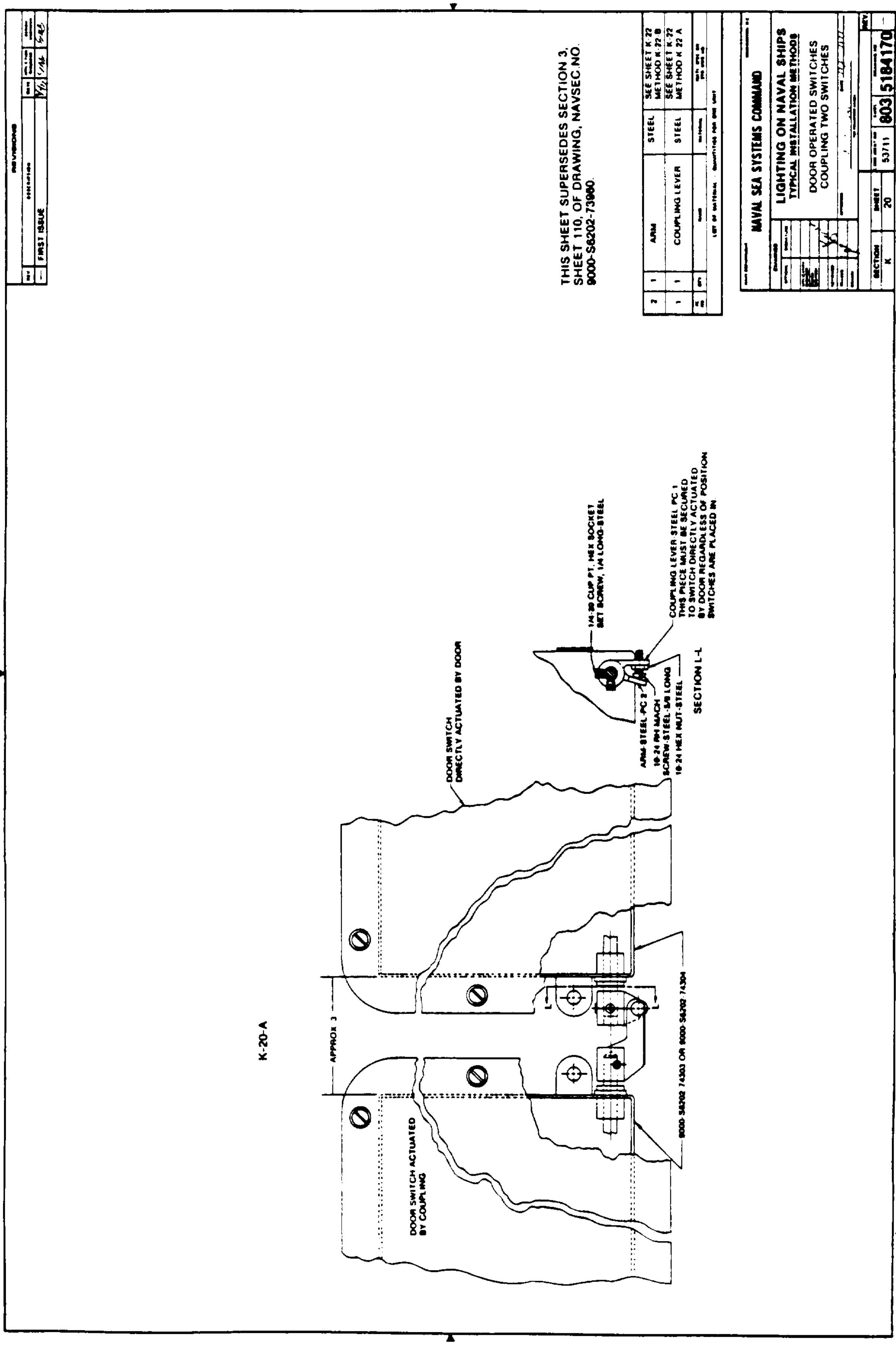
THIS SHEET SUPERSEDES SECTION 3, SHEET 105, OF DRAWING, NAVSEC NO. 9000-S6202-73980

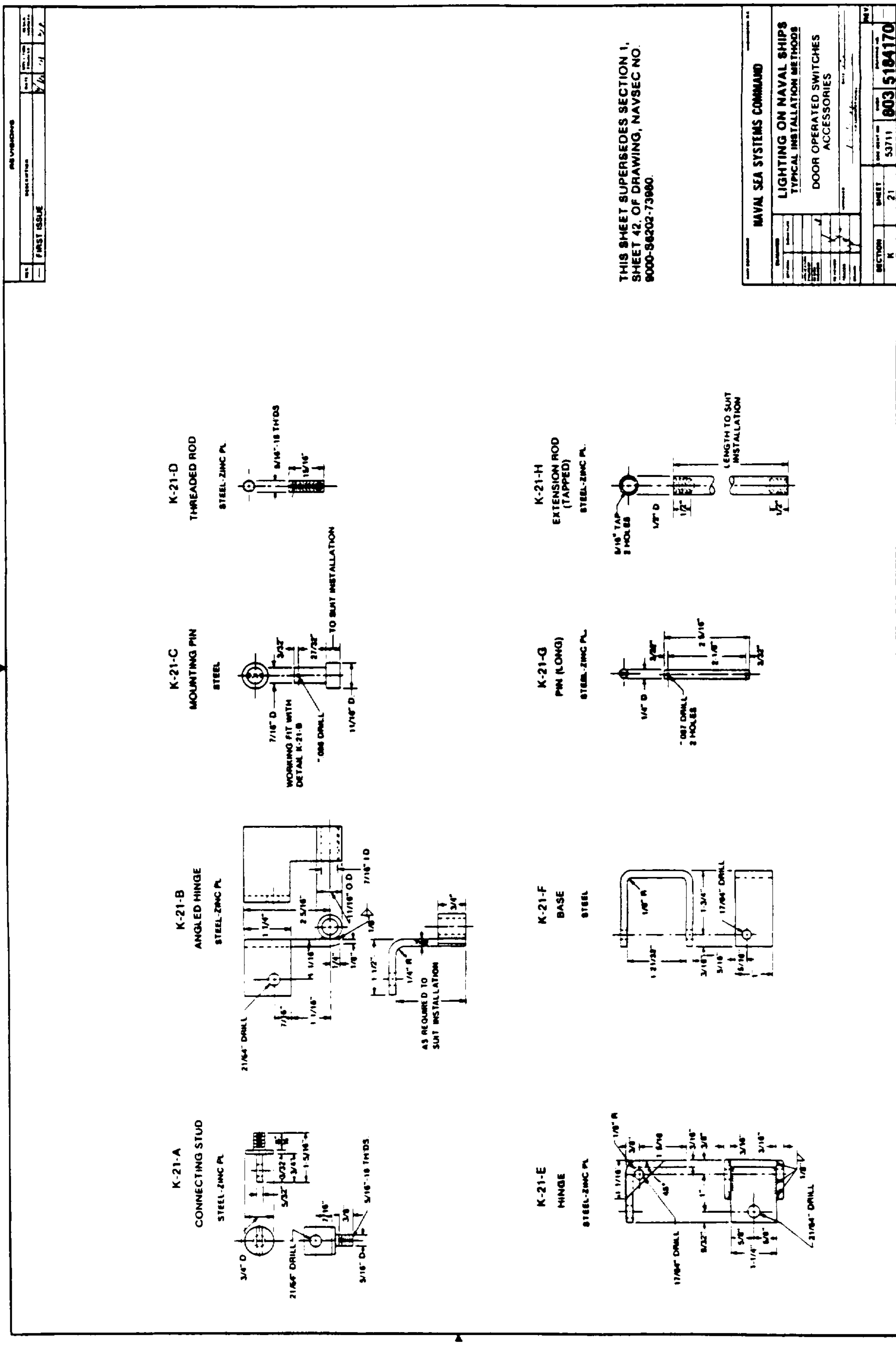
NAVAL SEA SYSTEMS COMMAND

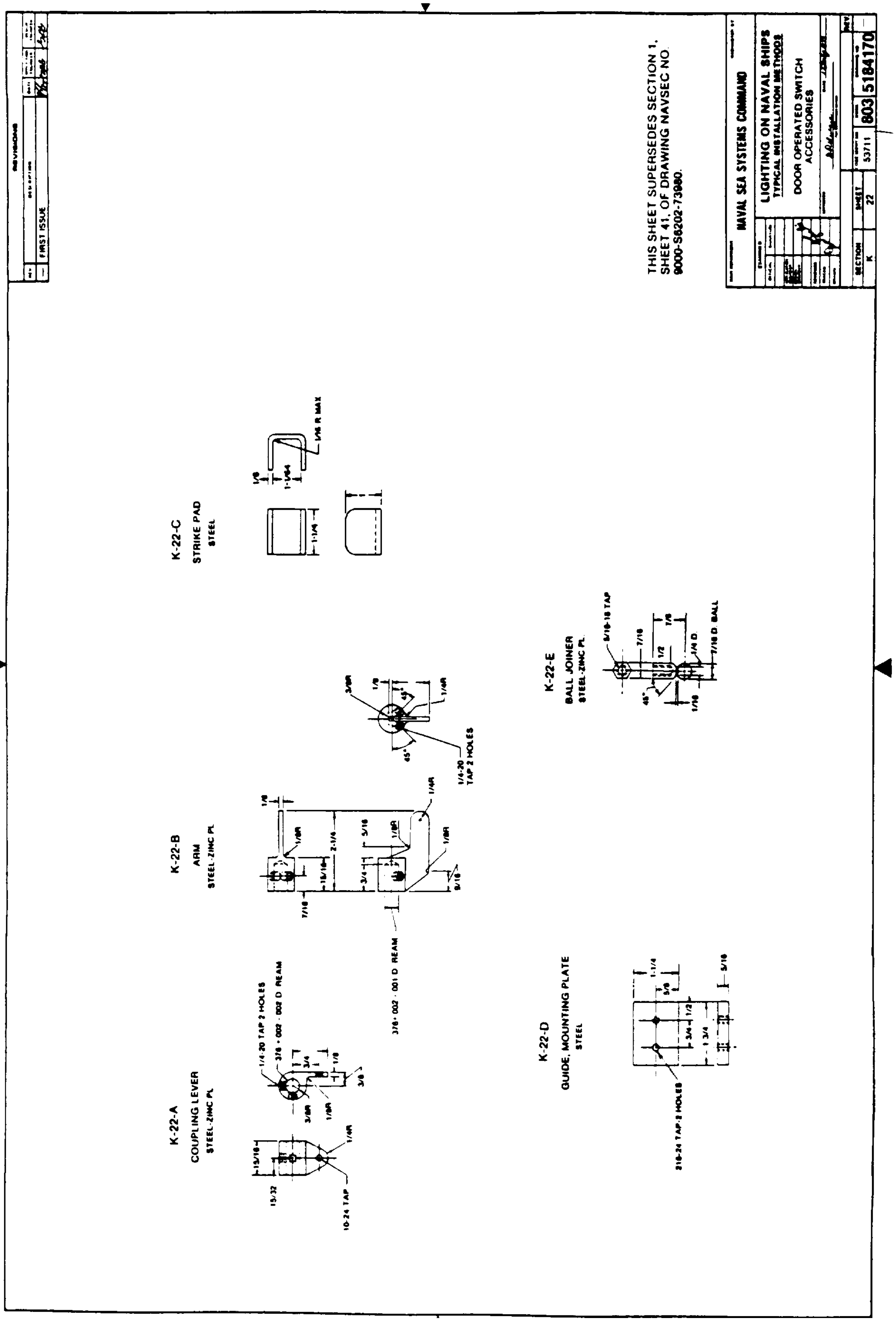
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES
RWT HATCH & SCUTTLE
(HATCH SWITCH)

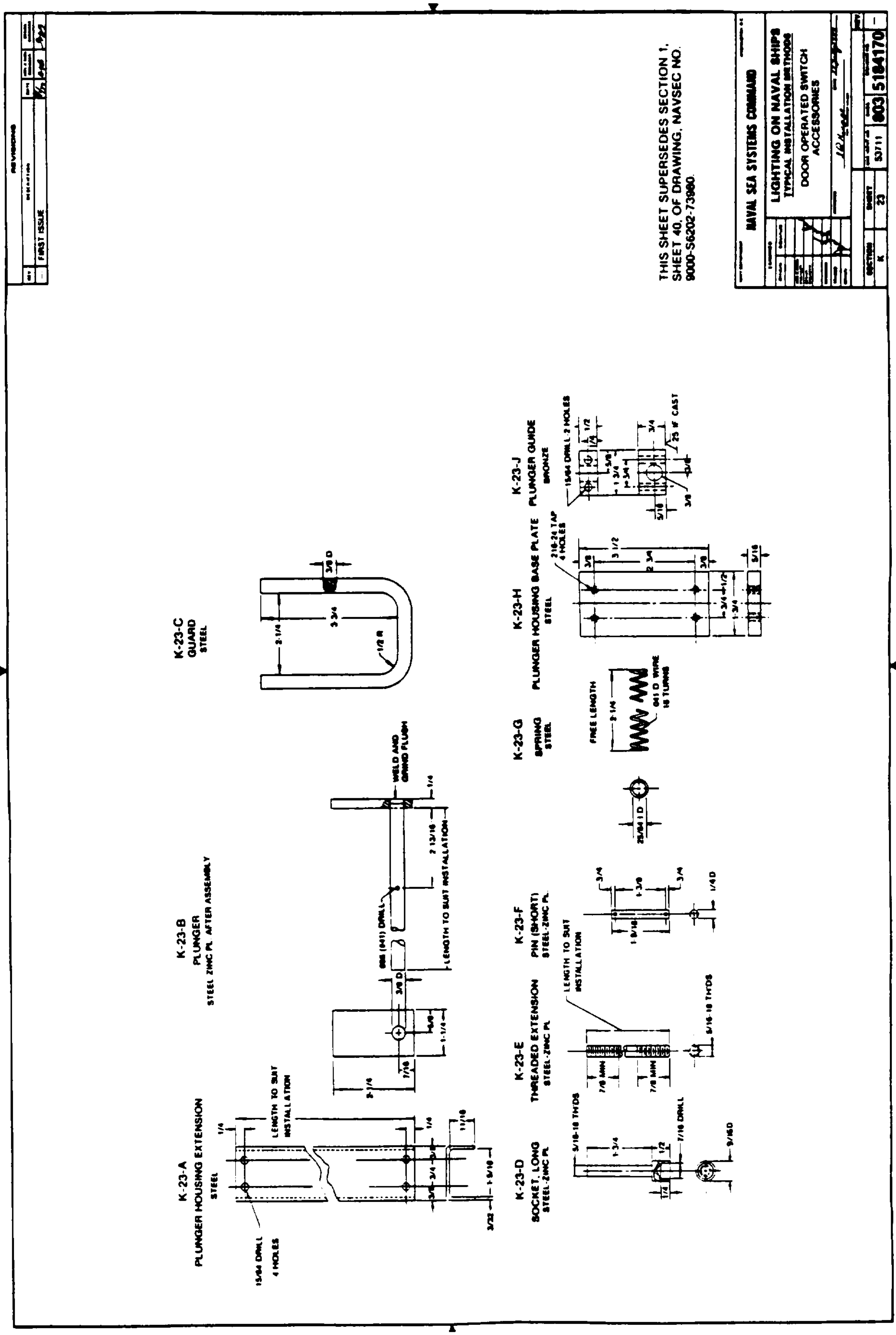
SECTION	SHEET				REV
K	18	53711	803	5184170	—


REVISIONS
FIRST ISSUE
K-19-A
9000-S6202-74052
SCUTTLE DOG
CL HINGE
9000-S6202-74052
℄ HINGE
TYPICAL RWT HATCH & SCUTTLE
SHOWING LOCATION OF SWITCHES
CUT 1 1/2 x 3/4 HOLE IN STIFFENER TO ACCOMMODATE PUSH ROD
SECTION "B" - "B"
NOTE: IN ORDER TO PREVENT SWITCH FAILURE DUE TO ICING, SWITCHES SHALL NOT BE MOUNTED IN OPEN WEATHER
SCUTTLE COVER
SCUTTLE HINGE
SCUTTLE COAMING
USE LONG PUSH ROD WHEN DISTANCE TO DOOR STRIKER IS TOO GREAT FOR THE REGULAR PUSH ROD SUPPLIED WITH THE DOOR SWITCH.
PUSH ROD
HATCH COVER
1/4-20 HEX NUT-STEEL
SHAKEPROOF WASHER FOR 1/4 SCREW-STEEL
PUSH ROD
STEEL
1/16
3/32
1/4-20 NC 2
1 3/4 MIN
2 1/8
1/8
1 D
1/8
SCUTTLE DOG
SWITCH IN OPEN POSITION
SWITCH IN CLOSED POSITION
MOUNTING PLATE WELD TO STIFFENER
1/8 THICK WEB
9000-S6202-74052
3/8-16 HEX HD BOLT & NUT-STEEL
SECTION "A" - "A"
THIS SHEET SUPERSEDES SECTION 3, SHEET, 107, OF DRAWING, NAVSEC NO. 9000-S6202-73980.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES
RWT HATCH & SCUTTLE
(SCUTTLE SWITCH)
SECTION
K
SHEET
19
53711
803
5184170


REVISIONS
FIRST ISSUE
THIS SHEET SUPERSEDES SECTION 3, SHEET 110, OF DRAWING, NAVSEC NO. 9000-S6202-73980.
2 1 ARM STEEL SEE SHEET K-22 METHOD K-22 B
1 1 COUPLING LEVER STEEL SEE SHEET K-22 METHOD K 22 A
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES
COUPLING TWO SWITCHES
SECTION K
SHEET 20
53711
803
5184170
DOOR SWITCH DIRECTLY ACTUATED BY DOOR
1/4-20 CUP PT. HEX SOCKET SET SCREW, 1/4 LONG-STEEL
COUPLING LEVER-STEEL PC 1 THIS PIECE MUST BE SECURED TO SWITCH DIRECTLY ACTUATED BY DOOR REGARDLESS OF POSITION SWITCHES ARE PLACED IN
ARM-STEEL-PC 2
10-24 RH MACH SCREW-STEEL-5/8 LONG
10-24 HEX NUT-STEEL
SECTION L-L
K-20-A
APPROX 3
DOOR SWITCH ACTUATED BY COUPLING
9000 S6202 74303 OR 9000 S6202 74304


NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCHES ACCESSORIES
803 5184170
THIS SHEET SUPERSEDES SECTION 1, SHEET 42, OF DRAWING, NAVSEC NO. 9000-S6202-73980.
FIRST ISSUE
K-21-A CONNECTING STUD STEEL-ZINC PL
K-21-B ANGLED HINGE STEEL-ZINC PL
K-21-C MOUNTING PIN STEEL
K-21-D THREADED ROD STEEL-ZINC PL
K-21-E HINGE STEEL-ZINC PL
K-21-F BASE STEEL
K-21-G PIN (LONG) STEEL-ZINC PL
K-21-H EXTENSION ROD (TAPPED) STEEL-ZINC PL
WORKING FIT WITH DETAIL K-21-B
TO SUIT INSTALLATION
AS REQUIRED TO SUIT INSTALLATION
LENGTH TO SUIT INSTALLATION


THIS SHEET SUPERSEDES SECTION 1, SHEET 41, OF DRAWING NAVSEC NO 9000-S6202-73980.
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCH ACCESSORIES
SECTION K
SHEET 22
53711
803 5184170
REVISIONS
FIRST ISSUE
K-22-C
STRIKE PAD
STEEL
K-22-E
BALL JOINER
STEEL-ZINC PL
K-22-B
ARM
STEEL-ZINC PL
K-22-D
GUIDE, MOUNTING PLATE
STEEL
K-22-A
COUPLING LEVER
STEEL-ZINC PL


REVISIONS
FIRST ISSUE
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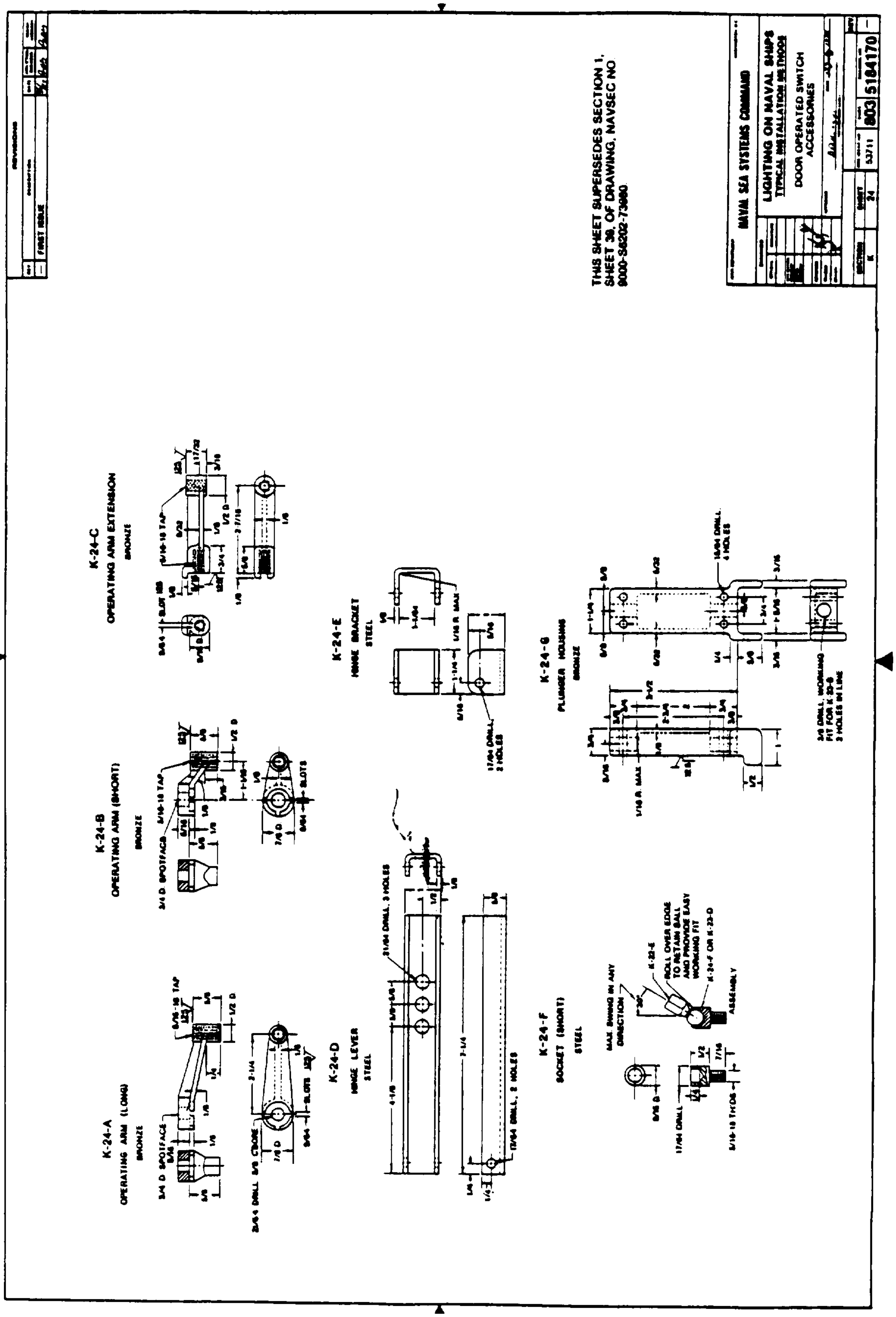
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCH ACCESSORIES
SECTION K
SHEET 23
53711
803 5184170
K-23-A
PLUNGER HOUSING EXTENSION
STEEL
15/64 DRILL 4 HOLES
LENGTH TO SUIT INSTALLATION
K-23-B
PLUNGER
STEEL ZINC PL AFTER ASSEMBLY
WELD AND GRIND FLUSH
LENGTH TO SUIT INSTALLATION
K-23-C
GUARD
STEEL
K-23-D
SOCKET, LONG
STEEL-ZINC PL
5/16-18 THDS
7/16 DRILL
K-23-E
THREADED EXTENSION
STEEL-ZINC PL
LENGTH TO SUIT INSTALLATION
5/16-18 THDS
K-23-F
PIN (SHORT)
STEEL-ZINC PL
K-23-G
SPRING
STEEL
FREE LENGTH
K-23-H
PLUNGER HOUSING BASE PLATE
STEEL
K-23-J
PLUNGER GUIDE
BRONZE
25 # CAST


THIS SHEET SUPERSEDES SECTION 1, SHEET 30, OF DRAWING, NAVSEC NO 9000-S6202-73980
NAVAL SEA SYSTEMS COMMAND
LIGHTING ON NAVAL SHIPS
TYPICAL INSTALLATION METHODS
DOOR OPERATED SWITCH ACCESSORIES
803 5184170
FIRST ISSUE
K-24-A
OPERATING ARM (LONG)
BRONZE
K-24-B
OPERATING ARM (SHORT)
BRONZE
K-24-C
OPERATING ARM EXTENSION
BRONZE
K-24-D
HINGE LEVER
STEEL
K-24-E
HINGE BRACKET
STEEL
K-24-F
SOCKET (SHORT)
STEEL
K-24-G
PLUNGER HOUSING
BRONZE

APPENDIX C

ABSTRACT INSTALLATION METHODS

10. GENERAL

10.1 Scope. This appendix provides pictorial views of the abstract installation methods shown in appendix B.

10.2 Application. Views of good and bad lighting installations are provided to illustrate how improvements in the utilization of lighting fixtures and general appearance of the area can be accomplished with little or no extra effort.

20. REFERENCED DOCUMENTS

Not applicable.

30. DEFINITIONS

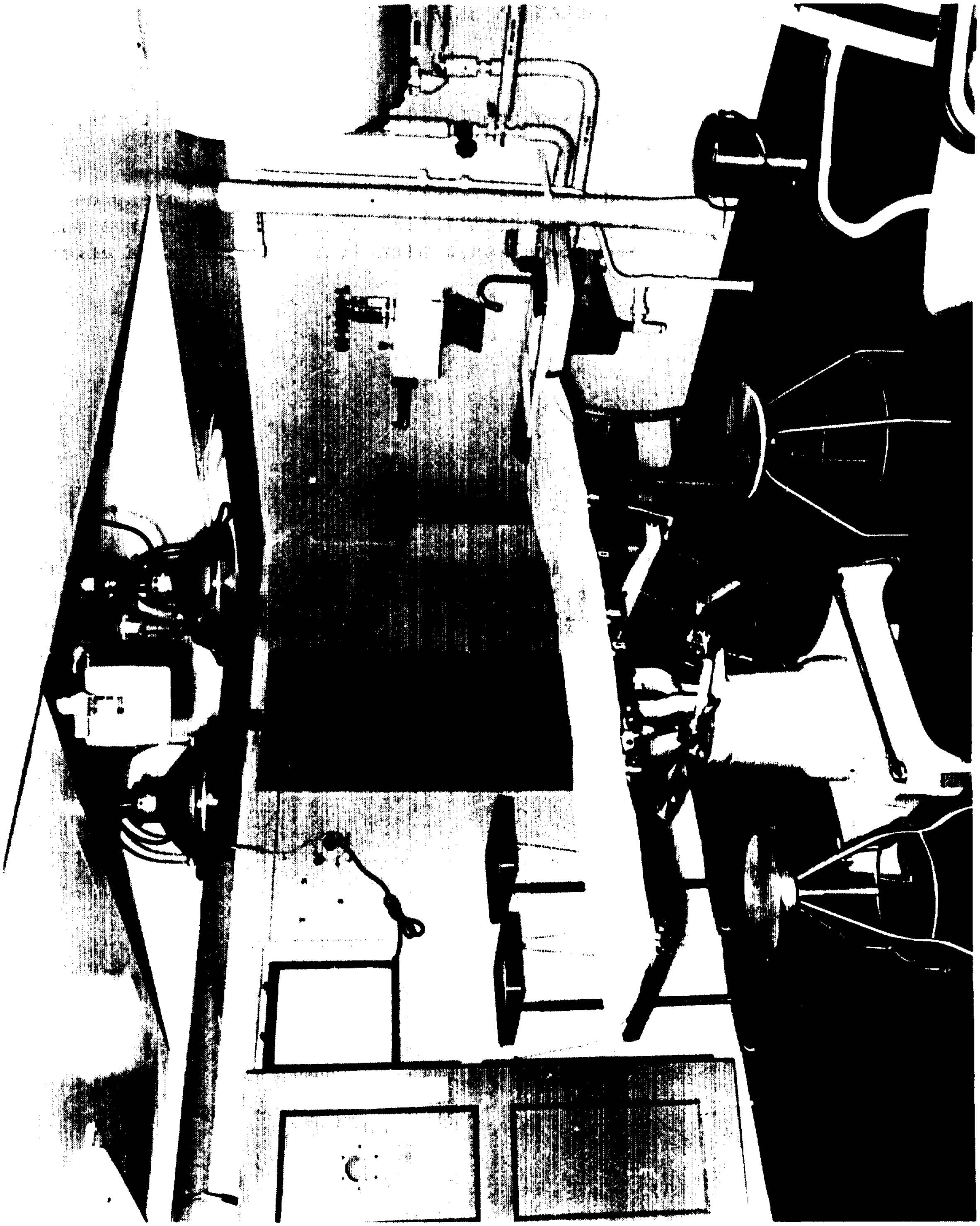
Not applicable.

40. GENERAL DESIGN CONSIDERATIONS

40.1 Lighting installations. The figures show good and bad lighting installations of medical spaces, berth, mirror, and desk illumination, installation of fluorescent, incandescent, and miscellaneous lights, and examples of good and bad lighting installation.

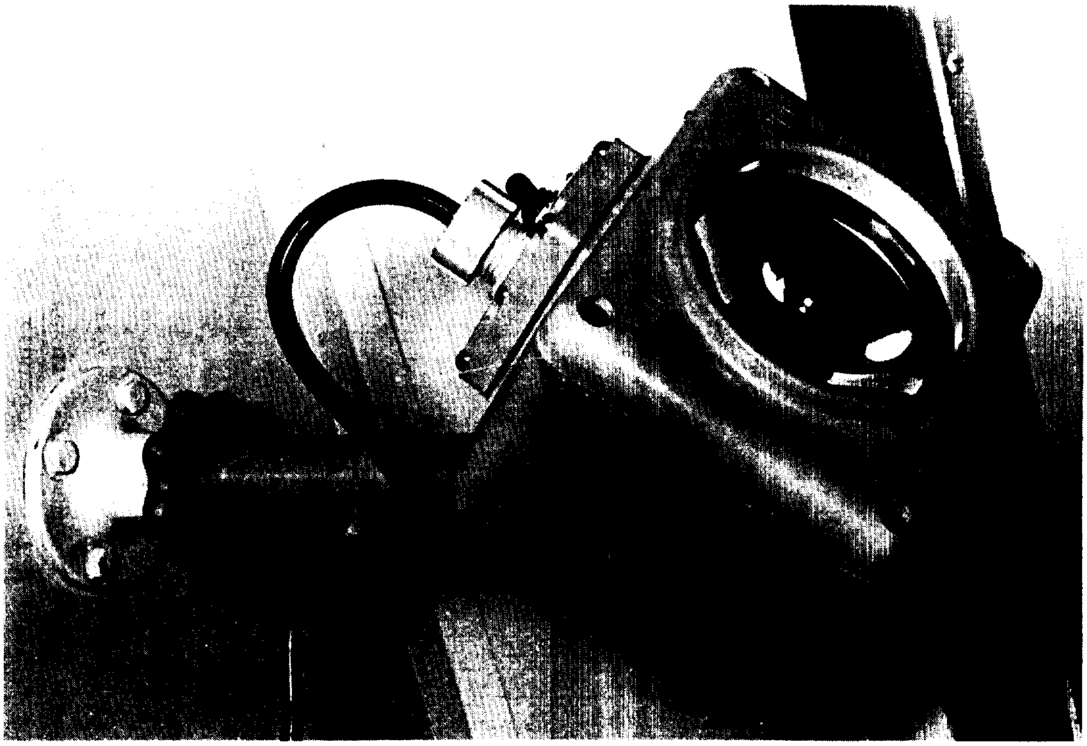
50. DETAIL DESIGN CONSIDERATIONS

Not applicable.

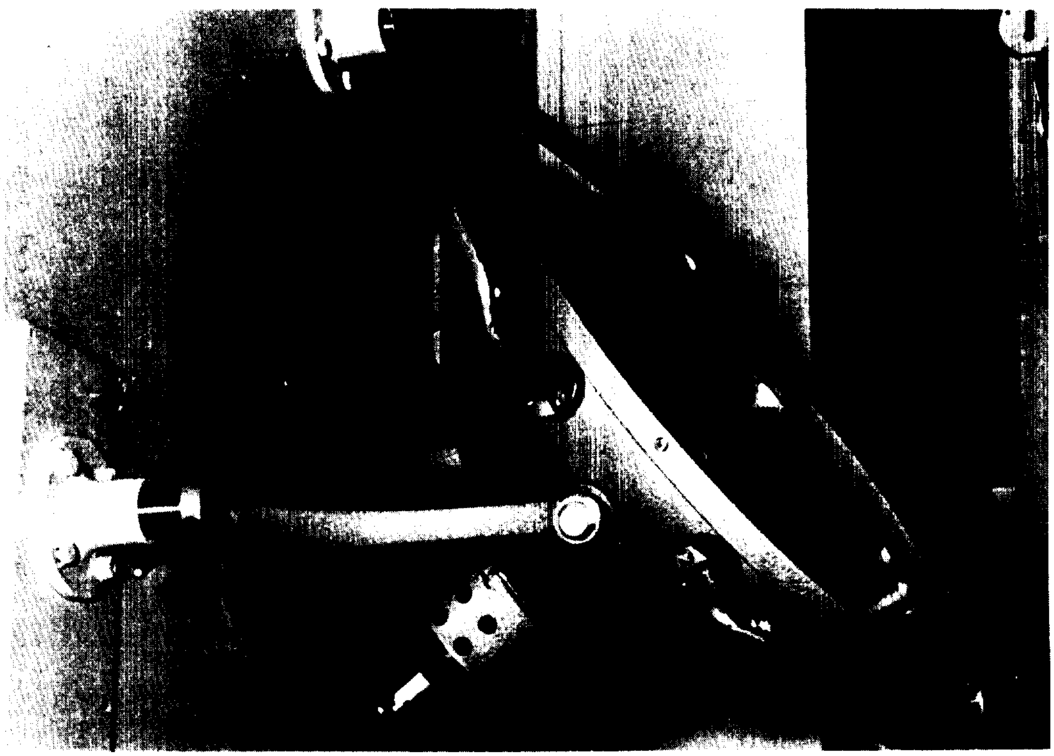


SH 964-C1

FIGURE 92. Typical arrangement of surgical lights and lanterns over table in surgical dressing room.
(For details see method A-3-A of appendix B)



B
Lantern, Symbol 101.2



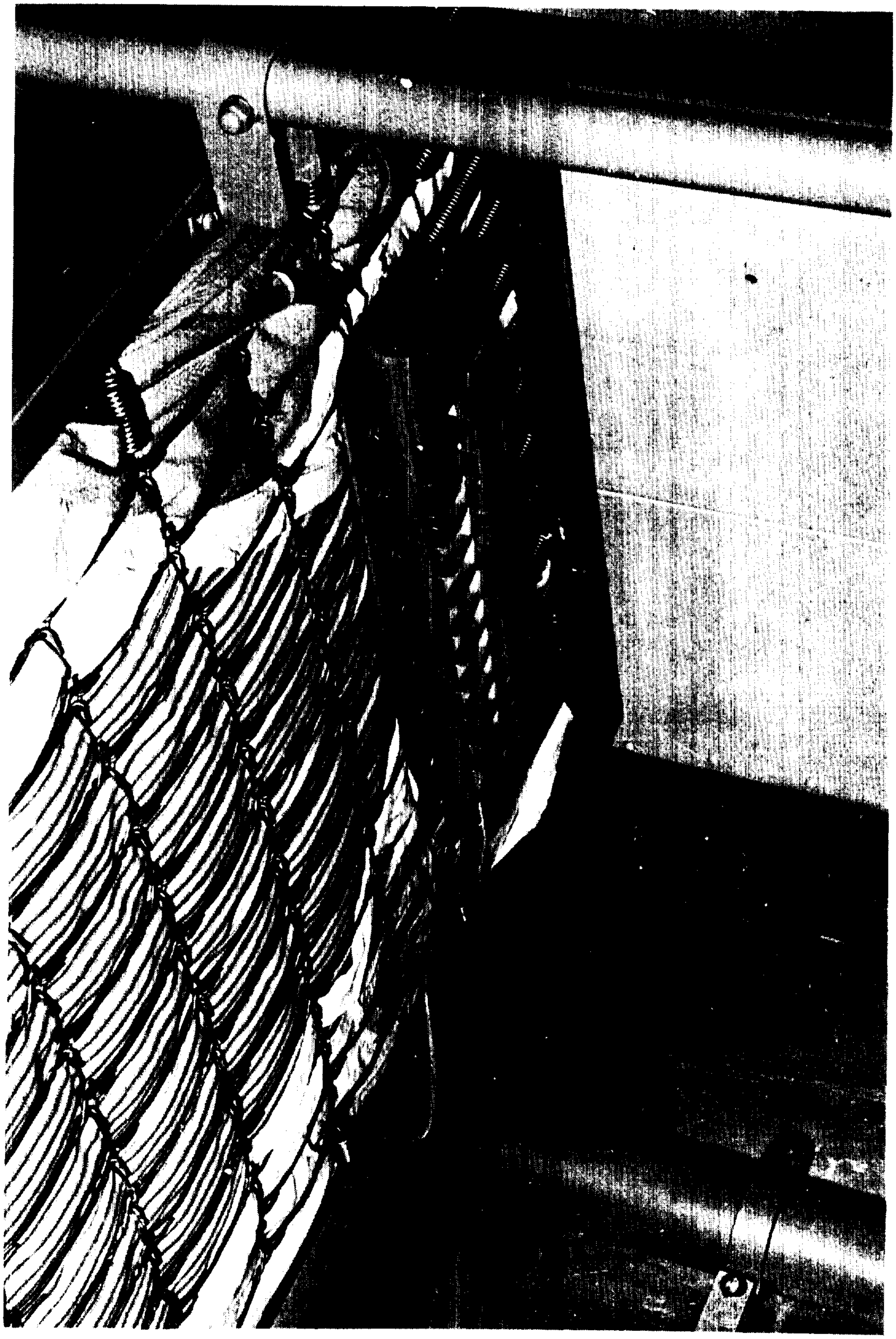
A
Surgical Light, Symbol 107.1

FIGURE 93. Typical installation of surgical lights and lanterns.
(For details see method A-6-A of appendix B)

SH 964-C2

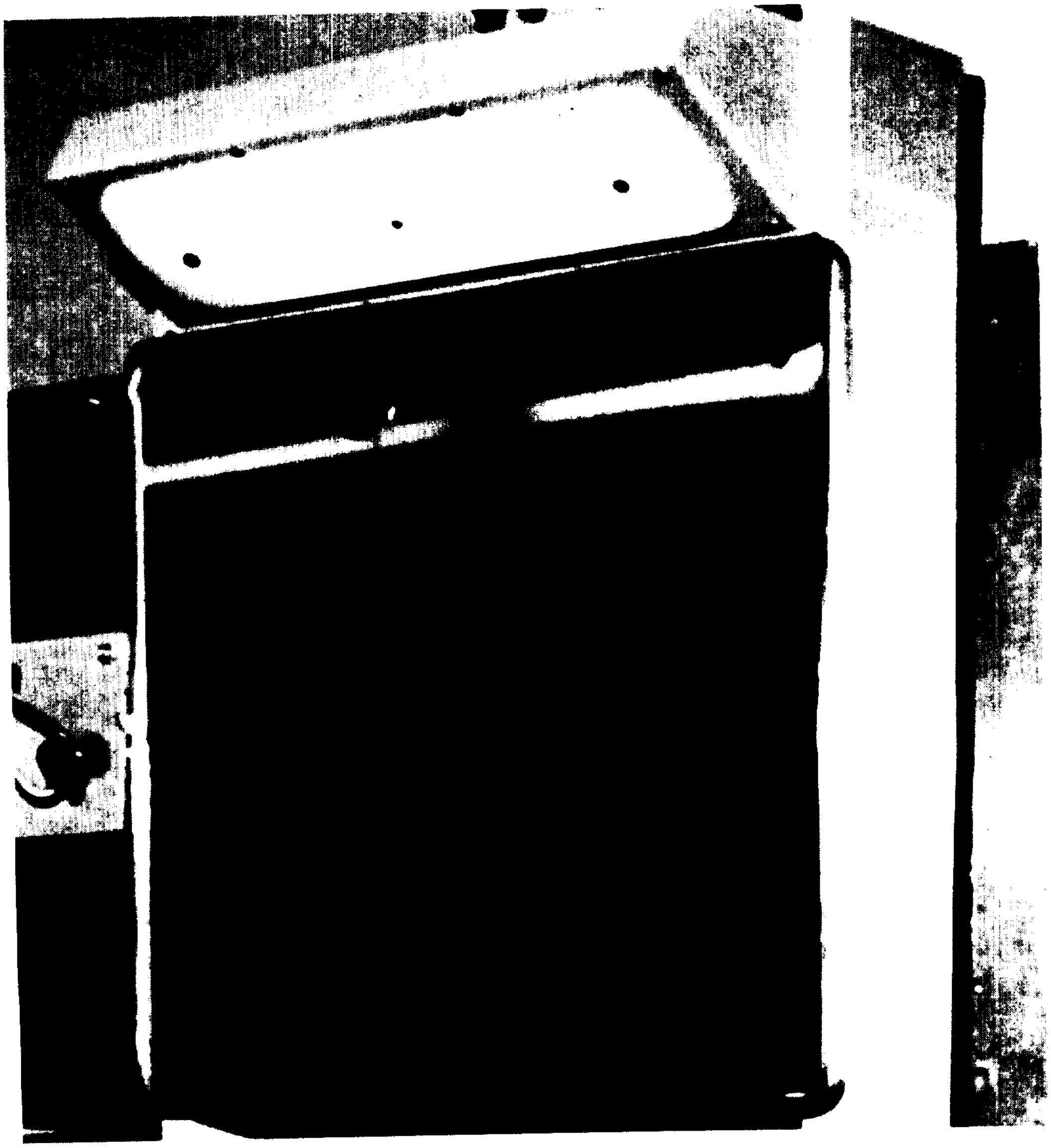
FIGURE 94. Typical installation of berth light, symbol 232 in pan type berths.
(For details see method B-1-C of appendix B)

SH 964-C3



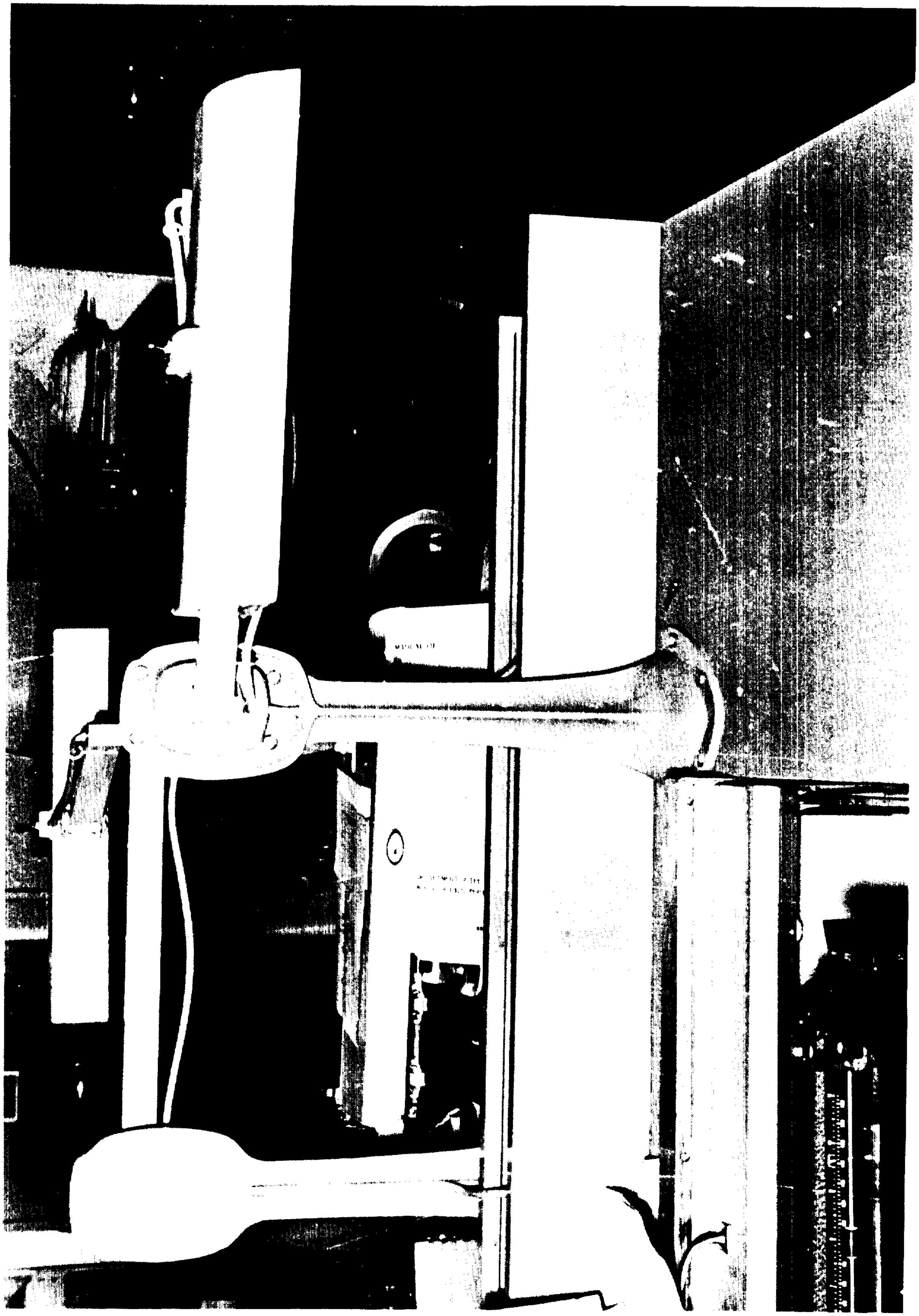
SH 964-C4

FIGURE 95. Typical installation of berth light, symbol 231, in spring type berths. (For details see method B-1-A of appendix B).



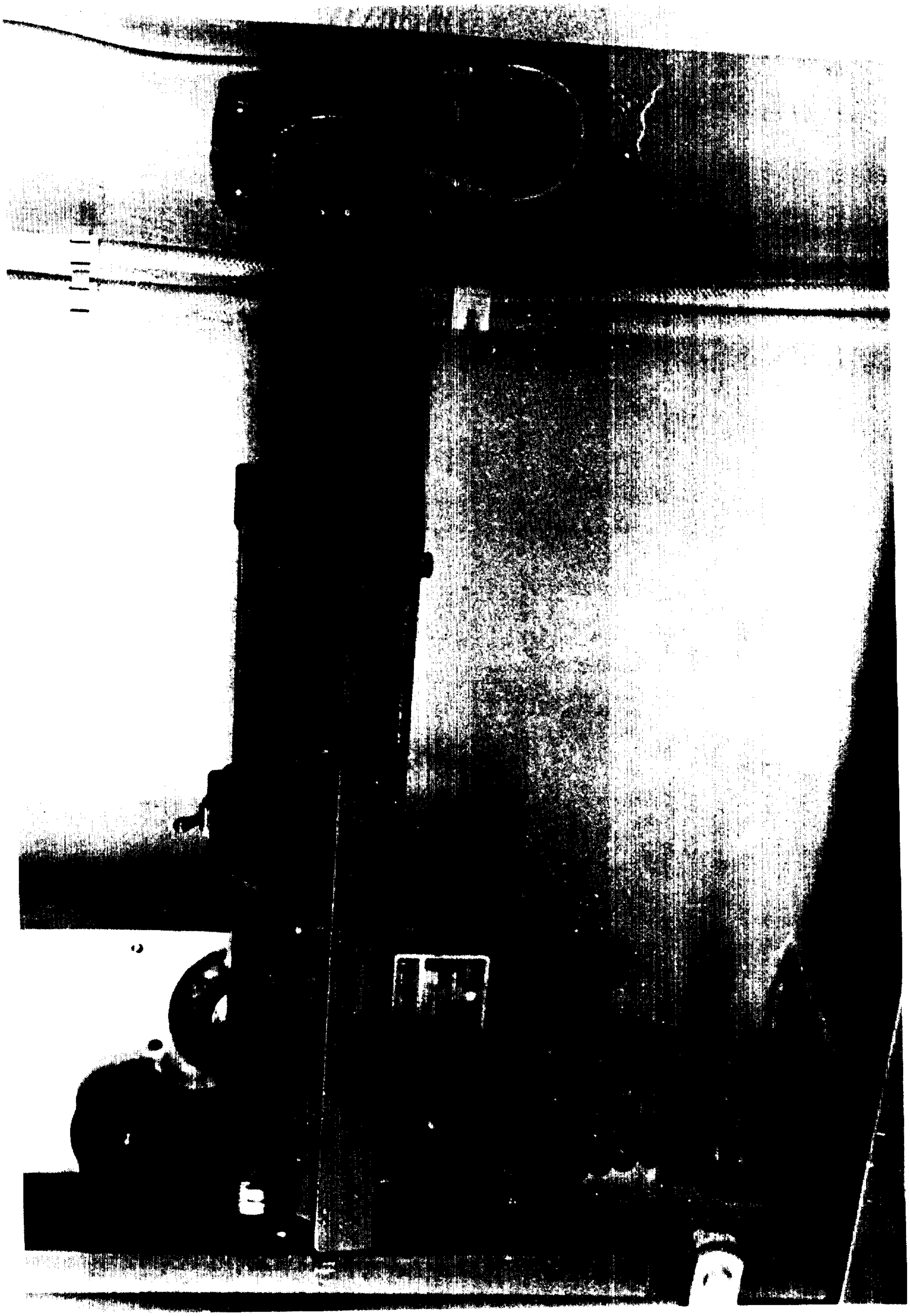
SH 964-C5

FIGURE 96. Typical illumination of single flat mirrors.
(For detail see method C-5-A of appendix B)



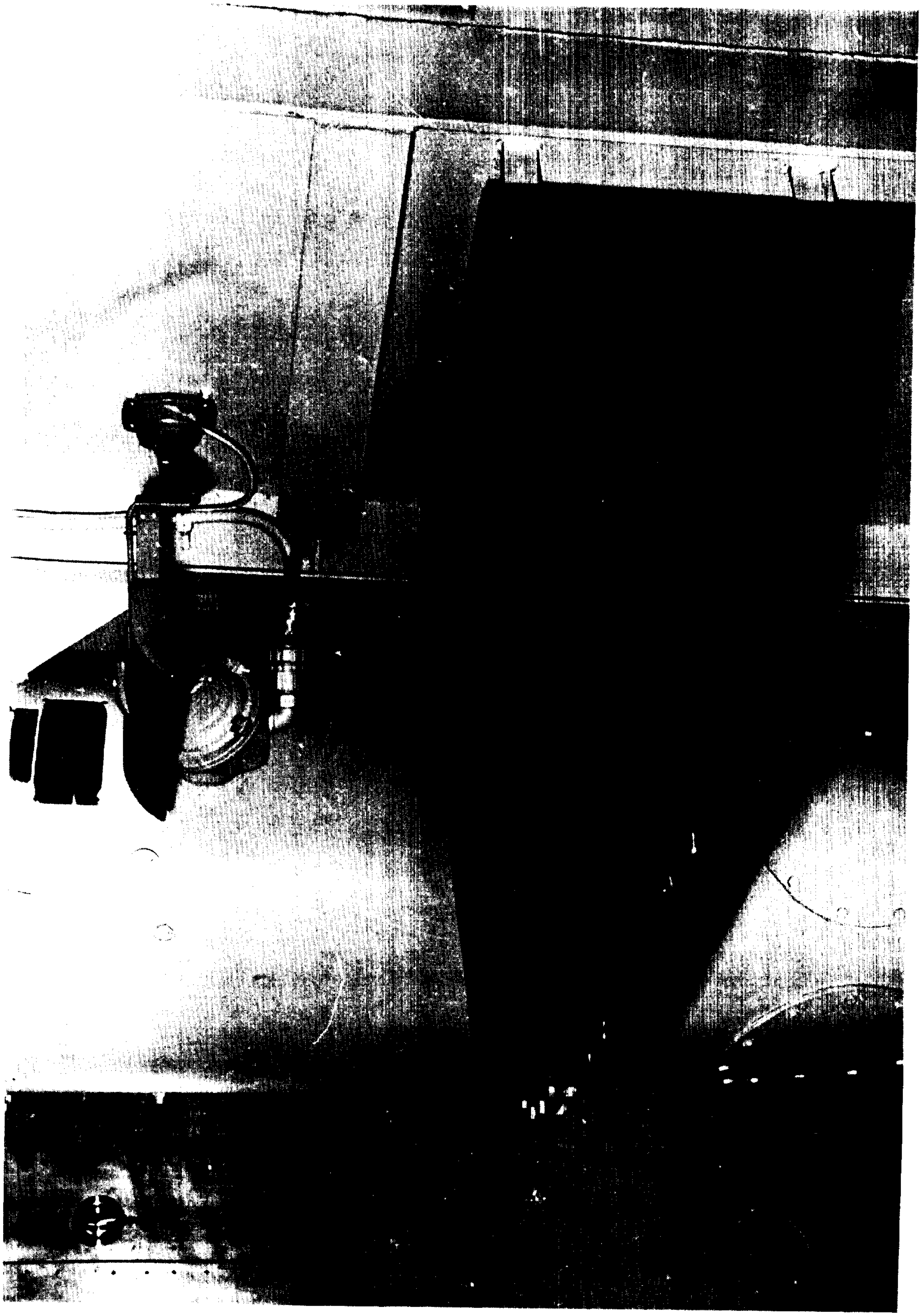
SH 964-C6

FIGURE 97. Typical installation of desk light, symbol 150.2.
(For details see method D-1-C of appendix B)



SH 964-C7

FIGURE 98. Typical installation of desk light, symbol 141.2 with filter assembly, symbol 121.1 red, or symbol 121.2 blue.
(For details see method D-1-B of appendix B)



SH 964-C8

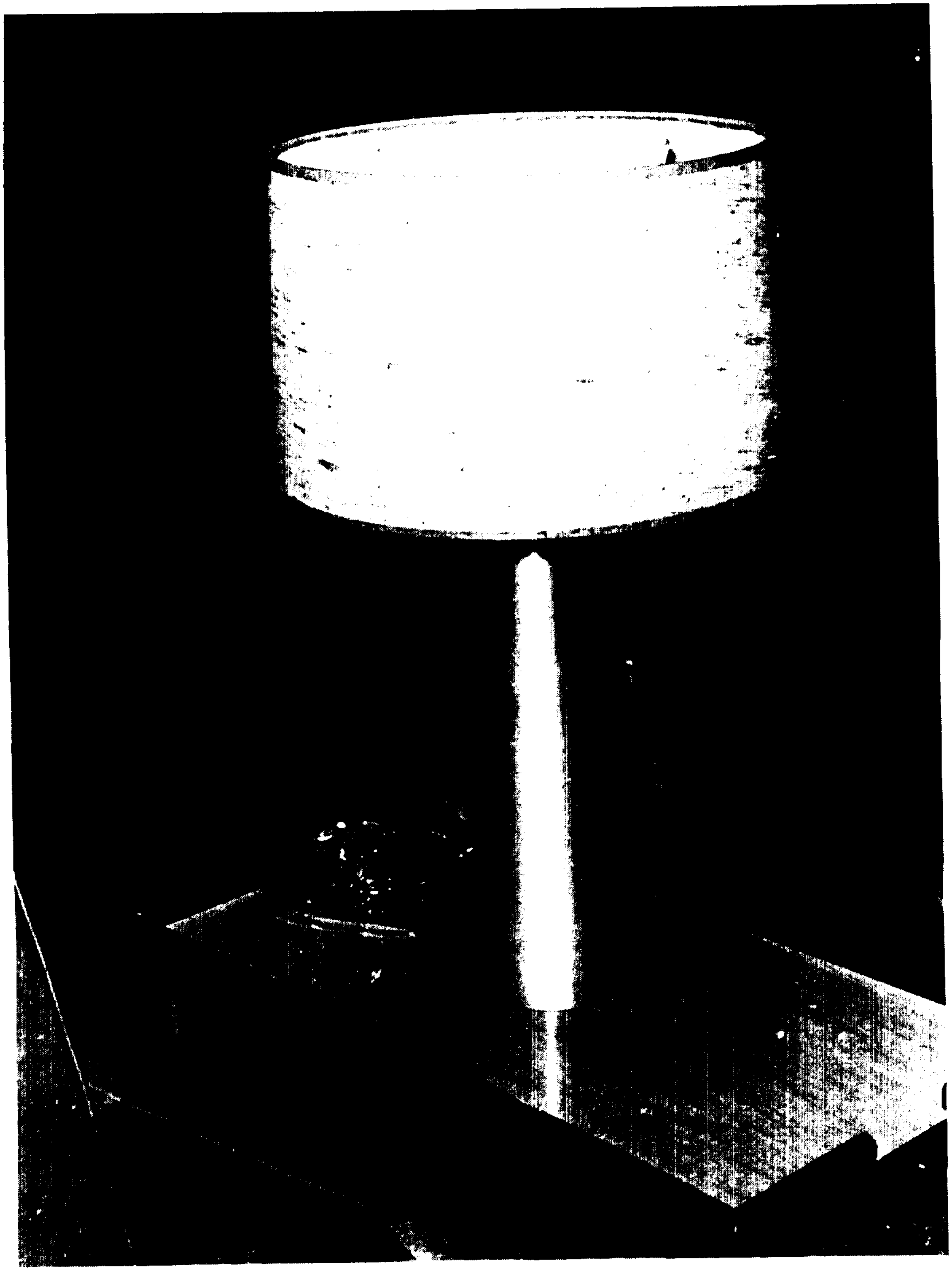
FIGURE 99. Typical installation of desk light, symbol 141.2, for log desk illumination.
(For details see method D-4-A of appendix B)

SH 964-C9

FIGURE 100. Typical installation of light symbol 142.2, for illumination of continuous work area with book or instrument shelf over it. (For details see method D-4-D of appendix B)

SH 964-C10

FIGURE 101. Typical installation of light, symbol 142.2 for illumination of secretary bureau.
(For details see method D-5-A of appendix B)

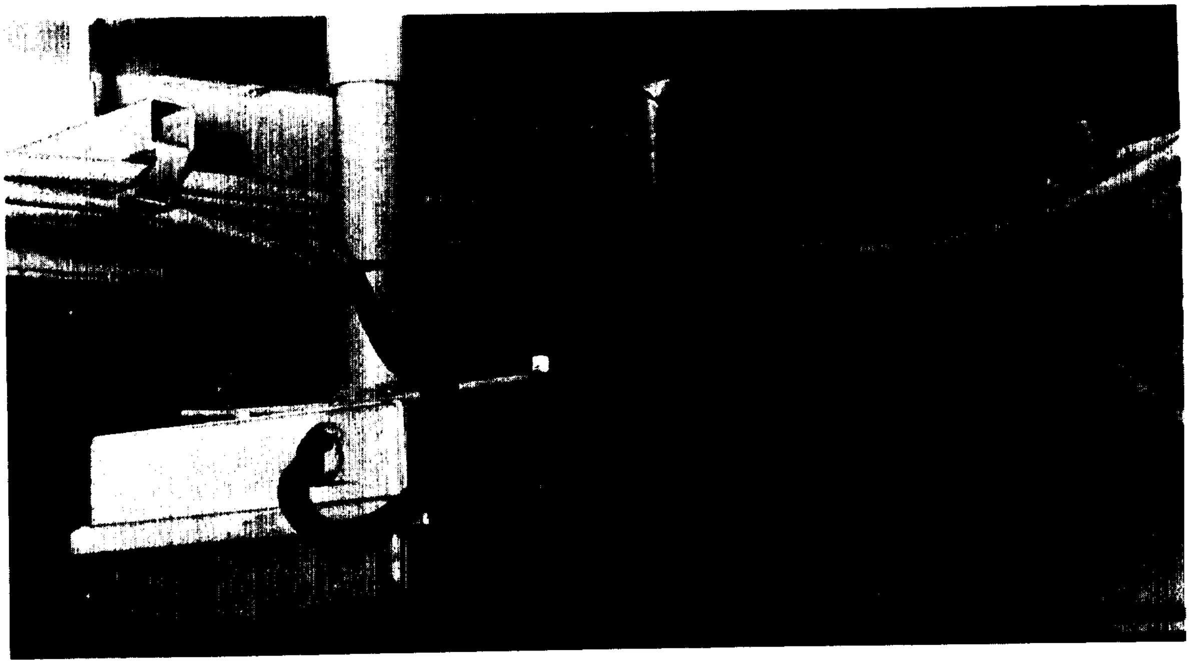


SH 964-C11

FIGURE 102. Typical installation of table lamps.
(For details see method D-6-D of appendix B)

SH 964-C12

FIGURE 103. Typical flush mounting of fluorescent lighting fixtures. (For details see method E-1-B of appendix B)

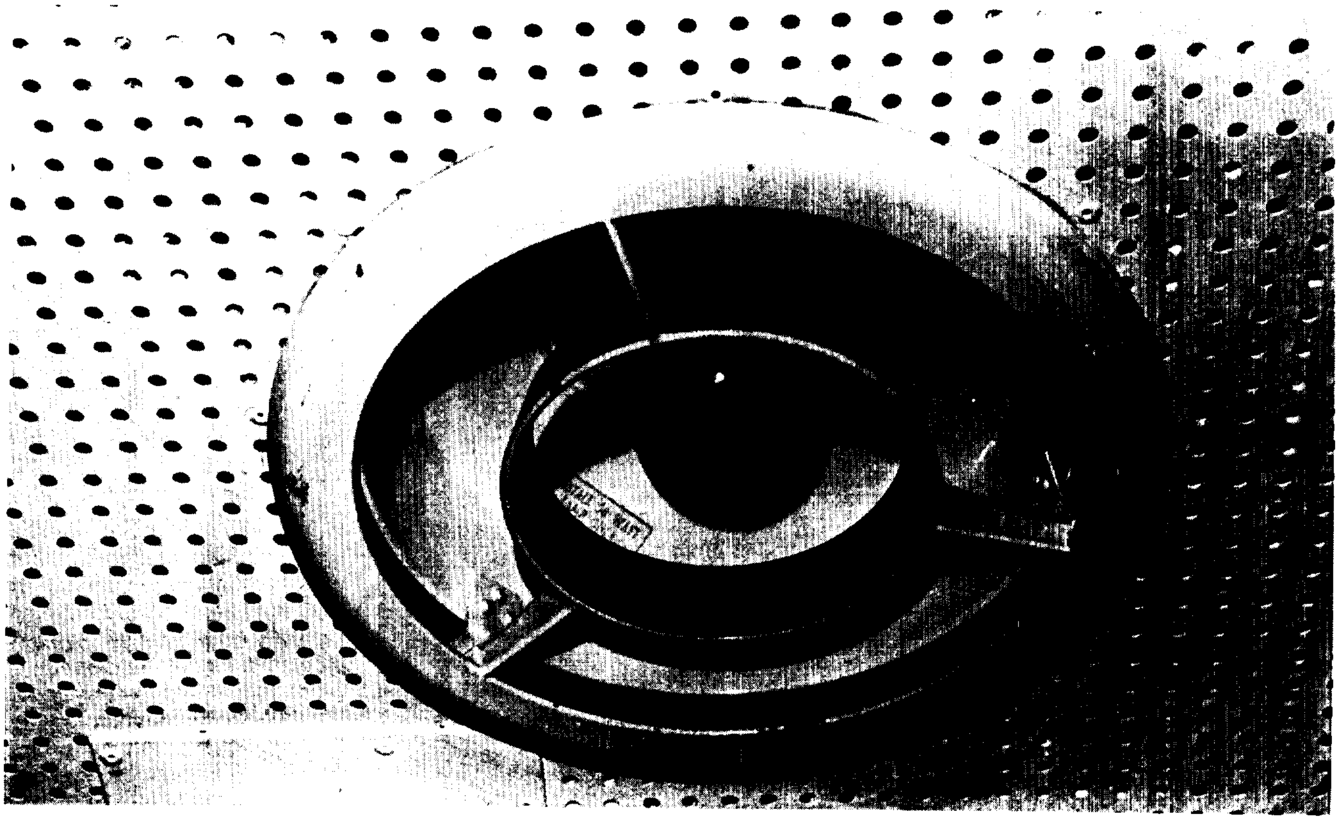


A
For details see method E-2-A of appendix B.

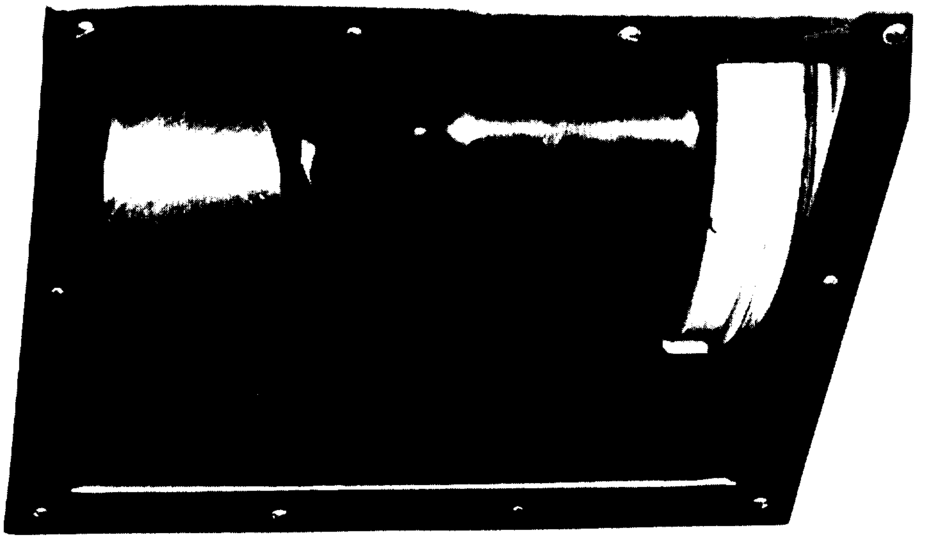
B
For details see method E-2-B of appendix B.

SH 964-C13

FIGURE 104. Typical surface mounting of fluorescent lighting fixtures.



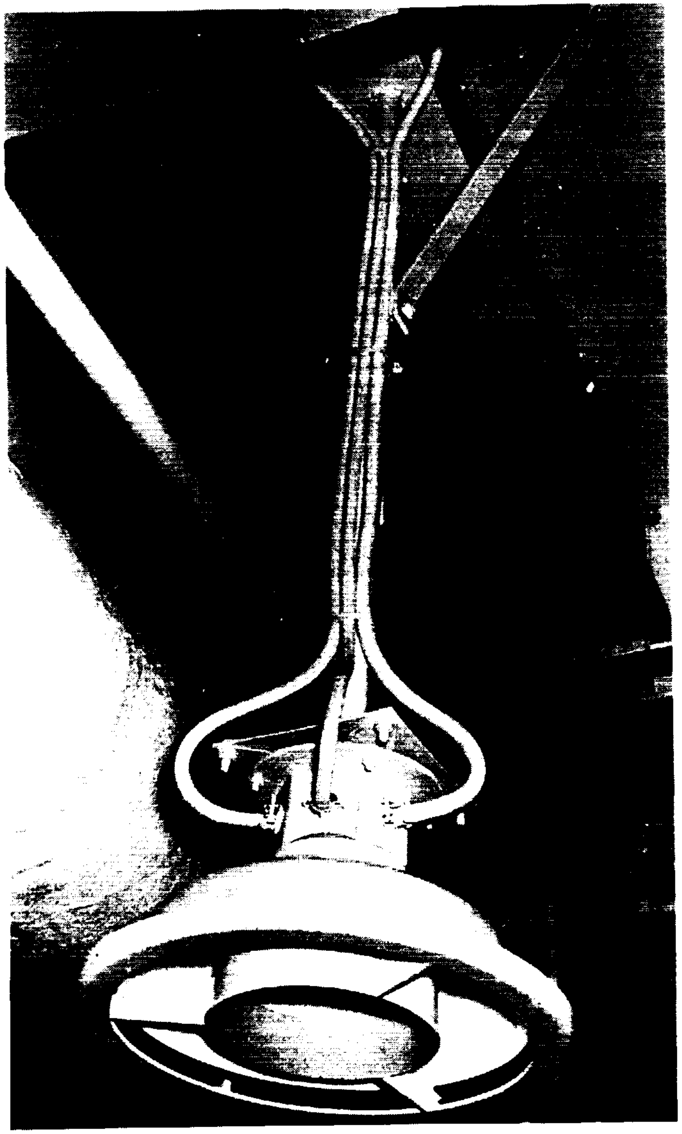
A
For details see method F-l-A of appendix B.



B
For details see method F-5-A of appendix B.

SH 964-C14

FIGURE 105. Typical installation of incandescent lighting fixtures.



A

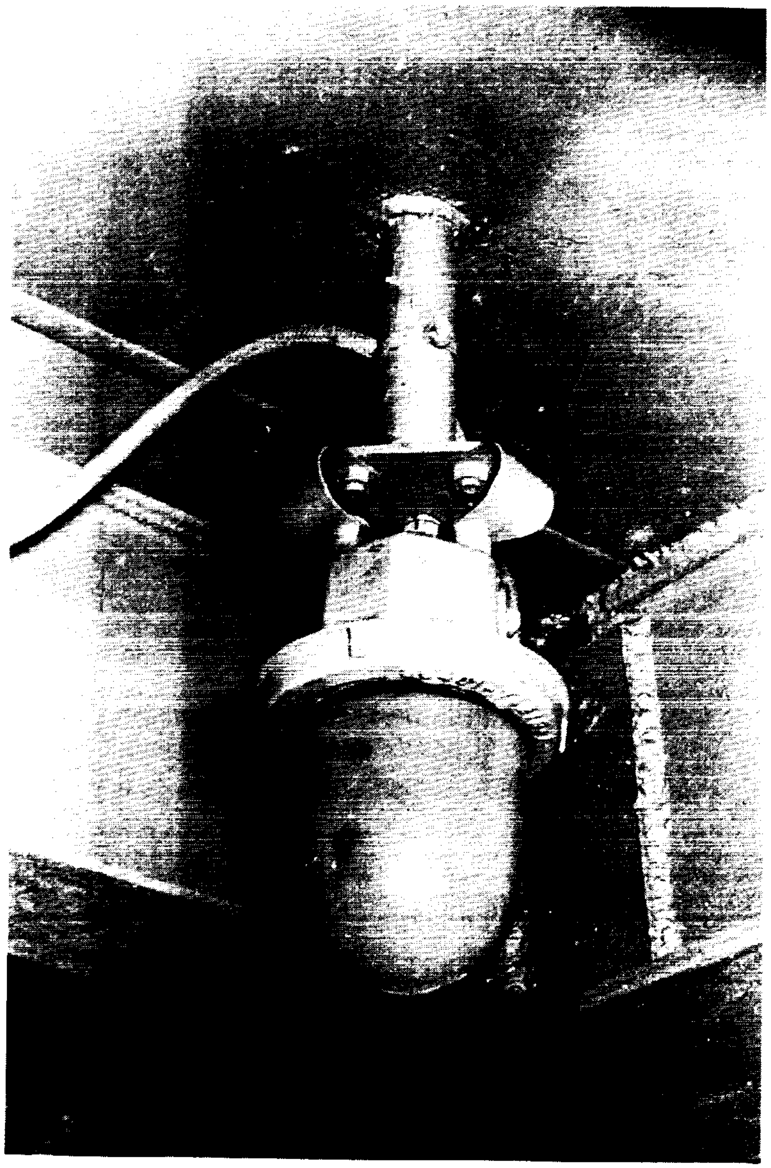
For details see method F-1-A of appendix B

B

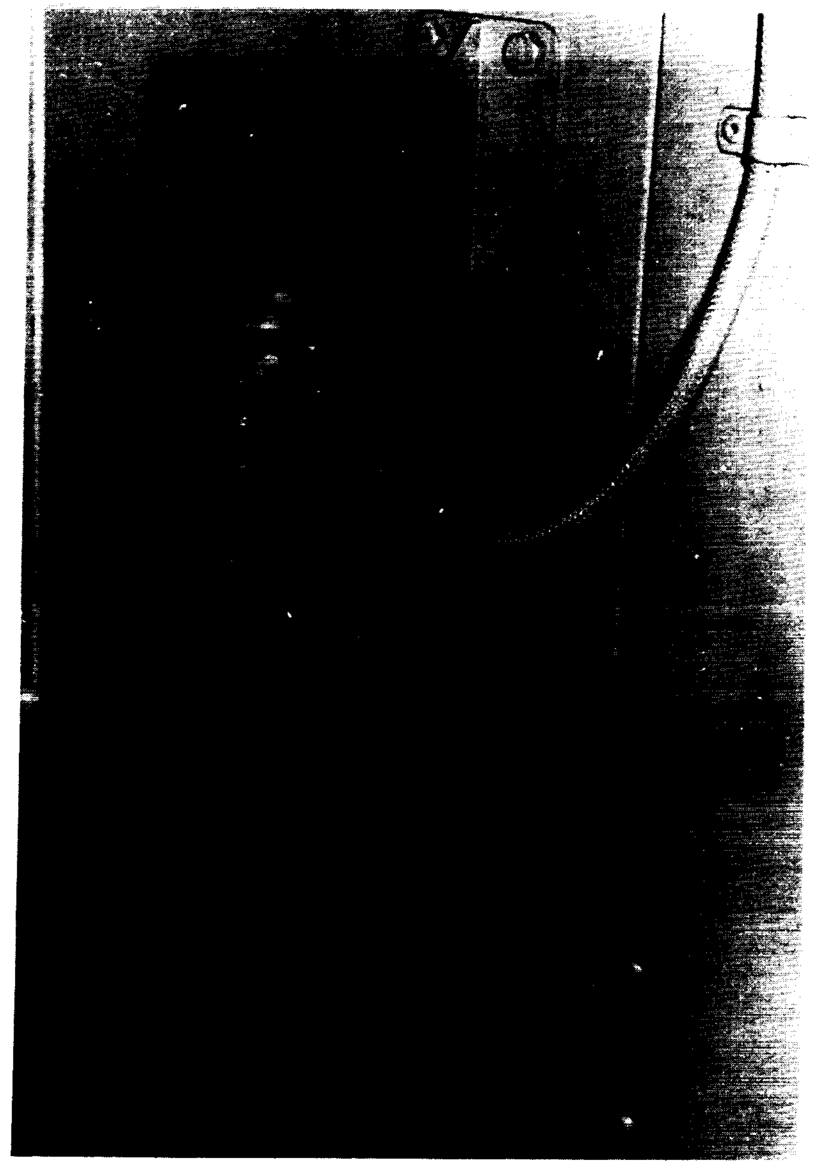
Typical installation of symbols 300.2 and 303.

SH 964-C15

FIGURE 106. Typical installation of incandescent lighting fixtures.



A
For details see method F-4-A of appendix B

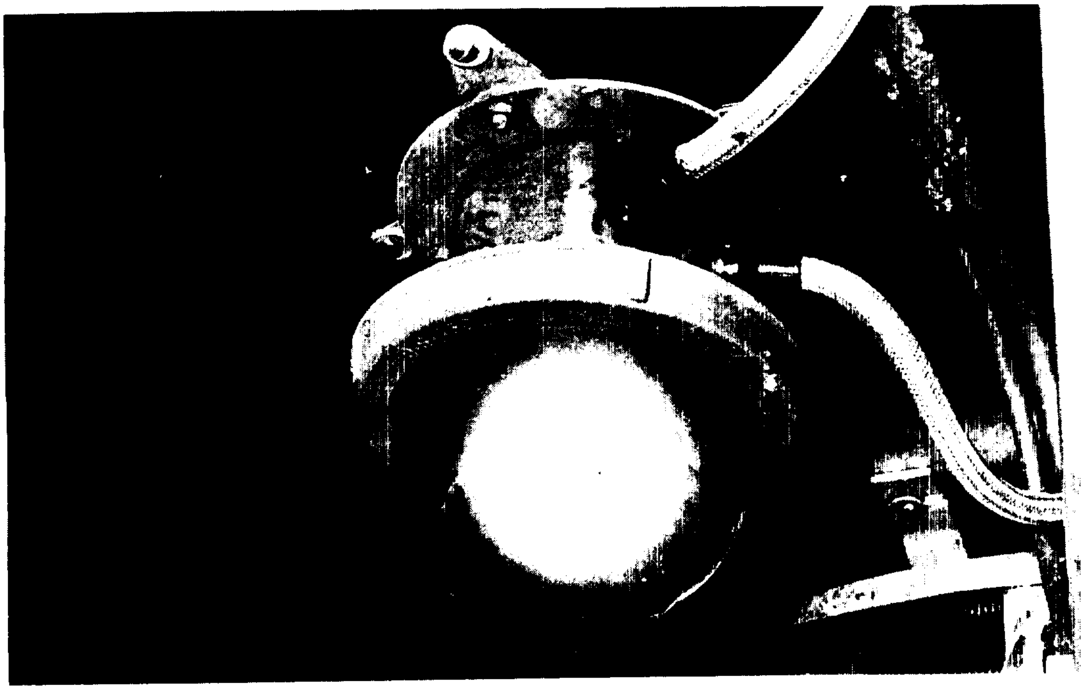


B
For details see method F-4-B of appendix B.

SH 964-C16

FIGURE 107. Typical installation of incandescent lighting fixtures.

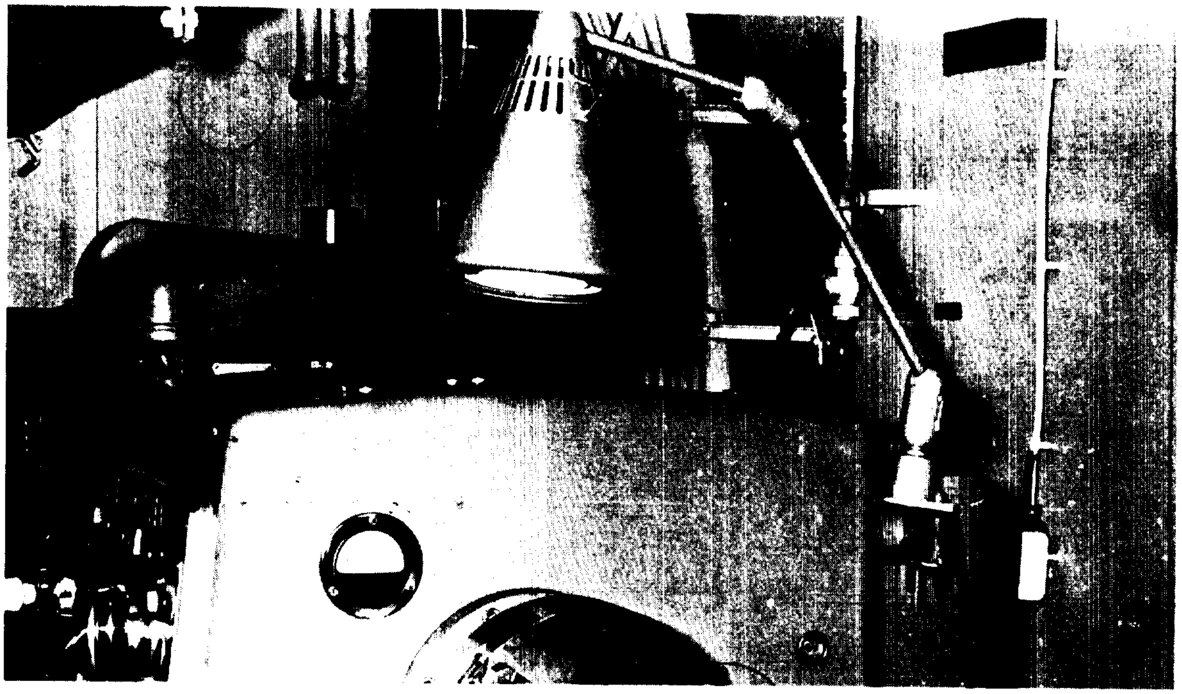
A
For details see method G-l-D of appendix B.



B
For details see method F-6-C of appendix B.

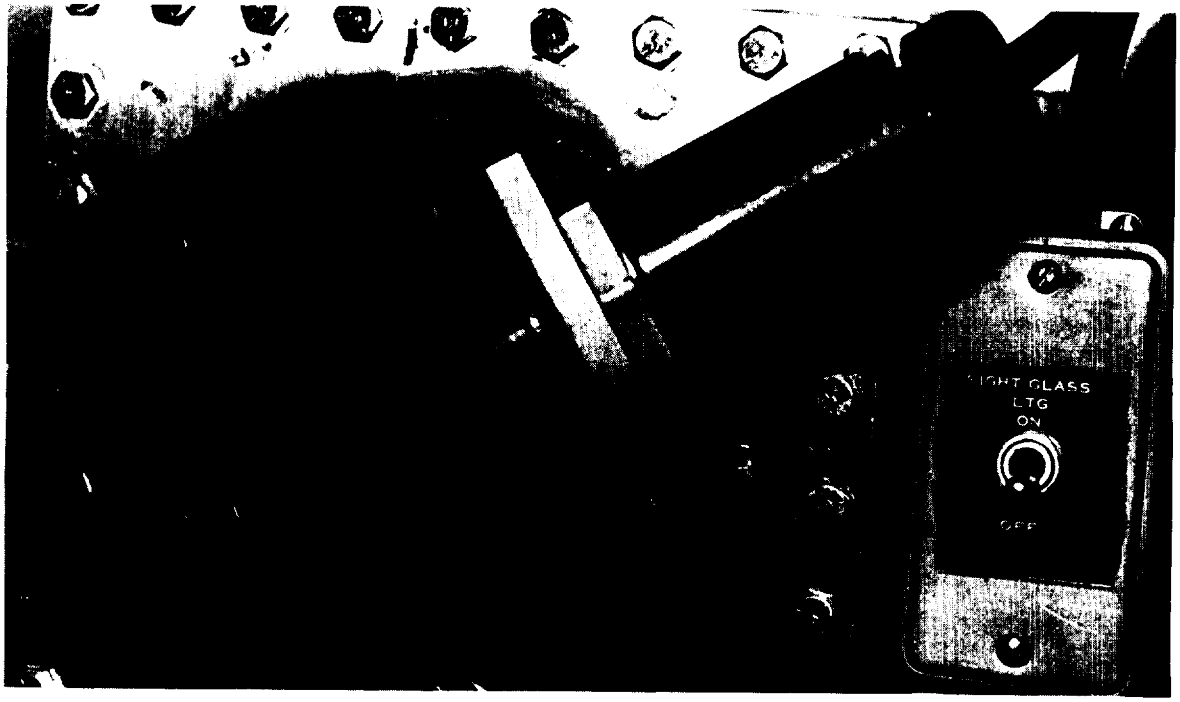
SH 964-C17

FIGURE 108. Typical installation of incandescent lighting fixtures.



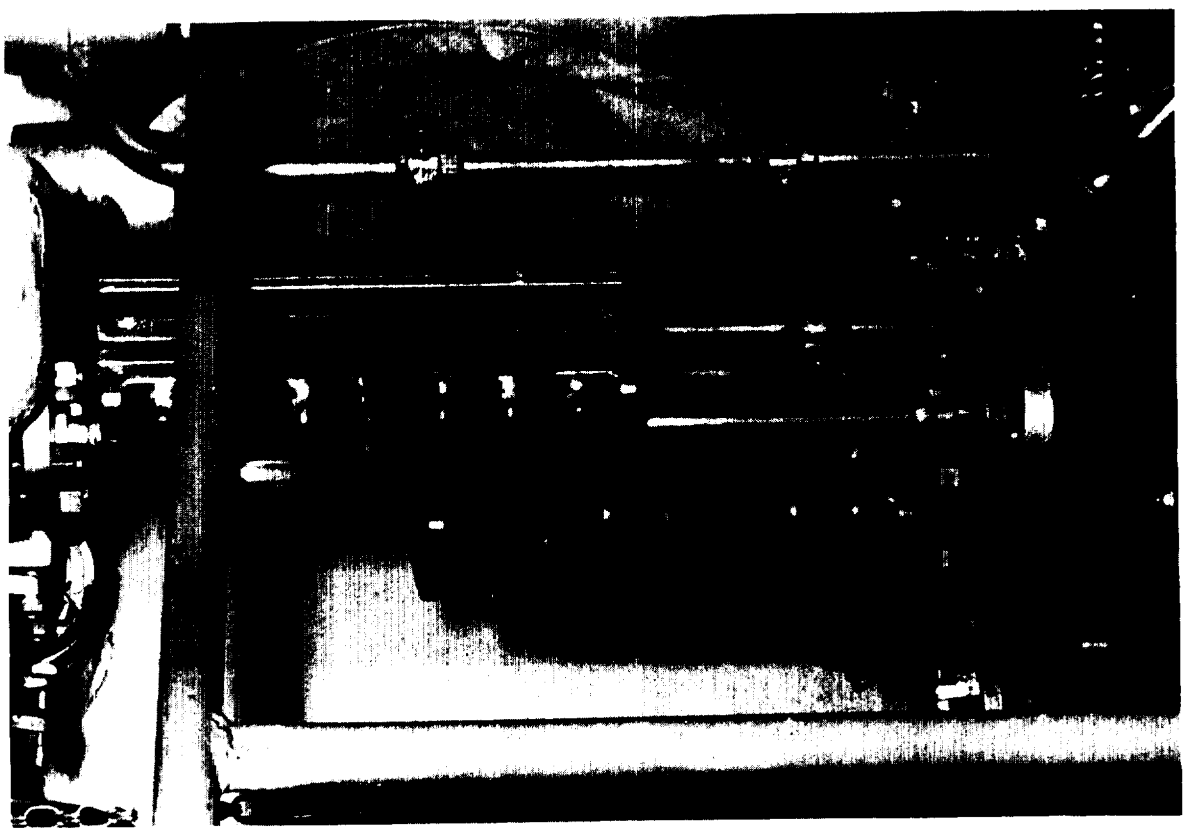
SH 964-C18

FIGURE 109. Typical installation of machine tool light, symbol 266.2.



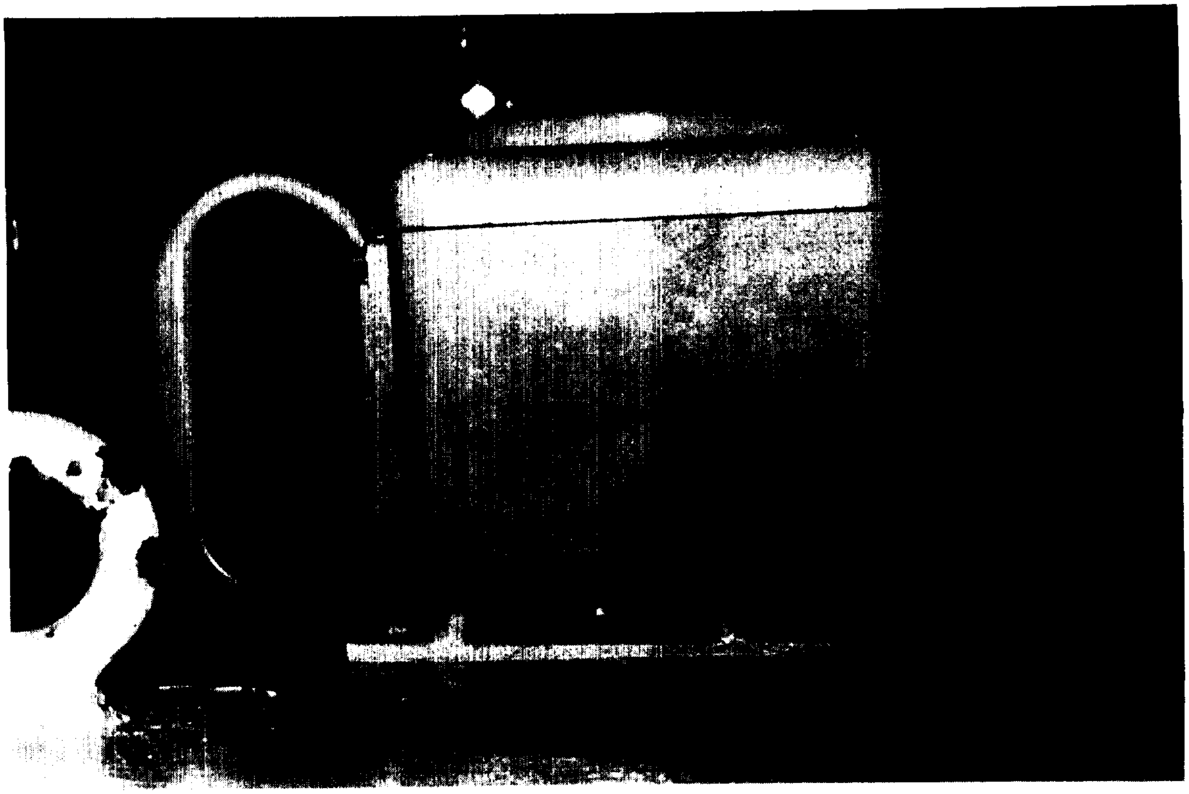
SH 964-C19

FIGURE 110. Typical installation of sightglass lights, symbols 136.1 and 156. (For details see method H-12-A of appendix B).



SH 964-C20

FIGURE 111. Typical installation of water gauge lights, symbol 134.1. (For details see method H-10-A of appendix B).



SH 964-C21

FIGURE 112. Typical installation of portable lanterns, symbol 100.2. (For details see method H-9-A of appendix B).

SH 964-C22

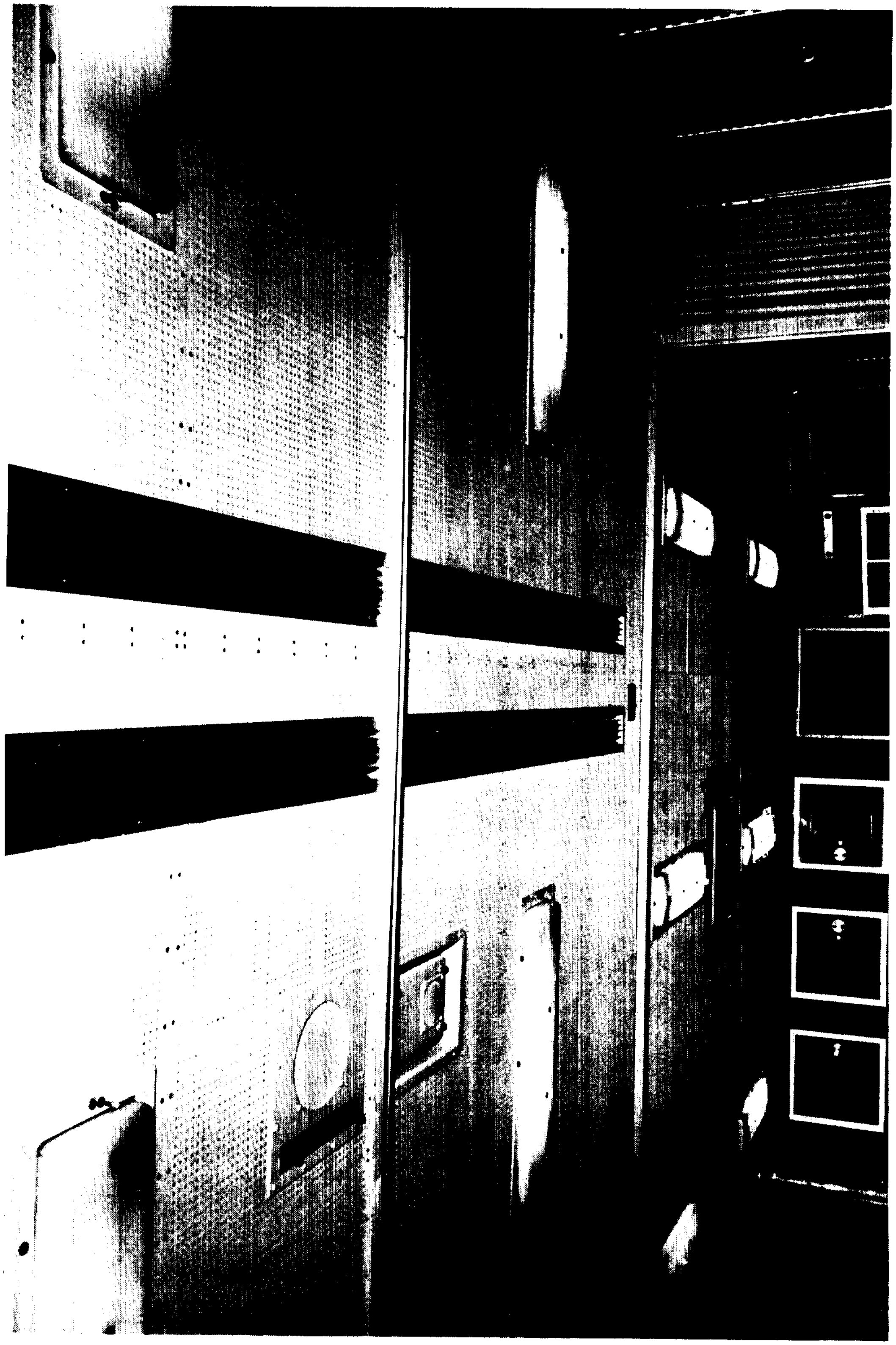
FIGURE 113. Illumination of a wardroom - surface ships.

FIGURE 113. Illumination of a wardroom - surface ships.

SH 964-C23

FIGURE 114. Illumination of a wardroom lounge - surface ships.

FIGURE 114. Illumination of a wardroom lounge - surface ships.



SH 964-C24

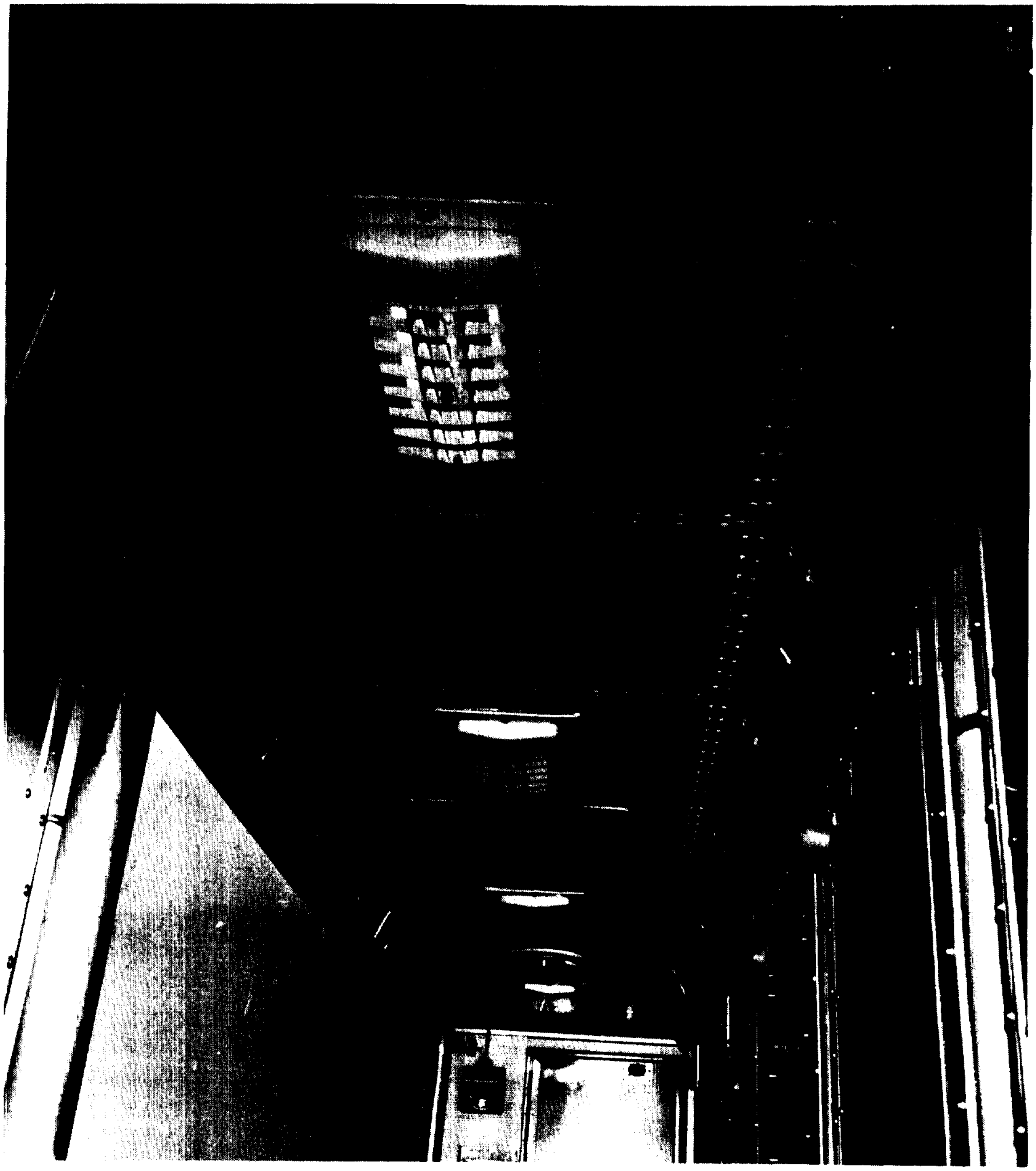
FIGURE 115. Illumination of a wardroom lounge - submarines.

FIGURE 115. Illumination of a wardroom lounge - submarines.

SH 964-C25

FIGURE 116. Illumination of crew's mess room - submarines.

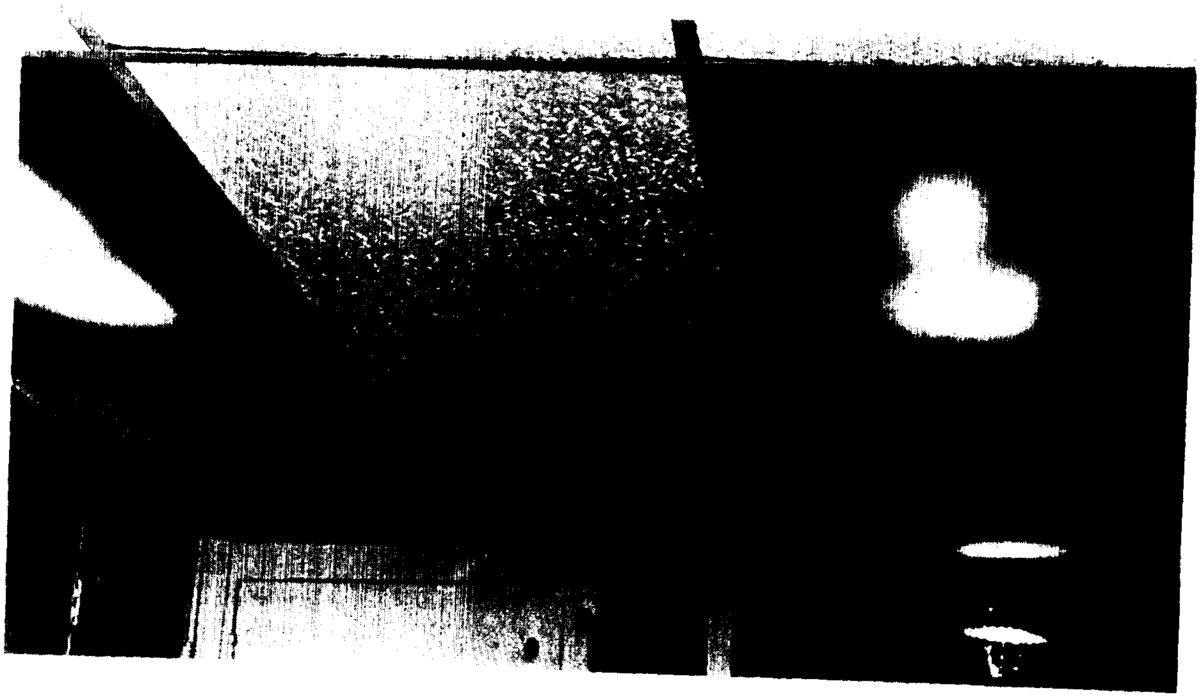
FIGURE 116. Illumination of crew's mess room - submarines.



SH 964-C26

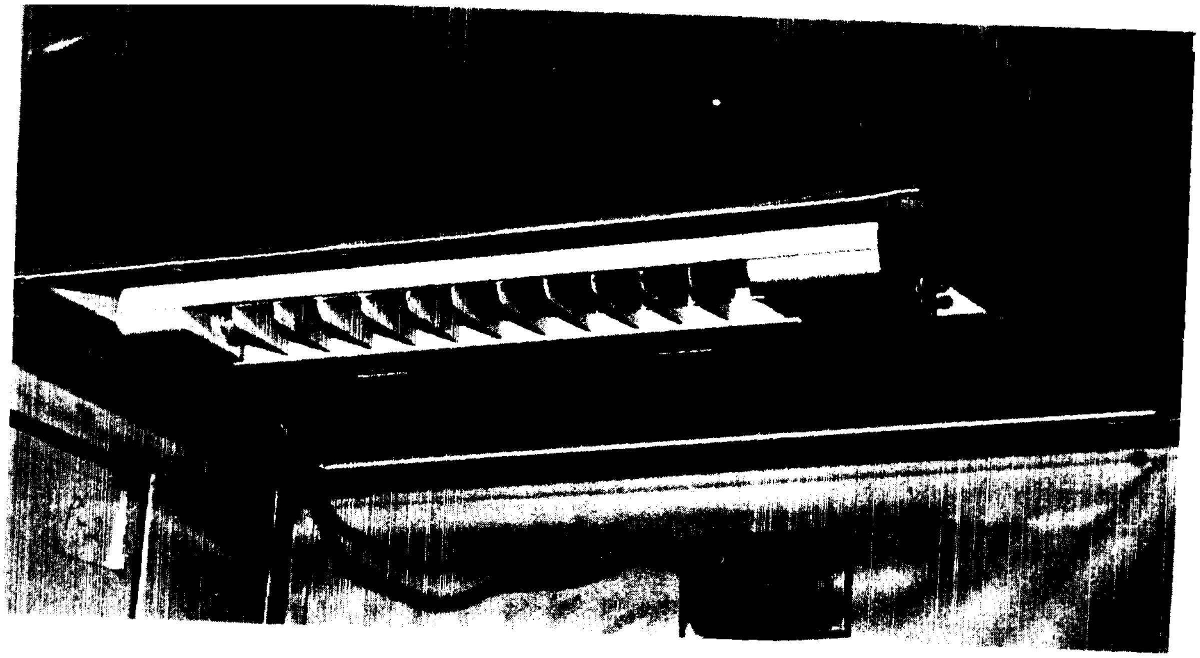
FIGURE 117. Illumination of an electronic space.

(Note flush mounting of clear white shielded fluorescent lighting fixtures, switches and receptacles).



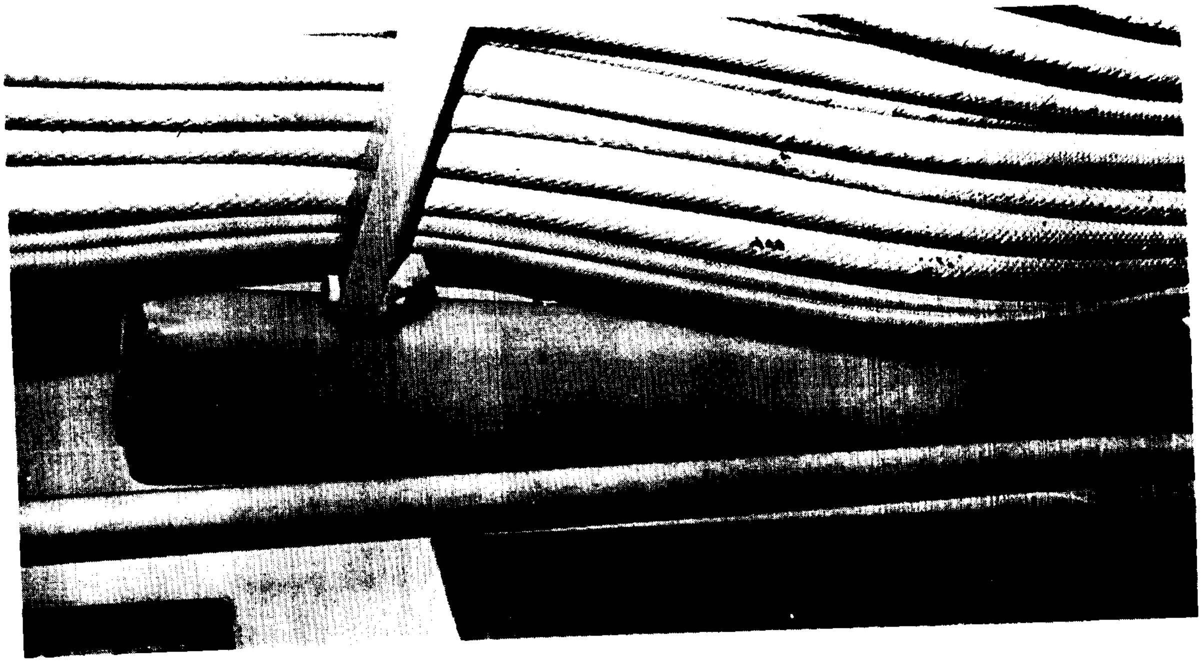
SH 964-C27

FIGURE 118. Spotty illumination results when improper lighting fixtures are used in type of overhead sheathing.
(For proper installation see method E-7-A of appendix B)



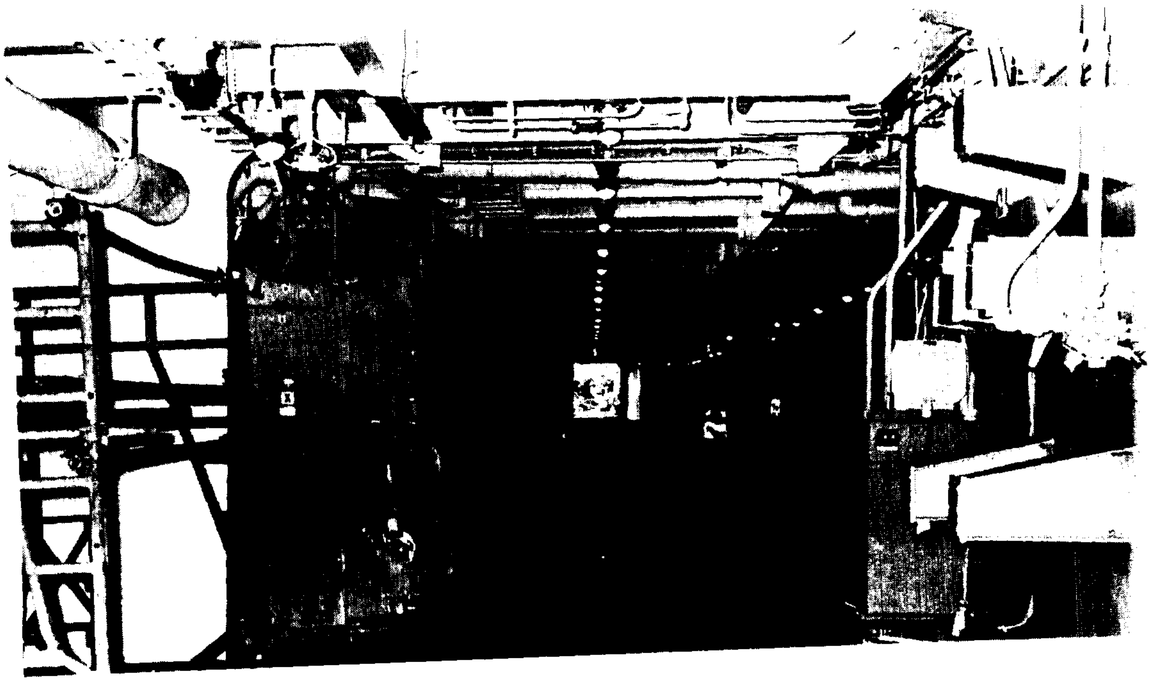
SH 964-C28

FIGURE 119. A lot is to be desired of the cable installation of this berth light.



SH 964-C29

FIGURE 120. Loss of illumination and difficulty in re-lamping are typical bad installation features of this light fixture.

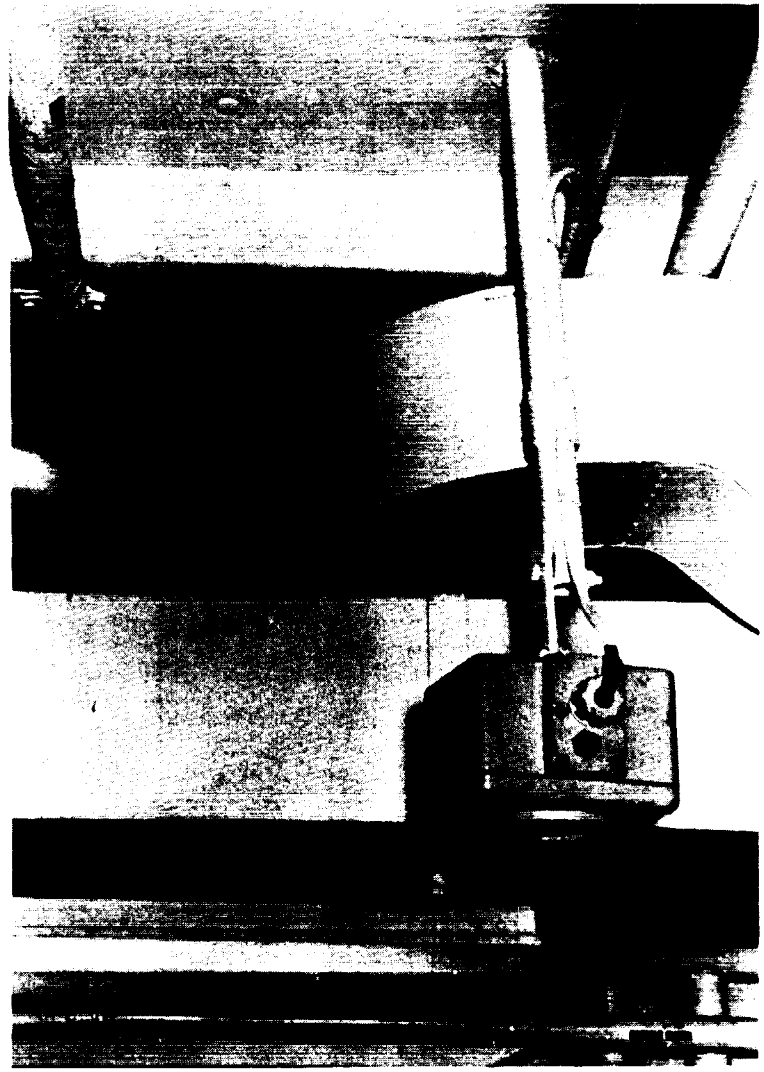


SH 964-C30

FIGURE 121. Flourescent lighting would have provided a much better and less costly illumination in this area. (It should be noted that rated life of incandescent lamps ranges between 750 and 2000 hours versus 7500 hours for flourescent lamps).

SH 964-C31

FIGURE 122. Use of method B-2-B of appendix B would have eliminated this expensive hanger for this berth light. (Judical selection of hangers is a must in order to keep shipbuilding costs down). costs down).



SH 964-C32

FIGURE 123. As a requirement, lanterns must be installed with the relay topside or in highest position possible; this installation violates this requirement. (For proper installation see method H-8-C of appendix B).

SH 964-C33

FIGURE 124. Appearance of this mirror illumination would have been improved ten-fold if concealed cable installation was employed or switch/receptacle was located on opposite side.

SH 964-C34

FIGURE 125. There is some doubt as to whether this light's purpose is to illuminate the billboard or the overhead.

APPENDIX D

LIGHT OUTPUT DATA

10. GENERAL

10.1 Scope. This appendix provides illumination patterns for red floodlights symbols 263 and 317 commonly used for replenishment-at-sea red lighting.

10.2 Application. These illumination patterns can be used in lieu of resorting to calculations. They are a quick reference to select particular lighting and mountings.

20. REFERENCED DOCUMENTS

Not applicable.

30. DEFINITIONS

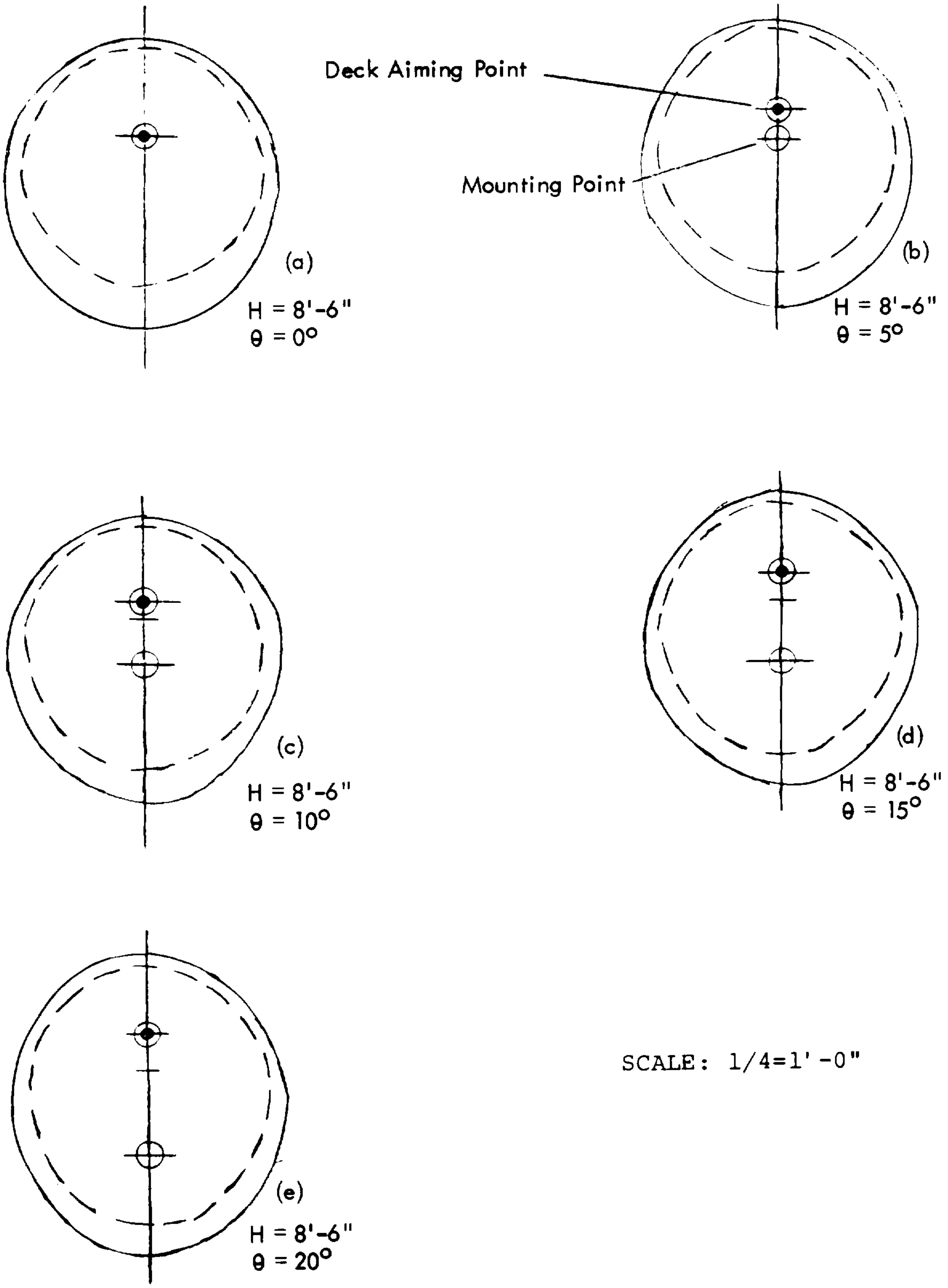
Not applicable.

40. GENERAL DESIGN CONSIDERATIONS

40.1 Illumination patterns. General illumination patterns are developed for two types of lamps shown in this appendix, the medium flood and wide flood. The patterns are developed at various heights and mounting angles; the heights ranging from 8 feet 6 inches to 50 feet 6 inches, and the mounting angles ranging from O to 45 degrees.

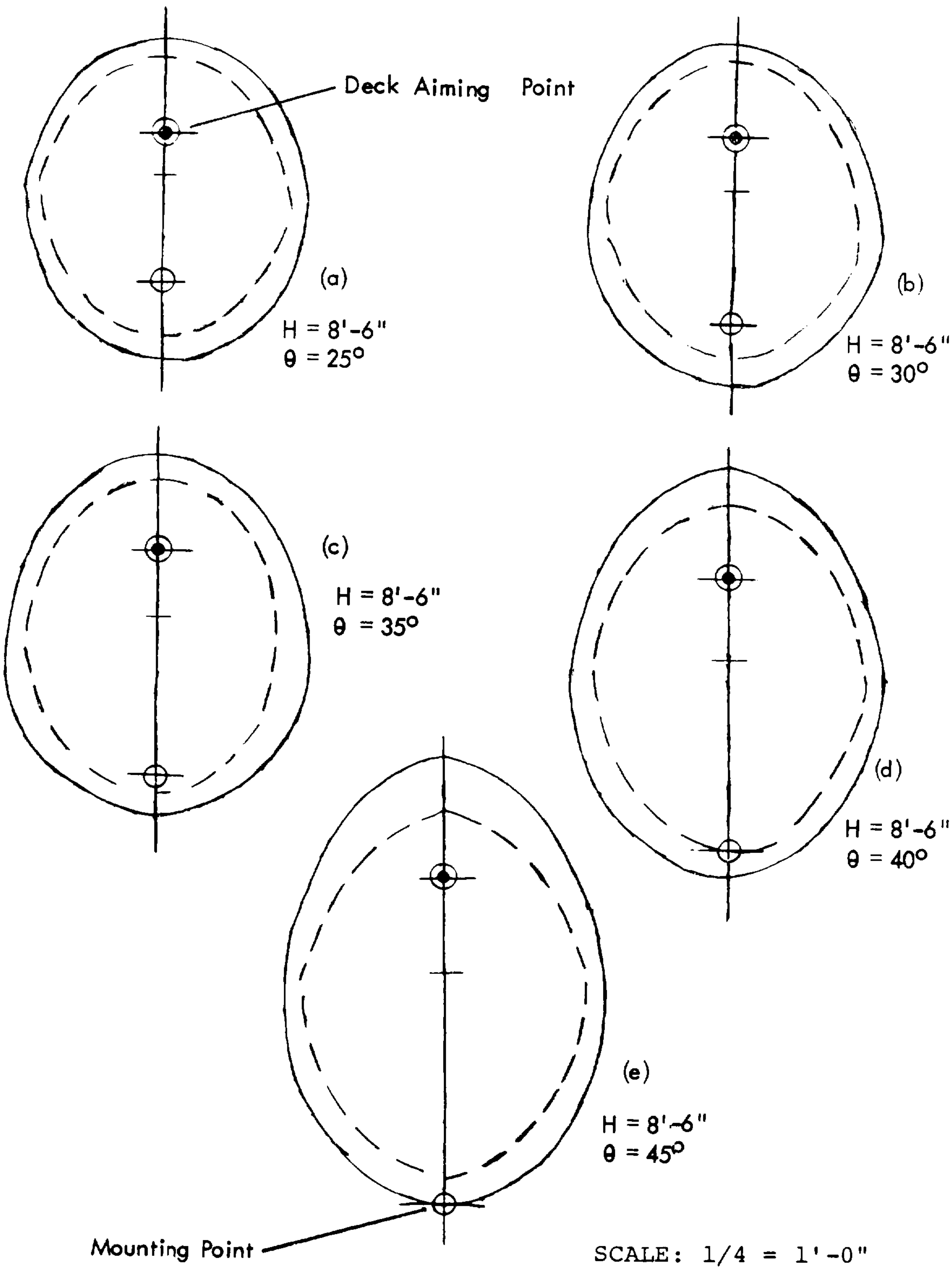
50. DETAIL DESIGN CONSIDERATIONS

Not applicable.



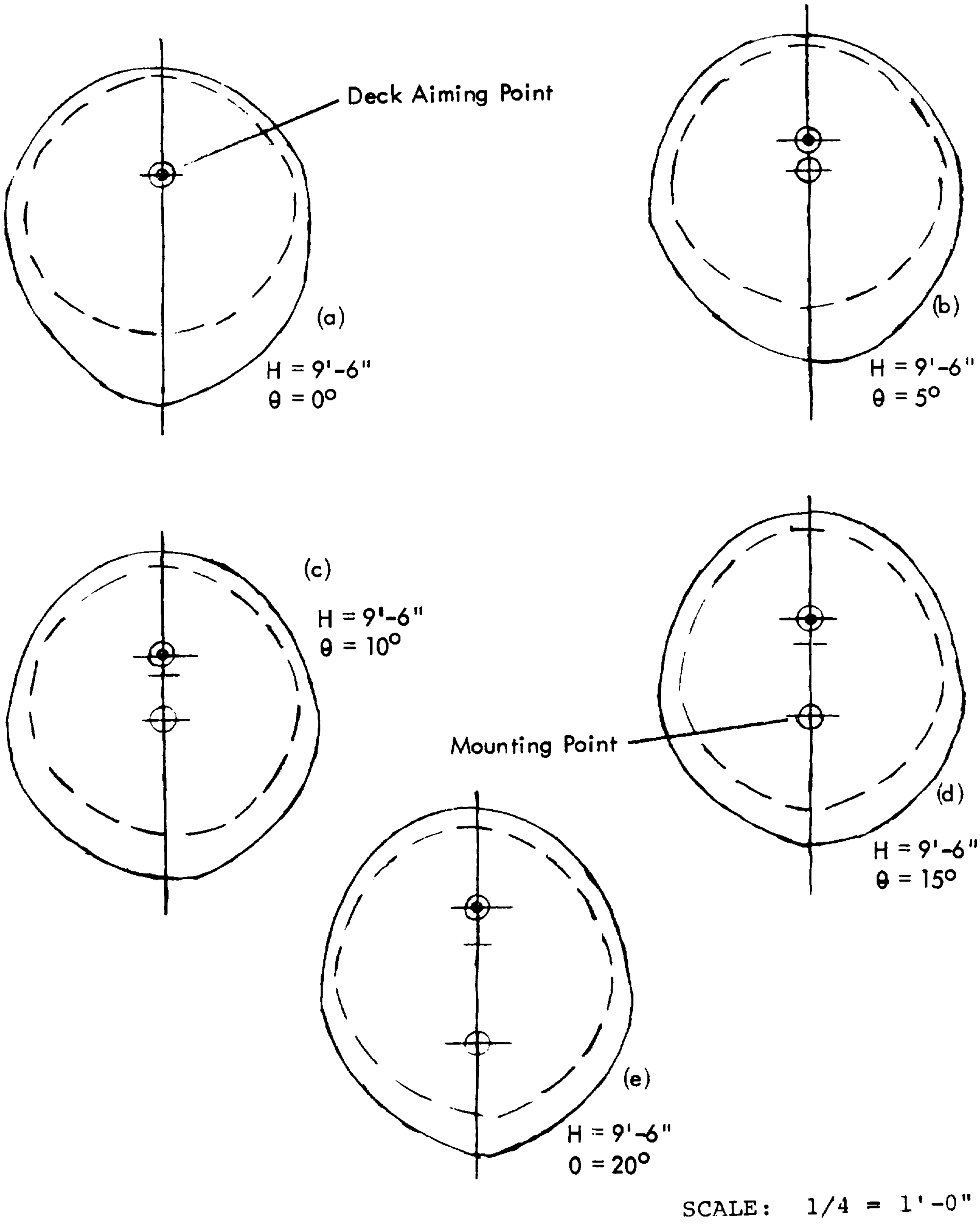
SH 964-D1

FIGURE 126. 150W MFL for H equals 8 feet 6 inches and θ equals 0 to 20 degrees.



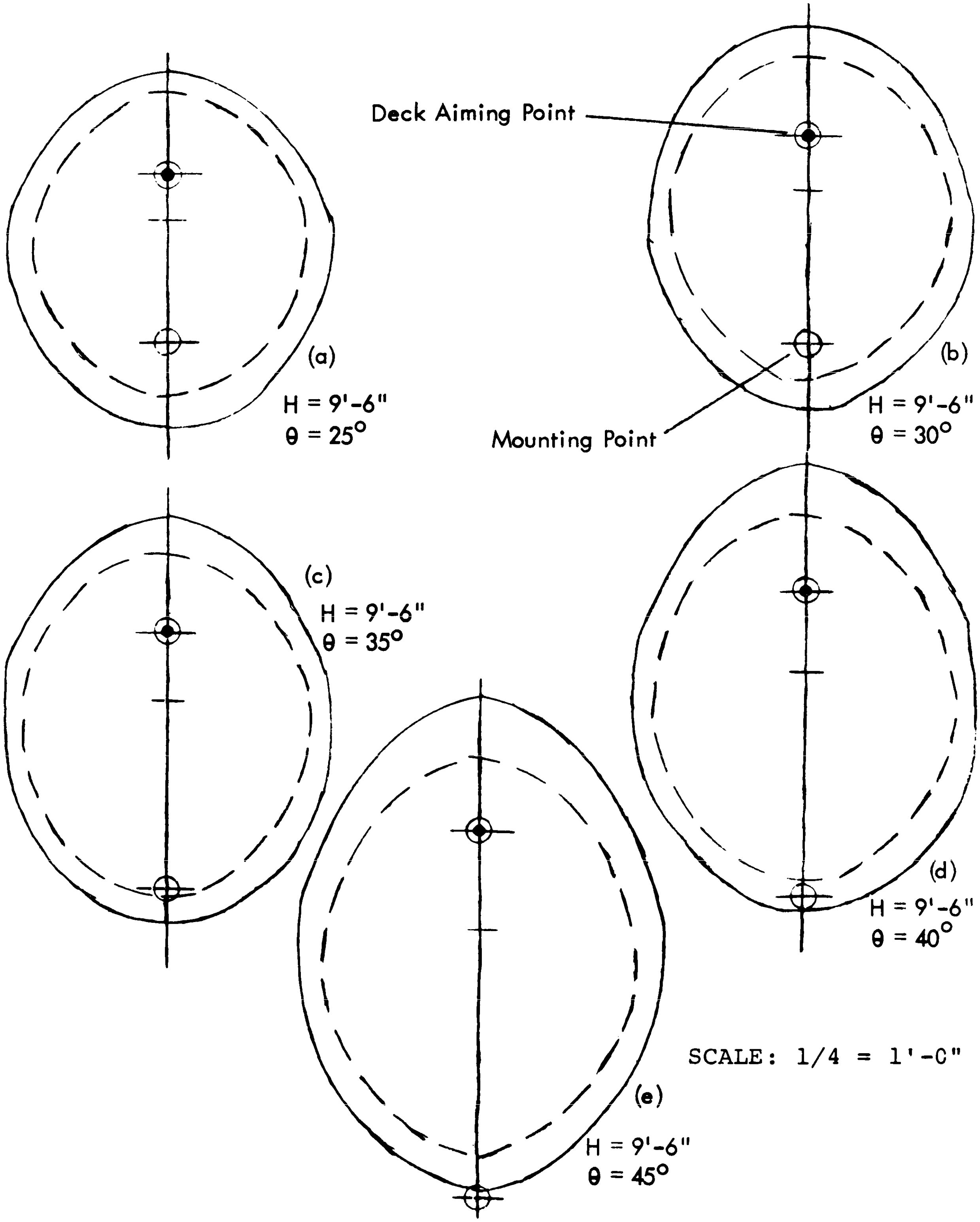
SH 964-D2

FIGURE 127. 150W MFL for H equals 8 feet 6 inches and θ equals 25 to 45 degrees.



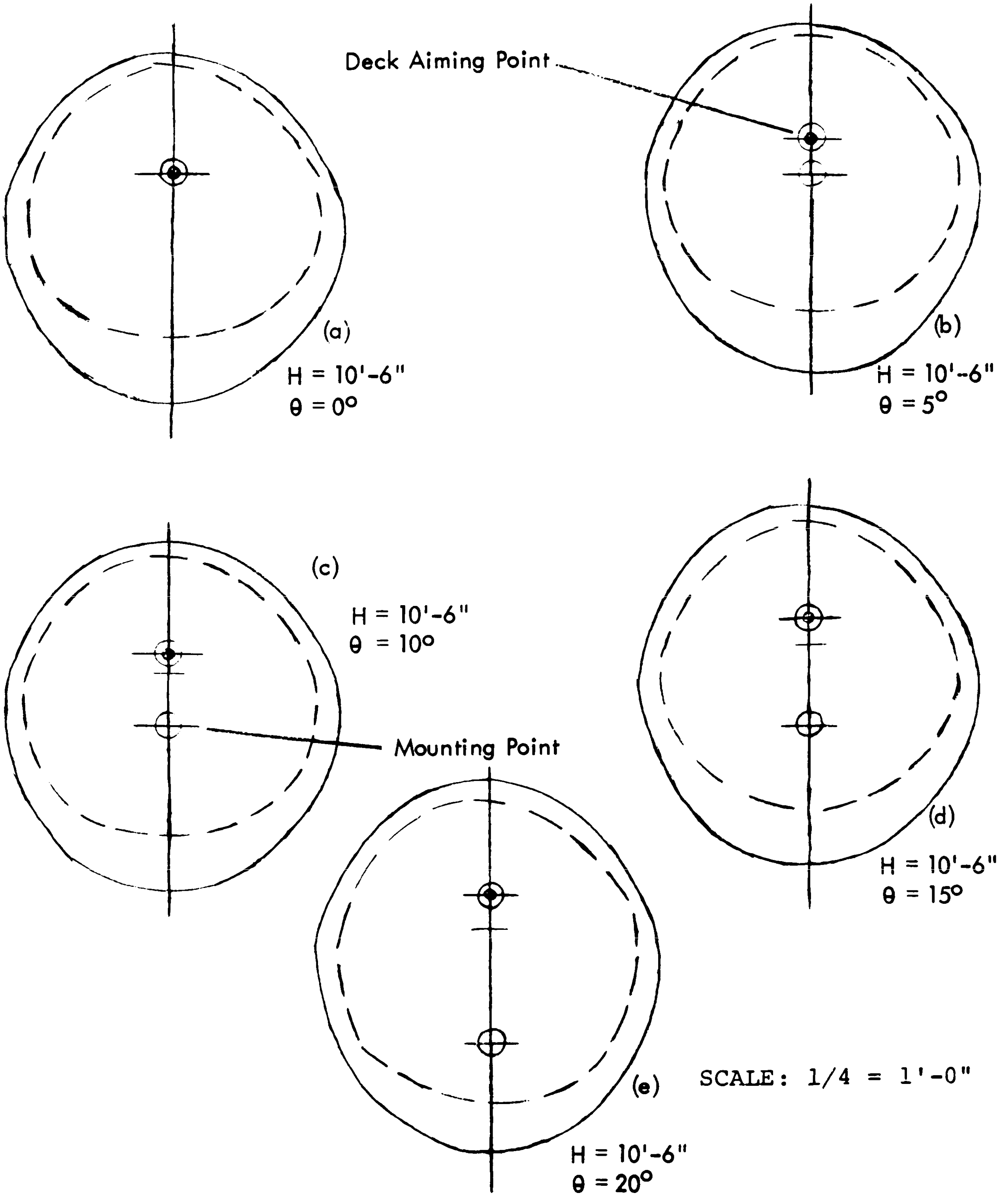
SH 964-D3

FIGURE 128. 150W MFL for H equals 9 feet 6 inches and θ equals 0 to 20 degrees.



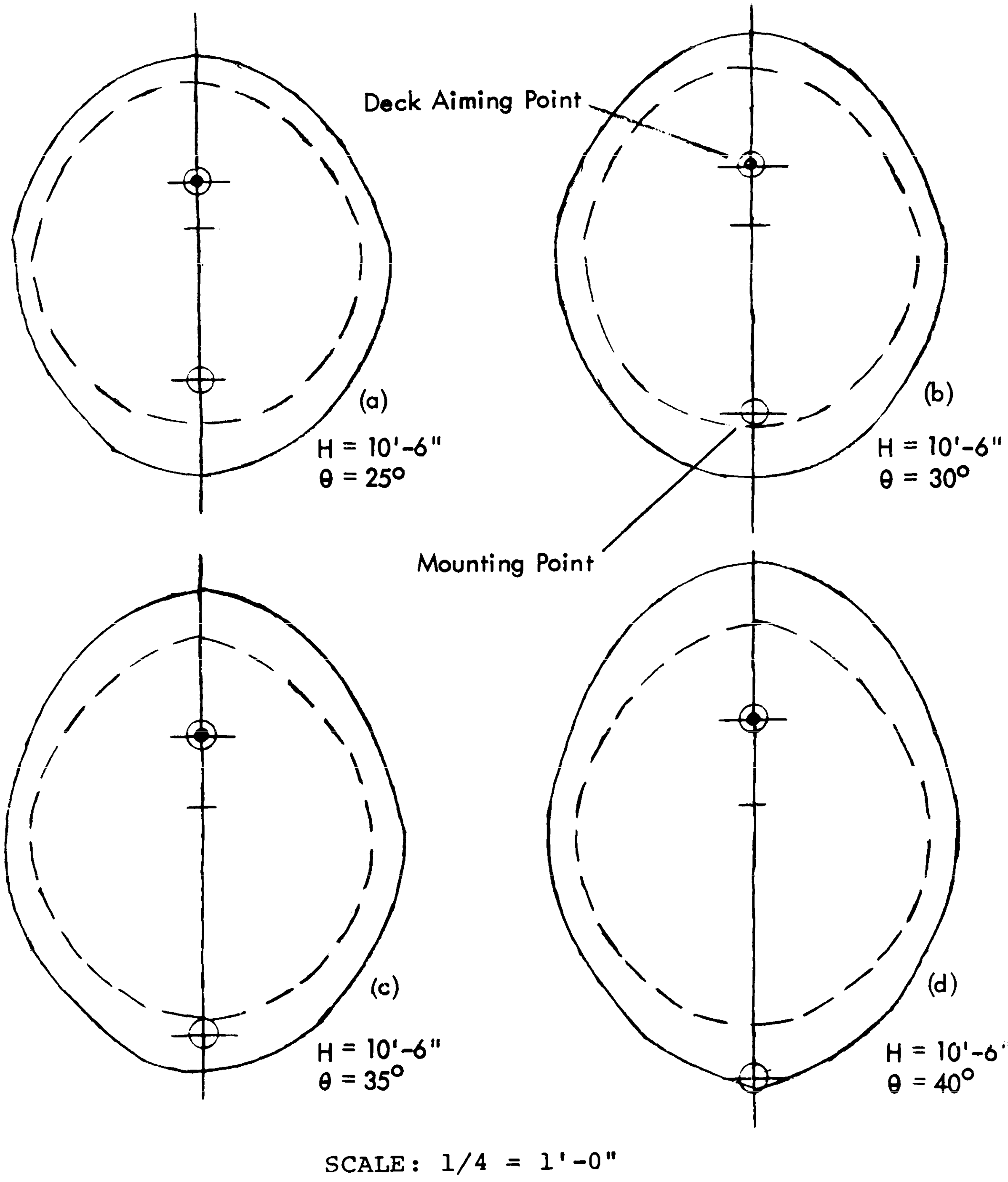
SH 964-D4

FIGURE 129. 150W MFL for H equals 9 feet 6 inches and θ equals 25 to 45 degrees.



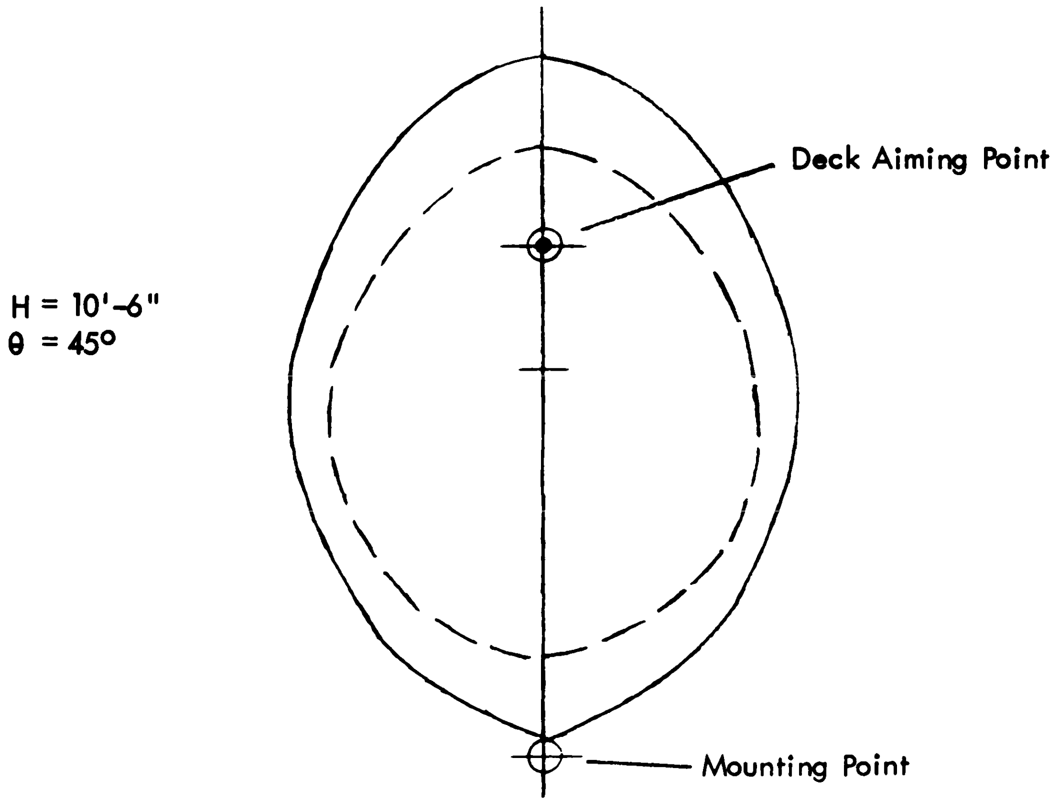
SH 964-D5

FIGURE 130. 150W MFL for H equals 10 feet 6 inches and θ equals 0 to 20 degrees.



SH 964-D6

FIGURE 131. 150W MFL for H equals 10 feet 6 inches and θ equals 25 to 45 degrees.



SCALE: 1/4 = 1'-0"

SH 964-D7

FIGURE 132. 150W MFL for H equals 10 feet 6 inches and θ equals 45 degrees.

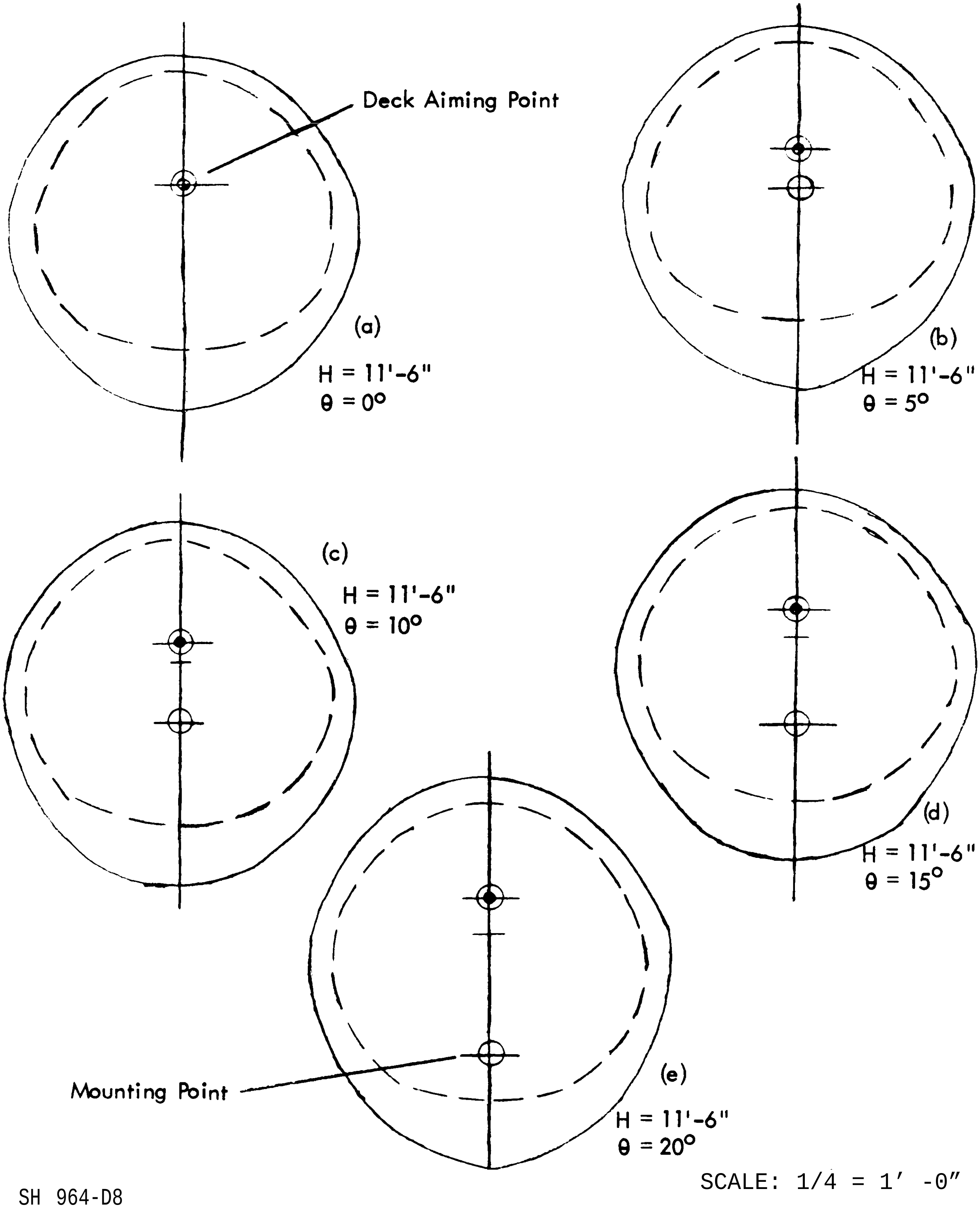
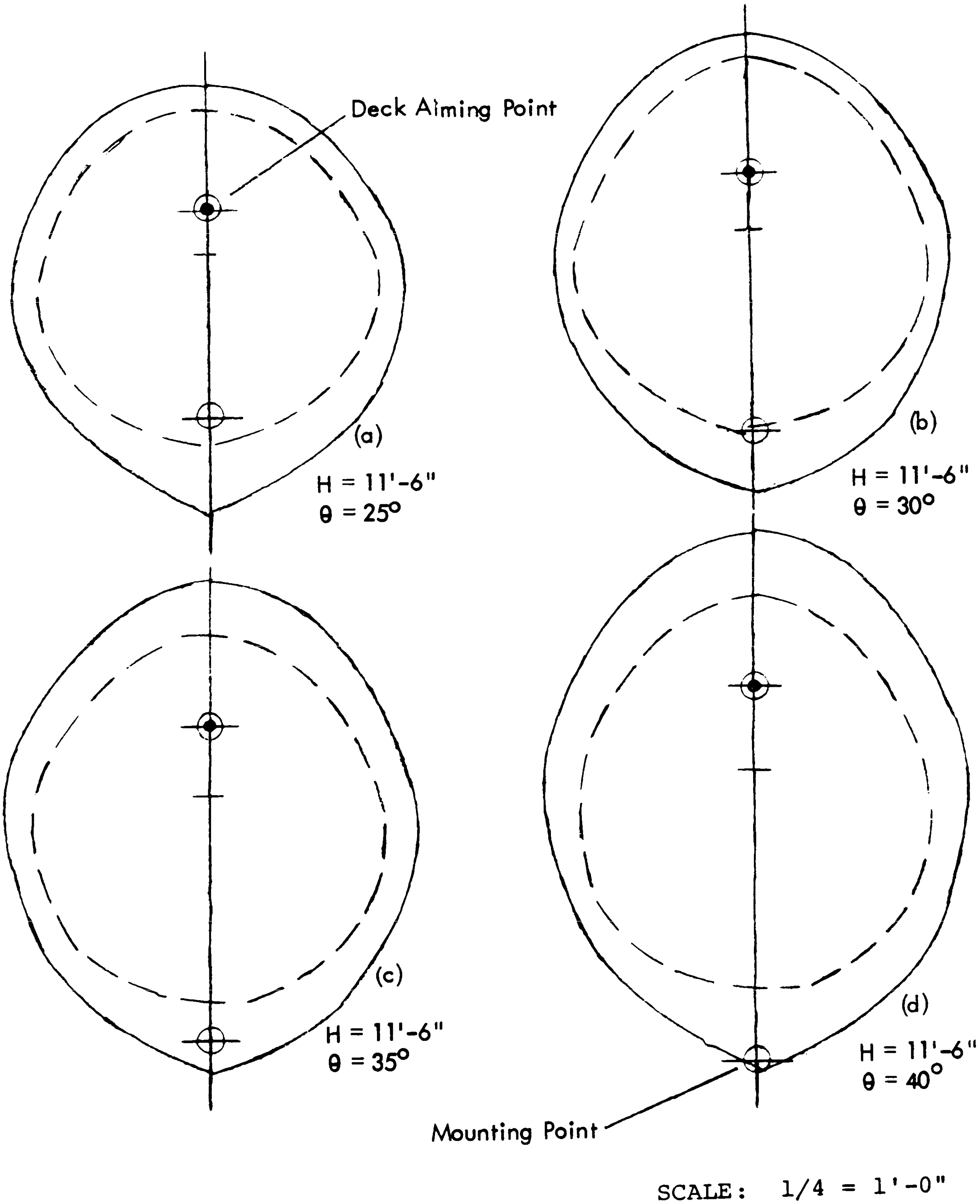
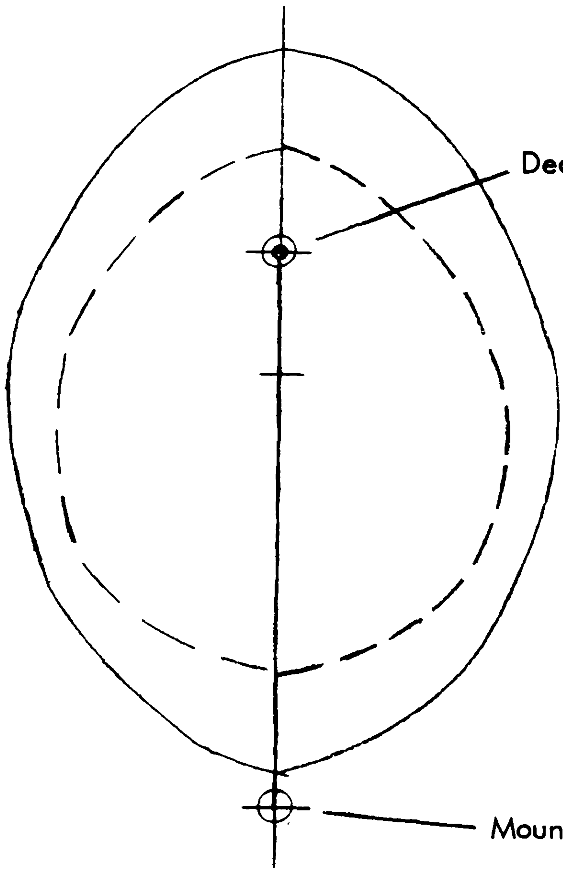


FIGURE 133. 150W MFL for H equals 11 feet 6 inches and θ equals 0 to 20 degrees.



SH 964-D9

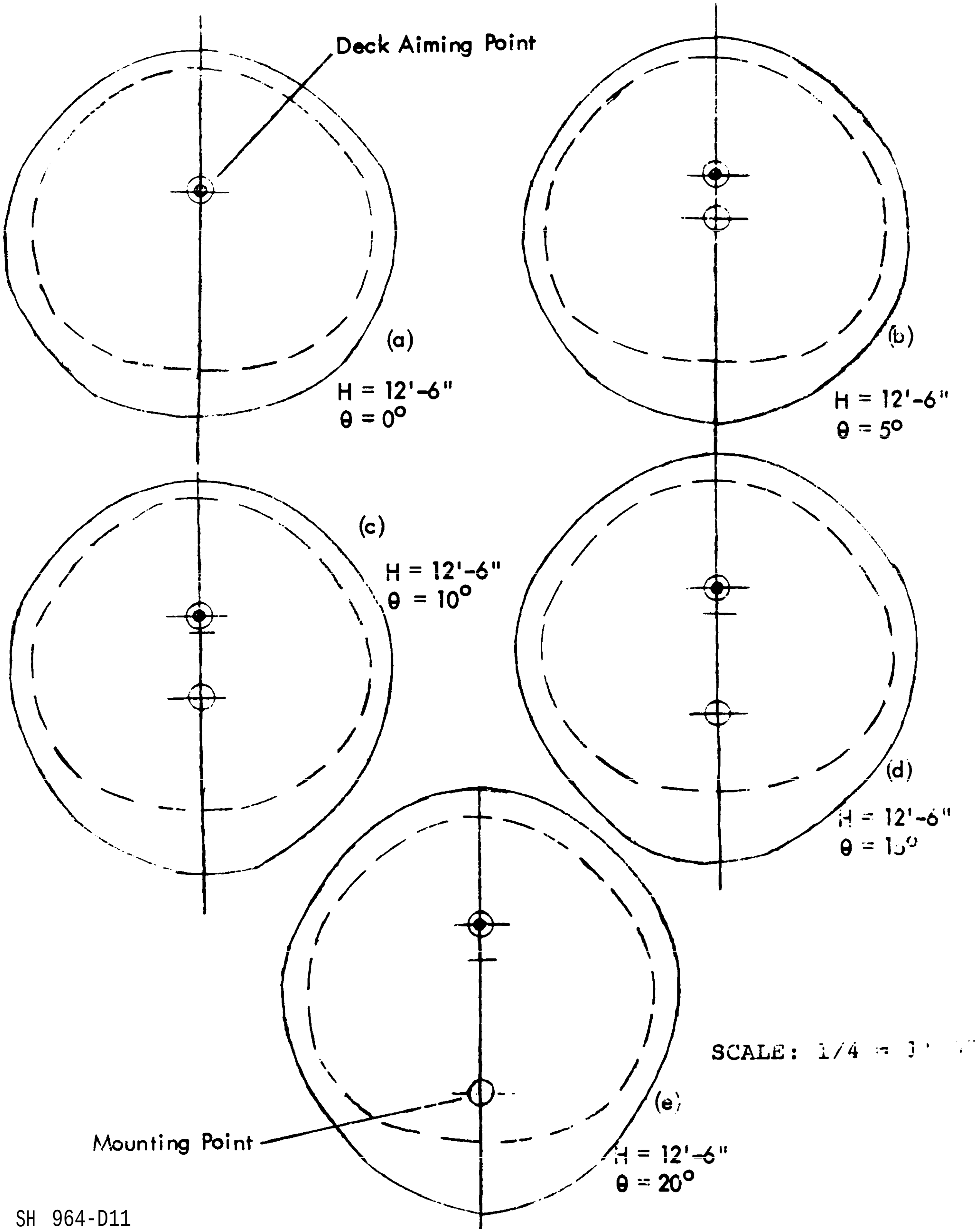
FIGURE 134. 150W MFL for H equals 11feet 6 inches and θ equals 45 degrees.



SCALE: 1/4 = 1'-0"

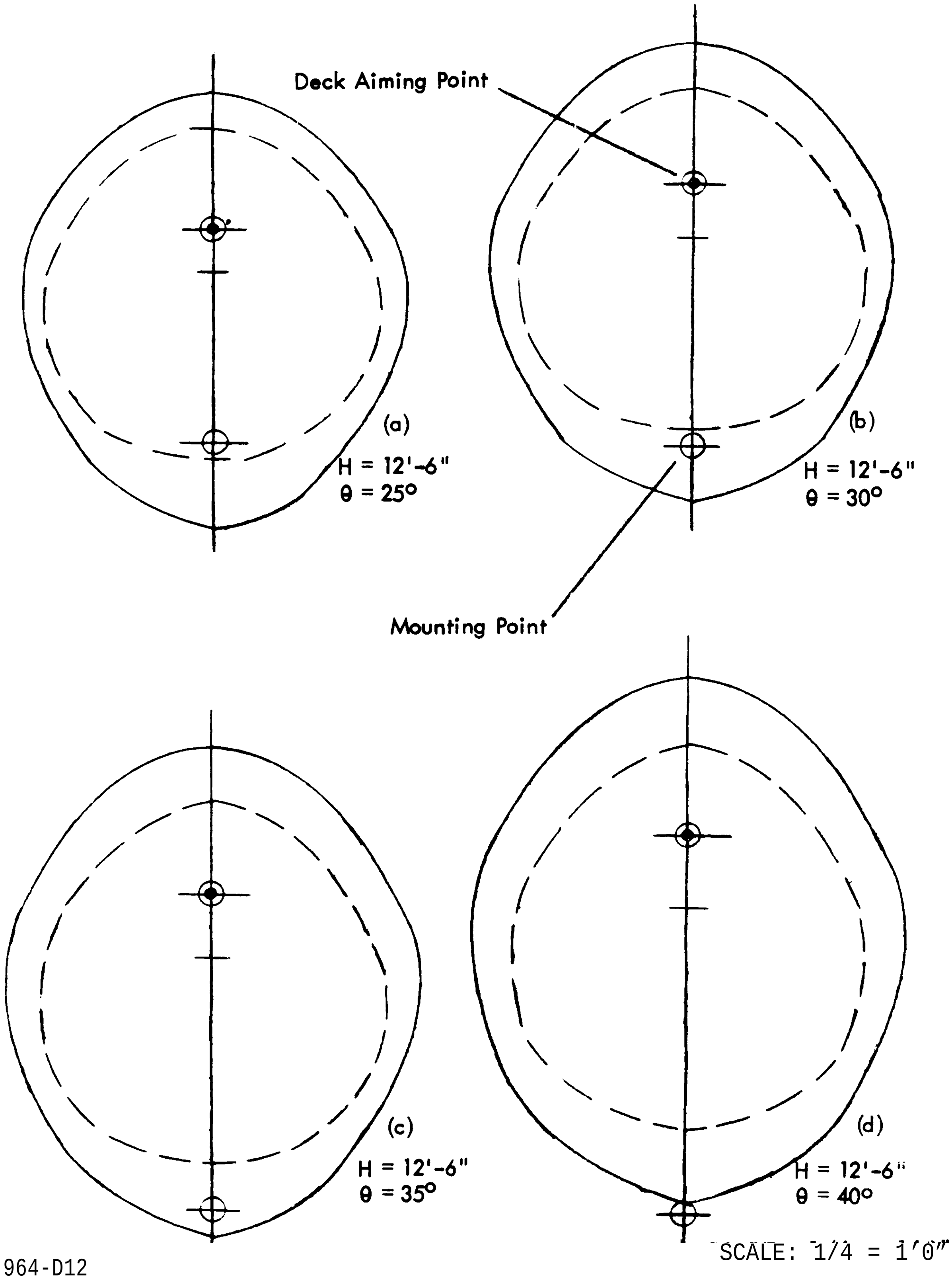
SH 964-D10

FIGURE 135. 150W MFL for H equals 11 feet 6 inches and θ equals 45 degrees.



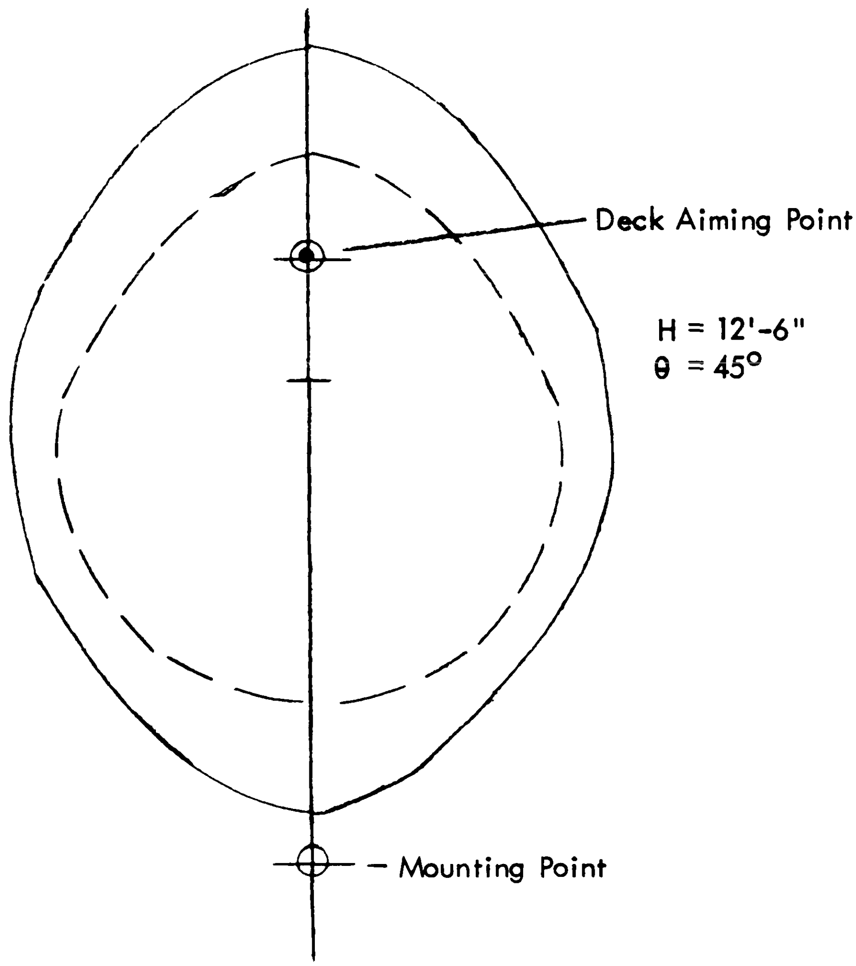
SH 964-D11

FIGURE 136. 150W MFL for H equals 12 feet 6 inches and θ equals 0 to 20 degrees.



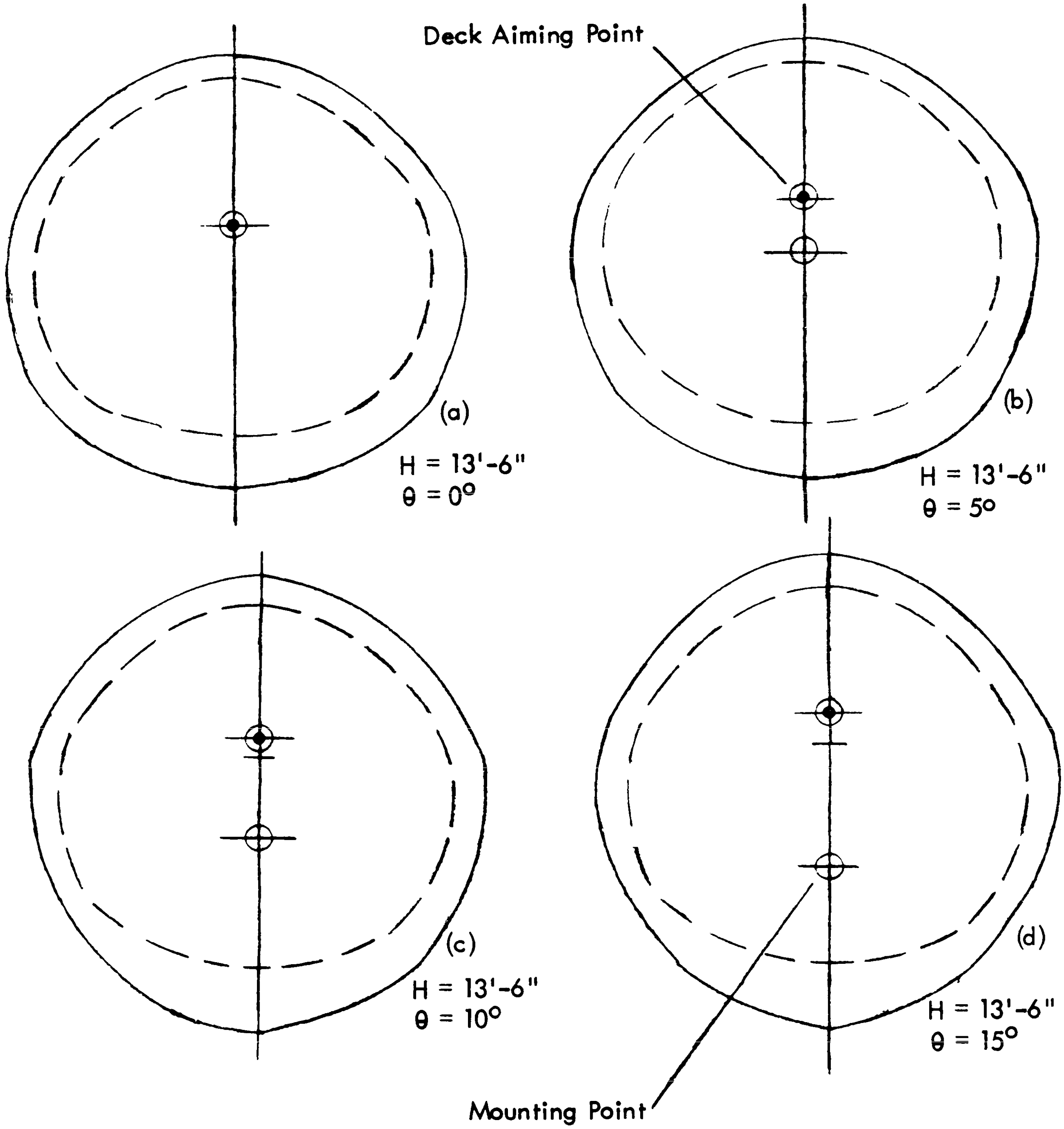
SH 964-D12

FIGURE 137. 150W MFL for H equals 12 feet 6 inches and θ equals 25 to 40 degrees.



SH 964-D13

FIGURE 138. 150W MFL for H equals 12 feet 6 inches and θ equals 45 degrees.

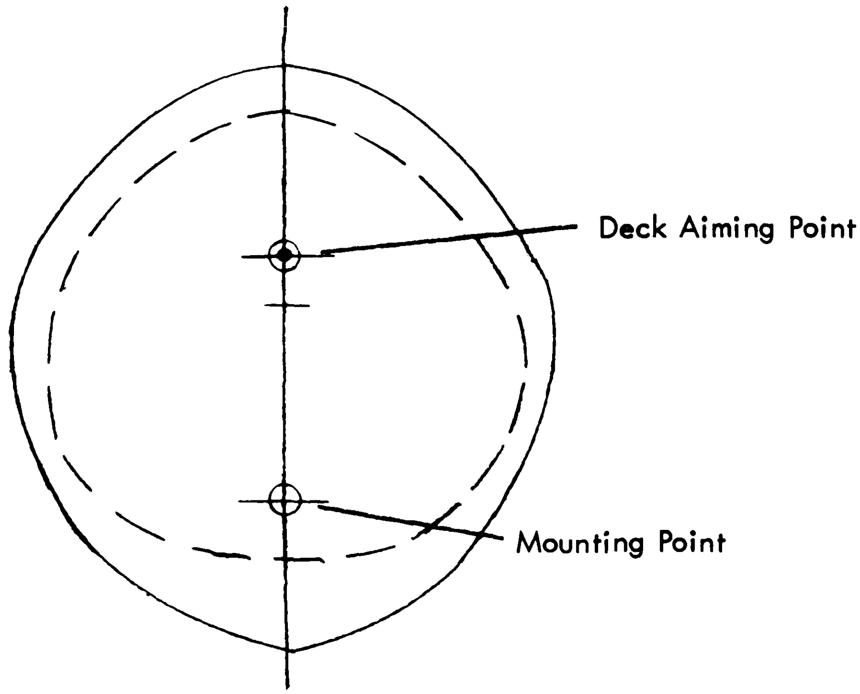


SCALE: 1/4 = 1'-0"

SH 964-D14

FIGURE 139. 150W MFL for H equals 13 feet 6 inches and θ equals 0 to 15 degrees.

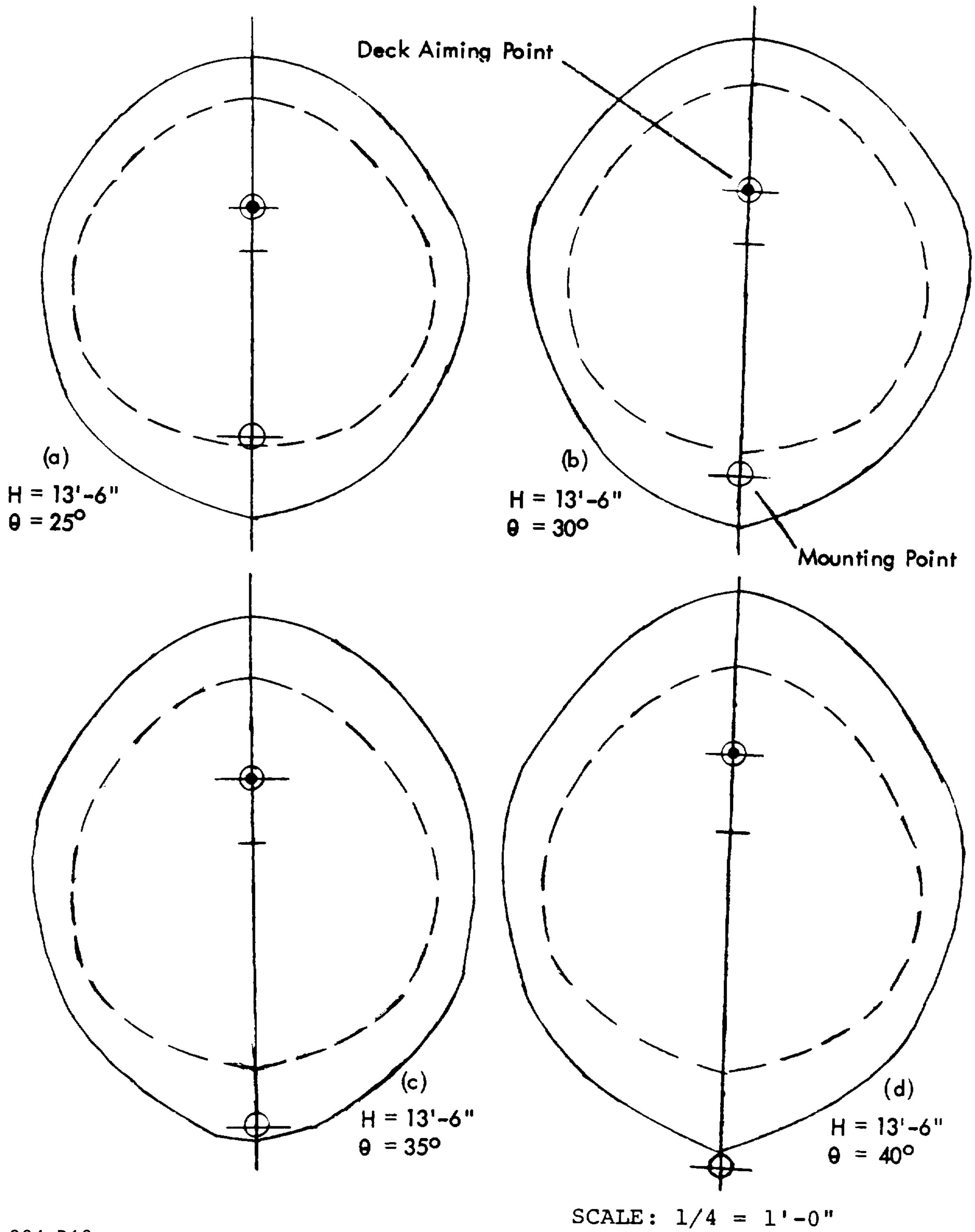
$H = 13'\text{-}6''$
$\theta = 20^{\circ}$



SCALE: 1/4 = 1'-0"

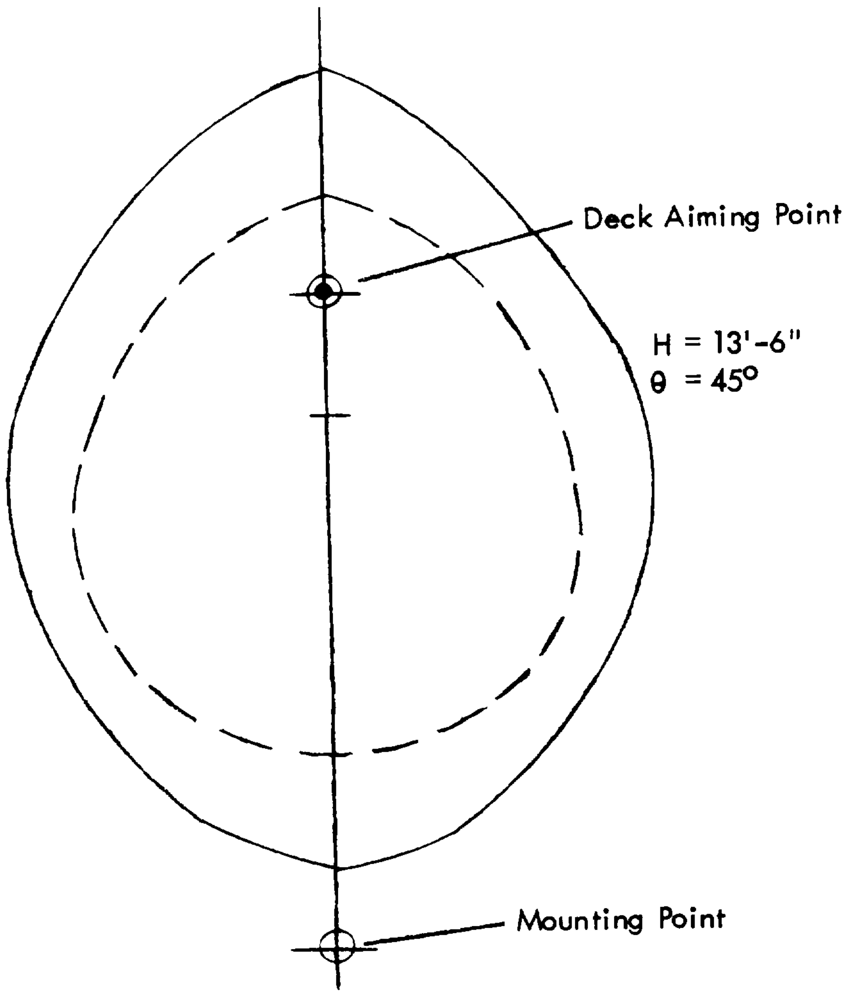
SH 964-D15

FIGURE 140. 150W MFL for H equals 13 feet 6 inches and θ equals 20 degrees.



SH 964-D16

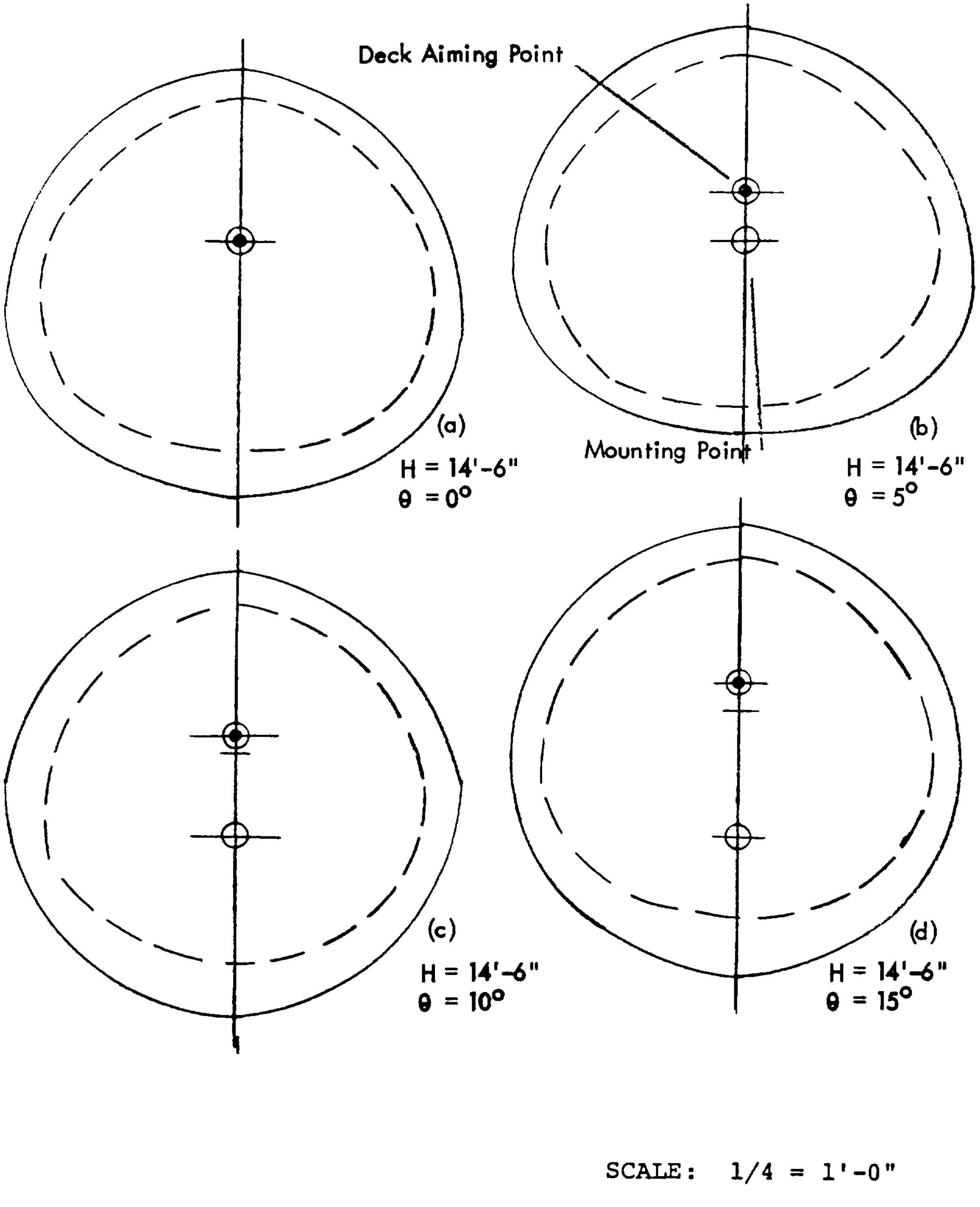
FIGURE 141. 150W MFL for H equals 13 feet 6 inches and θ equals 25 to 40 degrees.



SCALE: 1/4 = 1'-0"

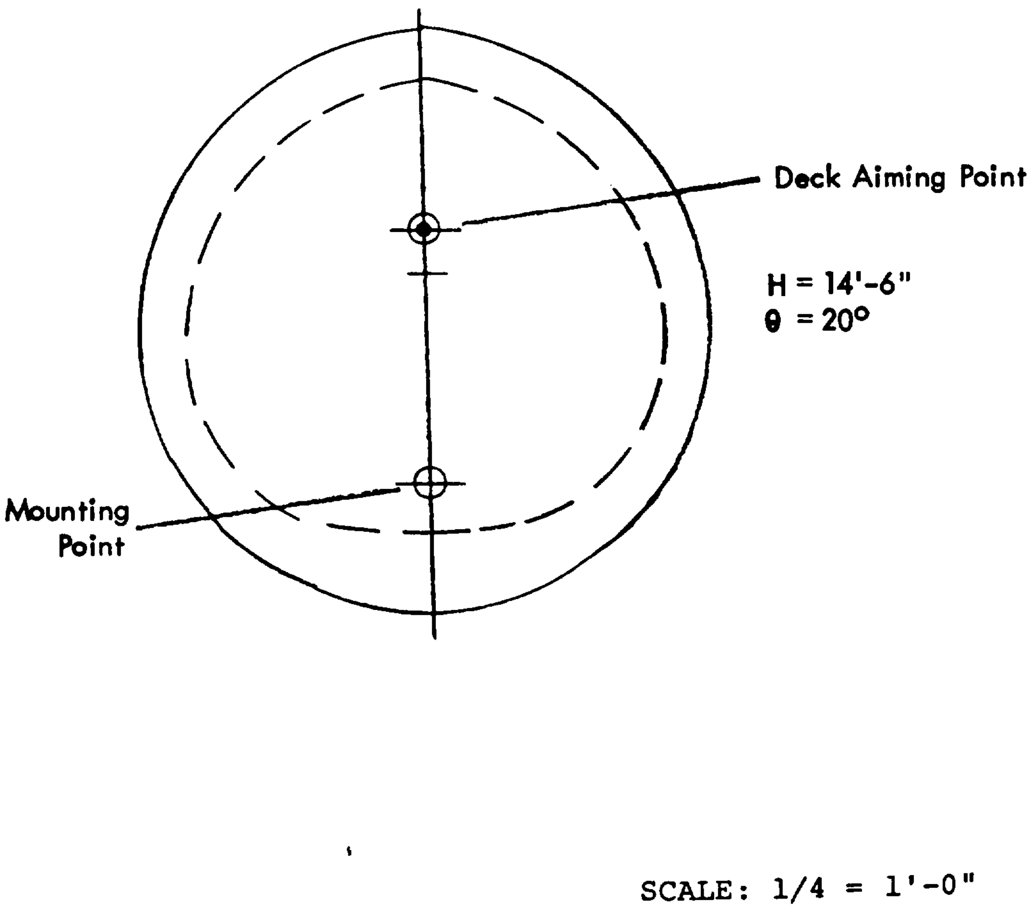
SH 964-D17

FIGURE 142. 150W MFL for H equals 13 feet 6 inches and θ equals 45 degrees.



SH 964-D18

FIGURE 143. 150W MFL for H equals 14 feet 6 inches and θ equals 0 to 15 degrees.



SH 964-D19

FIGURE 144. 150W MFL for H equals 14 feet 6 inches and θ equals 20 degrees.

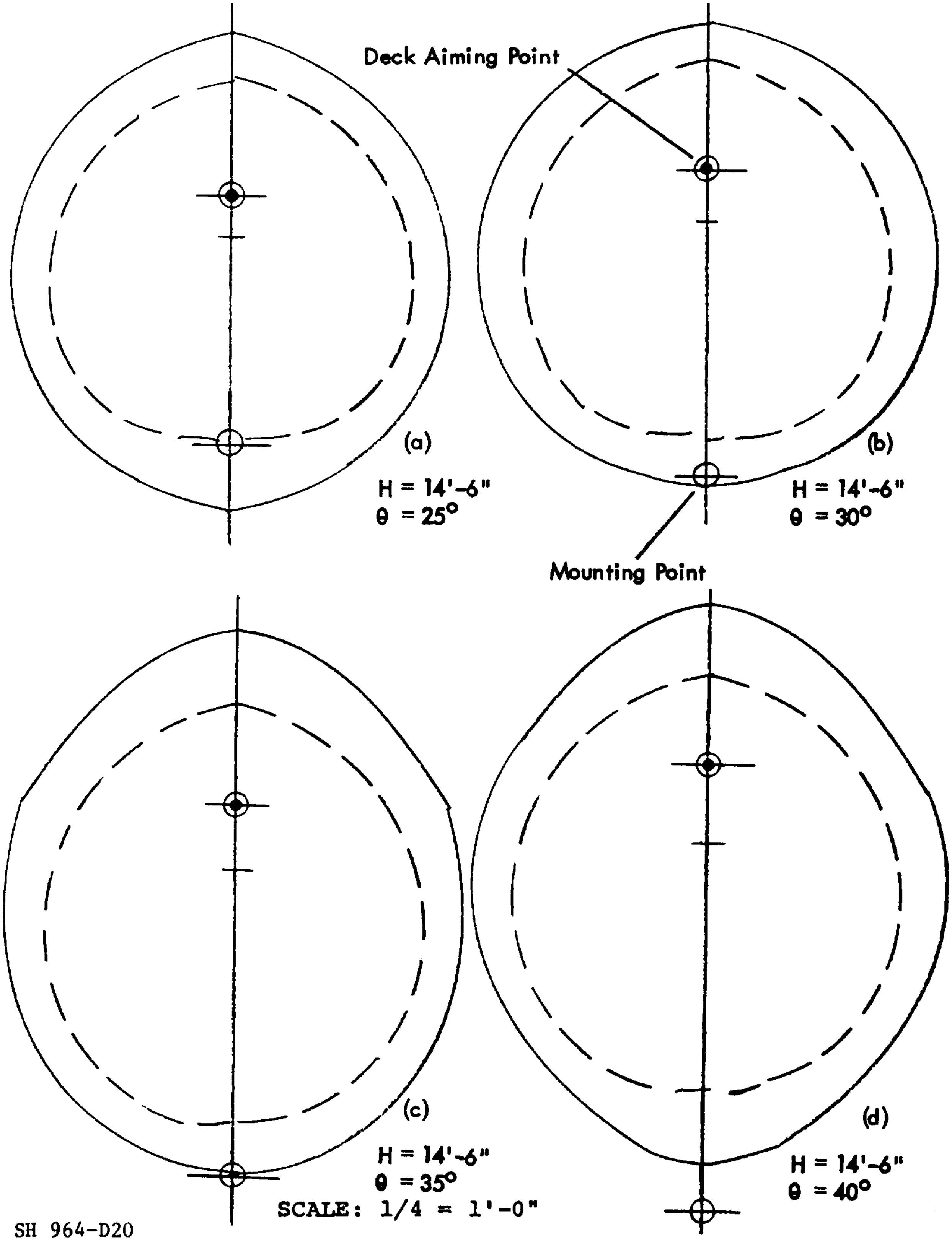
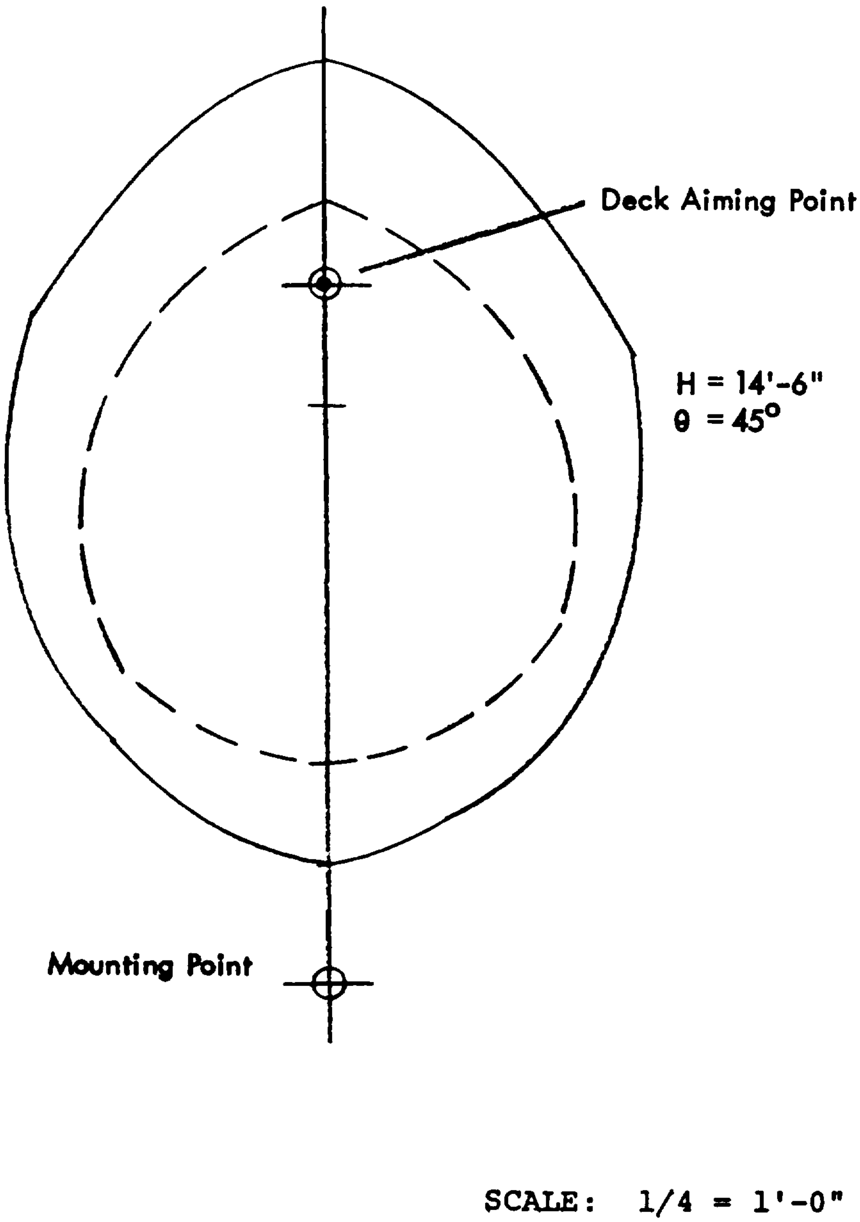
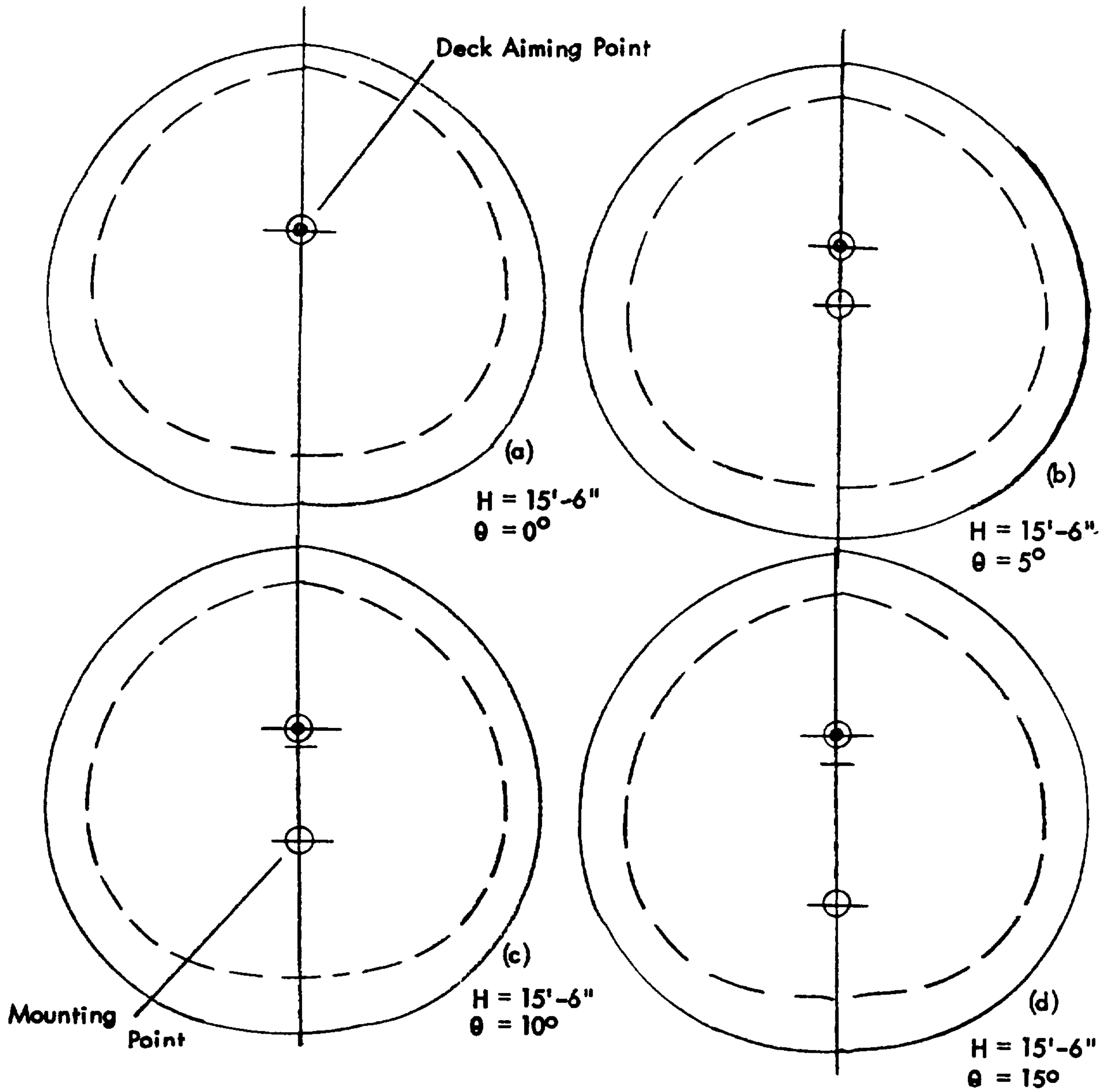


FIGURE 145. 150W MFL for H equals 14 feet 6 inches and θ equals 25 to 40 degrees.



SH 964-D21

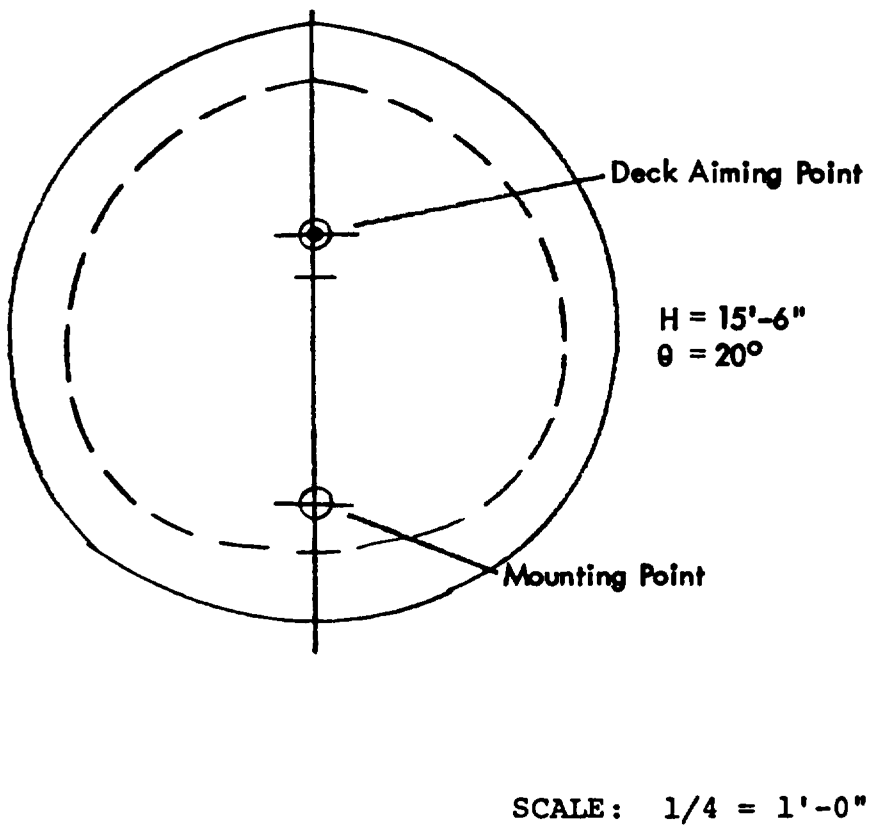
FIGURE 146. 150W MFL for H equals 14 feet 6 inches and θ equals 45 degrees.



SCALE: 1/4 = 1'-0"

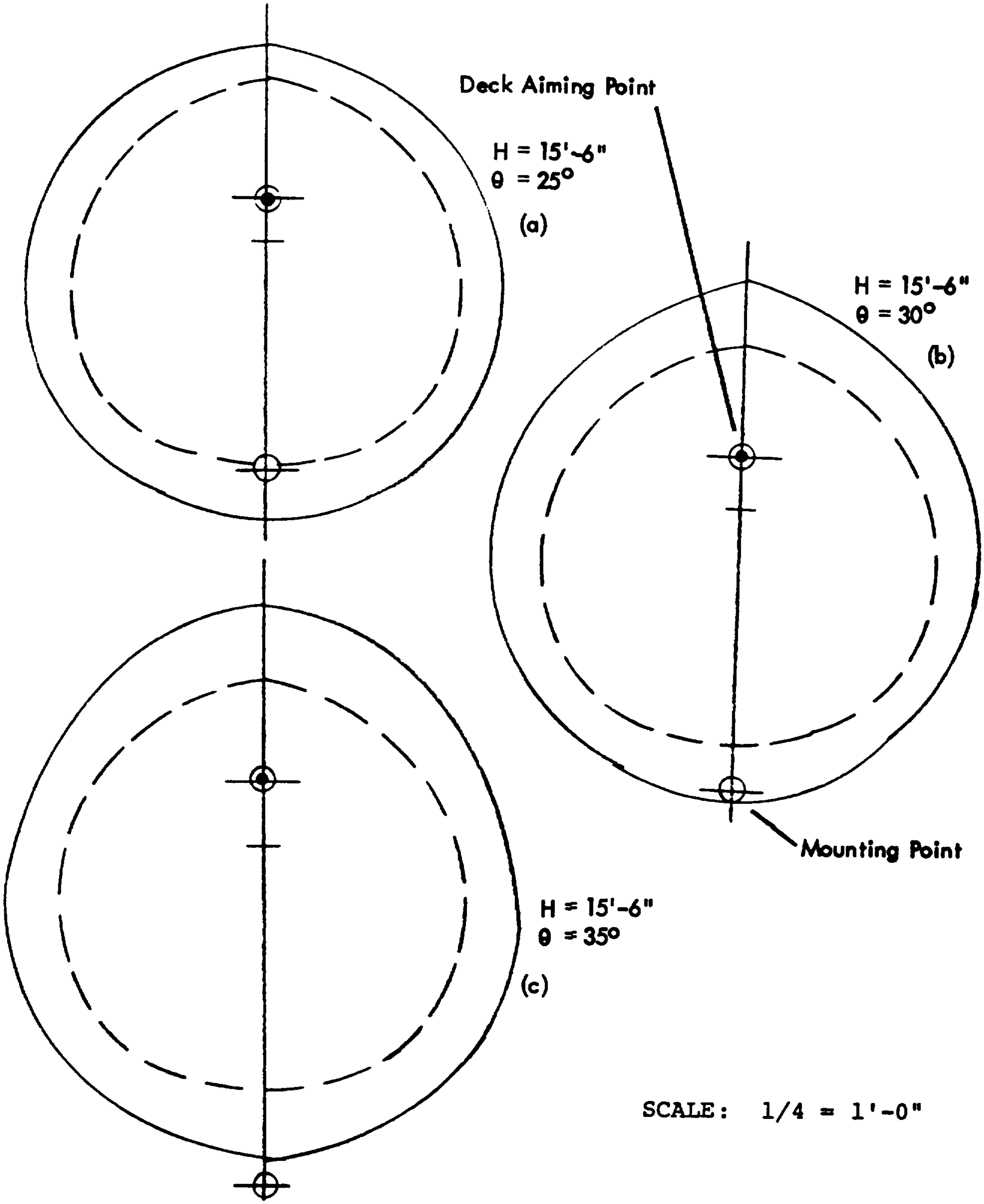
SH 964-D22

FIGURE 147. 150W MFL for H equals 15 feet 6 inches and θ equals 0 to 15 degrees.



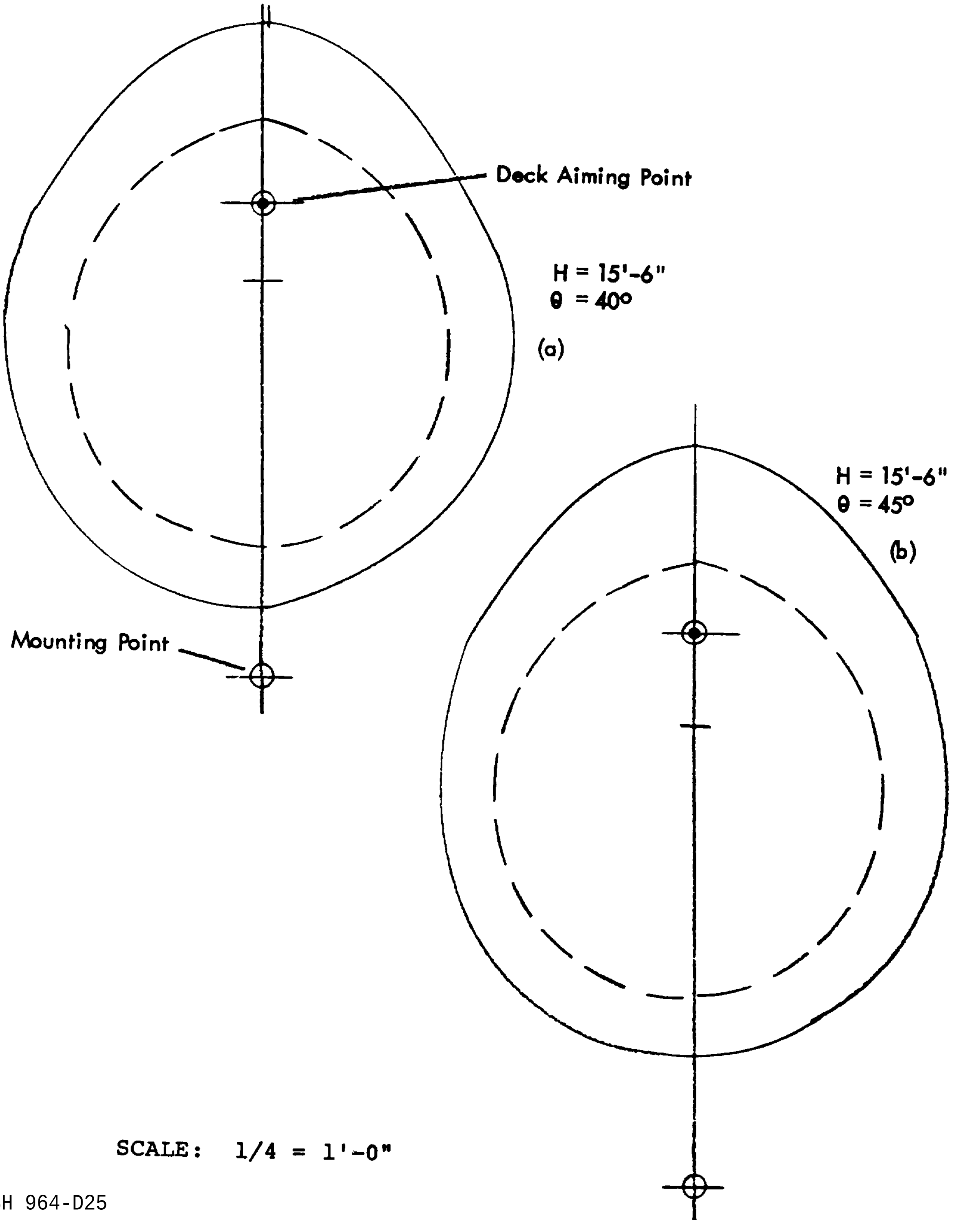
SH 964-D23

FIGURE 148. 150W MFL for H equals 15 feet 6 inches and θ equals 20 degrees.



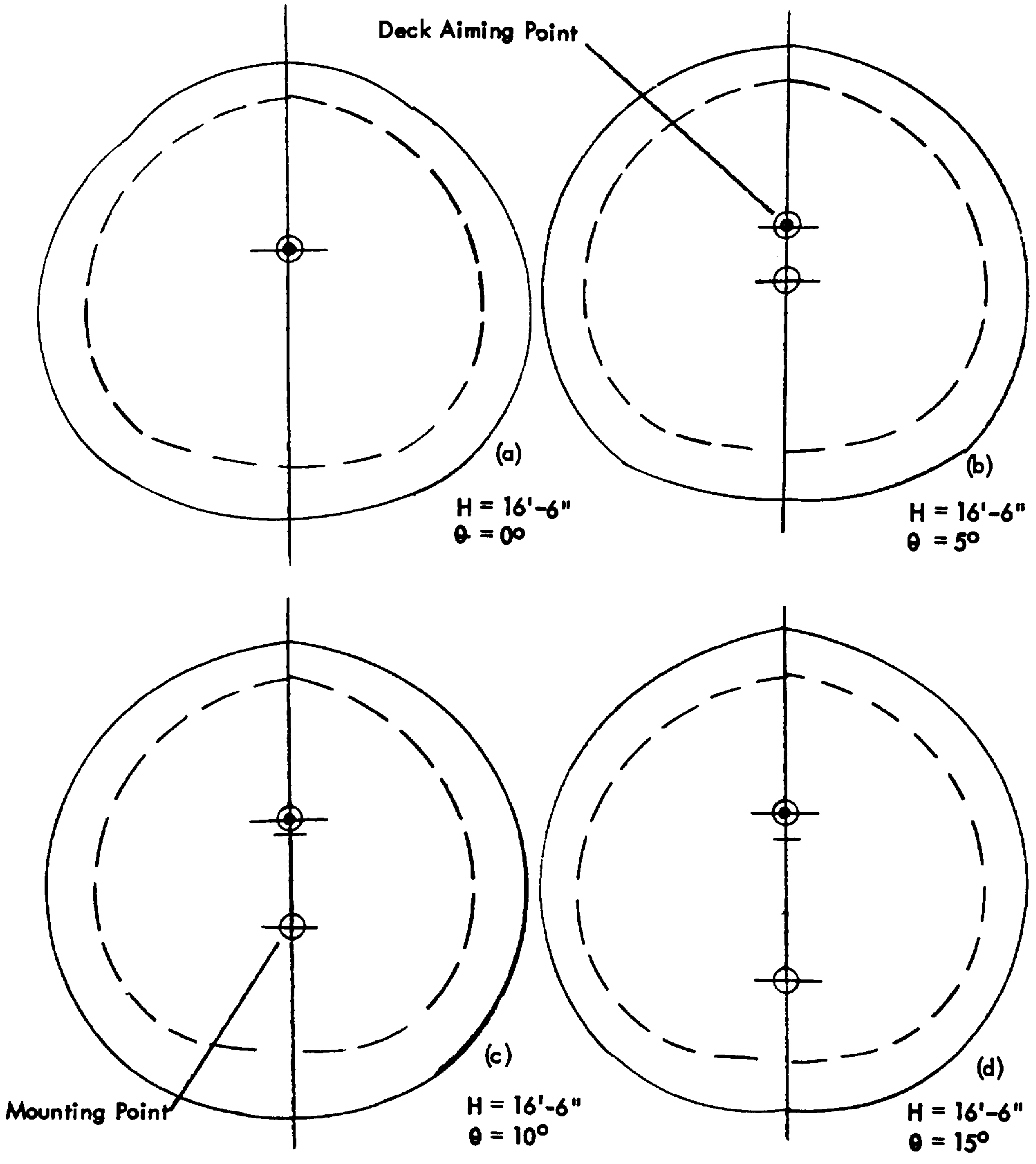
SH 964-D24

FIGURE 149. 150W MFL for H equals 15 feet 6 inches and θ equals 25 to 35 degrees.



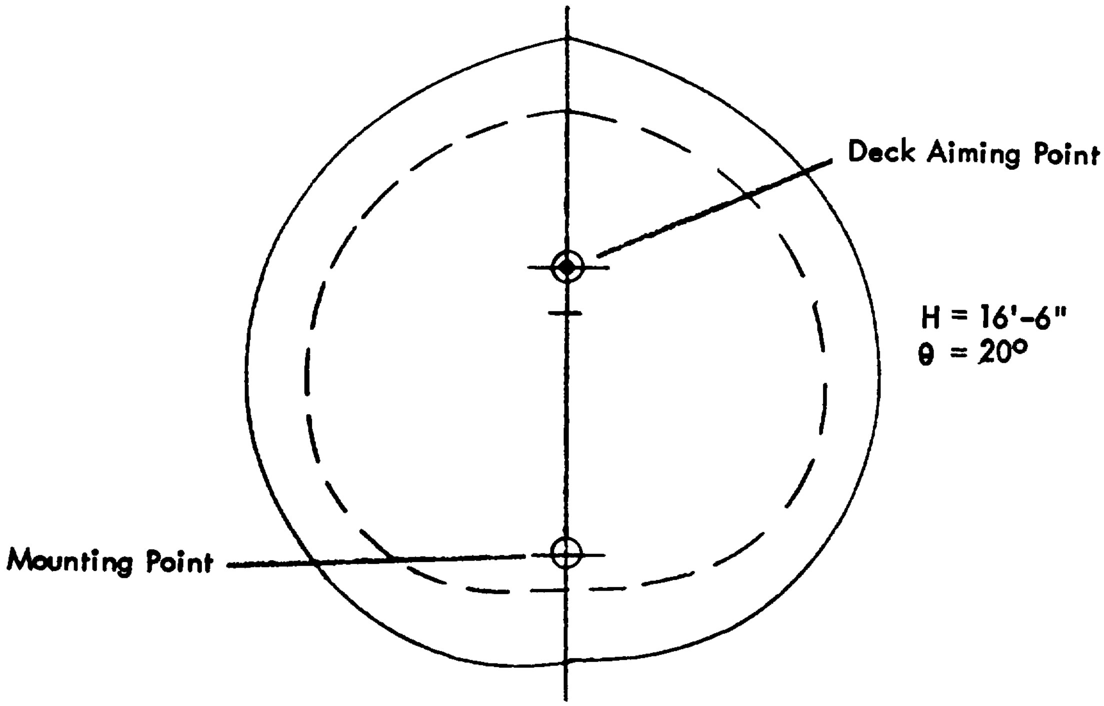
SH 964-D25

FIGURE 150. 150W MFL for H equals 15 feet 6 inches and θ equals 40 to 45 degrees.



SH 964-D26

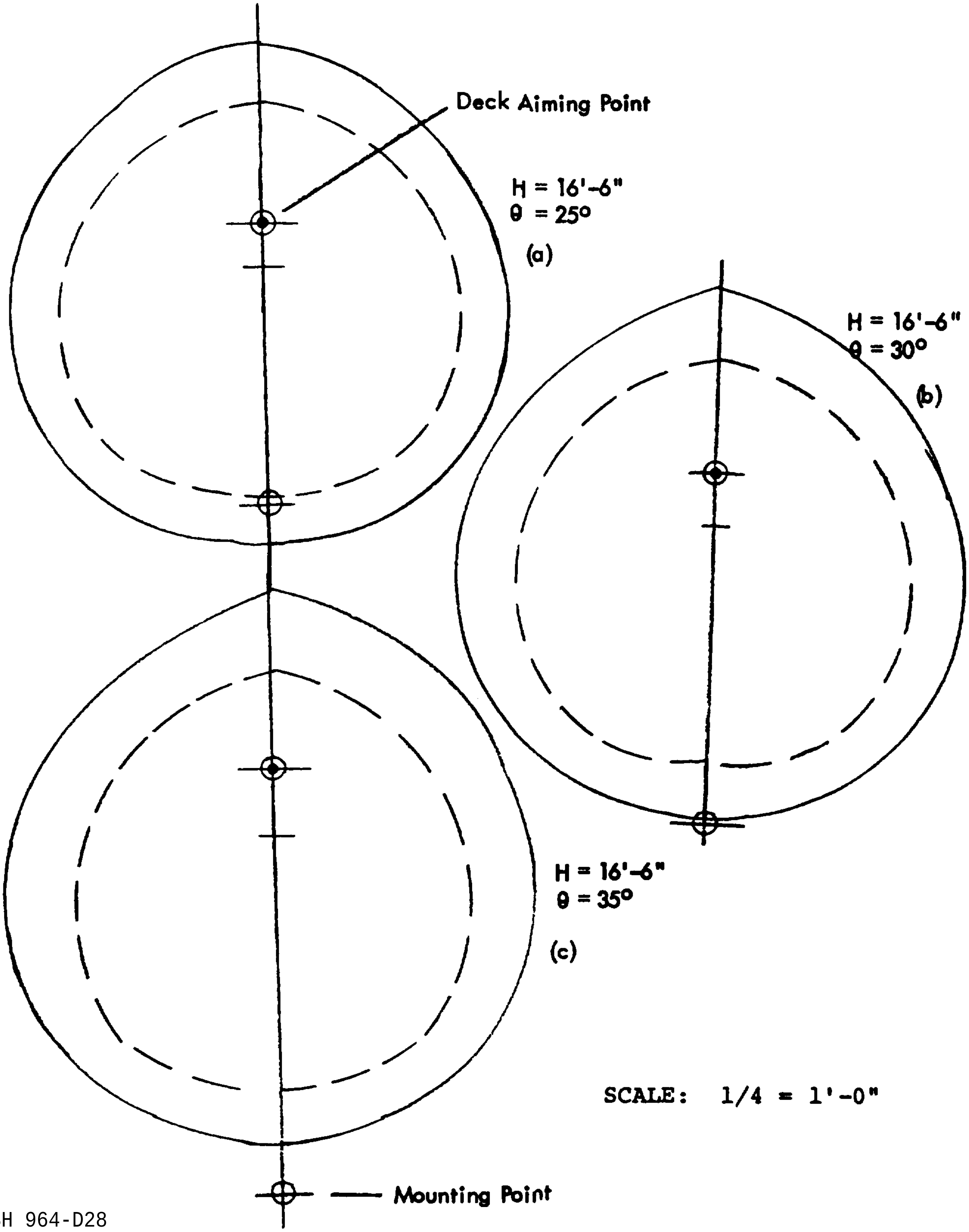
FIGURE 151. 150W MFL for H equals 16 feet 6 inches and θ equals 0 to 15 degrees.



SCALE: 1/4 = 1'-0"

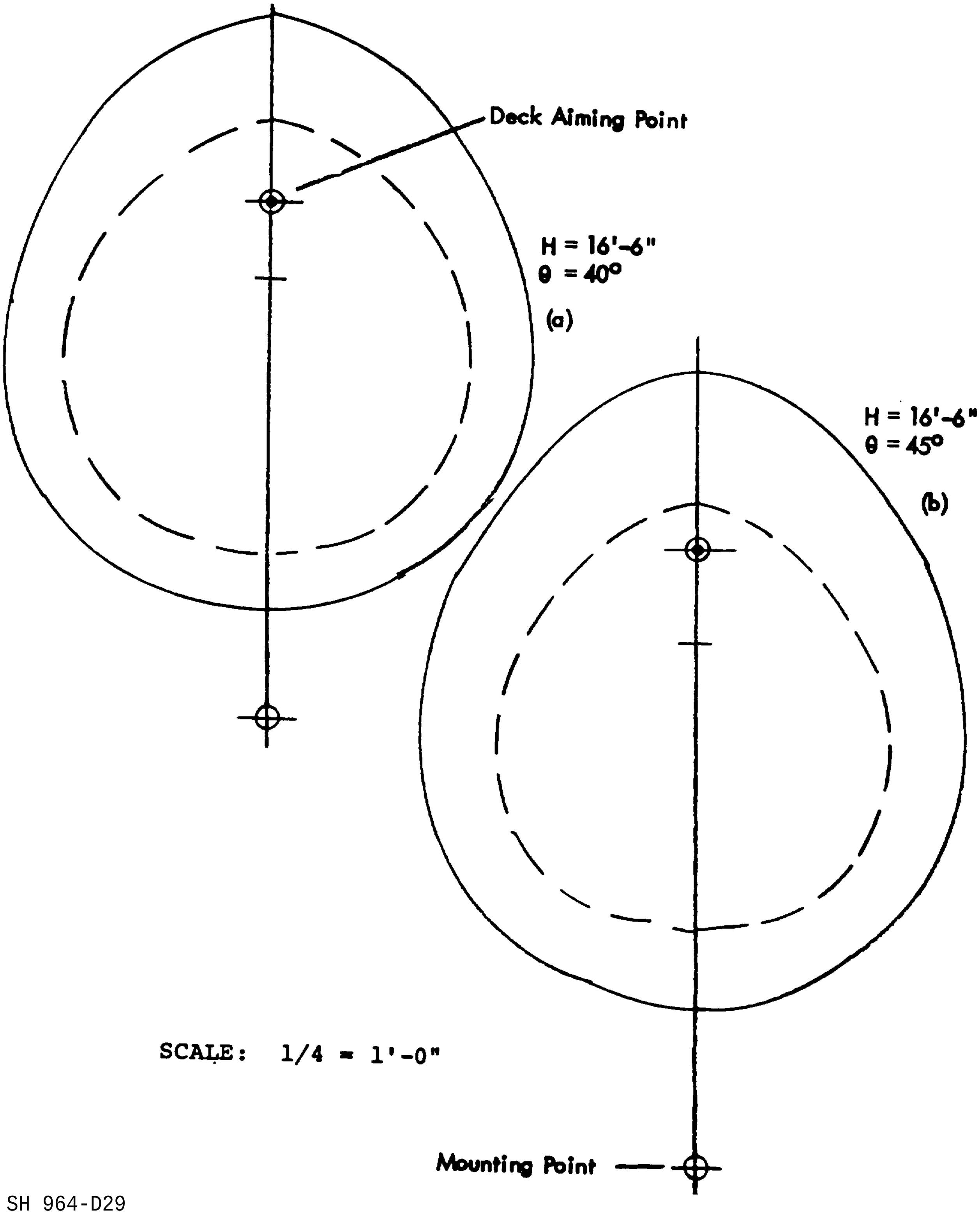
SH 964-D27

FIGURE 152. 150W MFL for H equals 16 feet 6 inches and θ equals 20 degrees.



SH 964-D28

FIGURE 153. 150W MFL for H equals 16 feet 6 inches and θ equals 25 to 35 degrees.



SH 964-D29

FIGURE 154. 150W MFL for H equals 16 feet 6 inches and θ equals 40 to 45 degrees.

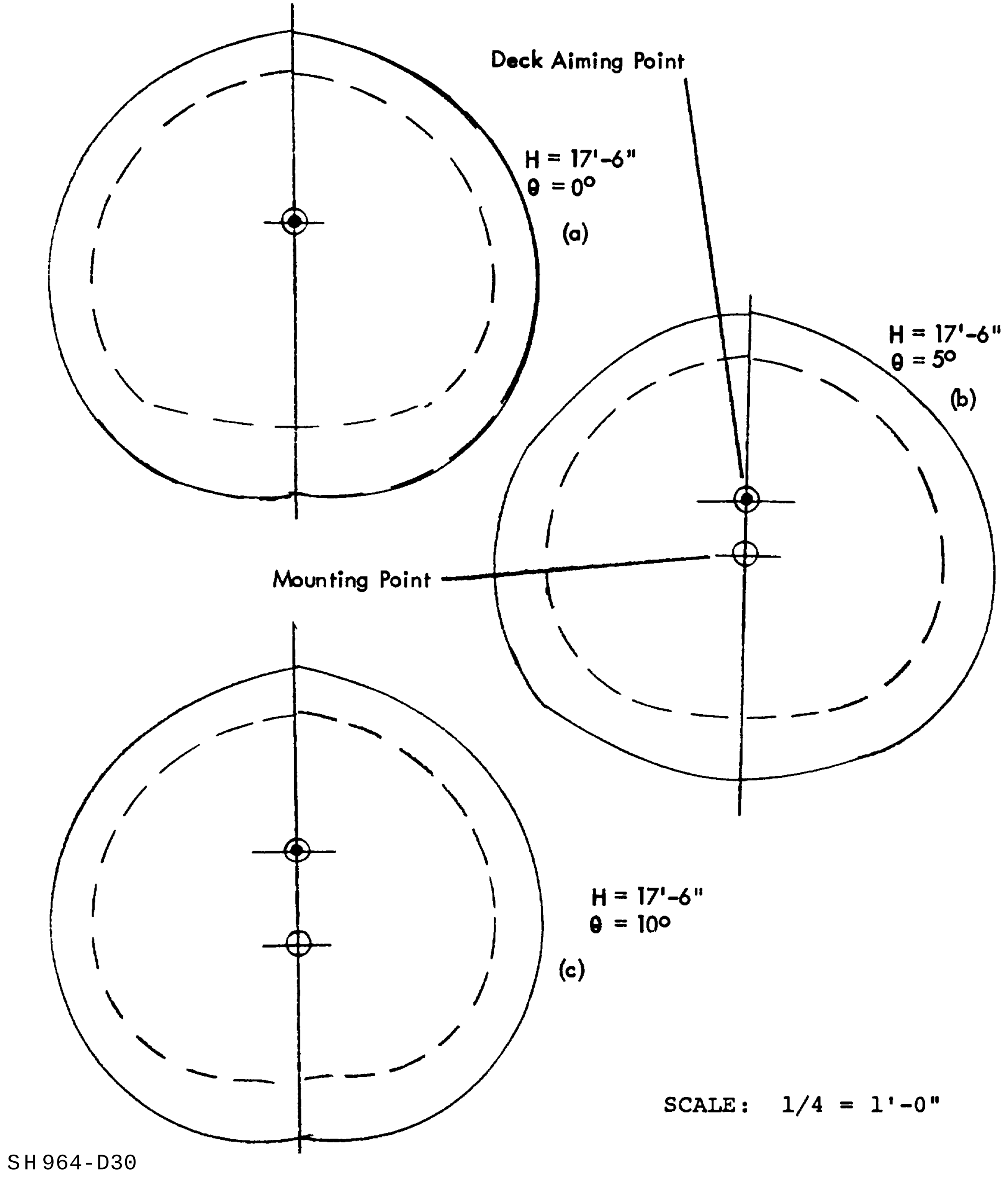
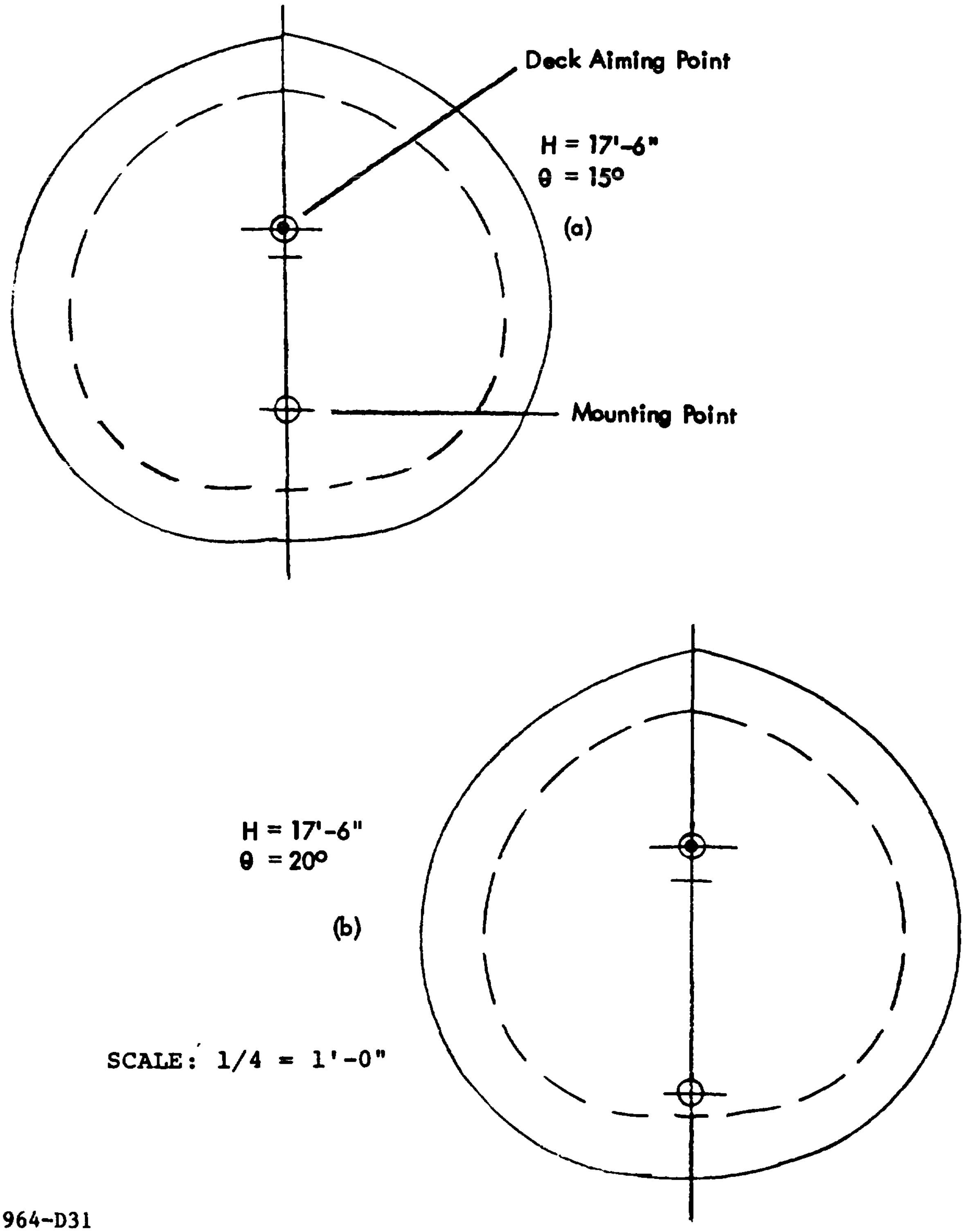
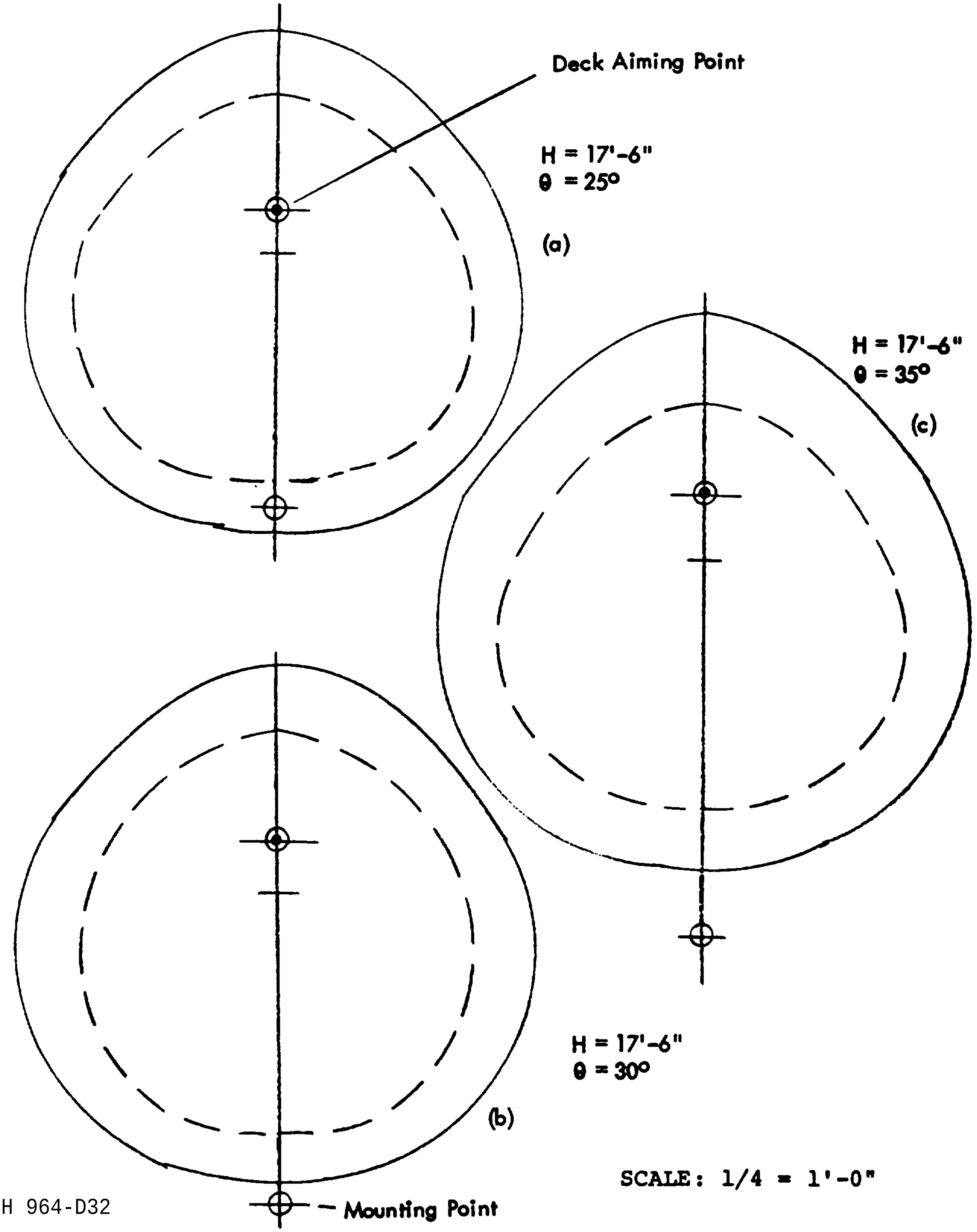


FIGURE 155. 150W MFL for H equals 17 feet 6 inches and θ equals 0 to 10 degrees.



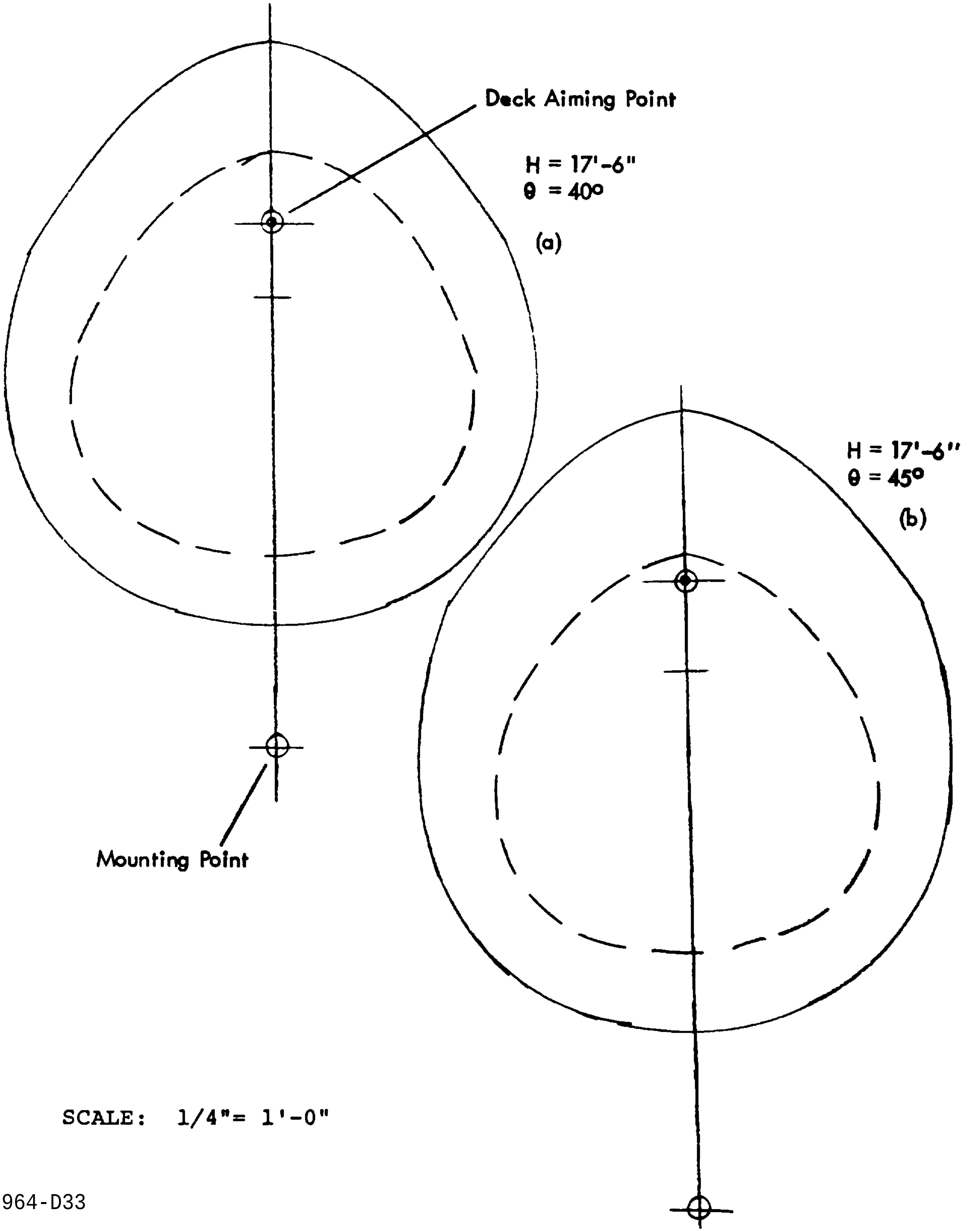
SH 964-D31

FIGURE 156. 150W MFL for H equals 17 feet 6 inches and θ equals 15 to 20 degrees.



SH 964-D32

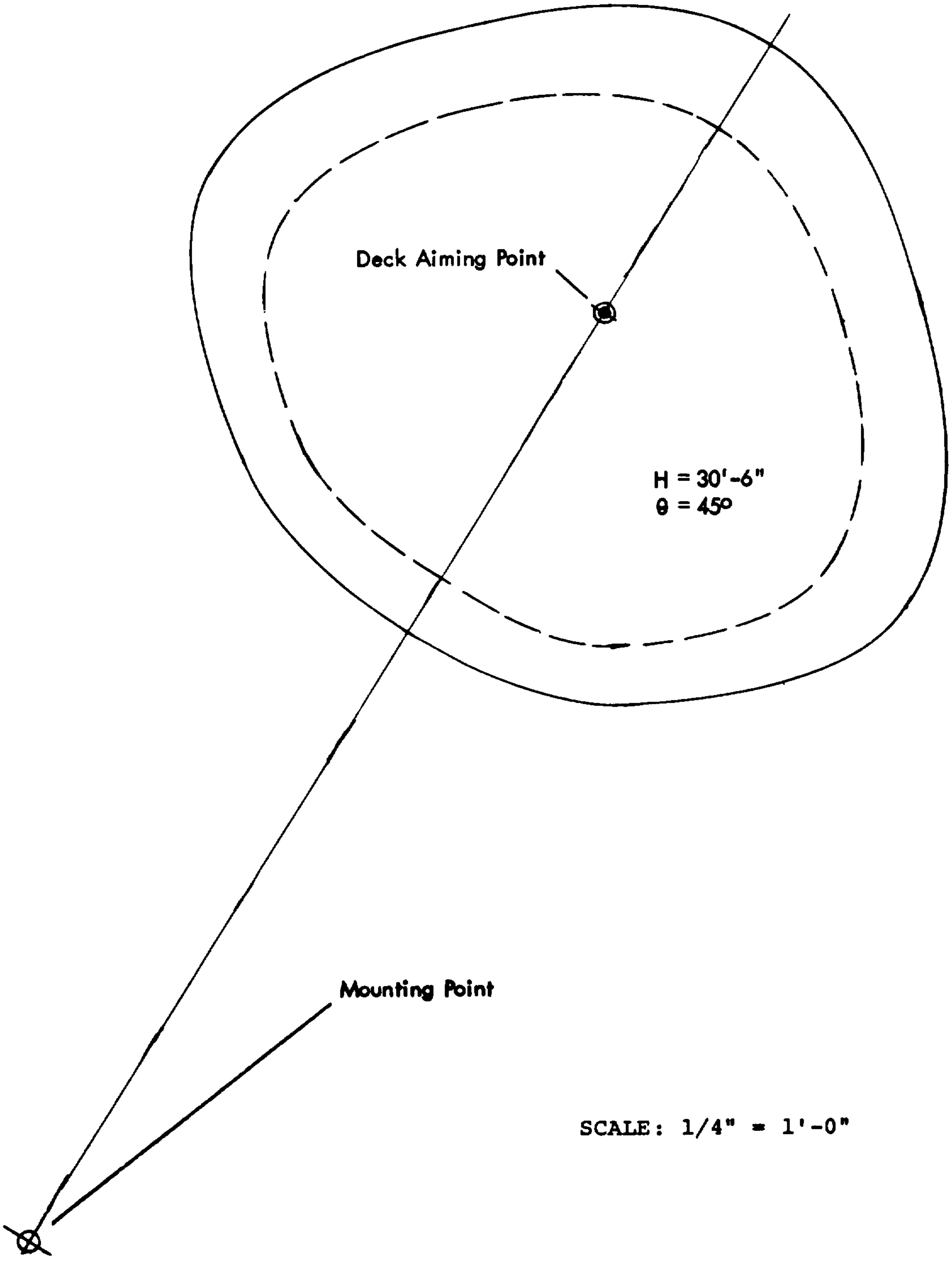
FIGURE 157. 150W MFL for H equals 17 feet 6 inches and θ equals 25 to 35 degrees.



SCALE: 1/4"= 1'-0"

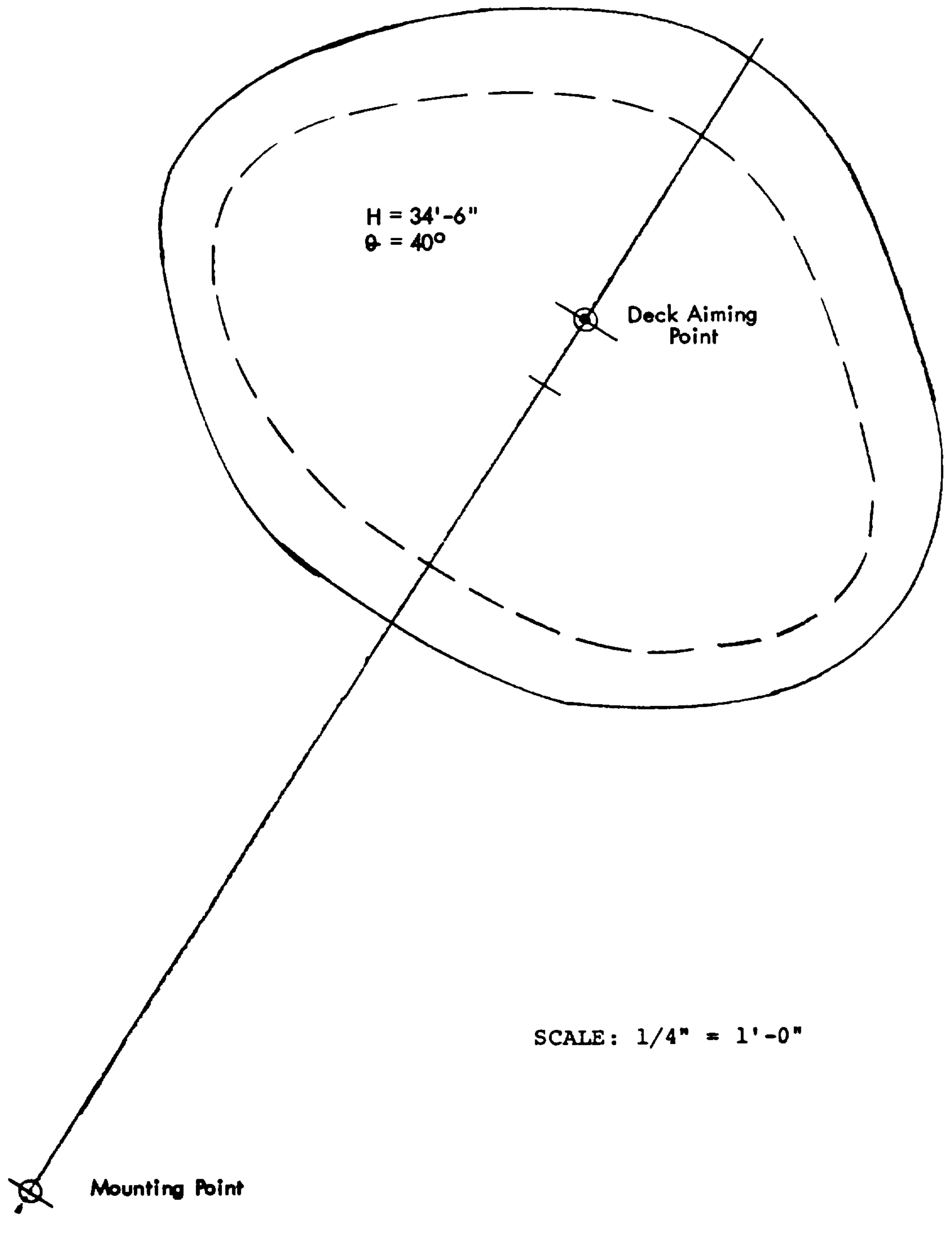
SH 964-D33

FIGURE 158. 150W MFL for H equals 17 feet 6 inches and θ equals 40 to 45 degrees.



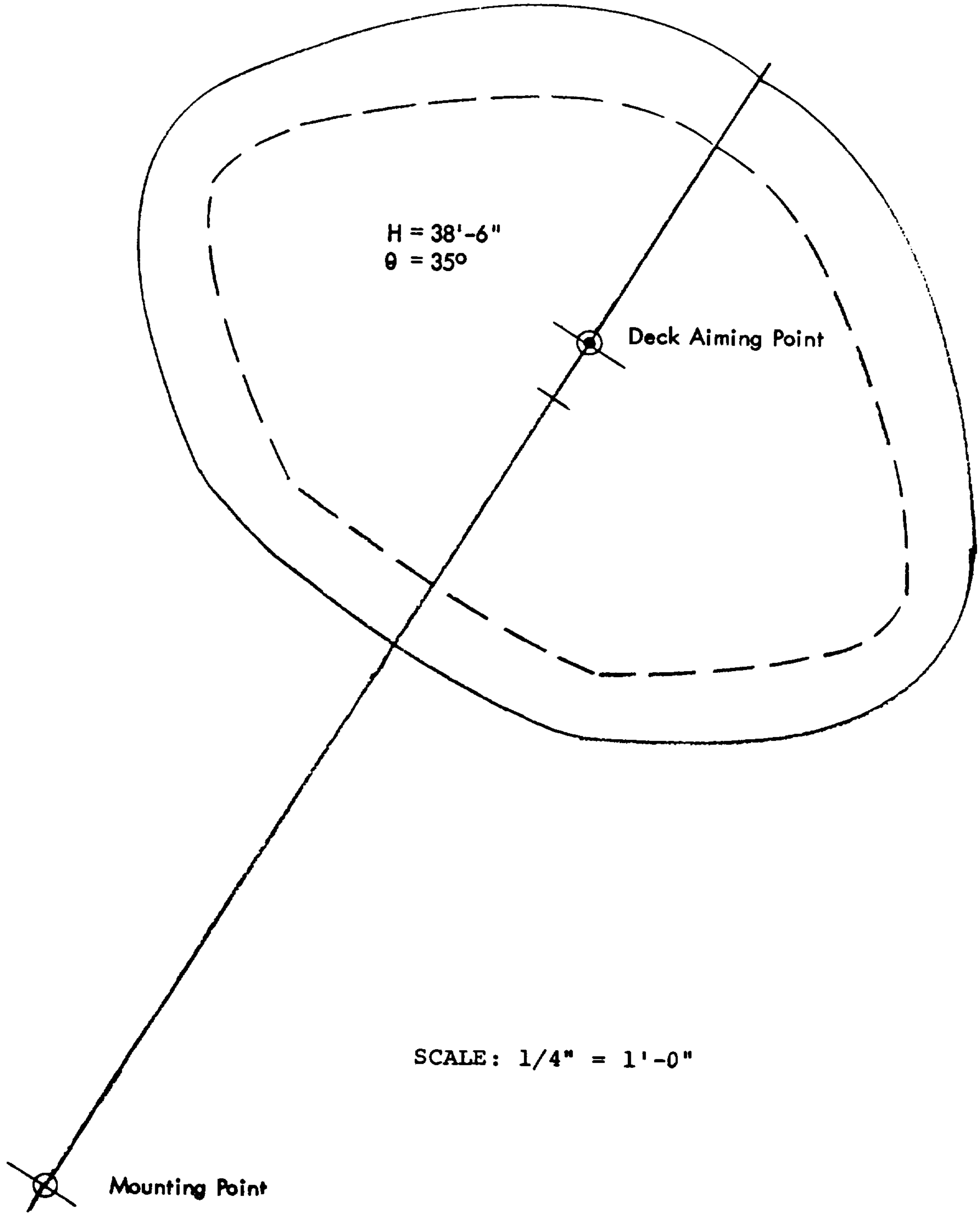
SH 964-D34

FIGURE 159. 300W MFL for H equals 30 feet 6 inches and θ equals 45 degrees.



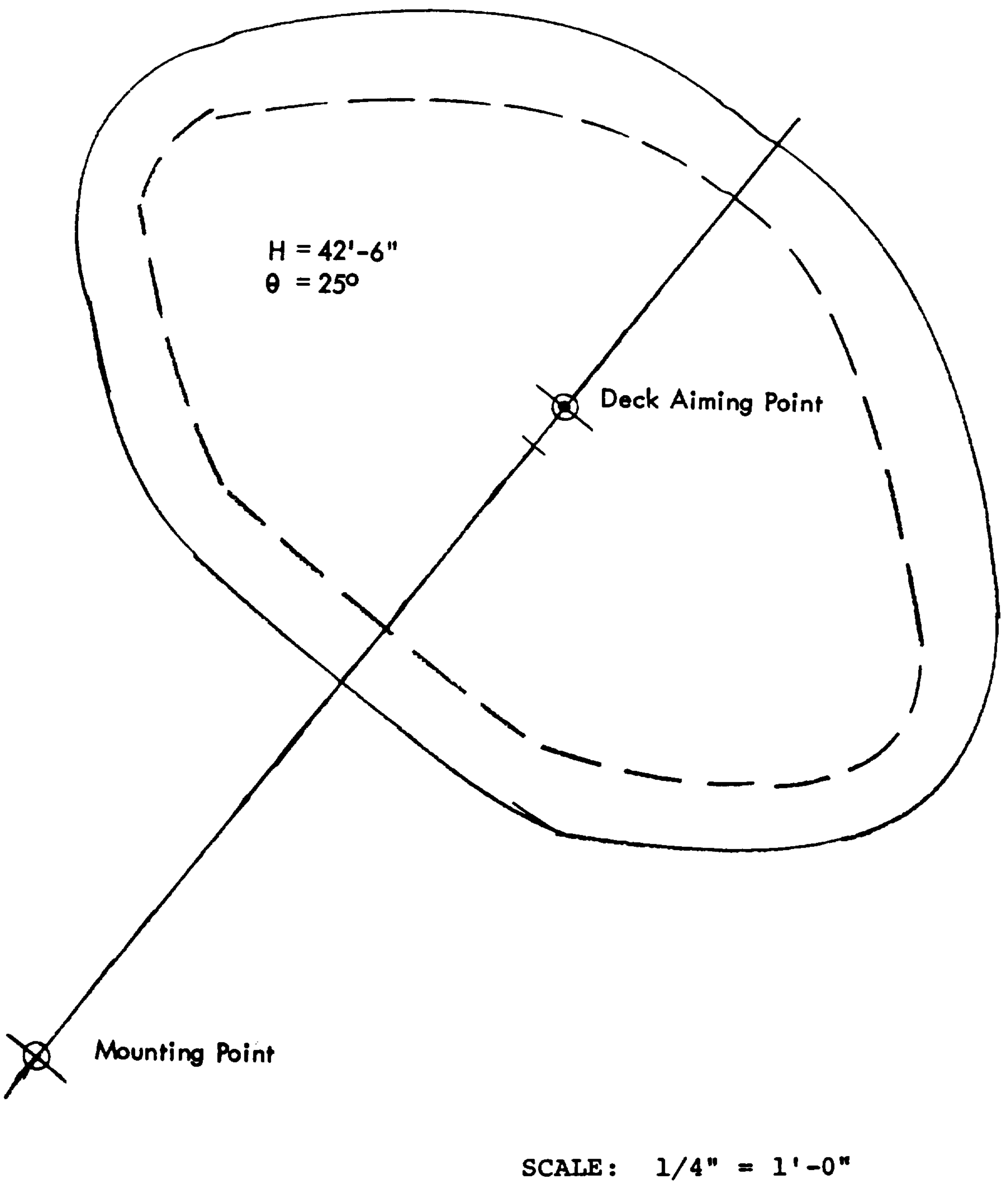
SH 964-D35

FIGURE 160. 300W MFL for H equals 34 feet 6 inches and θ equals 40 degrees.



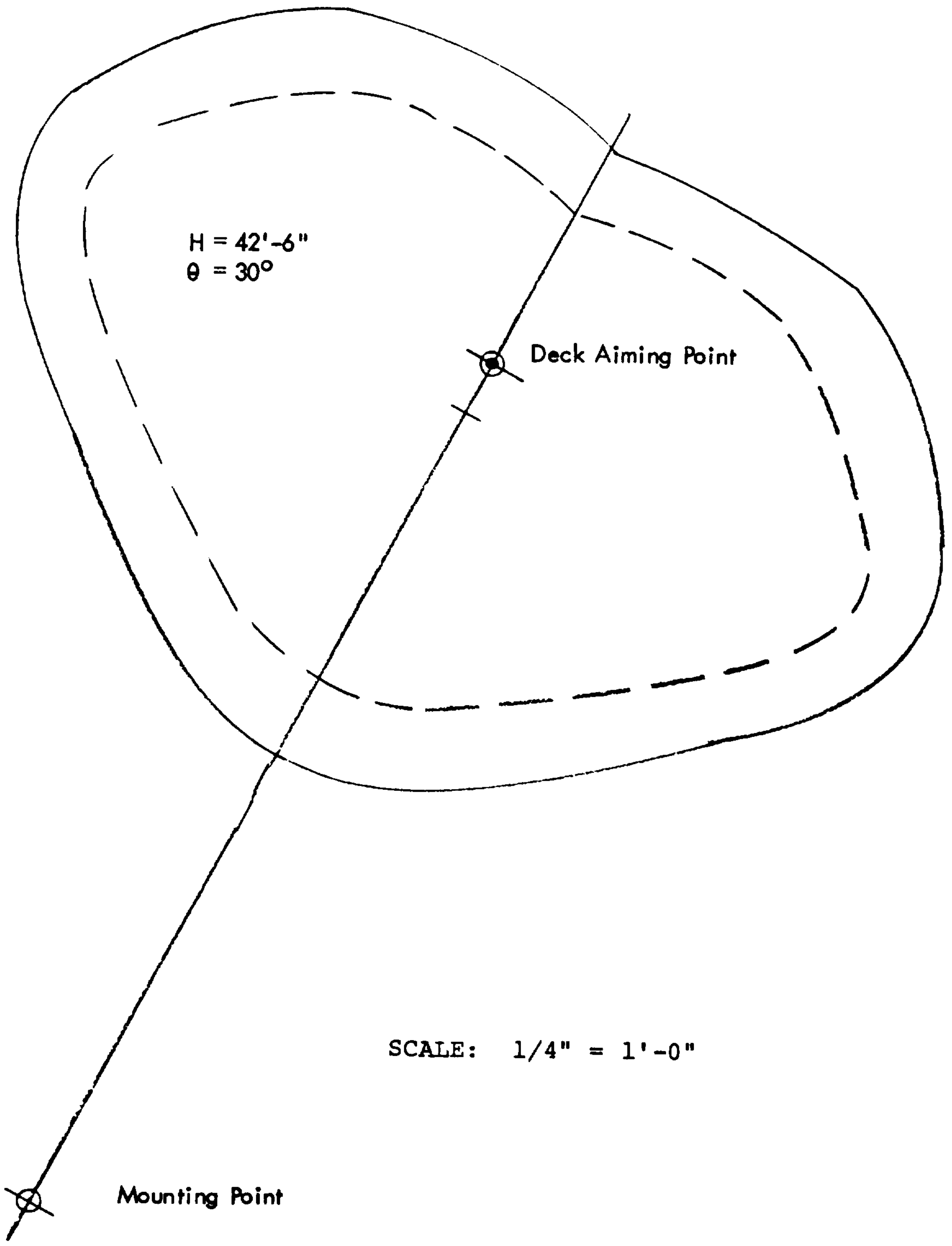
SH 964-D36

FIGURE 161. 300W MFL for H equals 38 feet 6 inches and θ equals 35 degrees.



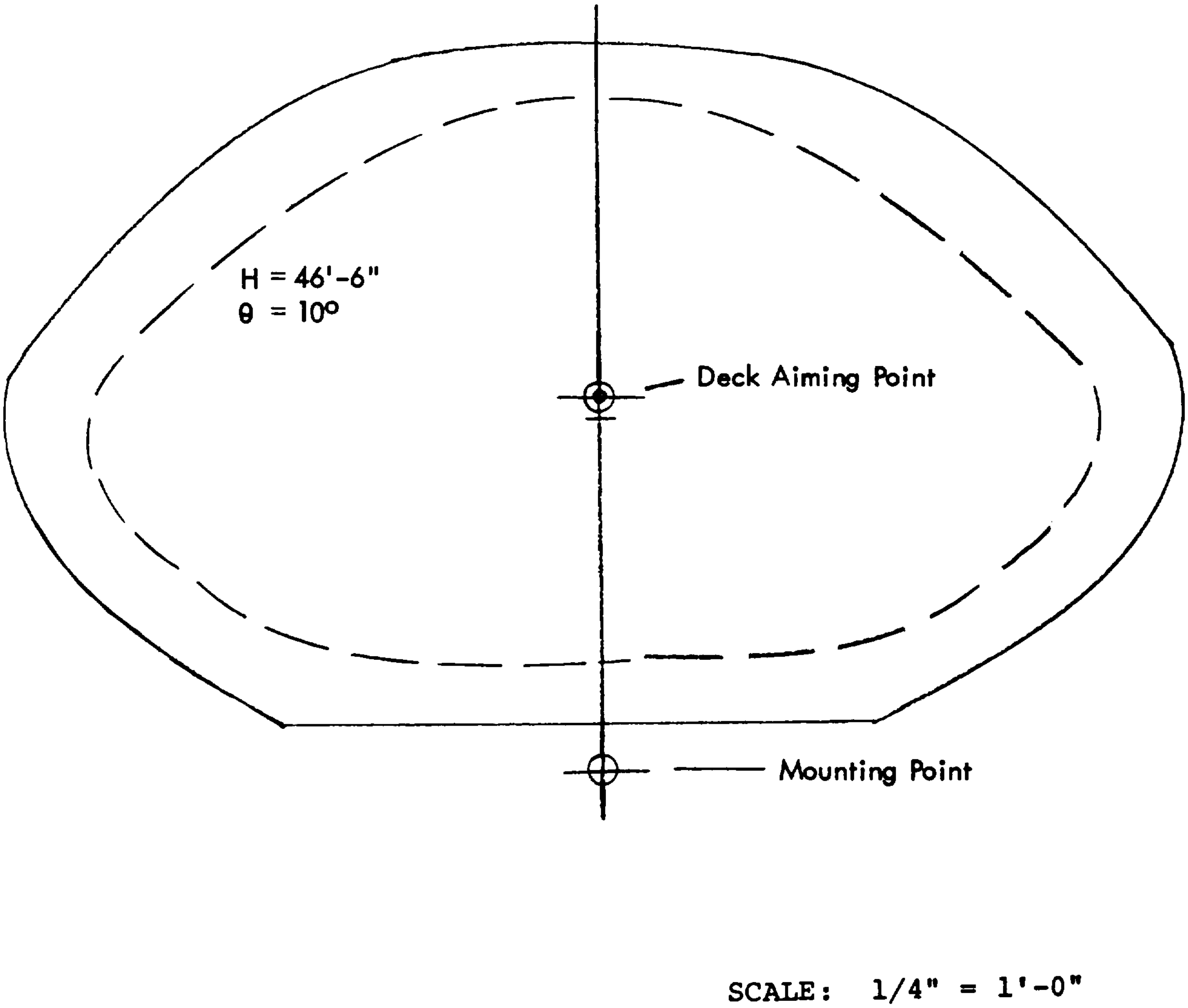
SH 964-D37

FIGURE 162. 300W MFL for H equals 42 feet 6 inches and θ equals 25 degrees.



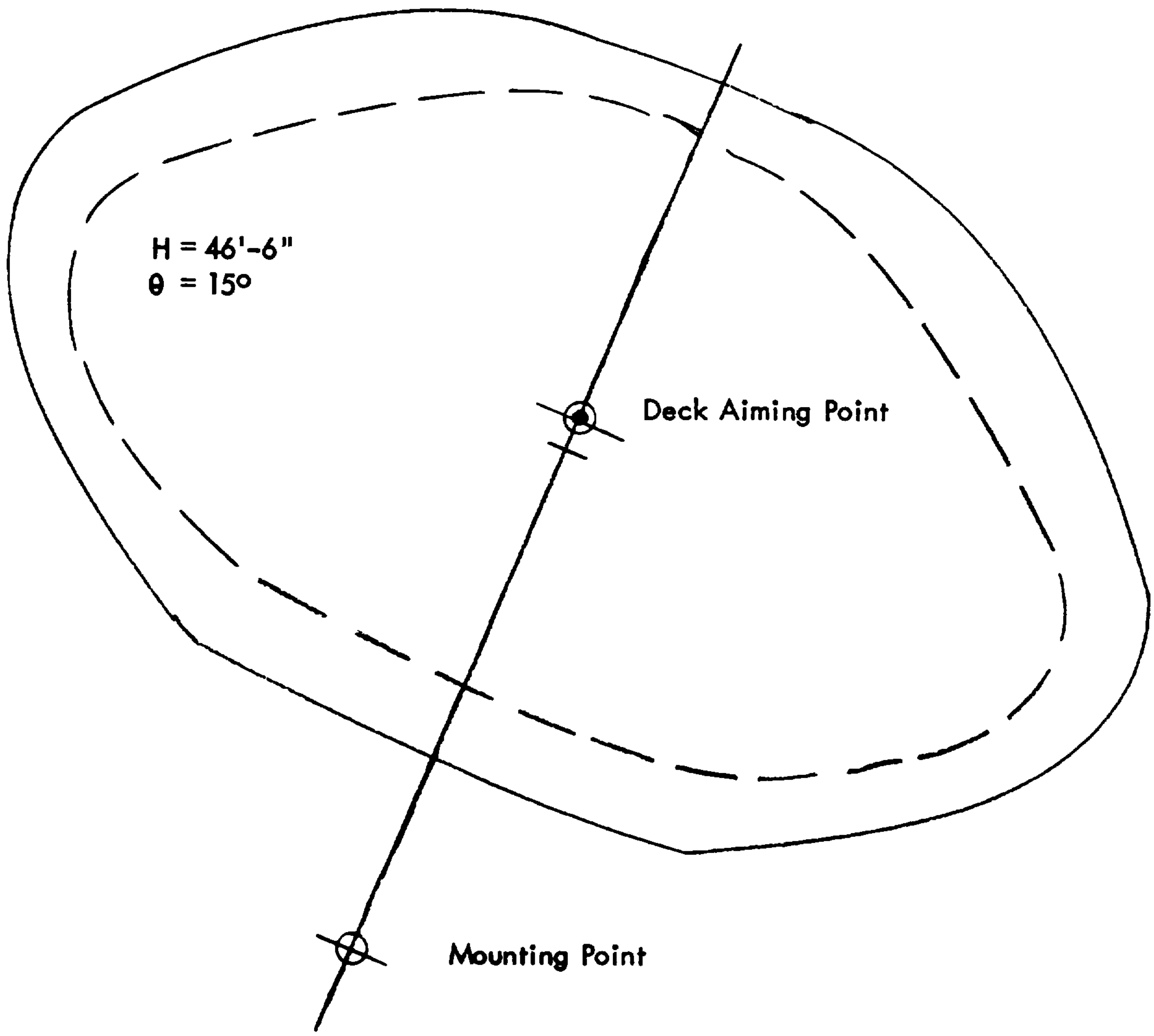
SH 964-D38

FIGURE 163. 300W MFL for H equals 42 feet 6 inches and θ equals 30 degrees.



SH 964-D39

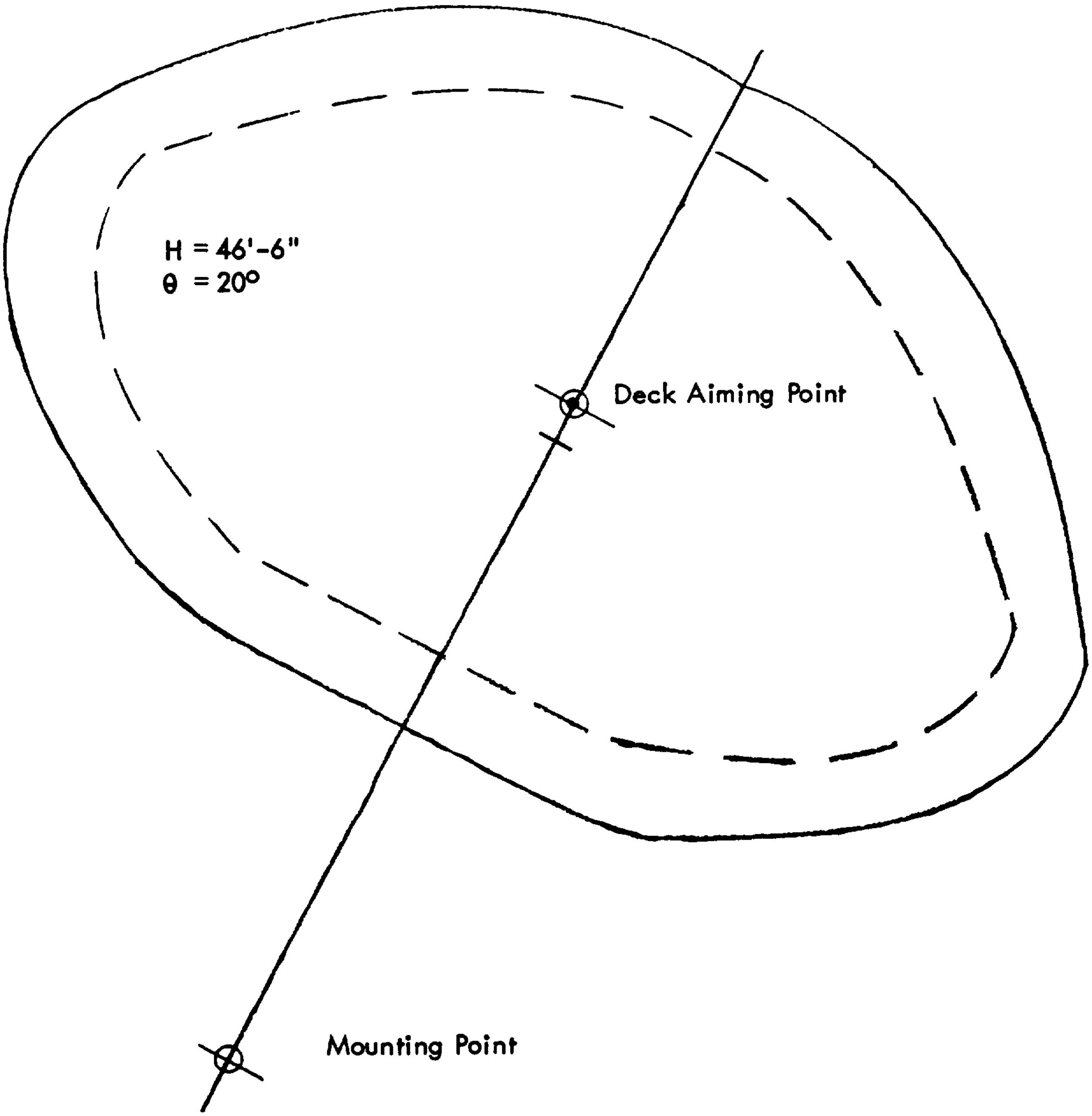
FIGURE 164. 300W MFL for H equals 46 feet 6 inches and θ equals 10 degrees.



SCALE: 1/4" = 1'-0"

SH 964-D40

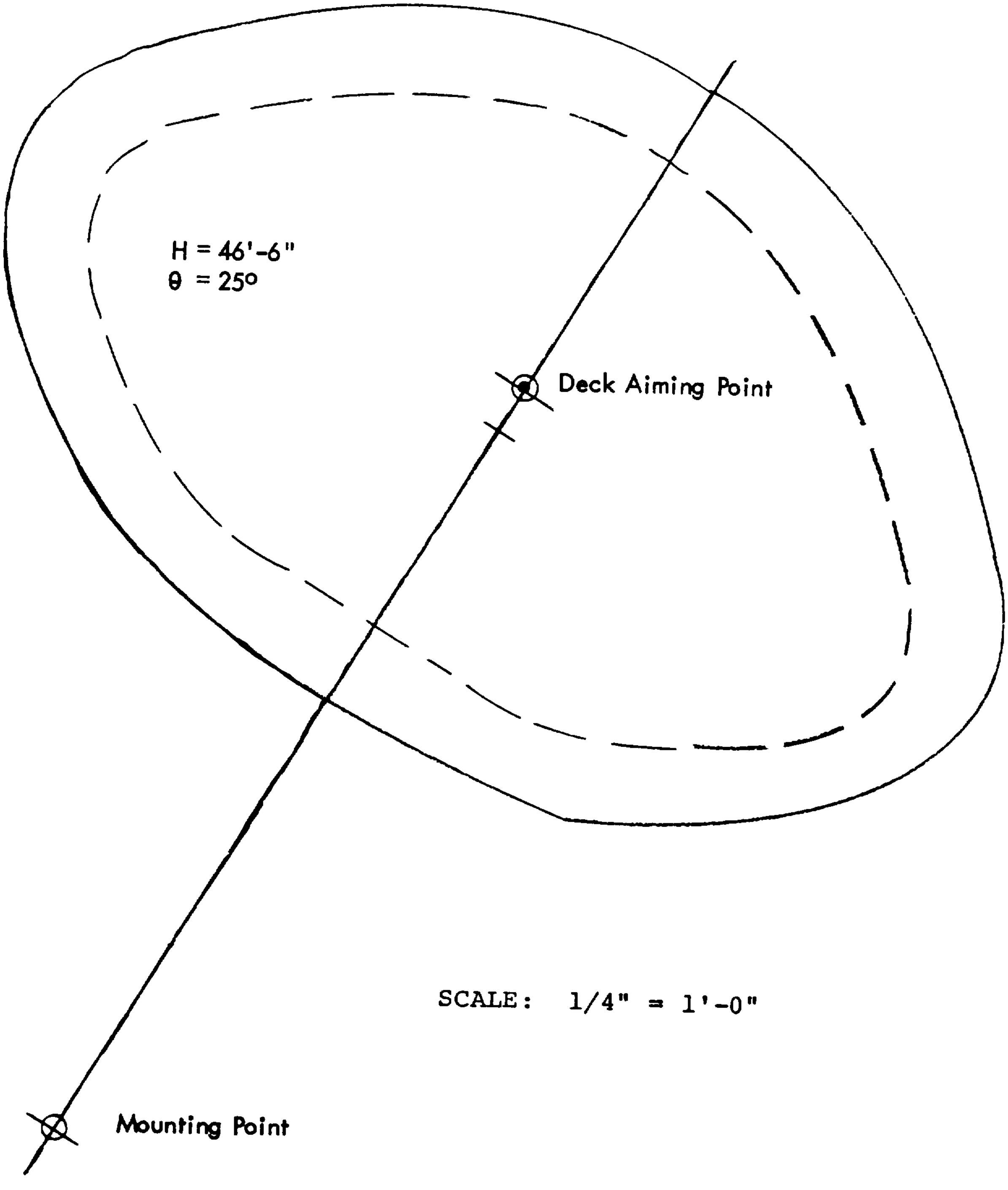
FIGURE 165. 300W MFL for H equals 46 feet 6 inches and θ equals 15 degrees.



SCALE: 1/4" = 1'-0"

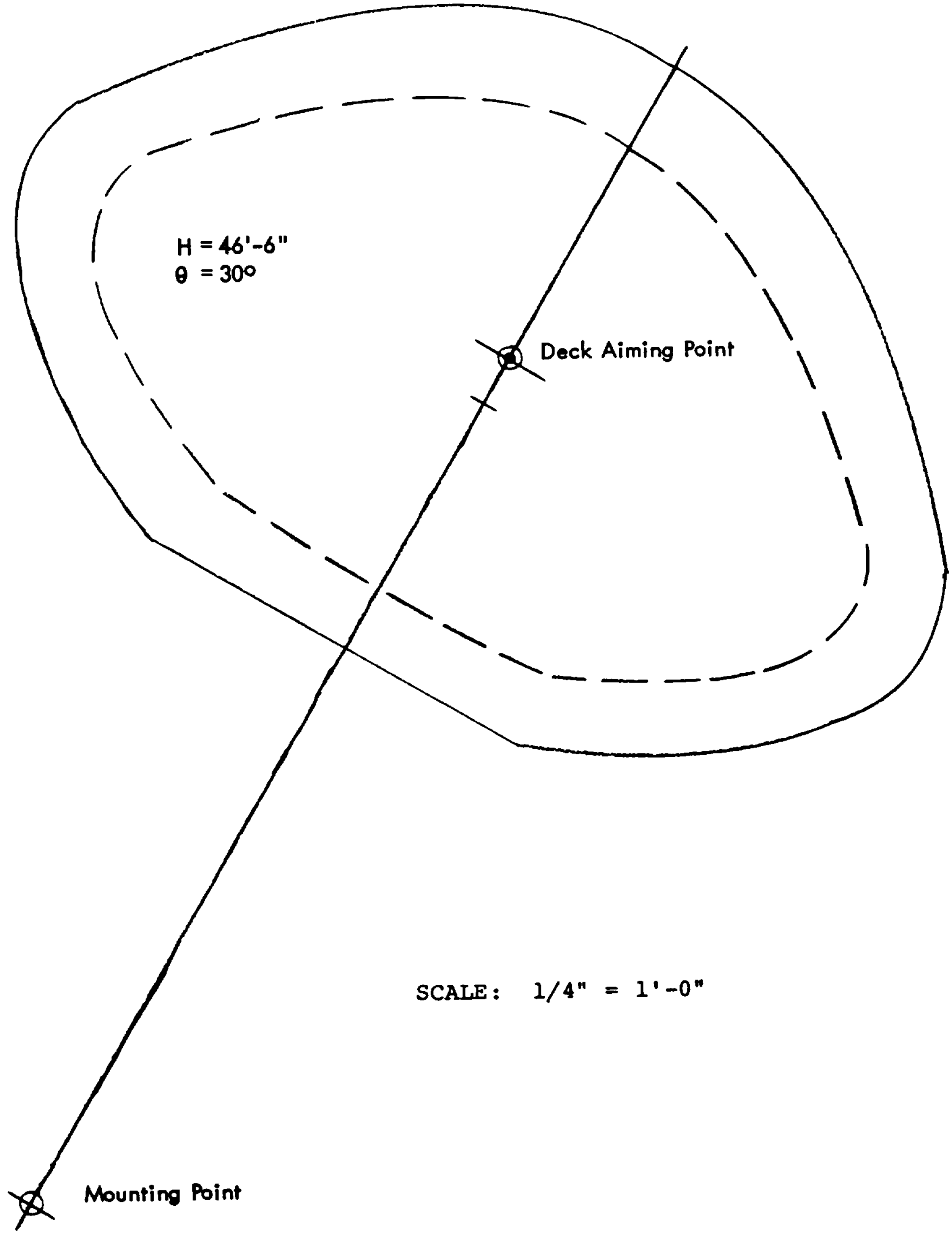
SH 964-D41

FIGURE 166. 300W MFL for H equals 46 feet 6 inches and θ equals 20 degrees.



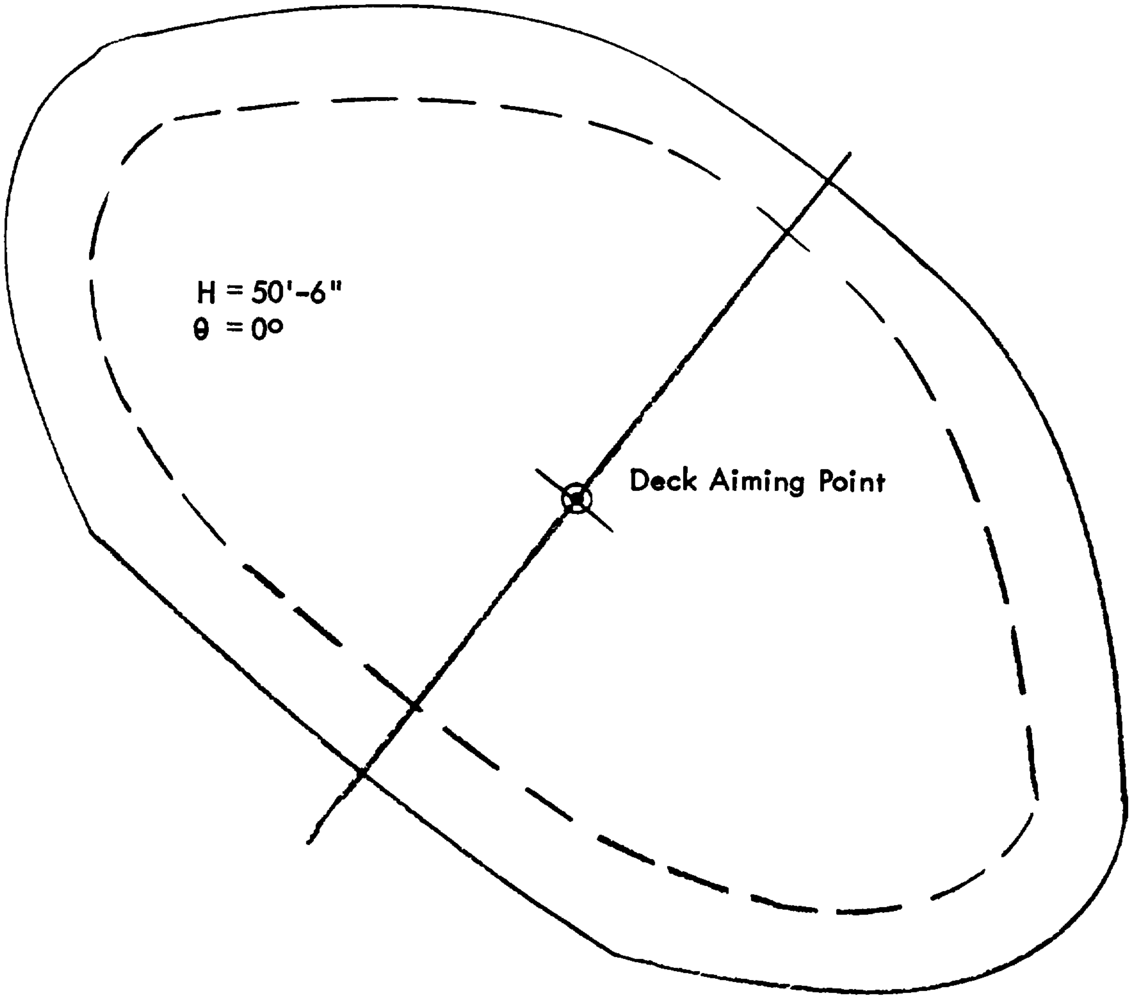
SH 964-D42

FIGURE 167. 300W MFL for H equals 46 feet 6 inches and θ equals 25 degrees.



SH 964-D43

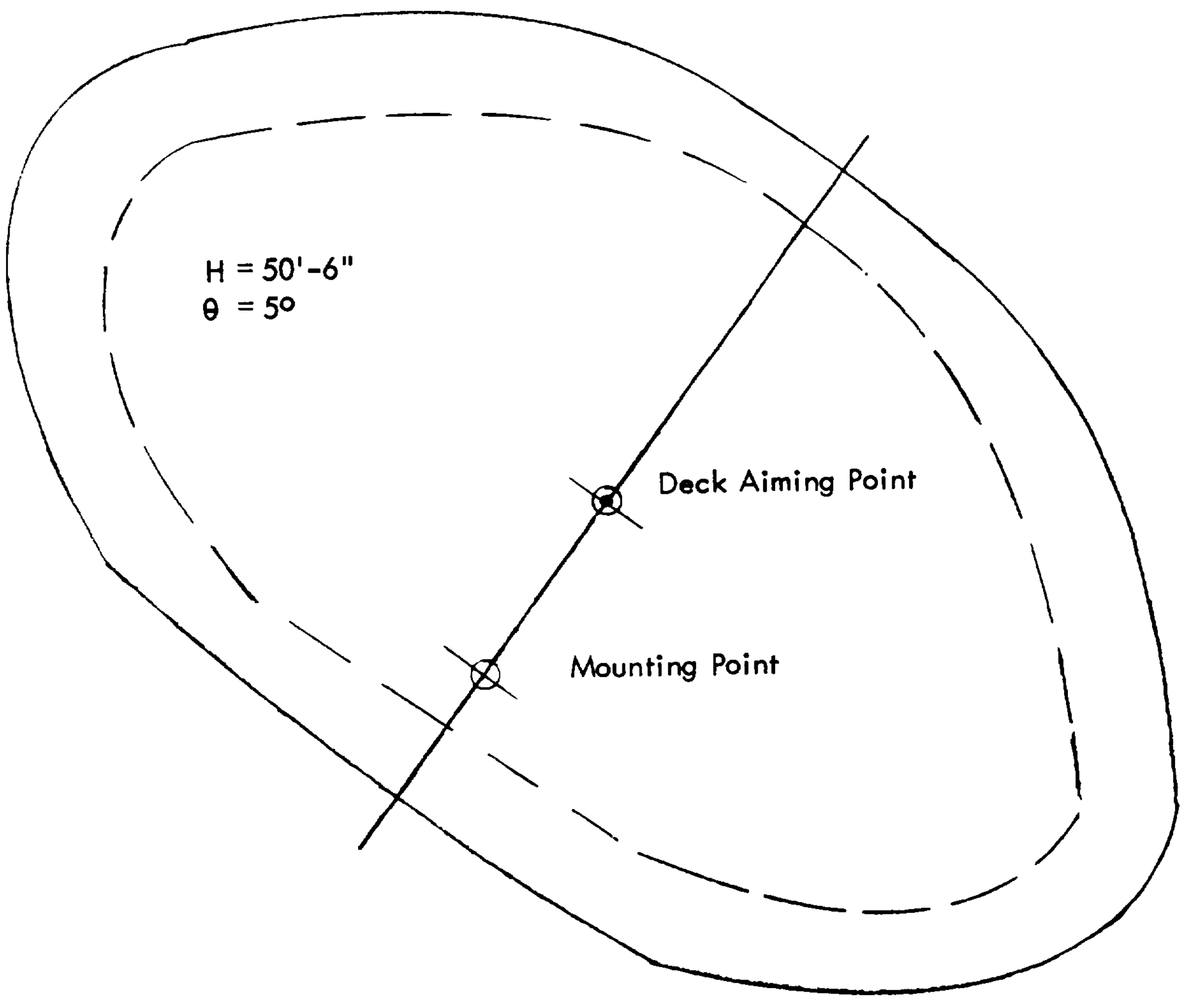
FIGURE 168. 300W MFL for H equals 46 feet 6 inches and θ equals 30 degrees.



SCALE: 1/4" = 1'0"

SH 964-D44

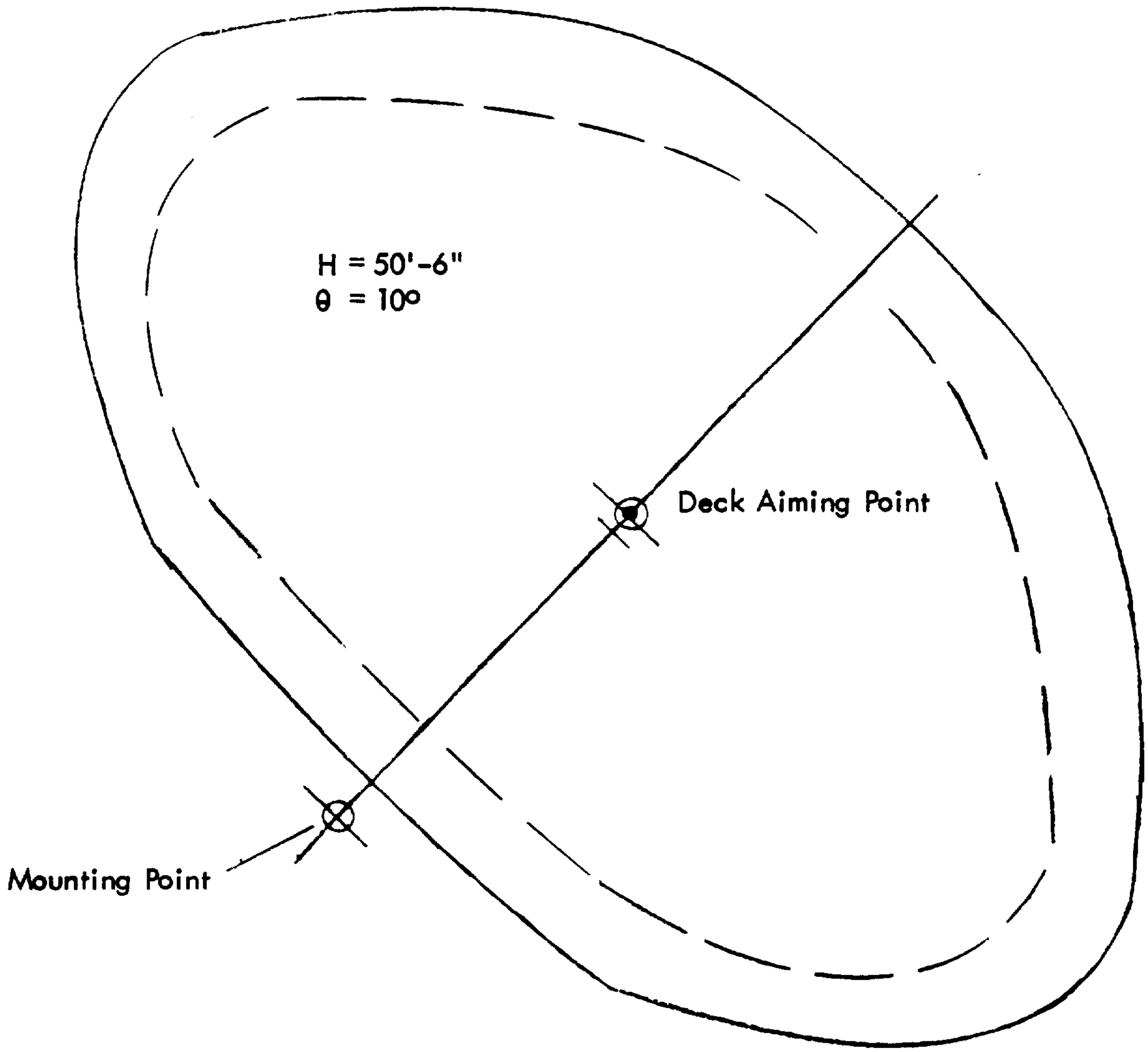
FIGURE 169. 300W MFL for H equals 50 feet 6 inches and θ equals 0 degrees.



SCALE: 1/4" = 1'-0"

SH 964-D45

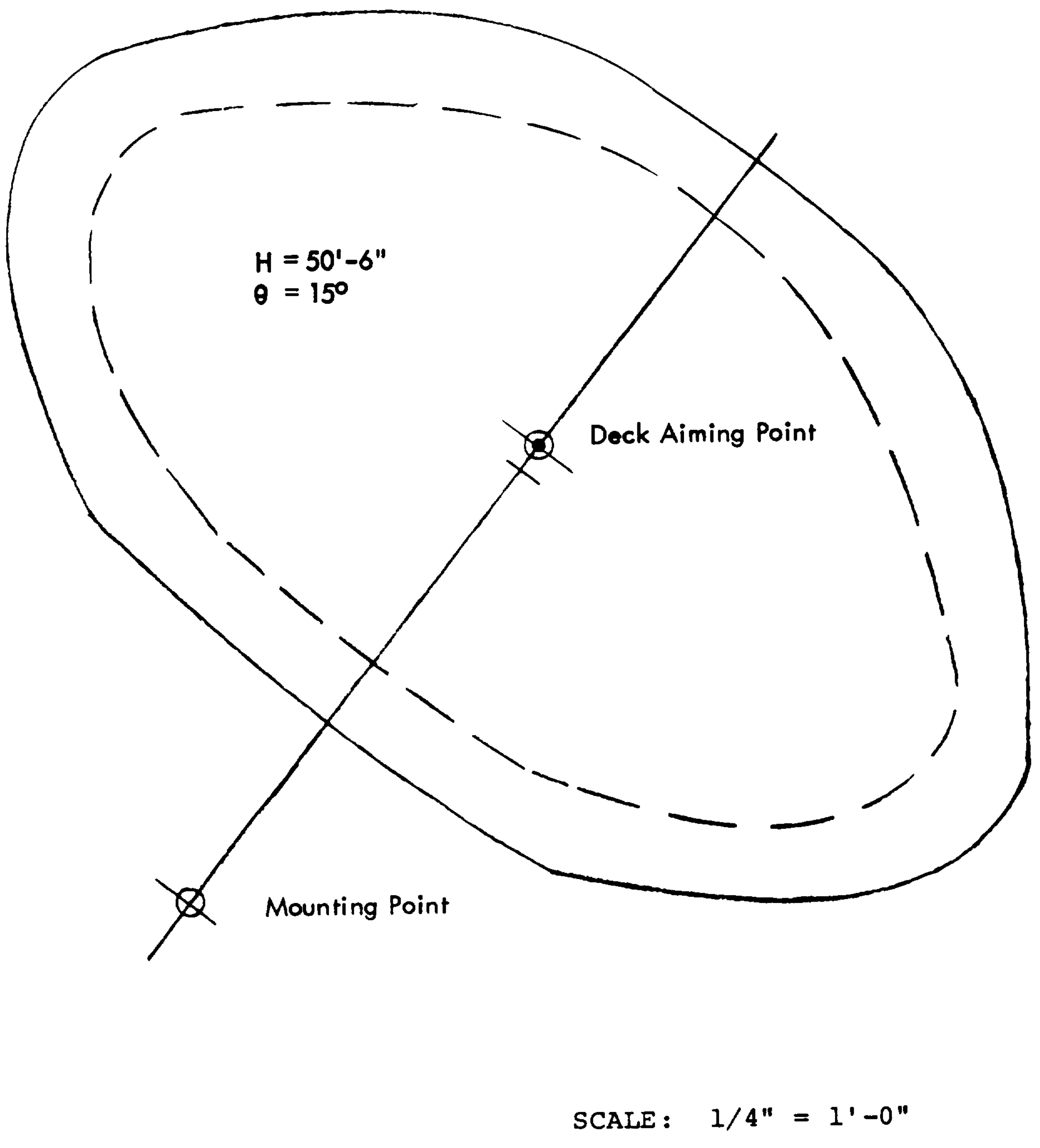
FIGURE 170. 300W MFL for H equals 50 feet 6 inches and θ equals 5 degrees.



SCALE: 1/4" = 1'-0"

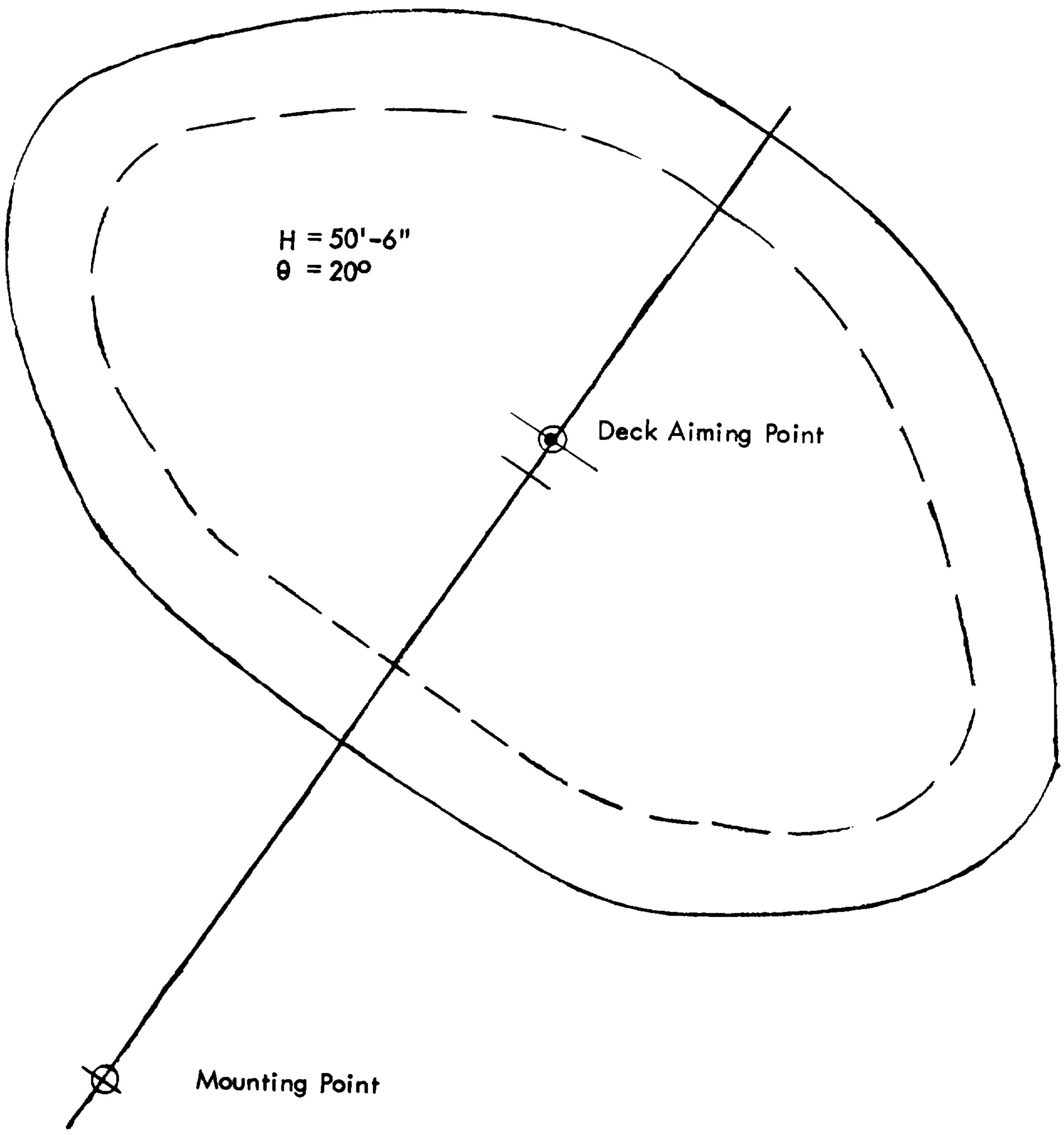
SH 964-D46

FIGURE 171. 300W MFL for H equals 50 feet 6 inches and θ equals 10 degrees.



SH 964-D47

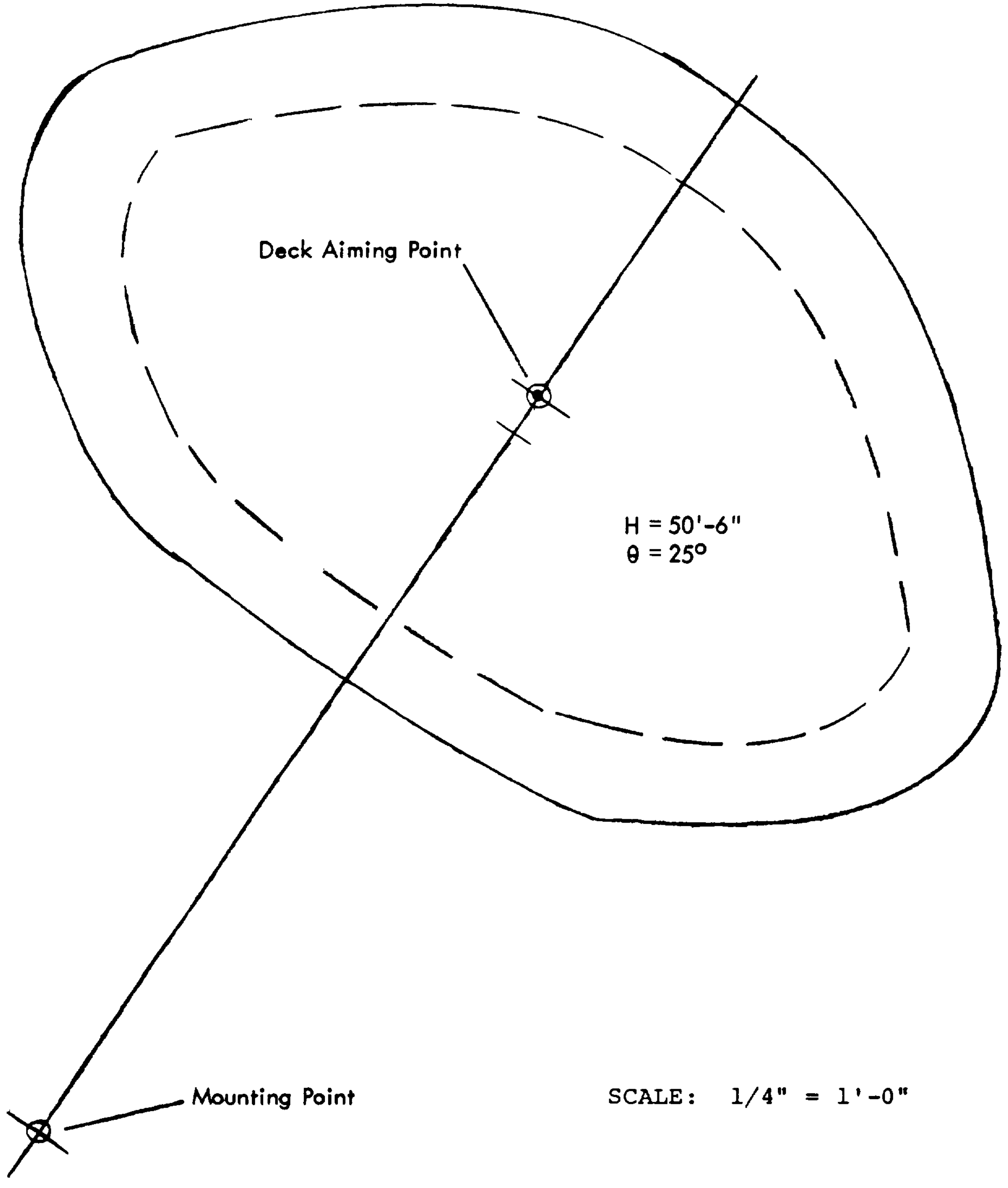
FIGURE 172. 300W MFL for H equals 50 feet 6 inches and θ equals 15 degrees.



SCALE: 1/4" = 1'-0"

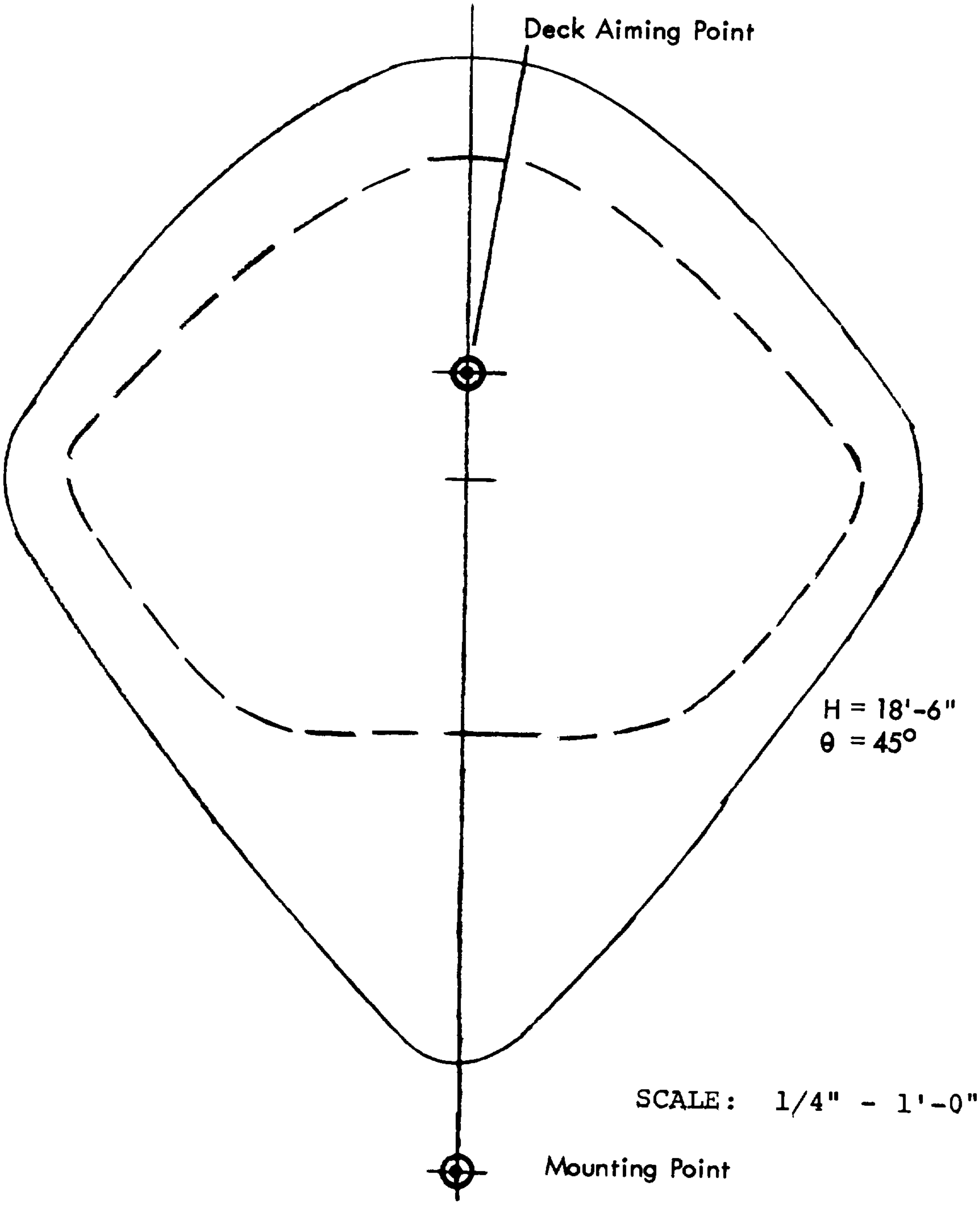
SH 964-D48

FIGURE 173. 300W MFL for H equals 50 feet 6 inches and θ equals 20 degrees.



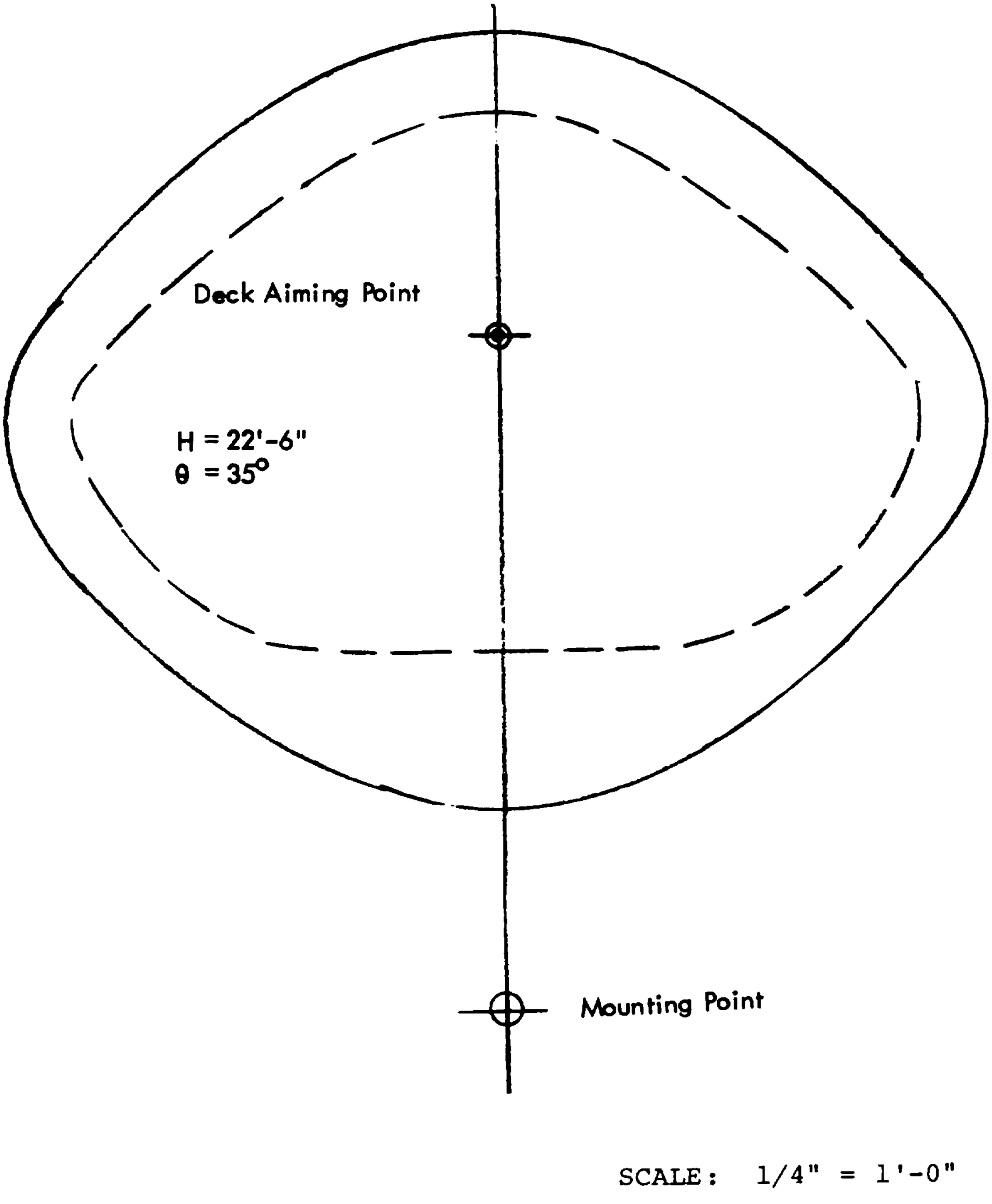
SH 964-D49

FIGURE 174. 300W MFL for H equals 50 feet 6 inches and θ equals 25 degrees.



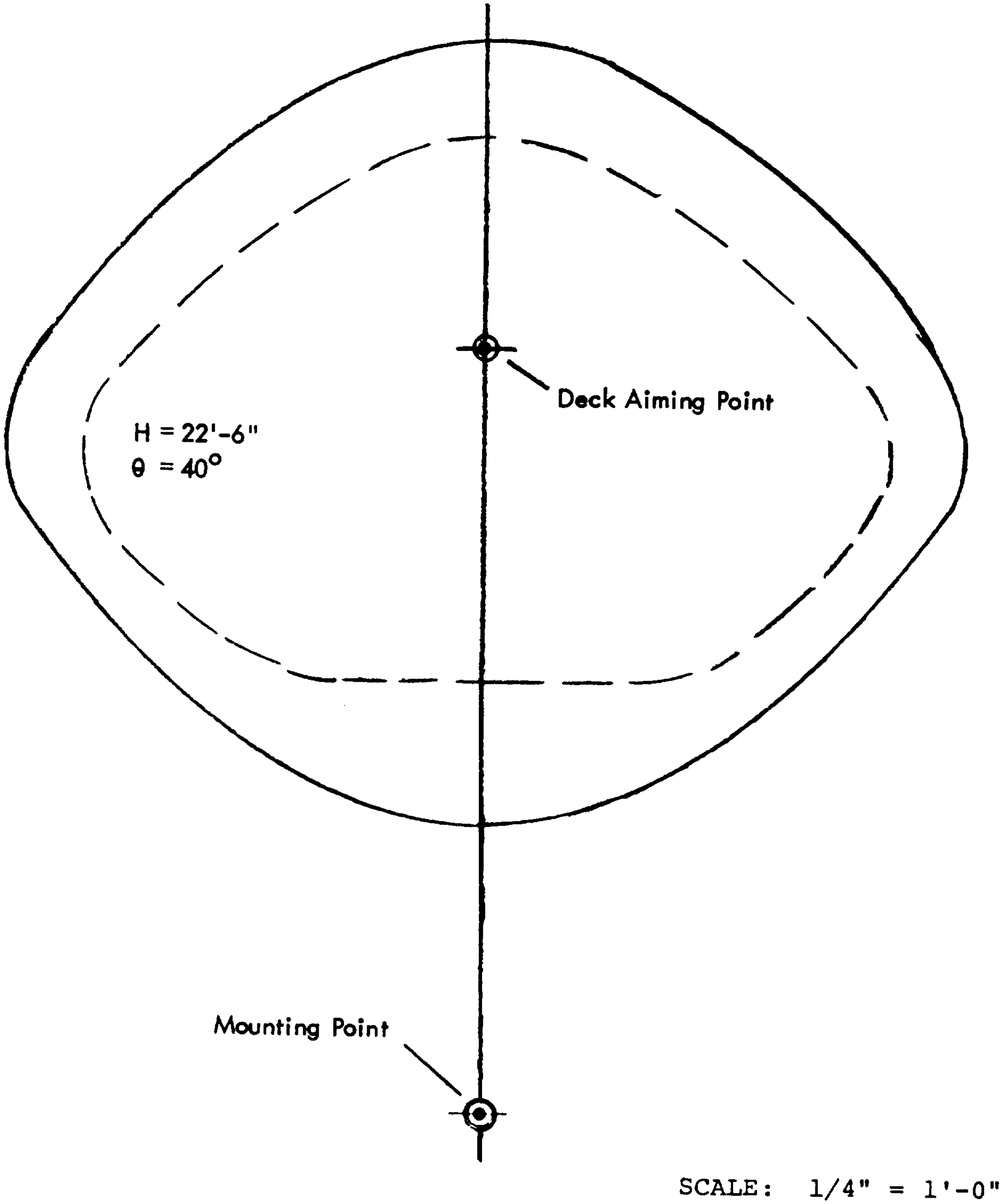
SH 964-D50

FIGURE 175. 300W WFL for H equals 18 feet 6 inches and θ equals 45 degrees.



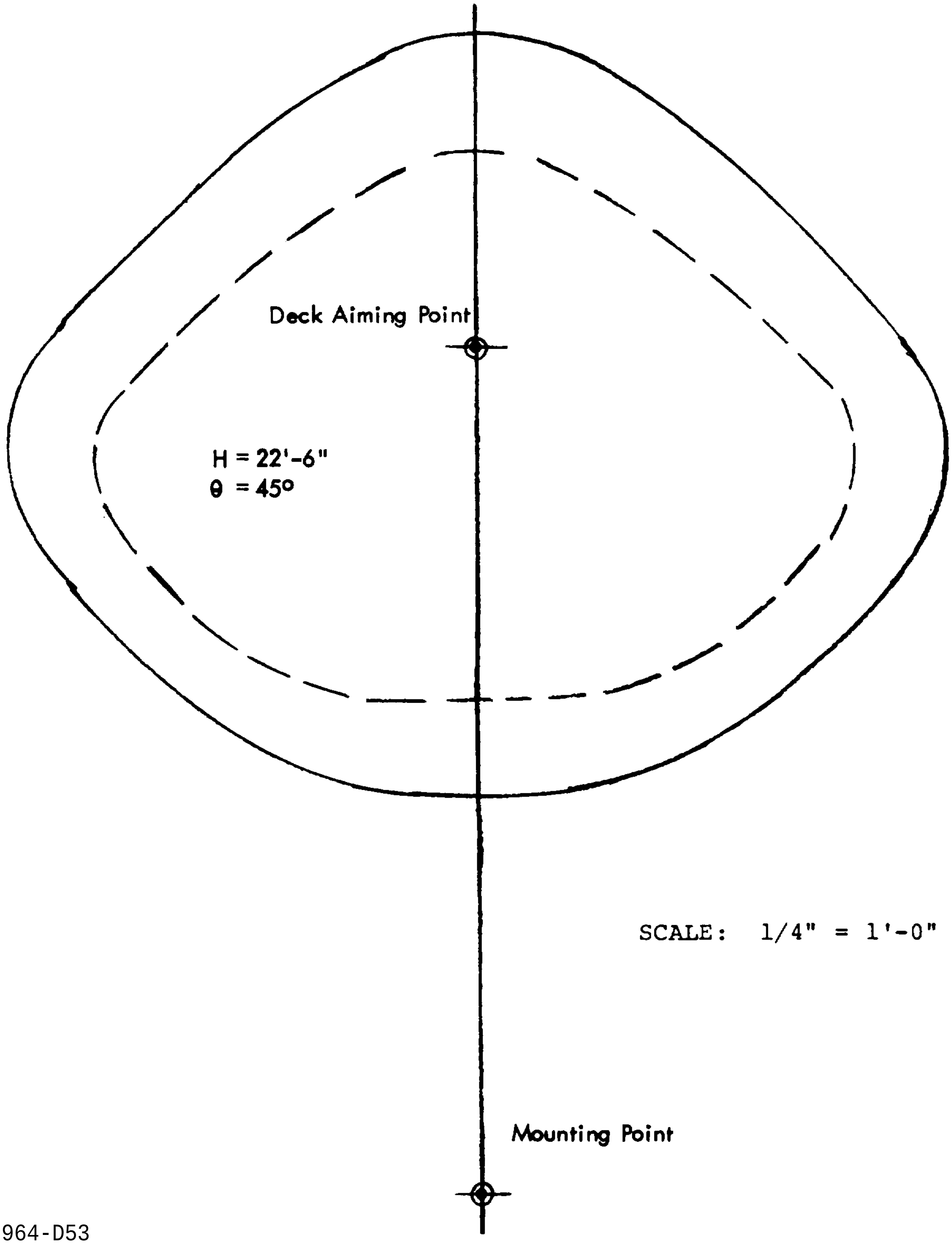
SH 964-D51

FIGURE 176. 300W WFL for H equals 22 feet 6 inches and θ equals 35 degrees.



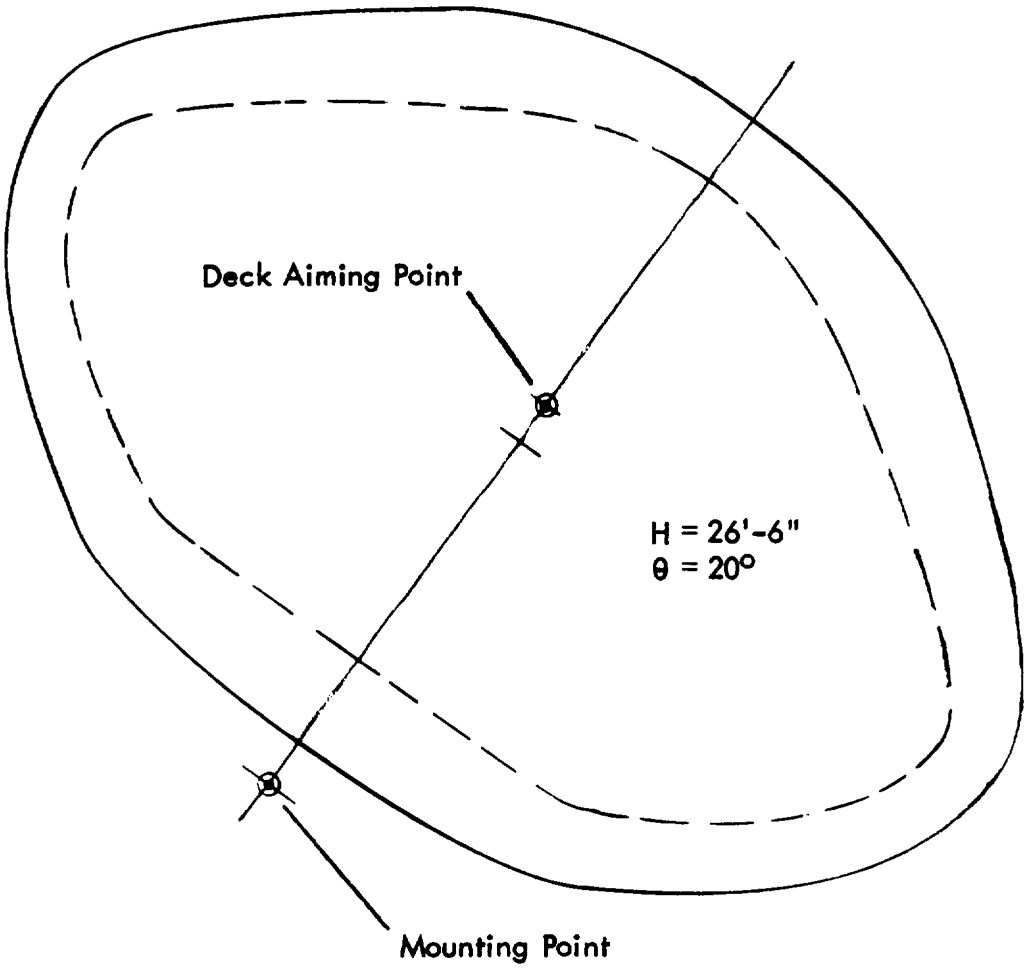
SH 964-D52

FIGURE 177. 300W WFL for H equals 22 feet 6 inches and θ equals 40 degrees.



SH 964-D53

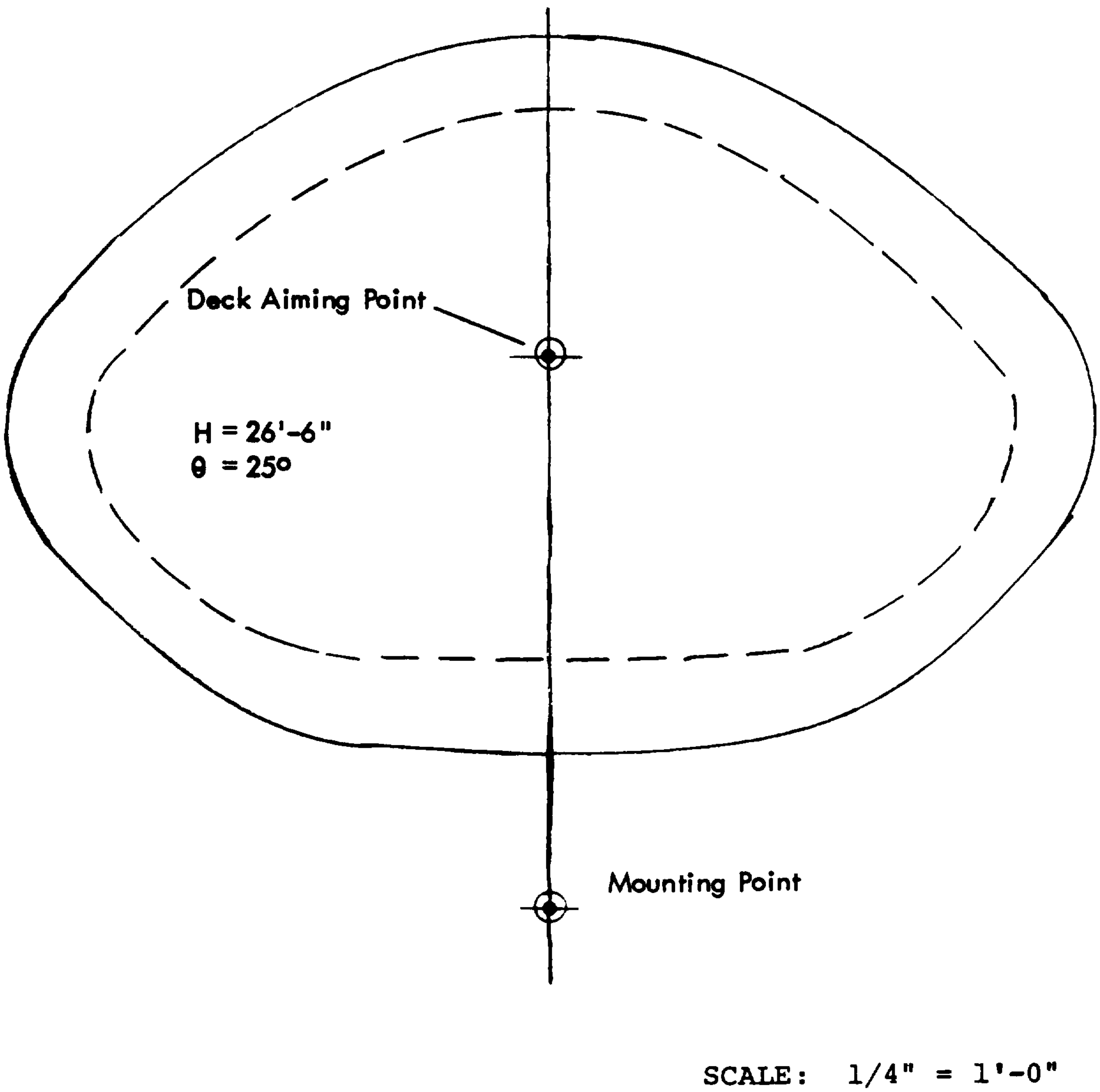
FIGURE 178. 300W WFL for H equals 22 feet 6 inches and θ equals 45 degrees.



SCALE: 1/4" = 1'-0"

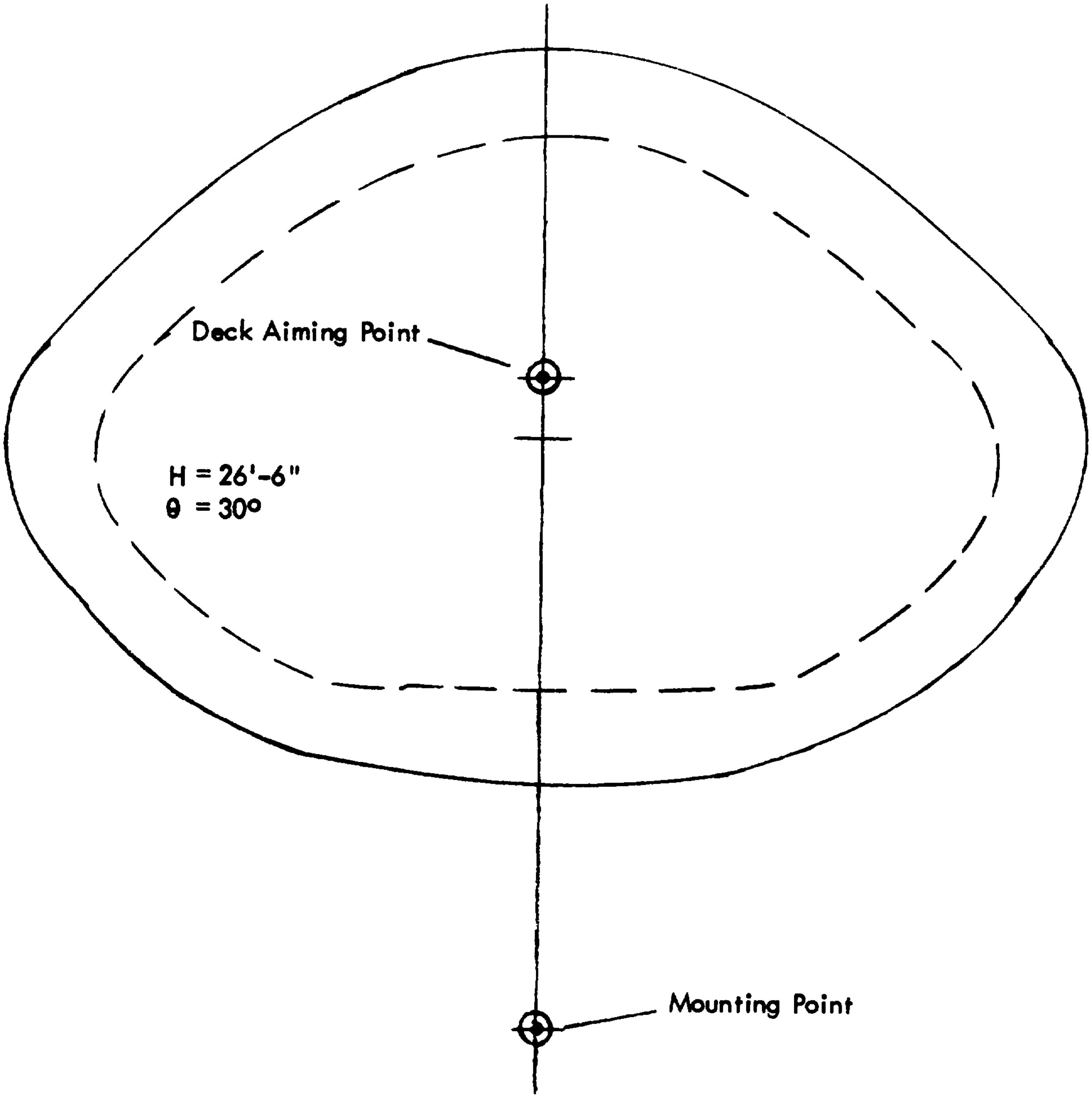
SH 964-D54

FIGURE 1790 300W WFL for H equals 26 feet 6 inches and θ equals 20 degrees.



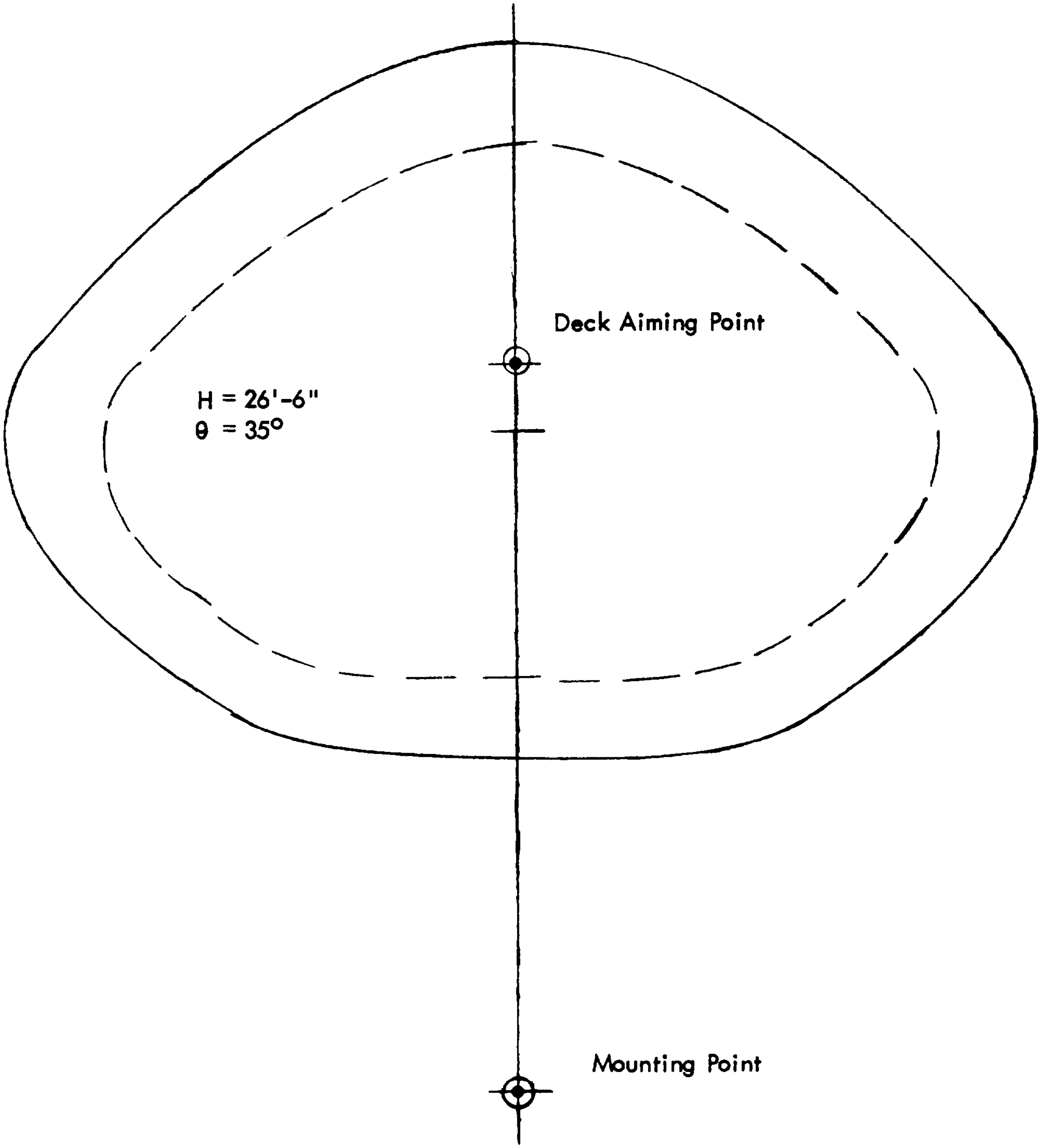
SH 964-D55

FIGURE 180. 300W WFL for H equals 26 feet 6 inches and θ equals 25 degrees.



SH 964-D56

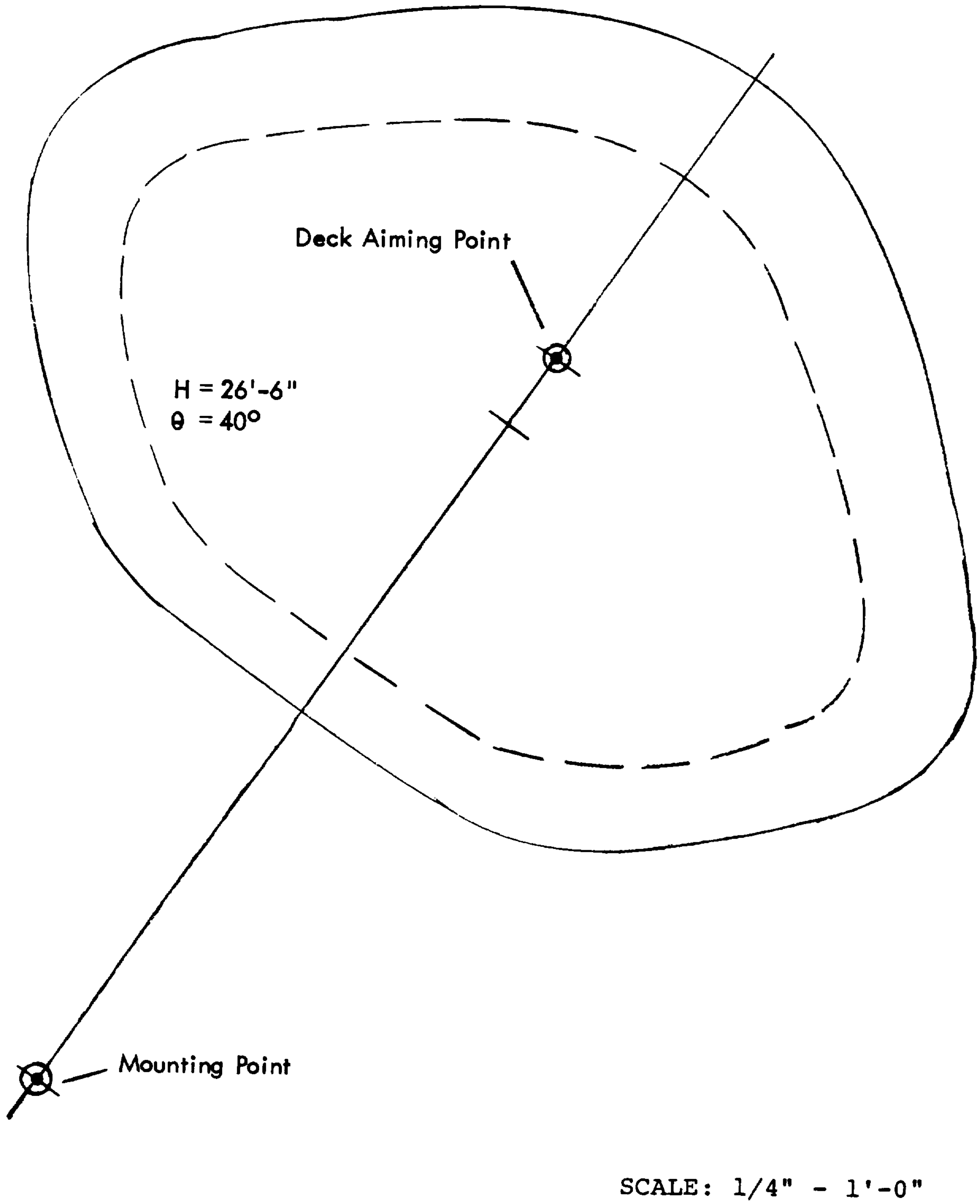
FIGURE 181. 300W WFL for H equals 26 feet 6 inches and θ equals 30 degrees.



SH 964-D57

SCALE: 1/4" = 1'-0"

FIGURE 182. 300W WPL for H equals 26 feet 6 inches and θ equals 35 degrees.



SH 964-D58

FIGURE 183. 300W WFL for H equals 26 feet 6 inches and θ equals 40 degrees.

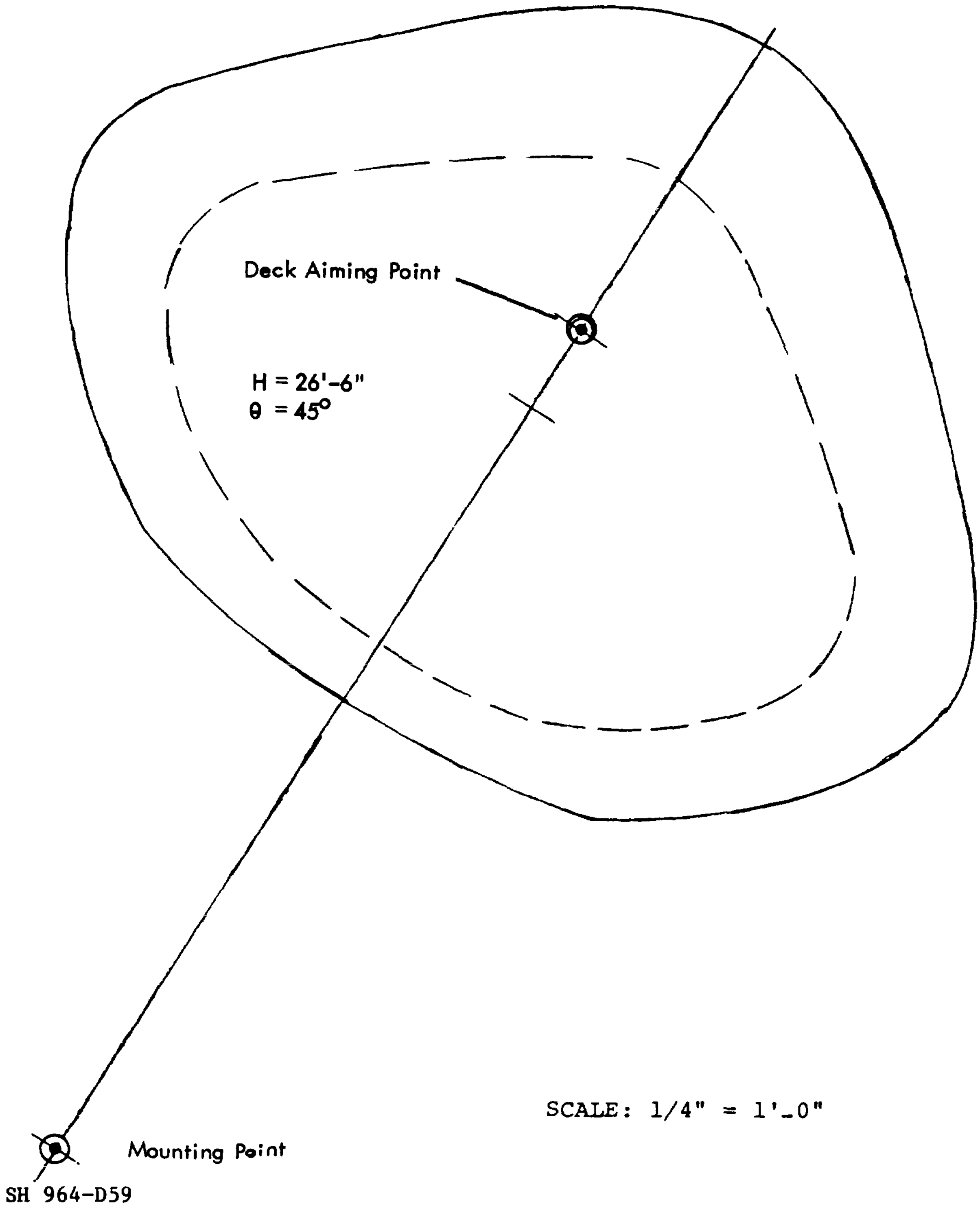
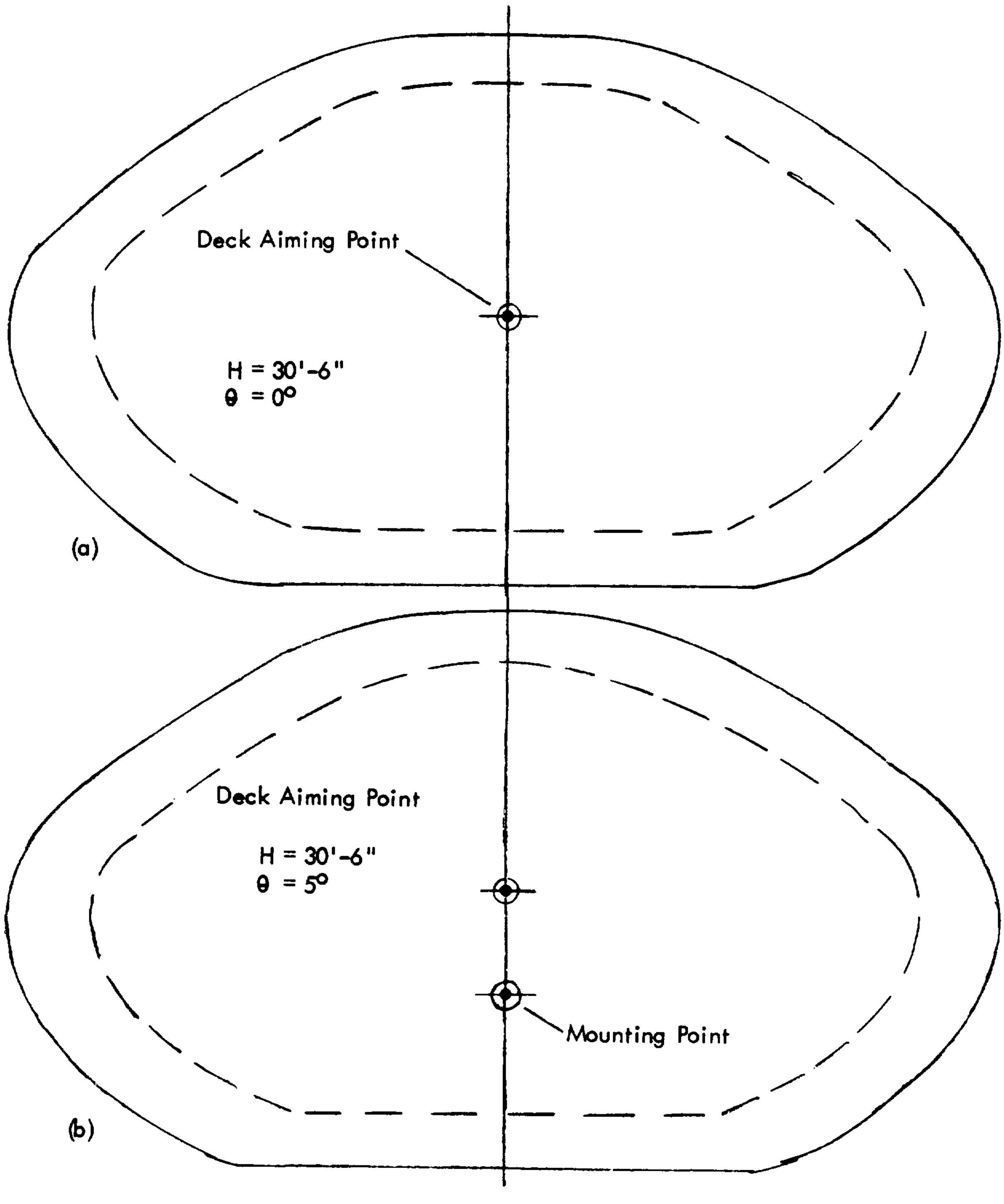


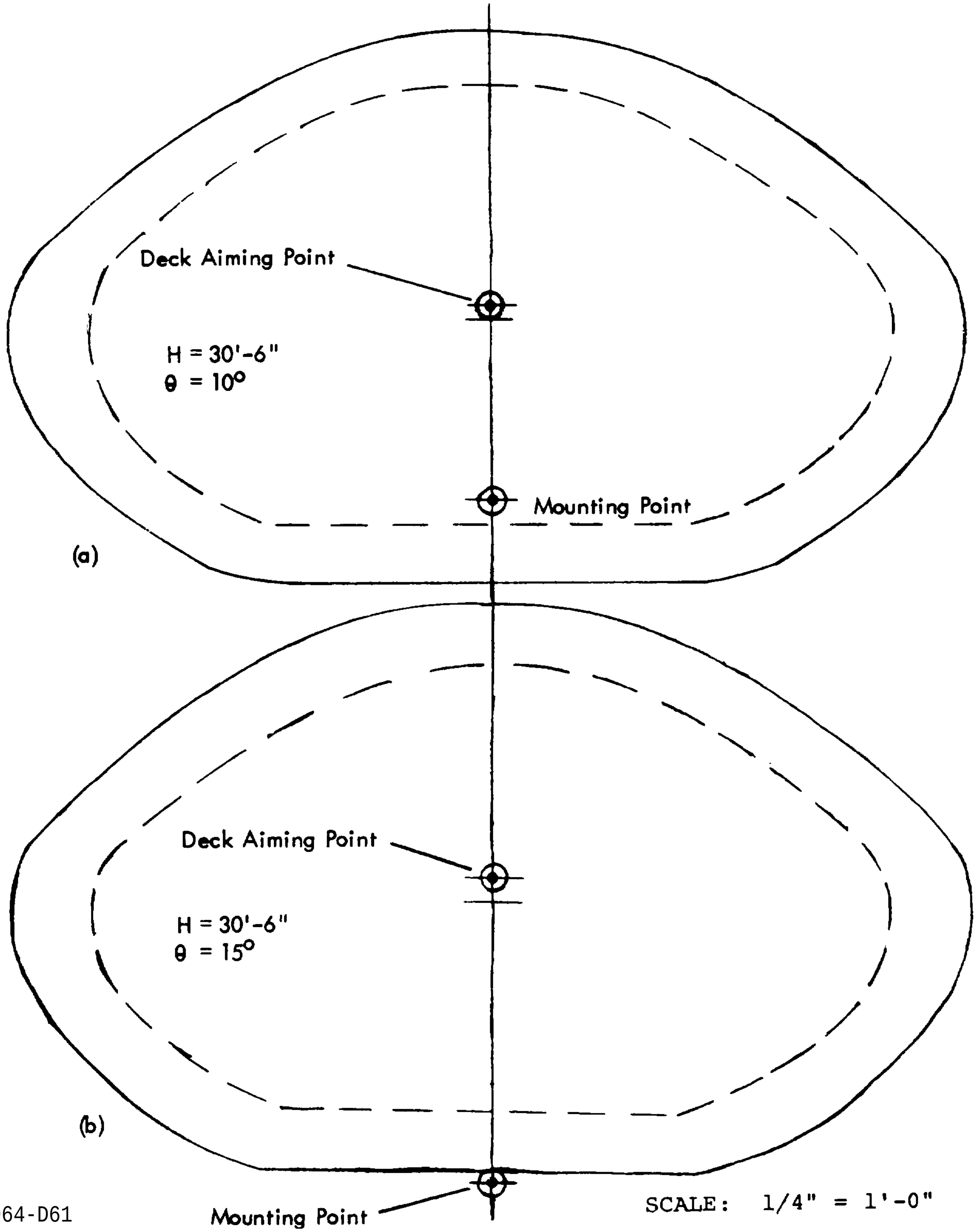
FIGURE 184. 300W WFL for H equals 26 feet 6 inches and θ equals 45 degrees.



SH 964-D60

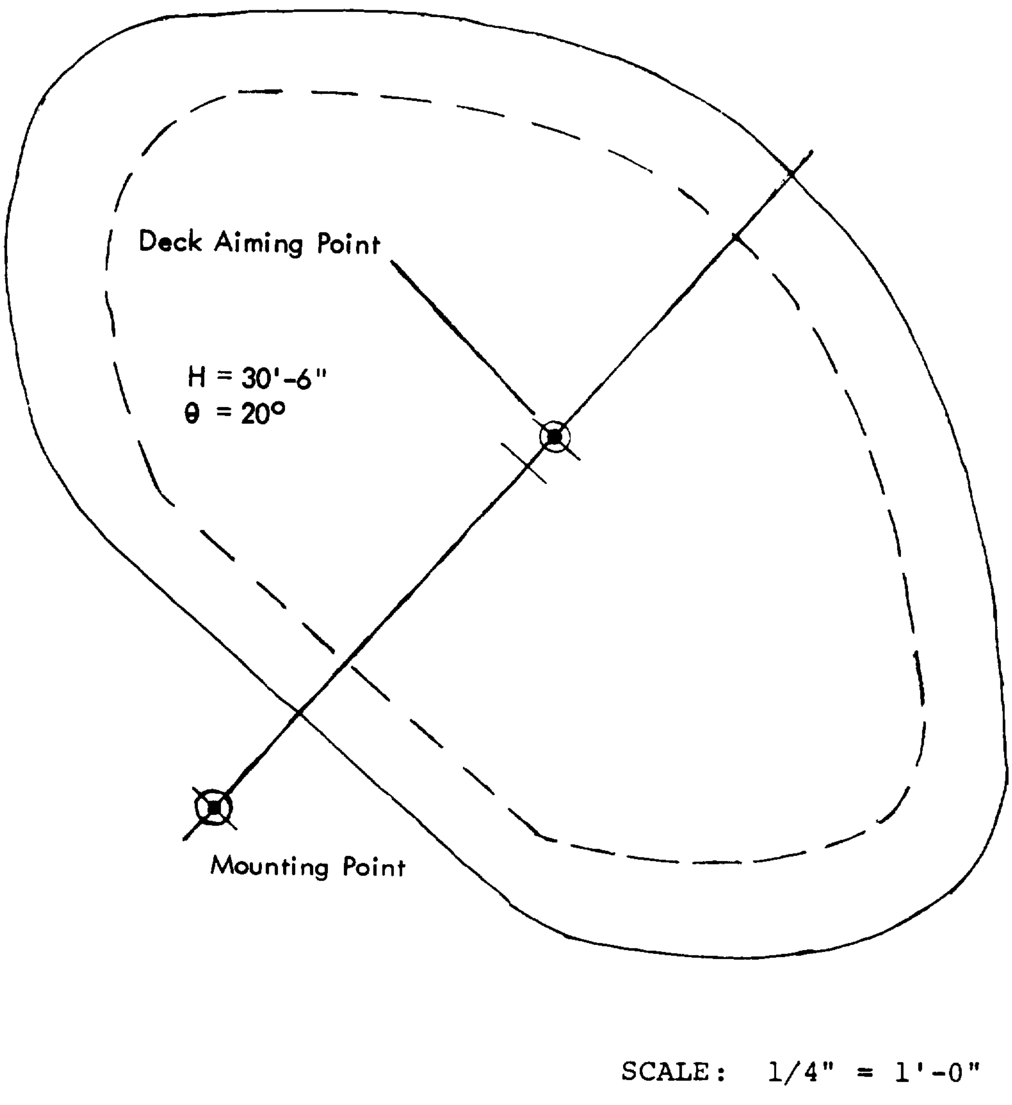
SCALE: 1/4" = 1'-0"

FIGURE 185. 300W WFL for H equals 30 feet 6 inches and θ equals 0 to 5 degrees.



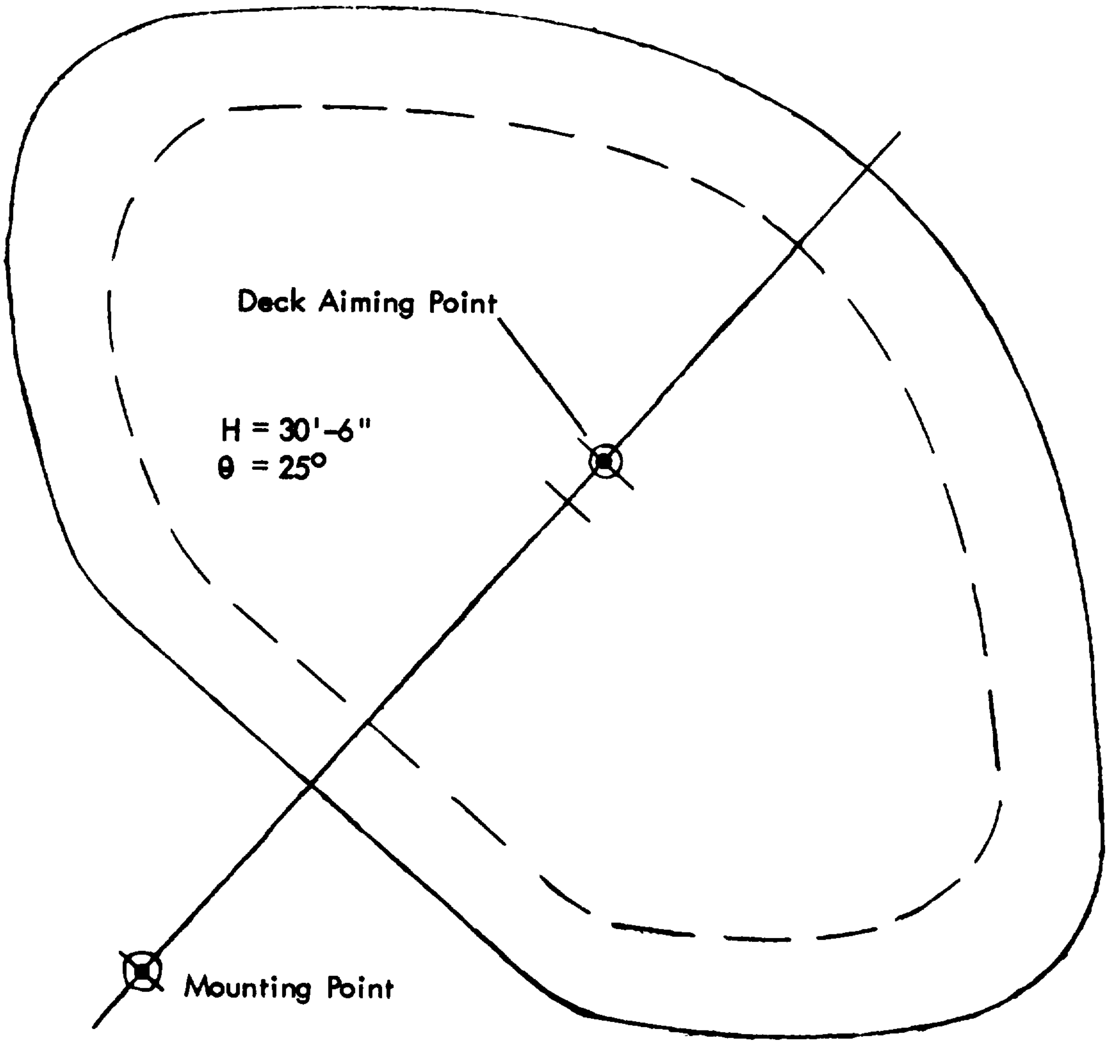
SH 964-D61

FIGURE 186. 300W WFL for H equals 30 feet 6 inches and θ equals 10 to 15 degrees.



SH 964-D62

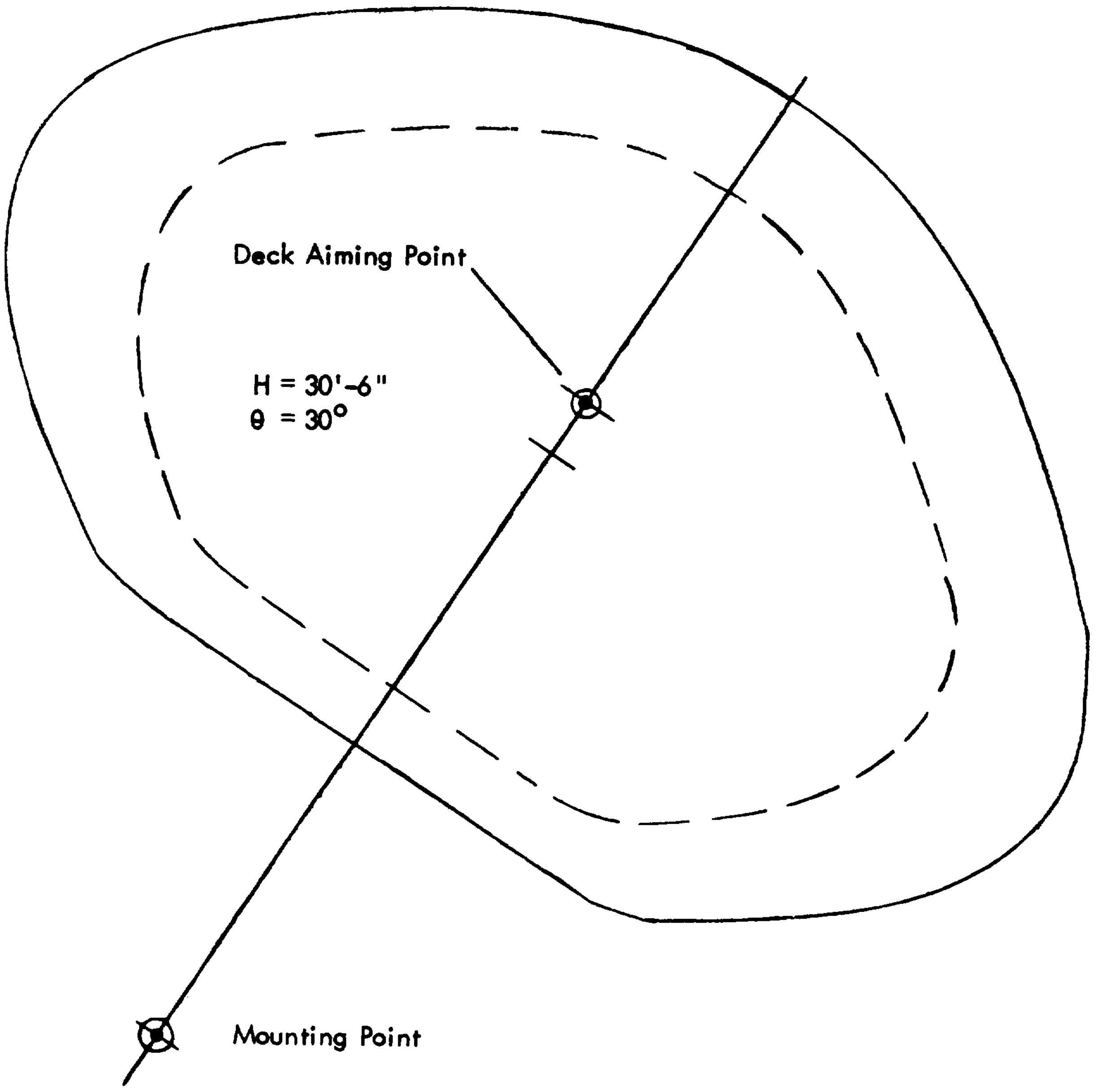
FIGURE 187. 300W WFL for H equals 30 feet 6 inches and θ equals 20 degrees.



SCALE: 1/4" = 1'-0"

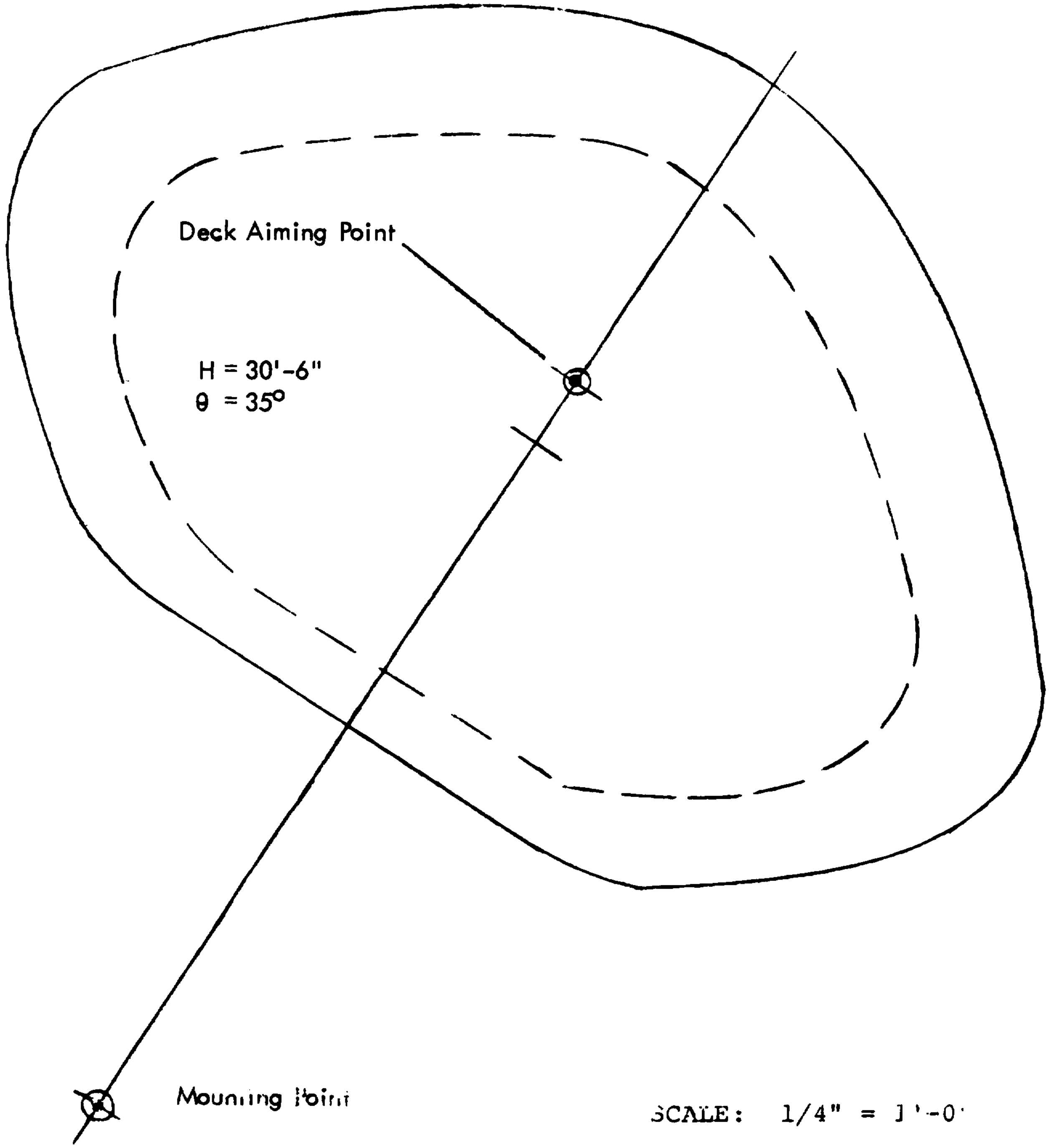
SH 964-D63

FIGURE 188. 300W WFL for H equals 30 feet 6 inches and θ equals 25 degrees.



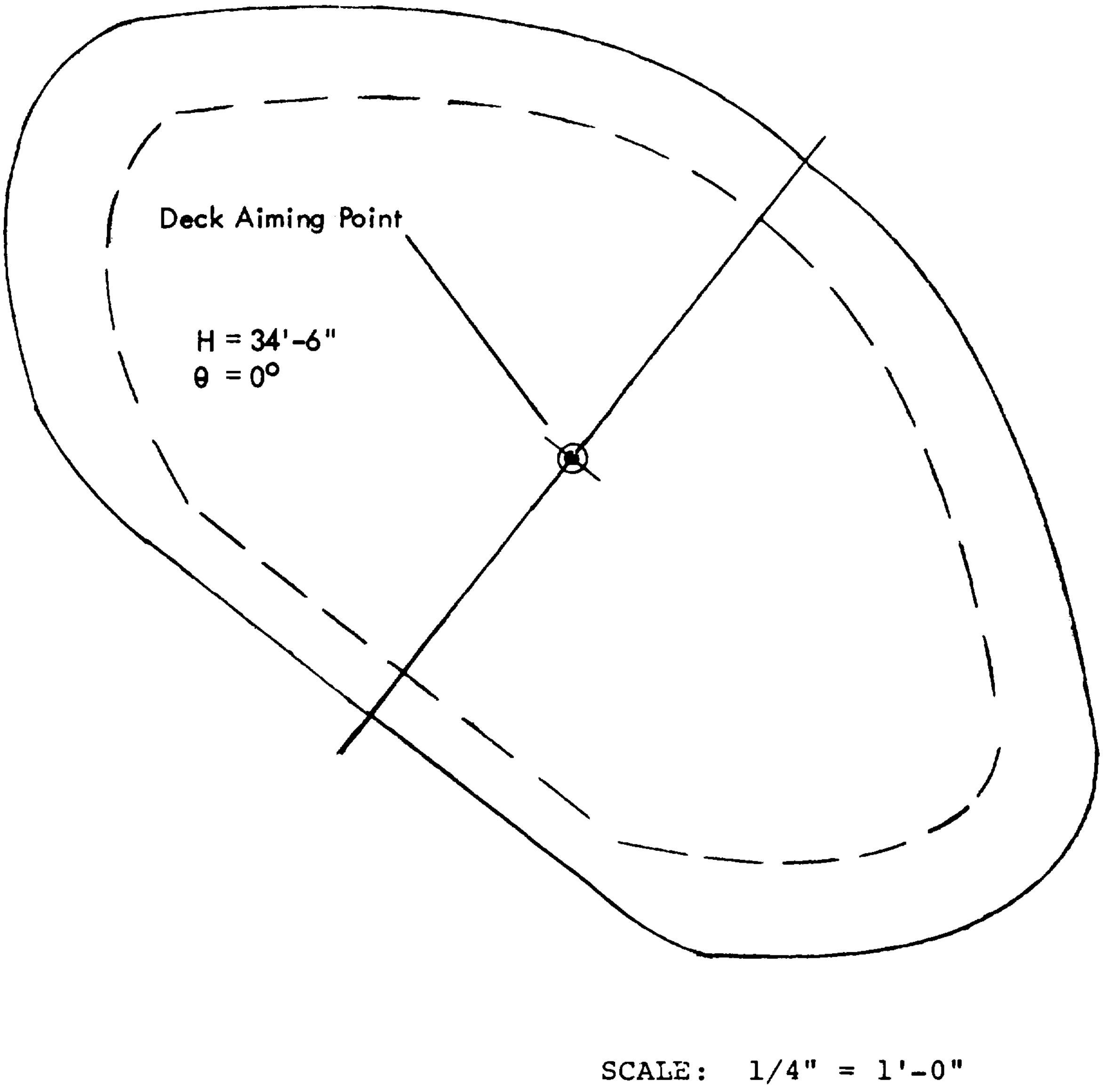
SH 964-D64

FIGURE 189. 300W WFL for H equals 30 feet 6 inches and θ equals 30 degrees.



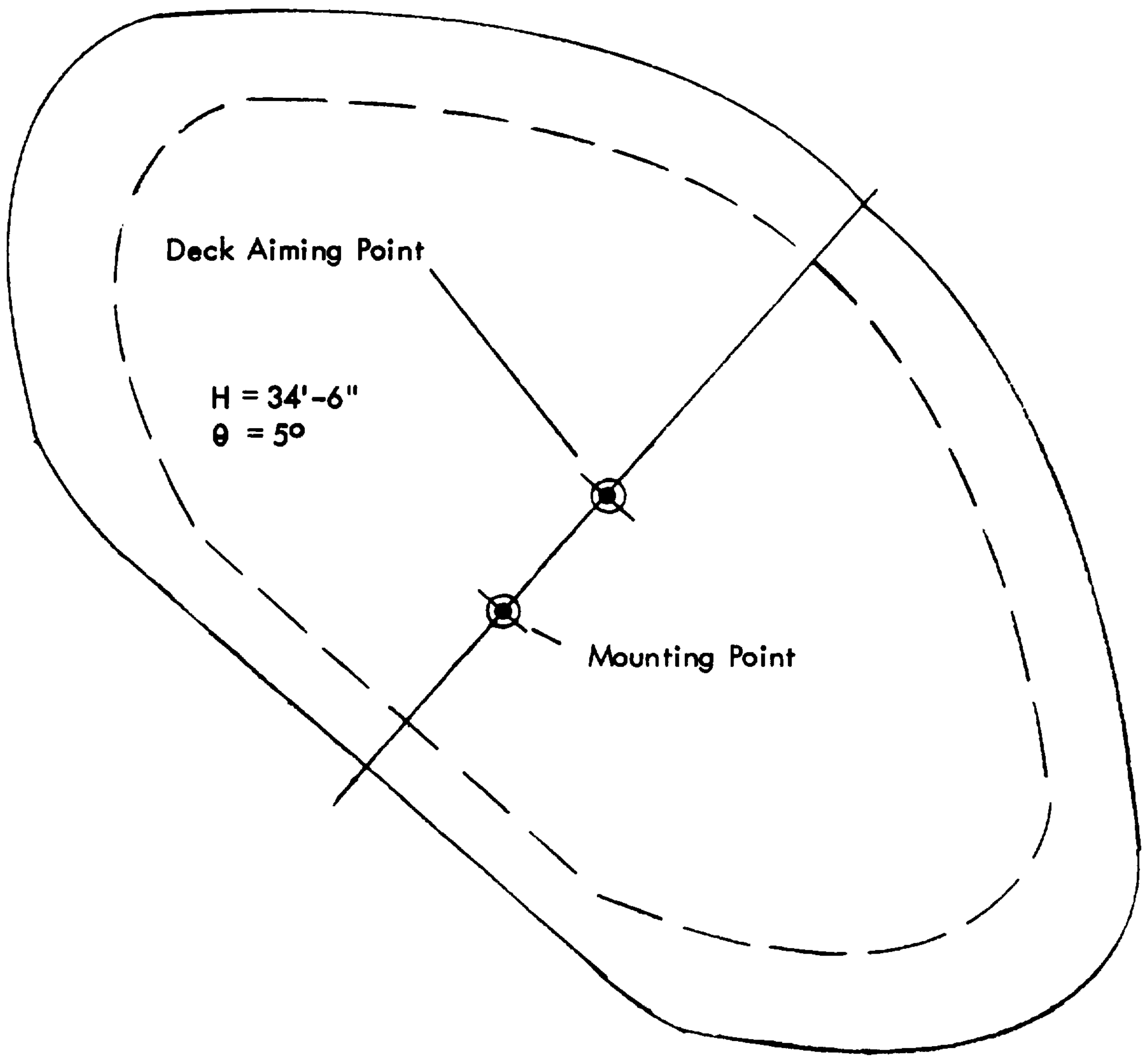
SH 964-D65

FIGURE 190. 300W WFL for H equals 30 feet 6 inches and θ equals 35 degrees.



SH 964-D66

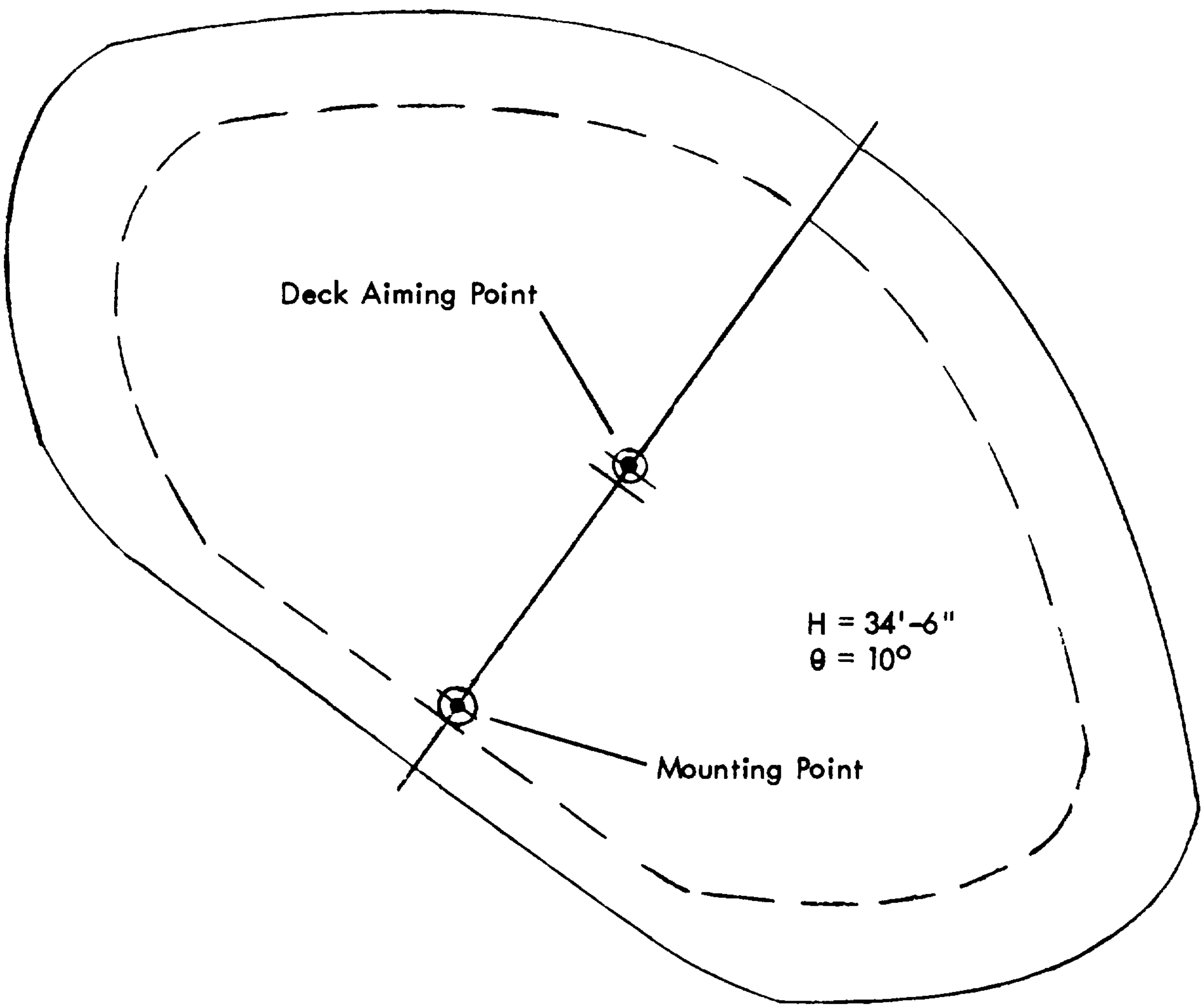
FIGURE 191. 300W WFL for H equals 34 feet 6 inches and θ equals 0 degrees.



SCALE: 1/4" = 1'-0"

SH 964-D67

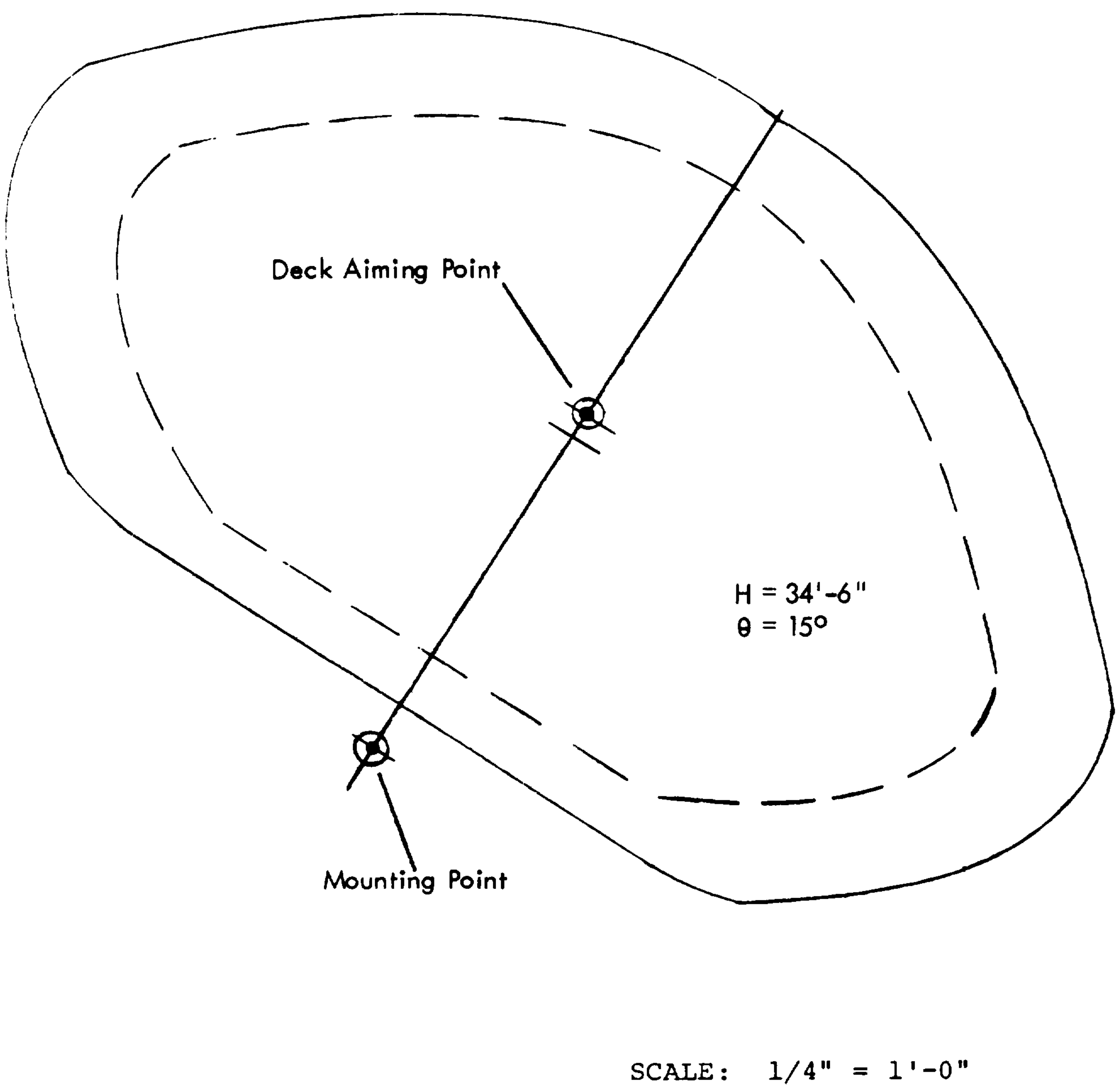
FIGURE 192. 300W WFL for H equals 34 feet 6 inches and θ equals 5 degrees.



SCALE: 1/4" = 1'-0"

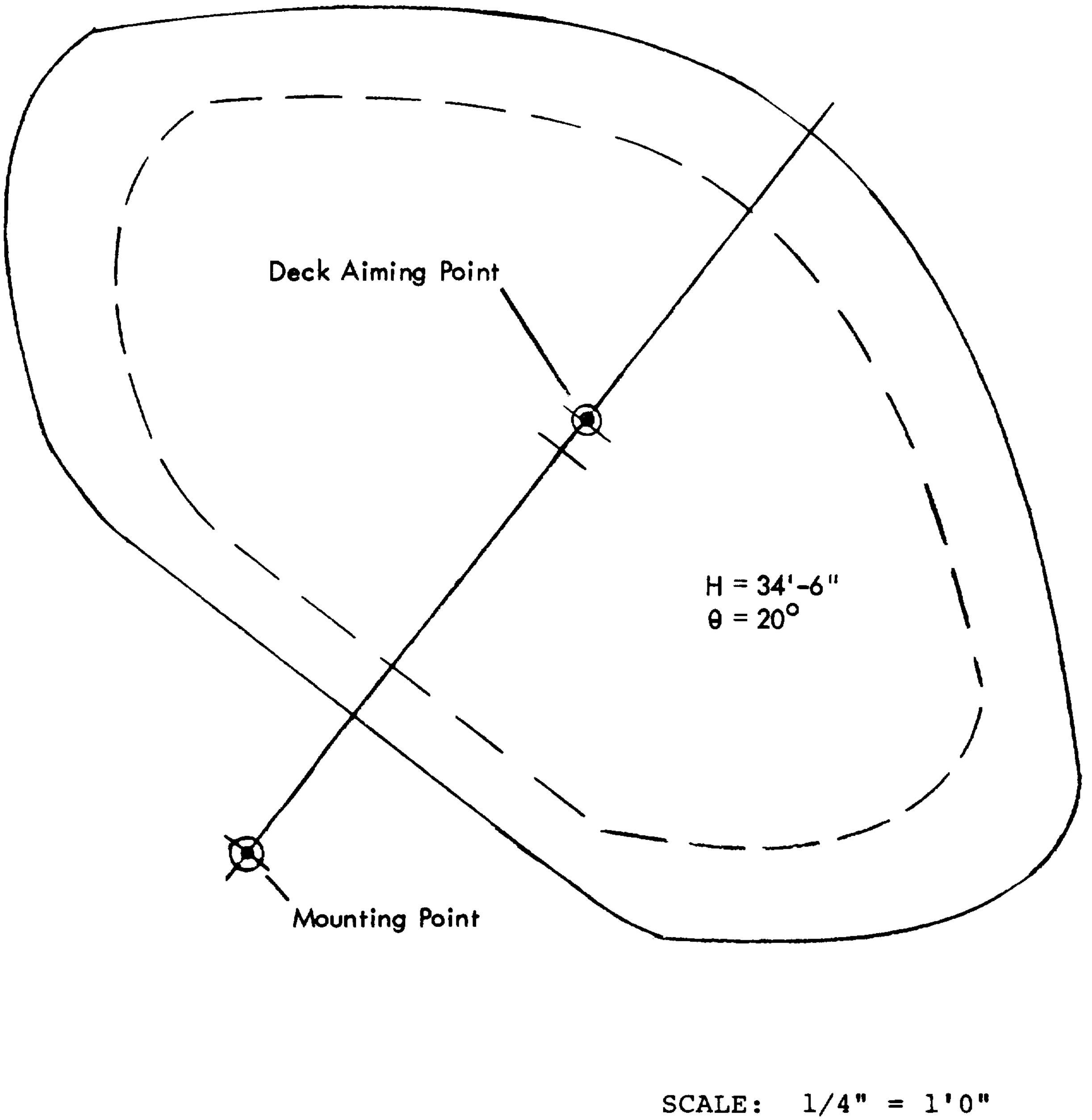
SH 964-D68

FIGURE 193. 300W WFL for H equals 34 feet 6 inches and θ equals 10 degrees.



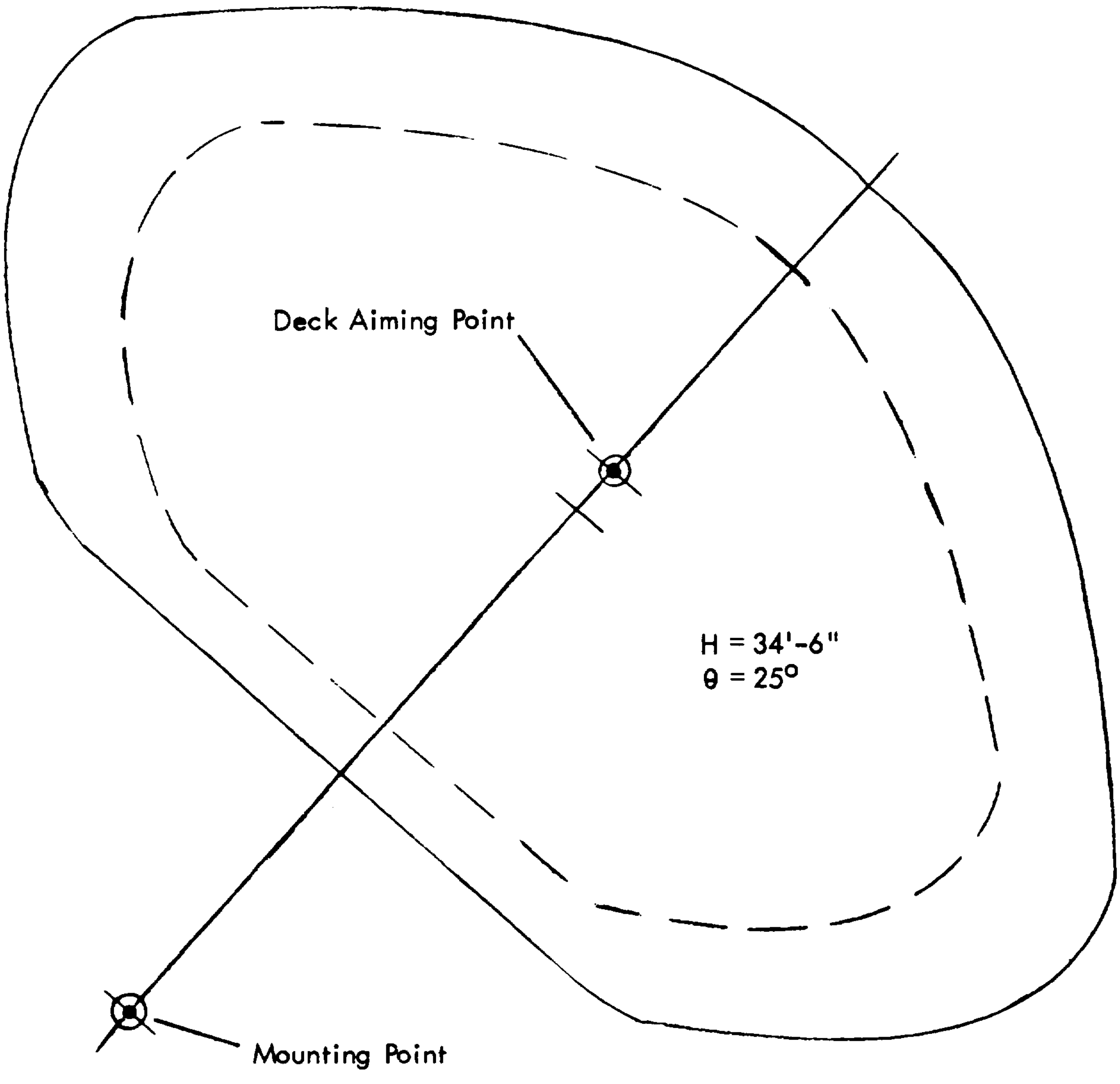
SH 964-D69

FIGURE 194. 300W WFL for H equals 34 feet 6 inches and θ equals 15 degrees.



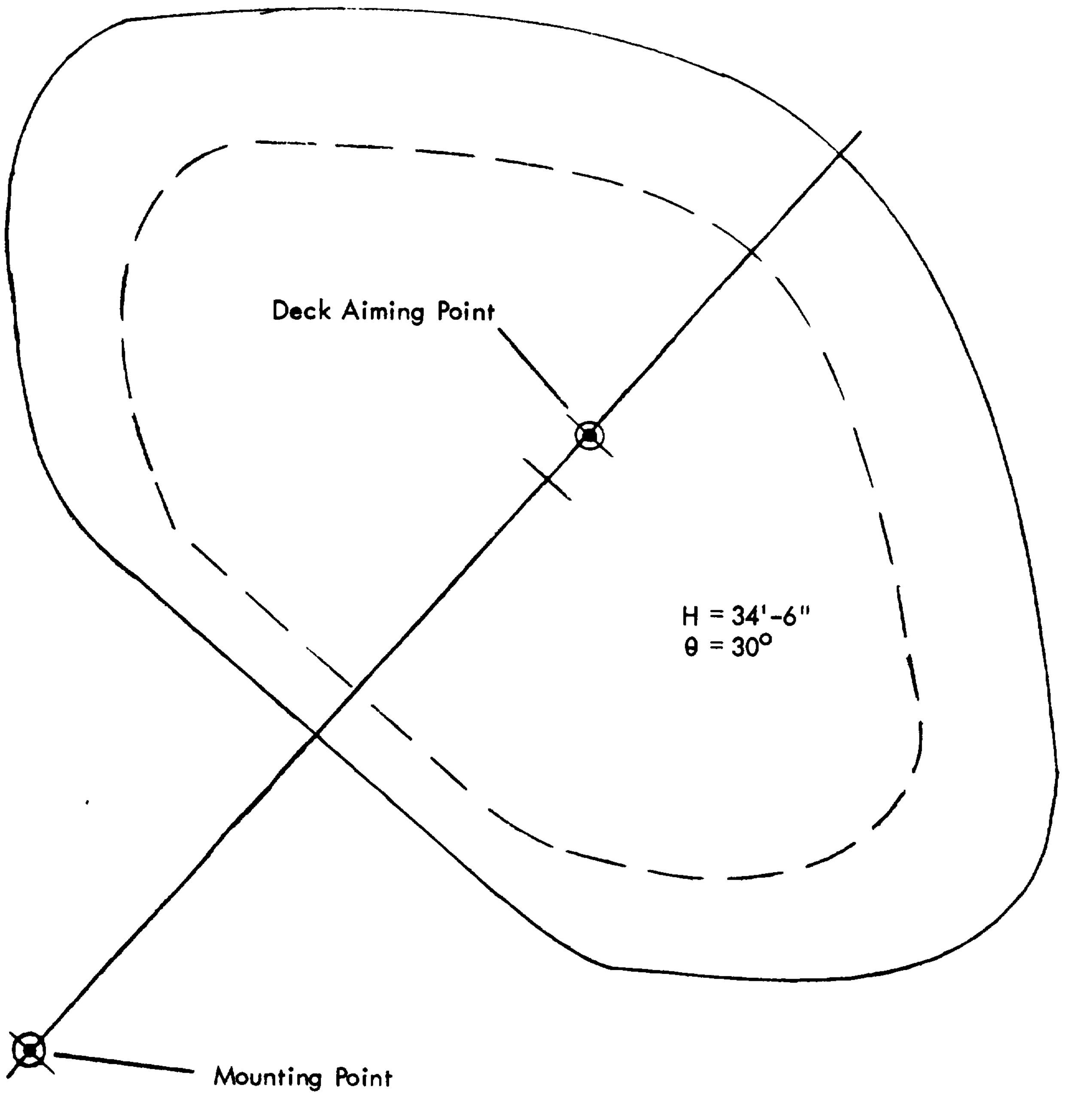
SH 964-D70

FIGURE 195. 300W WFL for H equals 34 feet 6 inches and θ equals 20 degrees.



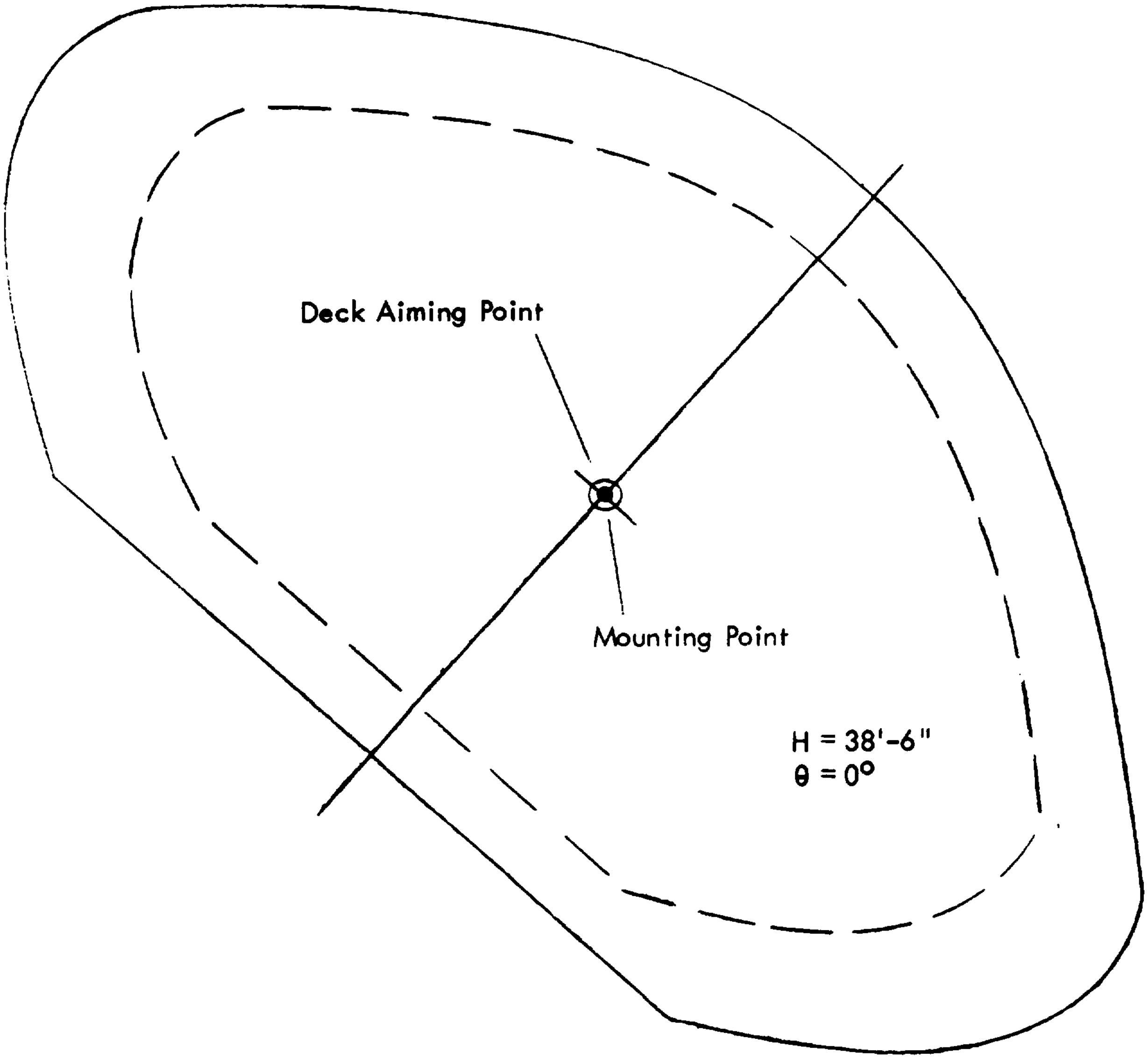
SH 964-D71

FIGURE 196. 300W WFL for H equals 34 feet 6 inches and θ equals 25 degrees.



SH 964-D72

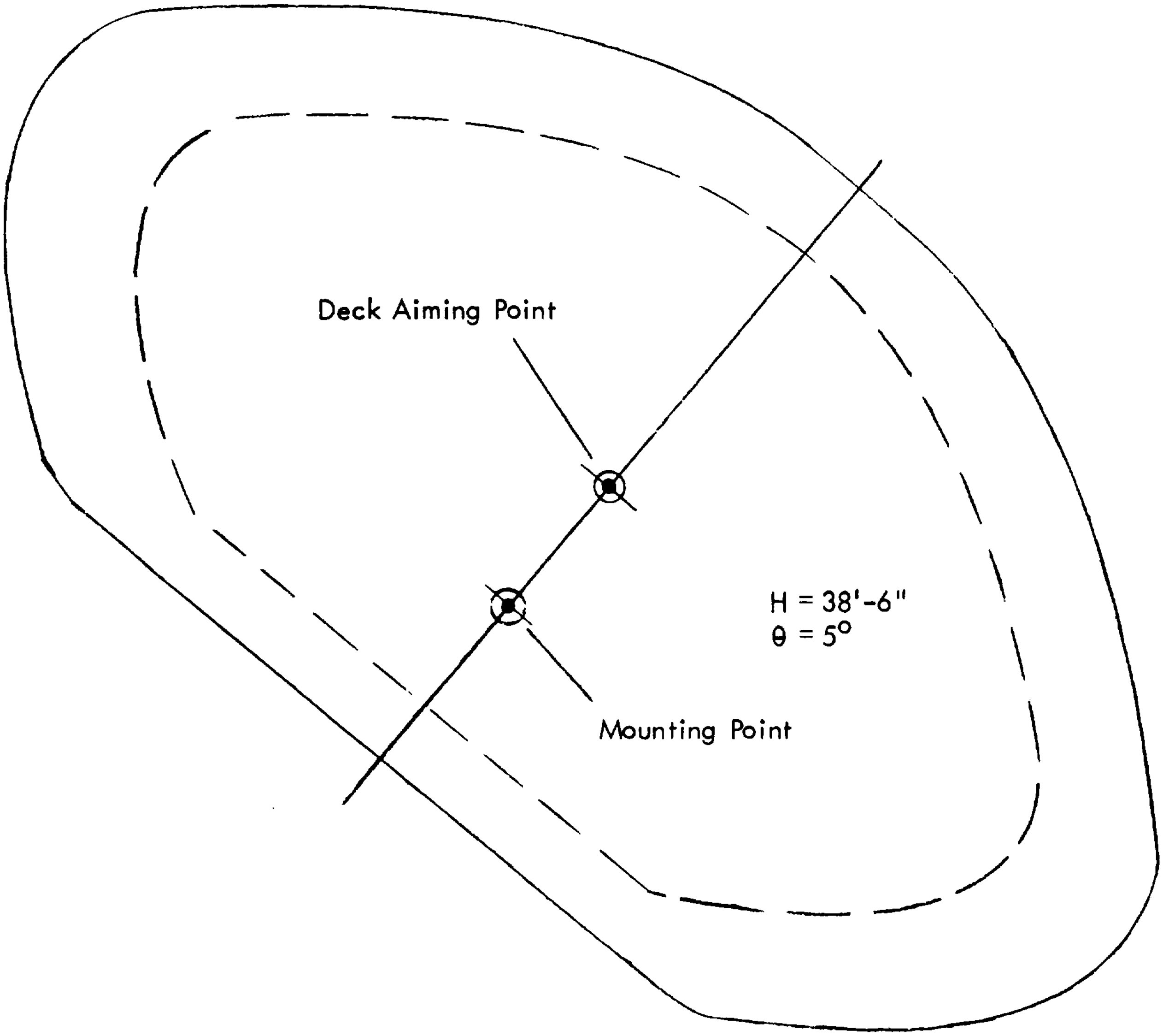
FIGURE 197. 300W WFL for H equals 34 feet 6 inches and θ equals 30 degrees.



SCALE: 1/4" = 1'-0"

SH 964-D73

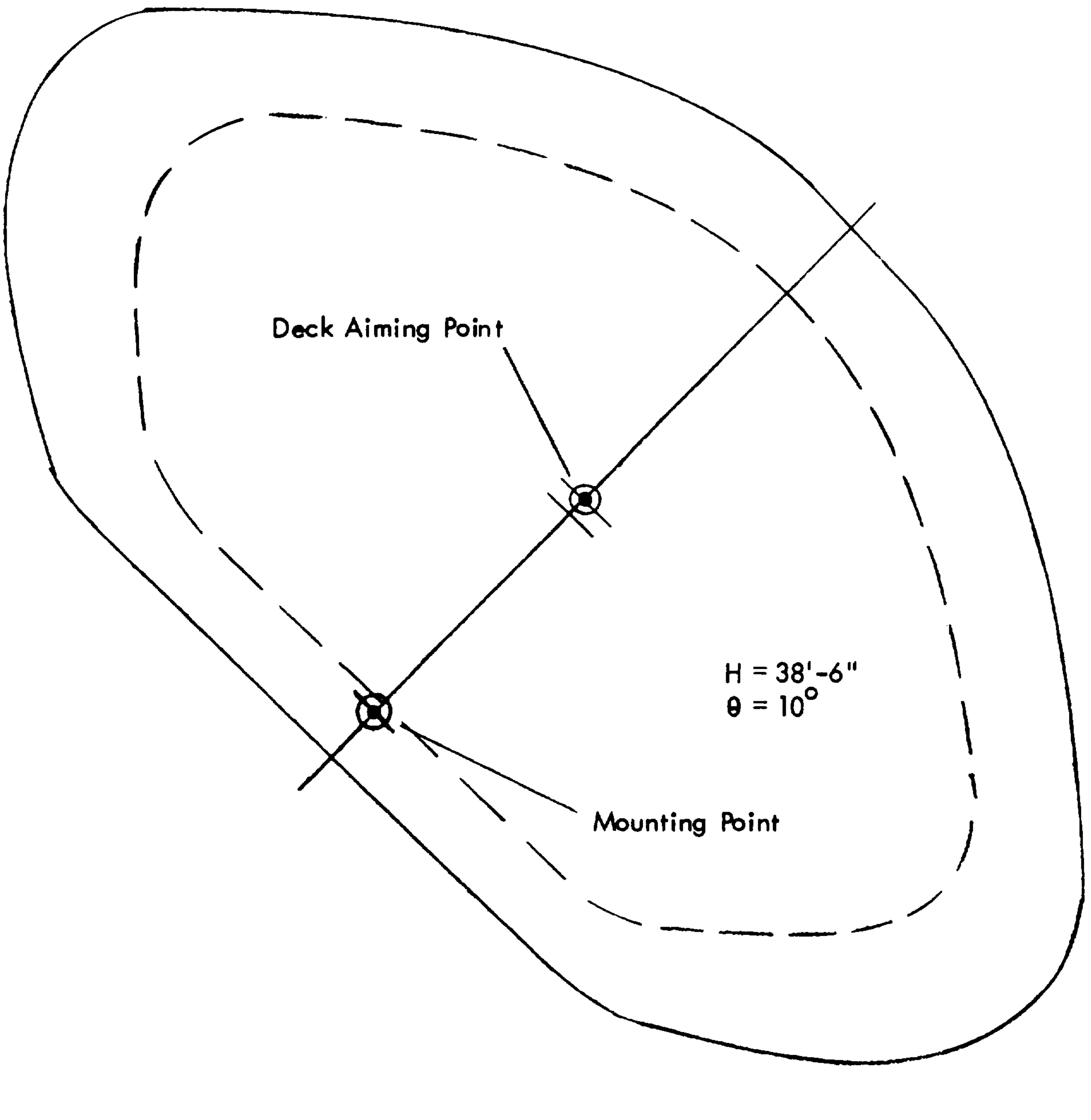
FIGURE 198. 300W WFL for H equals 38 feet 6 inches and θ equals 0 degrees.



SCALE: 1/4" = 1'-0"

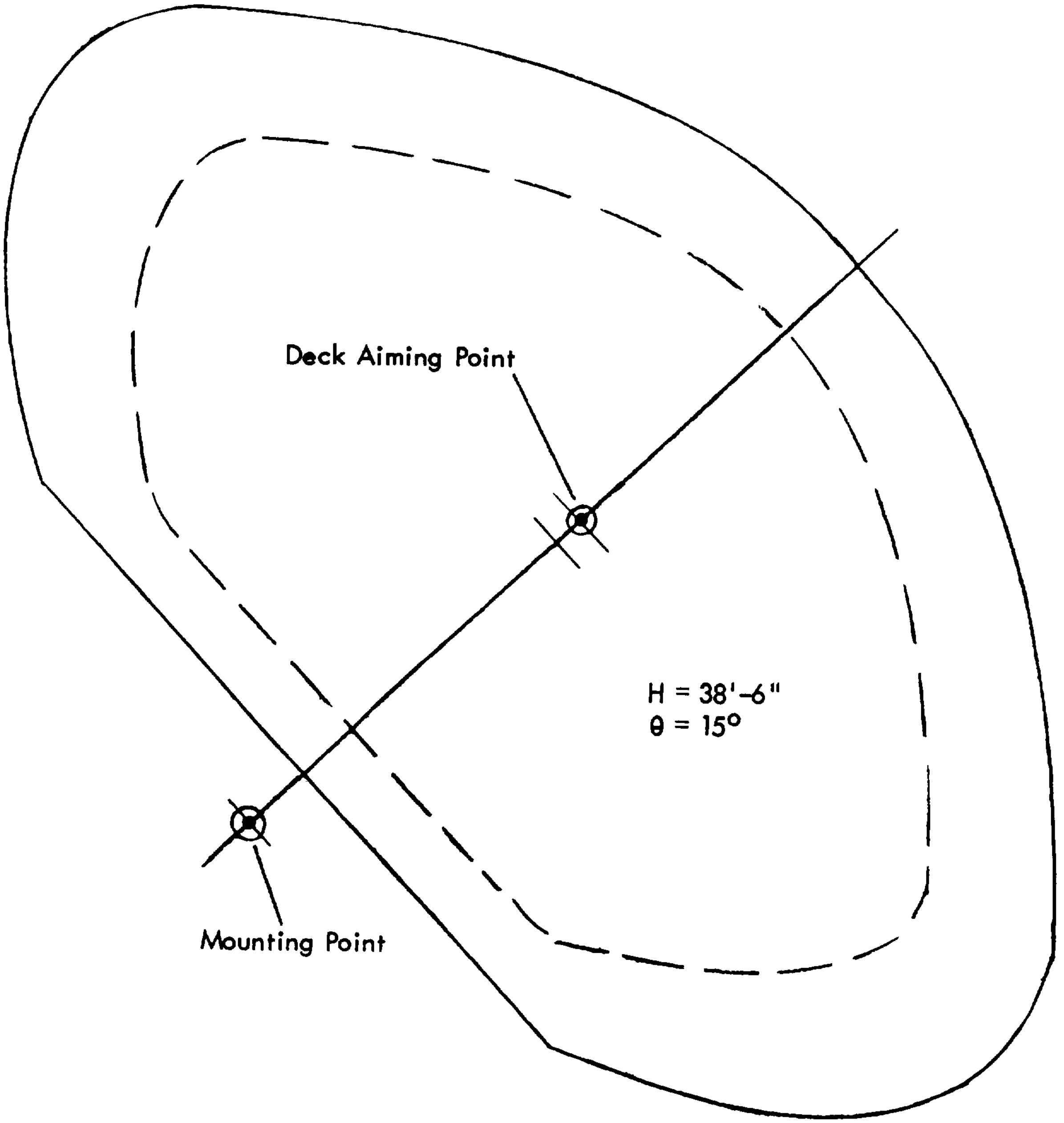
SH 964-D74

FIGURE 199. 300W WFL for H equals 38 feet 6 inches and θ equals 5 degrees.



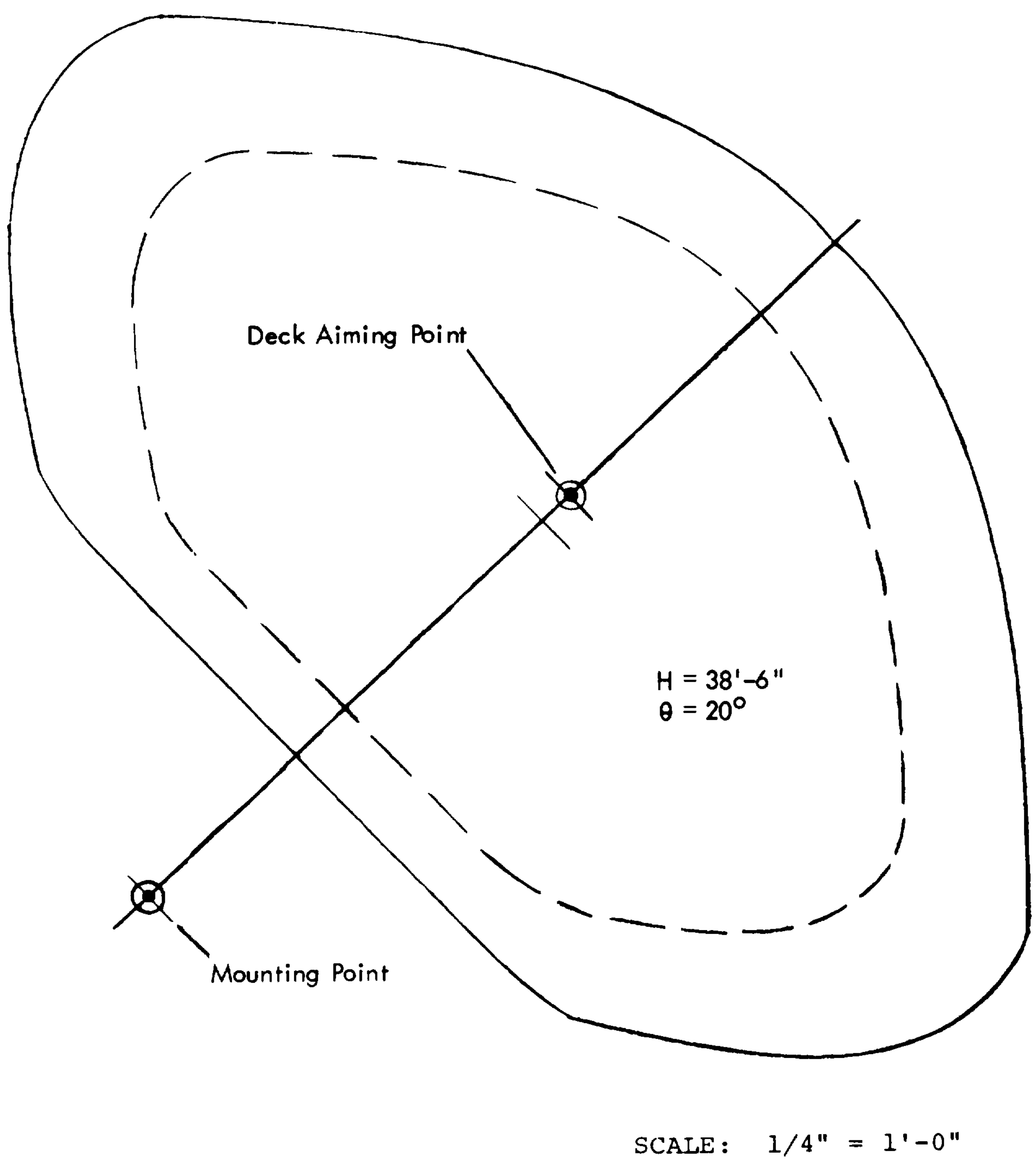
SH 964-D75

FIGURE 200. 300W WFL for H equals 38 feet 6 inches and θ equals 10 degrees.



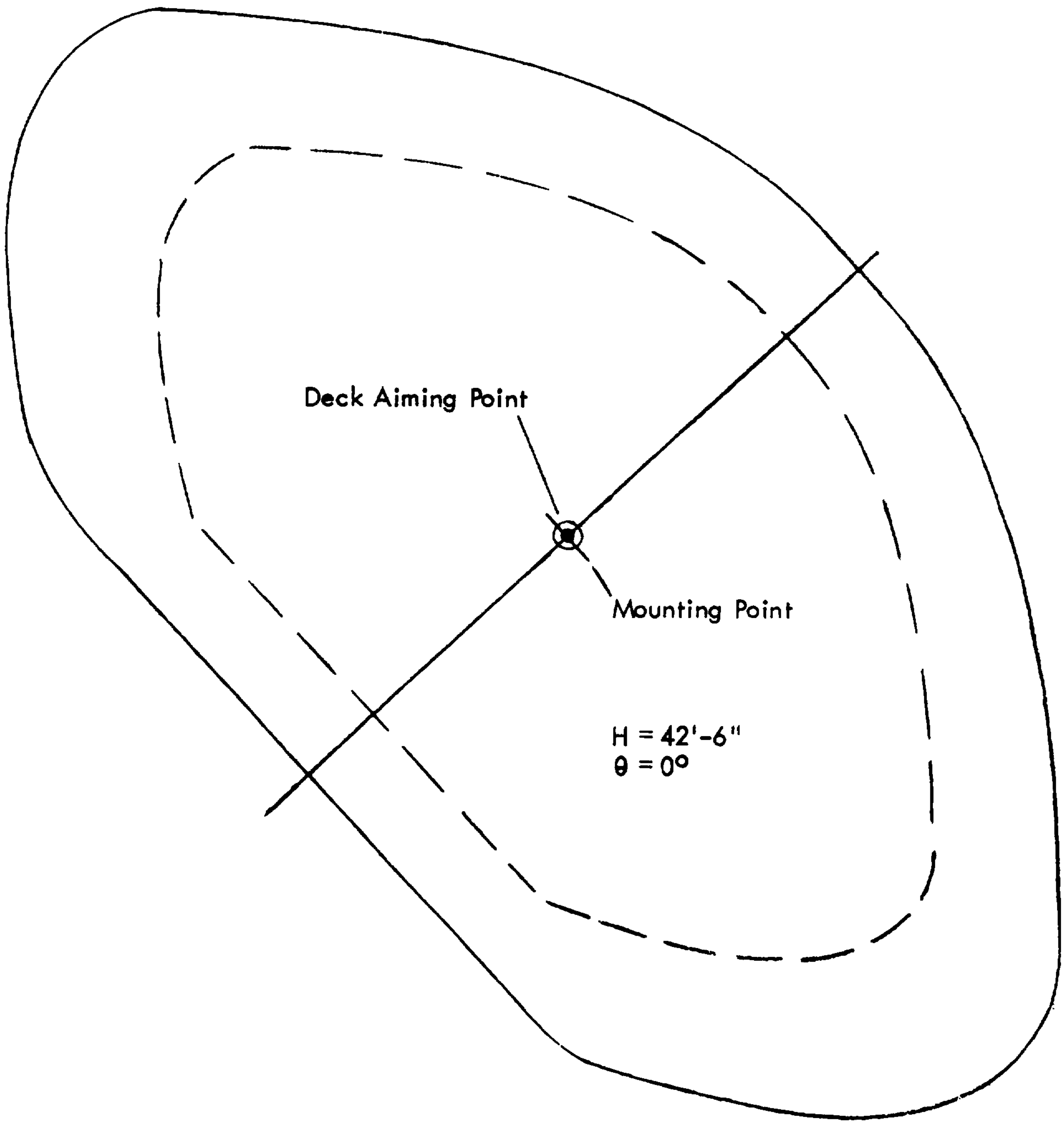
SH 964-D76

FIGURE 201. 300W WFL for H equals 38 feet 6 inches and θ equals 15 degrees.



SH 964-D77

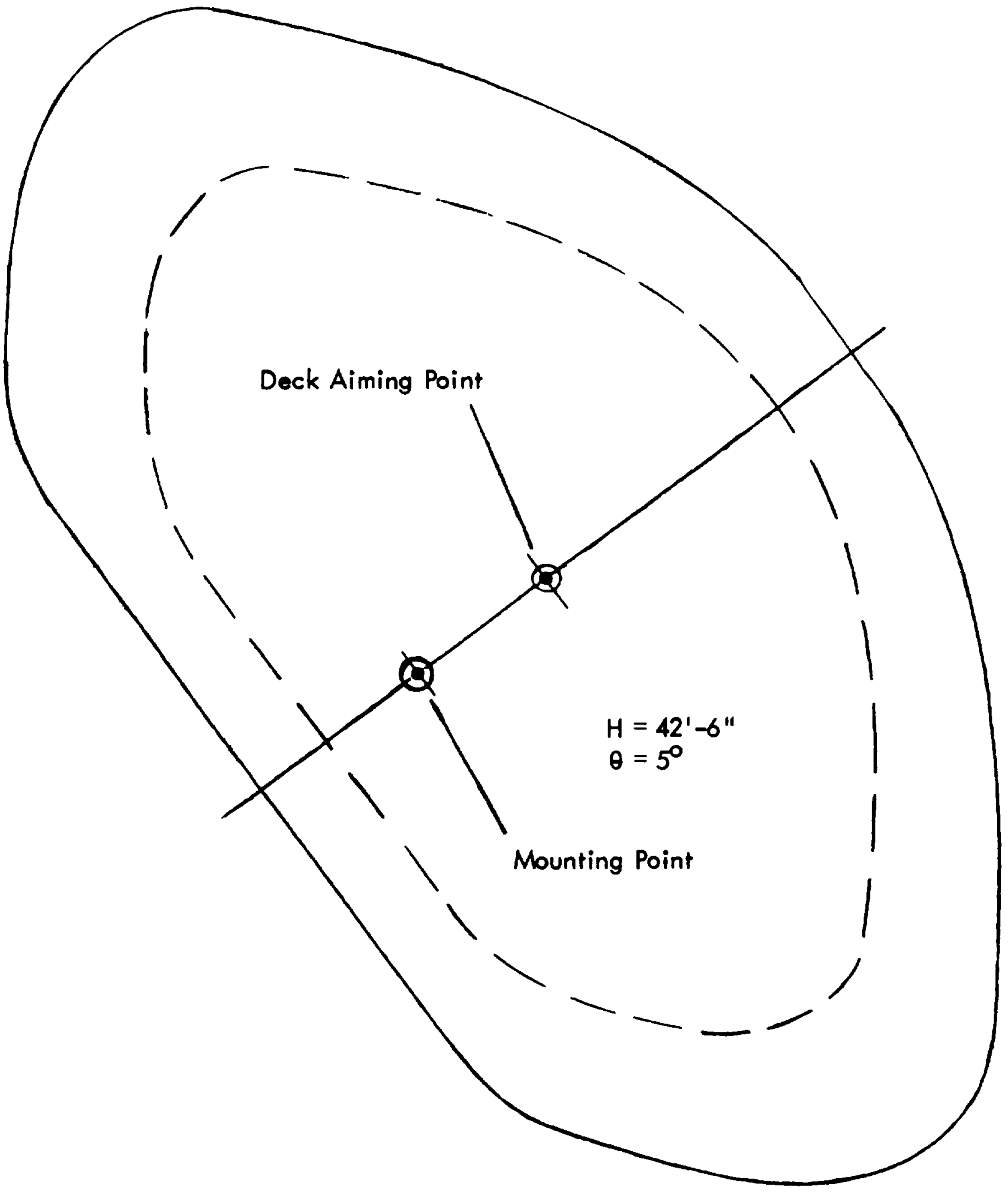
FIGURE 202. 300W WFL for H equals 38 feet 6 inches and θ equals 20 degrees.



SCALE: 1/4" = 1'-0"

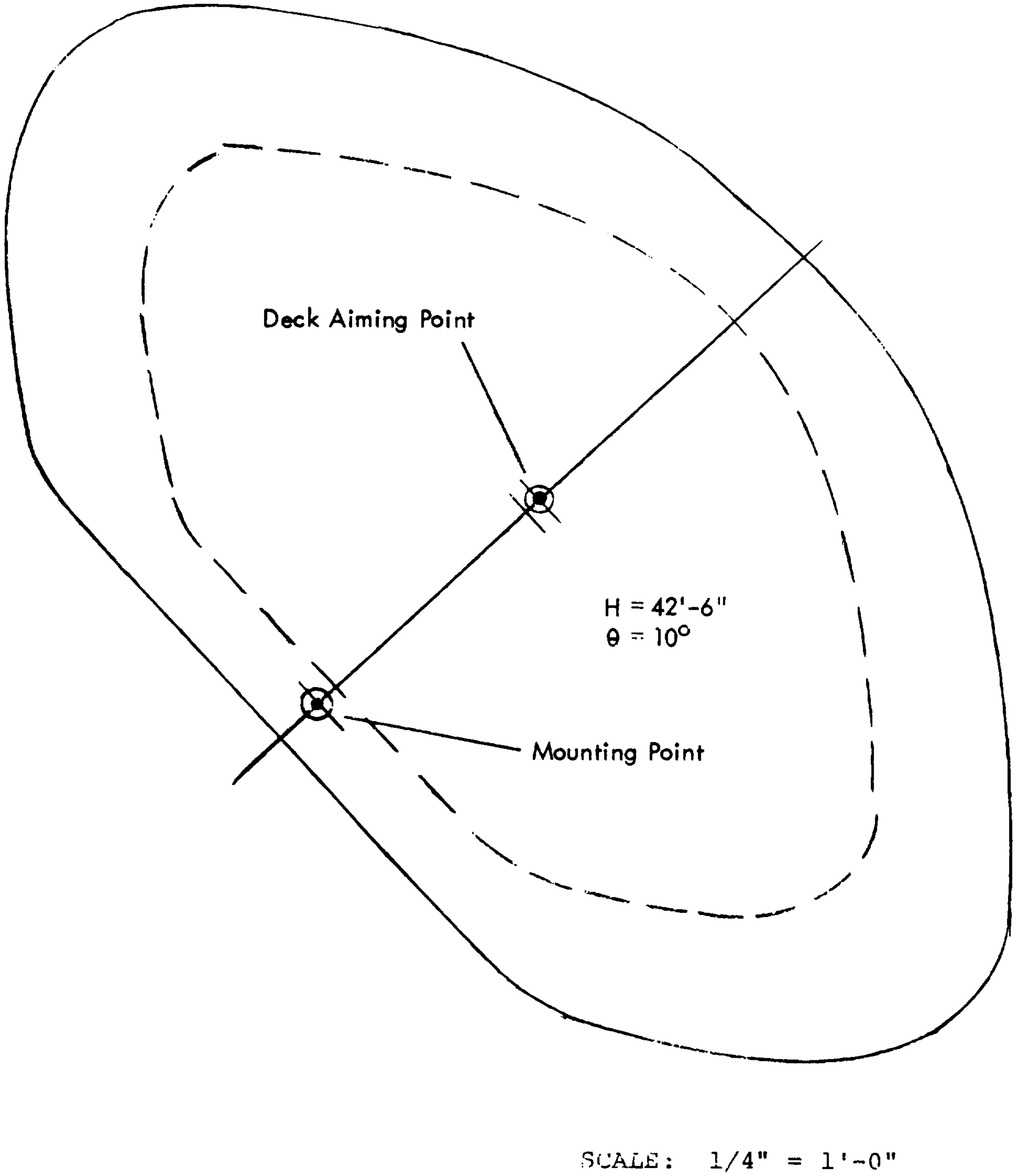
SH 964-D78

FIGURE 203. 300W WFL for H equals 42 feet 6 inches and θ equals 0 degrees.



SH 964-D79

FIGURE 204. 300W WFL for H equals 42 feet 6 inches and θ equals 5 degrees.



SH-964-D80

FIGURE 205. 300W WFL for H equals 42 feet 6 inches and θ equals 10 degrees.

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