INCH-POUND
M1L-S-16036K(SH)
4 August 1988
SUPERSEDING
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(See 6.9)

MILITARY SPECIFICATION

SWITCHGEAR, POWER, NAVAL SHIPBOARD

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

1. SCOPE

1.1 Scope. This specification covers the requirements for electrical power dead-front, deck-mounted switchgear for Naval shipboard use.

1.2 Classification. Switchgear shall be of the following types:

(a) Ship's power switchgear group for ships with alternating current (at) power.
(b) Emergency switchgear group for ships with ac power.
(c) Ship's service power switchgear group for ships with direct current (de) power,.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

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 5523, 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.

AMSC N/A
FSC 6110

SPECIFICATIONS

FEDERAL

A-A-208	- Ink, Marking, Stencil Opaque (Porous and Non-porous Surfaces).
L-P-387	- Plastic Sheet, Laminated, Thermosetting (for Designation Plates).
QQ-S-365	- Silver Plating, Electrodeposited: General Requirements for.
QQ-S-763	- Steel Bars, Wire, Shapes, and Forgings, Corrosion Resisting.
TT-C-490	- Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings.
TT-P-645	- Primer, Paint, Zinc Chromate, Alkyd Type.

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MIL-I-631	- Insulation, Electrical, Synthetic-Resin Composition, Nonrigid.
MIL-S-901	- Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.
MIL-E-917	- Electric Power Equipment, Basic Requirements (Naval Shipboard Use).
MIL-S-1222	- Studs, Bolts, Hex Cap Screws, Socket Head Cap Screws and Nuts.
MIL-I-1361	- Instrument Auxiliaries, Electrical Measuring: Shunts, Resistors, and Transformers.
MIL-R-2033	- Relays for Naval Shipboard Electrical Service.
MIL-C-2212	- Controller, Electric Motor A.C. or D.C., and Associated Switching Devices.
MIL-R-2729	- Regulator Sets, Voltage, A.C. Generator, Naval Shipboard Use.
MIL-I-3158	- Insulation Tape, Electrical Glass-Fiber (Resin-Filled): and Cord, Fibrous-Glass.
MIL-L-3661	- Lampholders, Indicator Lights, Indicator-Light Housings, and Indicator-Light Lenses, General Specification for.
MIL-L-3661/38	- Housings, Indicator-Light, Style LH80.
MIL-L-3661/62	- Lampholder, Lights, Indicator (Housing), Style LH95 (for D.C. Applications).
MIL-L-3661/63	- Lampholder, Lights, Indicator (Housing), Style LH96.
MIL-L-3661/64	- Lampholder, Lights, Indicator (Housing), Style LH97.
MIL-L-3661/65	- Lampholder, Lights, Indicator (Housing), Style LH98,
MIL-P-15024	- Plates, Tags and Bands for Identification of Equipment.
MIL-P-15024/5	- Plates, Identification.
MIL-E-15090	- Enamel, Equipment, Light-Gray (Formula No. 111).
MIL-T-15108	- Transformers, Power, Step-Down, Single-Phase, 60-Hertz, 1-Kilovoltampere Approximate Minimum Rating, Dry Type, Naval Shipboard.

MILITARY (Continued)

MIL-R-15109 - Resistors and Rheostats, Naval Shipboard.
MIL-F-15160 - Fuses: Instrument, Power, and Telephone.
MIL-T-15377 - Temperature Monitor Equipment Naval Shipboard.
MIL-M-16034 - Meters, Electrical-Indicating (Switchboard and Portable Types).
MIL-I-16103 - Indicator, Phase Sequence, Switchboard and Panel.
MIL-S-16104 - Synchroscope.
MIL-M-16125 - Meters, Electrical, Frequency.
MIL-C-16173 - Corrosion preventive Compound, Solvent Cutback, . Cold-Application.
MIL-T-16315 - Transformers, Power, Step-Down (Miscellaneous, Naval Shipboard Use).
MIL-T-16366 - Terminals, Electrical Lug and Conductor Splices, Crimp-Style.
MIL-W-16878 - Wire, Electrical, Insulated, General Specification for.
MIL-W-16878/3 - Wire, Electrical, Polyvinyl Chloride (PVC) Insulated, 105°C, 3000 Volts.
MIL-C-17361 - Circuit Breakers, Air, Electric, Insulated Housing (Shipboard Use).
MIL-E-17555 - Electronic and Electrical Equipment, Accessories, and Provisioned Items (Repair Parts): Packaging of l
MIL-C-17587 - Circuit Breakers, Low Voltage, Electric Power, Air, Open Frame, Removable Construction.
MIL-C-17588 - Circuit Breakers (Automatic-ALB-1) and Switch, Toggle (Circuit Breaker, Non-Automatic-NLB-1), Air, Insulated Housing, 125 Volts and Below, A.C. and D.C., (Naval Shipboard Use).
DOD-S-17773 - Switches, Bus Transfer, Electric Power, Automatic and Manual. (Metric)
MIL-S-18396 - Switches, Meter and Control, Naval Shipboard.
MIL-W-19088 - Wattmeters, Switchboard Type, 4-1/2-Inch.
MIL-F-19207 - Fuseholders, Extractor Post Type, Blown Fuse Indicating and Nonindicating General Specification for.
MIL-F-19207/1 - Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL10U and FHL10G.
MIL-F-19207/2 - Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL11U and FHL11G.
MIL-F-19207/3 - Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL12U and FHL12G.
MIL-F-19207/5 - Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL14G.
MIL-F-19207/21 - Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL32W.
MIL-F-19207/22 - Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL33W.
MIL-F-19207/23 - Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL34W.
MIL-F-19207/24 - Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL35W.

MILITARY (Continued)

MIL-R-19523 - Relays, Control, Naval Shipboard.
MIL-F-21346 - Fuseholders, Block, and Shroud Type, and Associated Fuse Clips; General Specification for.
MIL-F-21346/1 - Fuse Clip, Electrical; Styles FC21, FC22, FC23, and FC25.
MIL-S-21604 - Switches, Rotary, Multipole and Selector; General Specification for.
MIL-S-21604/5 - Switch, Rotary, Multipole and Selector, 10 Ampere, Style JR.
MIL-E-22118 - Enamel, Electrical-Insulating.
MIL-V-23151 - Voltmeter, Expanded Scale Switchboard Type (Naval Shipboard Use).
MIL-M-23167 - Meter, Frequency, Expanded Scale Switchboard Type (Naval Shipboard Use).
MIL-S-24188 - Synchronizing Control Equipment, 60 Cycles, 450 Volts, Naval Shipboard.
MIL-M-24350 - Monitor, Reverse Power, Electrical Power (Naval Shipboard Use).
MIL-I-24391 - Insulation Tape, Electrical, Plastic Pressure-Sensitive.
MIL-T-24552 - Terminals and Seals, Plugs and Switch, Casualty Power Systems, Receptacle Type, General Specification for.
MIL-T-24552/1 - Terminals and Seals, Plugs and Switch, Casualty Power, Receptacle Type, Back Connected 200-Ampere, 450-Volt, Alternating Current, Three-Phase, Symbol No. 1046.
MIL-T-24552/2 - Terminals and Seals, Plugs and Switch, Casualty Power, Receptacle Type, Upper and Lower Riser 200-Ampere, 450-Volt, Alternating Current, Three-Phase, Symbol No. 1047.
MIL-R-24563 - Relay, Alternating Current, Power-Sensing.
MIL-R-28750 - Relay, Solid State, General Specification for.
MIL-R-28803 - Readouts, Segmented, General Specification for.
MIL-H-46855 - Human Engineering Requirements for Military Systems, Equipment and Facilities.
MIL-T-55156 - Terminals, Lugs; Splices, Conductor; Screw Type, General Specification for.
MIL-T-55164 - Terminal Boards, Molded, Barrier, Screw and Stud Types, and Associated Accessories, General Specification for.
MIL-T-55164/2 - Terminal Boards, Molded, Barrier, Screw Type, Class 38TB.
MIL-T-55164/3 - Terminal Boards, Molded, Barrier, Screw Type, Class 39TB.

STANDARDS

MILITARY

MIL-STD-12 - Abbreviations for Use on Drawings, and in Specifications, Standards and Technical Documents.

MILITARY (Continued)

MIL-STD-108 - Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment.
MIL-STD-109 - Quality Assurance Terms and Definitions.
MIL-STD-167-1 - Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type 11 - Internally Excited).
MIL-STD-248 - Welding and Brazing Procedure and Performance Qualification.
MIL-STD-278 - Welding and Casting Standard.
MIL-STD-461 - Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.
MIL-STD-462 - Electromagnetic Interference Characteristics, Measurement of.
MIL-STD-471 - Maintainability Verification/Demonstration/Evaluation.
DOD-STD-2000-4 - General Purpose Soldering Requirements for Electrical and Electronic Equipment.
MS17831 Bus Disconnect Quick Opening Symbol 1484.
MS17832 Operating Wrench, Bus Disconnect Symbol 1485.

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

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

0362-LP-235-2000 - Wire Bundling Current Rating of Wire Bundles in Control and Instrumentation Equipment, Type ABT-S, TM.
TE000-AB-GTP-010 - Parts Application and Reliability Information Manual for Navy Electronic Equipment.

DEPARTMENT OF LABOR

Code of Federal Regulations, Title 29
Part 1910 - Occupational Safety and Health Standards.

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

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

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SP 2 - Surface Preparation Specification No. 2 Hand Tool Cleaning.

SP 3 - Surface Preparation Specification No. 3 Power Tool Cleaning. (DoD adopted)

(Application for copies should be addressed to the Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh, PA 15213.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A 131 - Standard Specification for Structural Steel for Ships.

A 167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip. (DoD adopted).

A 240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels. (DoD adopted)

A 457 - Standard Specification for Hot-Worked, Hot-Cold-Worked, and Cold-Worked Alloy Steel Plate, Sheet, and Strip for High Strength at Elevated Temperatures.

A 570 - Standard Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality. (DoD adopted)

A 666 - Standard Specification for Austenitic Stainless Steel, Sheet, Strip, Plate, and Flat Bar for Structural Applications. (DoD adopted)

B 36 - Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar. (DoD adopted)

B 98 - Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes. (DoD,adopted)

B 121 - Standard Specification for Leaded Brass Plate, Sheet, Strip, and Rolled Bar. (DoD adopted)

B 127 - Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip. (DoD adopted)

B 164 - Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire. (DoD adopted)

B 187 - Standard Specification for Copper Bus Bar, Rod, and Shapes. (DoD adopted)

B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate. (DoD adopted)

B 221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes (Metric). (DoD adopted)

B 317 - Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, and Structural Shapes for Electrical Purposes (Bus Conductor). (DoD adopted)

B 371 - Standard Specification for Copper-Zinc-Silicon Alloy Rod.

B 411 - Standard Specification for Copper-Nickel-Silicon Alloy Rod and Bar. (DoD adopted)

B 564 - Standard Specification for Nickel Alloy Forgings. (DoD adopted)

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Nongovernment 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.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order, a sample shall be subjected to first article inspection (see 4.4 and 6.3).

3.2 General requirements.

3.2.1 Safety. The switchgear shall provide fail-safe features for safety of personnel during the installation, operation, maintenance, and repair or interchanging of a complete equipment assembly or component parts thereof. Equipment design for personnel safety shall be equal to or better than the appropriate requirements of the Occupational Safety and Health Act (OSHA) as identified in Title 29, Part 1910, of the Code of Federal Regulations (CFR). Except as required herein, safety shall be in accordance with MIL-E-917.

3.2.2 Accidental contact. The switchgear shall provide protection to personnel against accidental contact with voltages in excess of 30 volts root mean square (rms) or dc with all removable,.panels in place and hinged doors closed.

3.3 Detailed requirements.

3.3.1 Materials, parts, and process. Unless otherwise required, materials, parts, and processes shall be in accordance with MIL-E-917. When a requirement of MIL-E-917 conflicts with a requirement of this specification, the requirement of this specification shall govern.

(a) Materials.
(b) Prohibited materials.
(c) Metals or coating.
(d) Threaded parts and fastening devices.
(e) Electrical insulation.
(f) Soldering.
(g) Brazing.

3.3.1.1 Switchgear groups. Whether or not specifically mentioned for the various units, switchgear groups shall be complete with all devices required to accomplish the function specified hereinafter.

3.3.1.2 Cadmium. Elemental cadmium shall not be present in any component of the final product.

3.3.1.3 Mercury. Mercury shall not be used in any process of manufacture or test of switchgear and its components.

3.3.2 Recovered materials. Unless otherwise specified herein, all equipment, material, and articles incorporated in the products covered by this specification shall be new and may be fabricated using materials produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. The term "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products is allowed under this specification unless otherwise specifically specified.

3.3.3 Component derating. Components shall be derated in accordance with NAVSEA TE000-AB-GTP-010 and applicable paragraphs of this specification.

3.4 Construction. Except as otherwise specified, the equipment shall conform to the general requirements of MIL-E-917 (see 4.6.3.1) and the human engineering requirements of MIL-H-46855. Whether or not specifically mentioned for the various units, switchgear groups shall be complete with all devices required to accomplish the functions specified herein.

3.4.1 Ship's service power switchgear group)see6.5.3) for ships having ac power.

3.4.1.1 Ac generator control unit for switchgear groups having an electric plant control panel (EPCP) or having both an EPCP and an electric plant control console (EPCC) (see figure 1 for a typical one-line diagram . The following shall be mounted on or within the unit:

(a) One generator circuit breaker.
(b) One control power transformer 450/120 volt, connected to generator side of circuit breaker, for generator circuit breaker and governor motor control circuits, if required.
(c) Potential transformers for metering and relaying, electric governor, and synchronizing, in number as required.
(d) Current transformers for metering and relaying and for electric governor, in number as required. Protective device when metering is remote.
(e) One current transformer with protective device for remote metering, where remote metering is required.
(f) Fuse panel for fusing of the potential and control transformer primary circuits and any control circuits extending outside of the section.
(g) Space, mounting, and wiring for the voltage regulator equipment, including associated current and potential transformers. Equipment shall be furnished with the generators (see 6.2.1).
(h) One circuit breaker (see 3.12), type AQB-A or AQB-LF, 250 ampere frame size. The casualty power circuit breaker shall be connected to the generator side of the generator circuit breaker. When the generator capacity is 500 kilowatts (kW) or greater, two casualty power circuit breakers shall be furnished.

(i) One casualty power terminal, riser type, conforming to MIL-T-24552, connected through the AQB-A or AQB-LF circuit breaker, item (h). When the generator capacity is 500 kW or greater, two casualty power terminals, riser type, shall be furnished.
(j) One reverse power relay, conforming to MIL-M-24350, to prevent the generator from motoring on the bus after loss of driving power from the prime mover.
(k) One indicator light (blue) to indicate that the generator circuit breaker is closed.
(1) One generator running and voltage available auxiliary relay for control of associated indicator lights.
(m) Space, mounting, and wiring for the electric governor equipment, if required (see 6.2.1). Equipment shall be furnished with the generator set.

3.4.1.1.1 Ac generator control unit for switchgear groups on ships provided with a centralized machinery control system including an EPCC, but not an EPCP. The following shall be mounted within the unit:

(a) One generator circuit breaker electrically operated.
(b) One control power transformer 450/120 volts, connected to generator side of generator circuit breaker, for generator breaker and governor motor control circuits, if required.
(c) Potential transformer for metering and relaying, electric governor, and synchronizing, in number as required.
(d) Current transformers, for metering and relaying, and for electric governor, in number as required. Protective device when metering is remote.
(e) One current transformer with protective device for remote metering.
(f) Fuse panel for fusing of the potential and control transformer primary circuits and any control circuits extending outside of the section.
(g) Space, mounting, and wiring for the voltage regulator equipment, including associated current and potential transformers. Equipment shall be furnished with the generators (see 6.2.1).
(h) Relays for remote control of the generator circuit breaker. Relays shall be energized from EPCC power.
(i) Load sensing relays in accordance with MIL-R-24563 to sense generator overload and activate the load shedding system, if required (see 6.2.1).
(j) One type AQB-A or AQB-LF circuit breaker (see 3.12), instantaneous element only, for power supply to the pump supplying cooling (sea) water to the generator diesel or gas turbine prime mover. Circuit breaker shall be connected on the generator side of the generator circuit breaker. A red warning instruction plate shall be provided stating that the circuit breaker shall always be in the closed position when the gas turbine or diesel are set up for starting.

(k) One circuit breaker (see 3.12), type AQB-A or AQB-LF, 250 ampere frame size. Casualty power circuit breaker shall be connected to the generator side of the generator circuit breaker. When the generator capacity is 500 kW or greater, two casualty power circuit breakers shall be furnished.
(l) One casualty power terminal, riser type, conforming to MIL-T-24552 connected through the AQB-A or AQB-LF circuit breaker, item (k). When the generator capacity is 500 kW or greater, two casualty power terminals, riser type, shall be furnished.
(m) One reverse power relay, conforming to MIL-M-24350, to prevent the generator from motoring on the bus after loss of driving power from prime mover.
(n) One generator running and voltage available auxiliary relay for control of associated indicator lights. This relay is not required when a supervisory control system (SCS) is incorporated in the EPCC, and the signal can be derived from generator voltage and speed signals.
(o) Space, mounting, and wiring for the electric governor equipment, if required (see 6.2.1). Equipment shall be furnished with the generator set.
(P) One type I synchronizing system for each switchgear group. The synchronizing control system may be mounted in the bus tie unit instead of the generator control unit.
(q) One type 11 automatic paralleling device, if required (see 6.2.1). The automatic paralleling system may be mounted in the bus tie unit instead of the generator control unit.

3.4.1.1.1.1 The following shall be mounted on the front panel of the generator unit:

(a) One ac ammeter for reading one phase of generator current.
(b) One ac voltmeter with transfer switch for reading one phase of generator potential and one phase of each bus tie voltage and one phase of shore power voltage for switchgear group containing shore power connection.
(c) One polyphase wattmeter for reading generator output.
(d) One frequency meter with transfer switch for reading frequency of generator and each bus tie frequency and shore power for switchgear group containing shore power connection.
(e) One control switch for control of the generator circuit breaker.
(f) Control switches as required in conjunction with the governor speed regulation of the generator prime mover (see 6.2.1).
(g) One local/remote control transfer switch for the purpose of transferring control from the local station to the EPCC. Monitoring and indicating circuits shall not be transferred except as noted below. Circuits transferred by this switch shall include:

(1) Generator starting and stopping. Remote generator starting shall be transferred by the switch. Remote generator stopping shall be locked out when the switch is in the local position. Local stopping and remote emergency stopping shall be effective regardless of the position of the switch.

(2) Generator output voltage control.
(3) prime mover governor manual control.
(4) Voltage regulator mode selection.
(5) Governor mode selection.
(6) Circuit breaker control of all circuit breakers which are controlled at the EPCC. This shall include control of the synchronizing control system. Local automatic protection such as reverse power protection shall remain operative regardless of the position of the local/remote transfer switch.
(7) Elements of the generator green light circuit which are duplicated locally and at the EPCC.
(8) Local/remote transfer switch position indication.

(h) Local/remote transfer switch position indicator (white).
(i) One control switch with white indicator light for control of the generator space heaters when provided with the generator (see 6.2.1).
(j) Control switches, rheostats, and similar equipment that is designed for panel mounting and is required in conjunction with the voltage regulator equipment mounted in the generator unit shall be mounted and operated from the front panel (see 6.2.1).
(k) For installation in which a bus tie unit is not provided, one set of three ground indicator lights with a control switch to indicate ground on the main bus or its connected feeders.
(l) One synchroscope and one set of synchronizing lights with selector switch for synchronizing with the main bus, the main bus with the bus tie circuit and the bus tie with shore power for switchgear group containing shore power connection.

(1) For synchronizing monitor devices (type I) and automatic paralleling devices (type II):

a. System selector switch for selecting the system to be paralleled. This switch may be combined with the synchroscope selector switch.
b. An indicator light (white) to indicate that the synchronizing control system is energized.

(2) For synchronizing monitor devices the following applies:

a. Synchronizing control monitor operating mode selector switch having Operating, Test, and Off positions.

(3) For automatic paralleling devices the following applies:

a. One operating mode selector switch having Automatic, Manual Permissive, Test, and Off positions.
b. One pushbutton control switch for initiation of the automatic paralleling operation.
c. An indicator light (red) to indicate that the synchronizing control equipment is unable to close the circuit breaker when in the automatic mode.

d. A pushbutton to interrupt the automatic paralleling cycle to completion of paralleling.
e. Indicating devices as required by MIL-S-24188.

(m) Test receptacles with test plugs for connecting portable instruments to the metering current and potential circuits. Removal of the receptacle protective cover shall automatically short circuit the secondary winding of metering current transformers so that only the meters are electrically removed from the circuit.
(n) One temperature indicator with select switch and accessories, when temperature detectors are provided with the generator (see 6.2.1).
(0) One indicator light (blue) to indicate that the generator circuit breaker is closed.

3.4.1.1.2 Ac bus tie unit for switchgear groups on ships provided with a centrailized machinery control system including an EPCC, but not an EPCP. The following shall be mounted within the unit:

(a) One electrically operated bus tie circuit breaker.
(b) One feeder circuit breaker.
(c) Necessary disconnecting devices for performing isolating functions as may be required (see 6.2.1).
(d) Potential transformers, for metering and relaying, and for synchronizing, in number as required for the bus connections of the switchgear group.
(e) One current transformer for metering the current interchange through the bus tie circuit breaker.
(f) Fuse panel for fusing the potential and control power transformer primary circuits.
(g) Transfer relays to automatically transfer the source of circuit breaker closing power between the switchboard bus and bus tie.
(h) Relays for remote control of the bus tie circuit breaker. Relays shall be energized from EPCC power.

Bus tie units of the switchgear group containing the shore power connection shall be designated as a “bus tie and shore power unit”. In addition, this unit shall substitute item (i) for the feeder circuit breaker, and items (j), (k), and (1) as follows shall be added:

(i) Circuit breakers, type AQB-LF, motor operated, 400 ampere frame size, to be furnished on only one bus tie unit of any switchgear group. One shall be provided for each shore power receptacle. Shore power circuit shall be connected to the bus tie circuit so that power may be fed to either the local or remote switchboard through a bus tie circuit breaker. Where more than four circuit breakers are required, a separate switchgear unit may be provided.
(j) Current transforurs for metering the total shore power current.
(k) potential transformers for metering and synchronizing, in number as required.
(l) Relays for remote control of the shore power circuit breaker motor operators. Motor operators shall be controlled from the local switchboard.

3.4.1.1.2.1 Front panel. The following shall be mounted on the front panel of the bus tie unit:

(a) One control switch for control of the bus tie circuit breaker.
(b) Indicator lights (blue) to show the closed position of the bus tie circuit breaker and the type ACB (see 3.12) feeder circuit breaker.
(c) One set of three indicator lights with a control switch to indicate ground conditions on the main bus or any of its connected feeders.
(d) One ac ammeter for indicating the bus tie current.
(e) One zero neutral wattmeter for reading bus tie power and direction of power flow.

3.4.1.1.2.2 Bus tie and shore power unit. When this unit is designated a bus tie and shore power unit the following additional devices shall be mounted on the front panel of the unit:

(a) One shore power circuit breaker control switch for operating all shore power circuit breakers simultaneously.
(b) One indicator light (white) per shore power receptacle to indicate the shore power feeder energized. One indicator light (white) to indicate the bus feeder energized. These indicator lights shall be mounted near the shore power circuit breakers.
(c) Indicator lights (blue) to indicate that each shore power circuit breaker is closed.
(d) One switchboard type phase sequence indicator with a multi-position selector switch for use in checking phase rotation and orientation of shore power connections (see figure 2). Two indicator lights (green) to indicate phase orientation.
(e) One transfer switch for use with the generator unit frequency meter for reading the frequency of the bus tie circuit and shore power.
(f) One reference selector switch for use in checking phase orientation of shore power connections.
(g) One ac ammeter for reading shore power current.

3.4.1.2 Ac generator control unit for switchgear groups not having an EPCP or an EPCC (see figure 3 for a typical one-line diagram). Devices listed in 3.4.1.1, except item (l), shall be mounted on or within the unit.

3.4.1.2.1 Front panel. The following devices shall be mounted on the front panel of the generator unit:

(a) One ac ammeter for reading one phase of generator current.
(b) One ac voltmeter with transfer switch for reading one phase of generator potential, one phase of each bus tie voltage, and one phase of shore power voltage for switchgear group containing shore power connection.
(c) One polyphase wattmeter for reading generator output.
(d) One frequency meter for reading the frequency of the generator.

(e) One control switch for control of the generator circuit breaker where an electrically operated breaker is used.
(f) Control switches, rheostats, and similar devices, as required in conjunction with the governor speed regulation of the generator prime mover (see 6.2.1).
(g) One transfer switch to transfer the governor control from the local control switch to the remote control switch on the ac bus tie unit (or control unit) of the control switchgear group. It shall also control the lamp (see 3.4.1.4.1(c)) on the bus tie unit or control unit to indicate when the remote switch is in control. This shall be provided only when the unit has control of a remote generator.
(h) One control switch with white indicator light for control of the generator space heaters when provided with the generator (see 6.2.1).
(i) Control switches, rheostats, and similar equipment that is for panel mounting and is required in conjunction with the voltage regulator equipment mounted in the generator unit shall be mounted and operated from the front panel (see 6.2.1).
(j) For installations in which a bus tie unit is not provided, one set of three indicator lights with a control switch, to indicate ground conditions on the main bus or any of its feeders, shall be mounted on the front panel of the generator unit.
(k) One synchroscope and one set of synchronizing lights with transfer switch for synchronizing the generator with the main bus, and the main bus with the bus tie circuit, and the bus tie with shore power for switchgear group containing shore power connection.
mounted and operated from the front panel.
(l) One type I synchronizing control equipment shall be provided for each single or two generator switchgroup. The synchronizing control monitor may be mounted in the bus tie unit instead of the generator control unit.
(m) One type 11 automatic paralleling device, if required (see 6.2.1). The automatic paralleling device may be mounted in the bus tie unit instead of the generator control unit.
(n) Test receptacles with test plugs for connecting portable instruments to the metering current and potential circuits. Removal of the receptacle protective cover shall automatically short circuit the secondary winding of metering current transformers, so that only the meters are electrically removed from the secondary circuit.
(o) One temperature indicator with selector switch and accessories, when temperature detectors are provided with the generator (see 6.2.1).

3.4.1.3 Ac bus tie unit for switchgear groups having an EPCP, or having both an EPCP and EPCC. The following shall be mounted within the unit:

(a) One bus tie circuit breaker.
(b) One feeder circuit breaker.
(c) Necessary disconnecting devices for performing isolation functions as may be required (see 6.2.1).

(d) Potential transformers, for metering and relaying, and for synchronizing, in number as required for the bus connections of the switchgear group.
(e) One current transformer for metering the current interchange through the bus tie circuit breaker.
(f) Fuse panel for fusing the potential and control power transformer primary circuits.
(g) Indicator light (blue) to show the closed position of the bus tie and feeder circuit breaker.

Bus tie units of the switchgear group containing the shore power connection shall be designated as a "bus tie and shore power unit". In addition, this unit shall substitute item (h) for the feeder circuit breaker, and add items (i) and (j) below:

(h) Circuit breakers, type AQB-LF, electrically operated, 400 ampere frame size shall be furnished on only one bus tie unit of any switchgear group. One shall be provided for each shore power receptacle. The shore power circuit shall be connected to the bus tie circuit so that power may be fed to either the local or remote switchboard through a bus tie circuit breaker. Where more than four circuit breakers are required, a separate switchgear unit may be provided.
(i) Current transformers for metering the total shore power current.
(j) Potential transformers for metering and synchronizing, in numbe, as required.

3.4.1.4 Ac bus tie unit for switchgear groups not having an EPCP or EPCC. The following shall be mounted within the ,unit:

(a) One bus tie circuit breaker.
(b) One feeder circuit breaker.
(c) Necessary disconnecting devices for performing switching functions as may be required.
(d) Potential transformers for metering and relaying, and for synchronizing, in number as required for the bus connections of the switchgear group.
(e) Fuse panel for fusing the control circuits fed from the control power bus.
(f) Fuse panel for fusing the potential and control power transformer primary circuits.

3.4.1.4.1 Front panel. The following shall be mounted on the front panel of the bus tie unit:

(a) One polyphase wattmeter, calibrated to indicate the 3-phase power output of remote ship's service generator.
(b) One ac ammeter for indicating the current of remote ship's service generator and from the shore power connection.
(c) Remote control switches or rheostats, and indicator lights (white), as required, to control the speed of the prime movers of the remote generators. The control switch power shall be connected through the transfer switches (see 3.4.1.2.1(h)) on

the generator units of the remote switchgear groups, and the indicating lamps shall be connected to indicate when the transfer of control is accomplished. This shall be provided when the unit has control of a remote generator.

(d) One composite transfer switch for reading the power and current of each remote generator by means of (a) and (b) above and the shore power current by means of (b) above.

(e) One control switch for control of the bus tie circuit breaker where an electrically operated circuit breaker is used.

(f) Indicator lights (blue) to show the closed position of the bus tie circuit breaker and the type ACB feeder circuit breaker.

(g) One frequency meter for reading the frequency of the bus tie circuit.

(h) One transfer switch, with two white indicator lights, for connecting the switchboard control bus to the local 450 volt ship's service bus, or the 450 volt bus of the corresponding (forward or aft) emergency switchboard. Transfer may be accomplished automatically; however, in such cases one source of power shall be the local 450 volt ship's service bus and the second source shall be a 450 volt bus tie supply.

(i) One set of three indicator lights with a control switch to indicate ground conditions on the main bus or any of its connected feeders.

(j) One zero neutral wattmeter for reading bus tie power and direction of power flow.

3.4.1.4.2 Bus tie and shore power unit. One bus tie unit of the switchgear group containing the shore power connection shall be designated as a "bus tie and shore power unit". In addition to. the devices specified in 3.4.1.4 and 3.4.1.4.1, this unit shall substitute item (a) for the feeder circuit breaker, and the additional items (b) through (h) shall be provided.

(a) Circuit breakers, type AQB-LF, electrically operated, 400 ampere frame size shall be furnished on only one unit of the switchgear group. One shall be provided for each shore power receptacle. The shore power circuit shall be connected to the bus tie circuit so that power may be fed to either the local or remote switchboard through a bus tie circuit breaker.

(b) One shore power circuit breaker control switch for operating all shore power circuit breakers simultaneously.

(c) One indicator light (white) per shore power receptacle to indicate the shore power feeder energized. One indicator light (white) to indicate the bus feeder energized. These indicator lights shall be mounted near the shore power circuit breakers.

(d) Indicator lights (blue) to indicate that each shore power circuit breaker is closed.

(e) Current transformers for metering the total shore power current.

(f) One switchboard type phase sequence indicator with a multi-position selector switch for use in checking phase rotation and orientation of shore power connections.

(g) potential transformers for metering and synchronizing, in number as required.

(h) One transfer switch for use with item (g) of 3.4.1.4.1 for reading the frequency of the bus tie circuit and shore power (see figure 2).
(i) One reference selector switch for use in checking phase orientation of shore power connections.
(j) Two indicator lights (green) for use with (f) and (i) above.

3.4.1.5 Electric plant control panels.

3.4.1.5.1 Desk type EPCP (see 6.5.4). Desk type EPCP (see figure 4) shall be of the bench type with vertical panels for the mounting of instruments, displays, and associated controls, a horizontal or inclined desk top for plant operation controls, and an apron section inclined desk top for plant operation controls, and an apron section below. When specified (see 6.2.1), desk type EPCP for surface ships shall be provided with a chair. It shall be so mounted that it can be swung out of the way when not in use.

3.4.1.5.1.1 Control switches. Control switches for the electrically operated circuit breakers controlled from the EPCP shall be mounted on the desk top and arranged within convenient reach of the operator. Circuit breaker control switches and their corresponding switches in the mimic bus system shall be located so that their relative positions as to their locations on the EPCP are similar. Automatic voltage adjusting rheostats shall be mounted close to the meters being affected by their adjustment. Large equipment which requires infrequent personnel attention shall be located in the apron portion to conserve panel and desk space. The portion of the apron panel used for mounting the equipment shall not project beyond the front edge of the desk top. Space shall be provided for filing the reduced size drawing. Space shall be provided for the mounting of the interior communication (IC) equipment (see 6.2.1).

3.4.1.5.2 Vertical EPCP (see 6.5.5). Vertical EPCP shall be arranged to orient instruments, displays, and their associated controls near the top, other plant operation controls toward the middle, and larger, infrequently used equipment at the bottom.

3.4.1.5.3 Requirements for either a desk type or vertical EPCP shall be as specified (see 6.2.1).

3.4.1.5.4 Surface ship EPCP. The following shall be mounted on the EPCP for surface ships:

(a) Control switches, rheostats, and similar equipment that is for panel mounting and is required in conjunction with the voltage regulator equipment mounted in the generator unit shall be mounted on and operated from the EPCP (see 6.2.1).
(b) One ac ammeter for each local generator for reading one phase of generator current.
(c) One ac voltmeter for each local generator for reading one phase of generator potential.
(d) One ac voltmeter with transfer switch for reading single phase voltage of the switchboard bus and of the bus tie feeders and shore power for switchgear groups containing shore power connection.

(e) One polyphase wattmeter for reading generator output for each local generator.

(f) One polyphase wattmeter with transfer switch to indicate the 3-phase power output of the remote ship's service generator (shall be provided where a switchgear group is to have control of a remote generator or generators.)

(g) One temperature indicator with selector switch and accessories when temperature detectors are provided with the generator (see 6.2.1).

(h) One frequency meter for reading the frequency of the generator for each local generator. For units controlling two local generators, each frequency meter shall be provided with a transfer switch for reading the frequency of one generator and one bus tie circuit and shore power, in which case 3.4.1.S.4(i) shall be omitted.

(i) One frequency meter with transfer switch for reading the frequency of the bus and of each bus tie circuit and shore power for switchgear group containing shore power connection. For units controlling two local generators, each frequency meter (see 3.4.1.5.4(h)) shall be provided with a transfer switch for reading the frequency of one generator and one bus tie circuit and shore power, in which case 3.4.1.5.4(i) shall be omitted.

(j) One local control switch, or other control device as required, for control of the speed governor of the generator prime mover for each local generator.

(k) One transfer switch to transfer the governor control of the generator prime mover from local control to the remote control on the master EPCP. It shall also control the indicator light on the master EPCP to indicate when the remote station is in control. This transfer switch shall be provided only on EPCPS for which remote control, item (l), is to be provided on the master EPCP.

(l) One remote control switch or other remote control devices as required, and indicator light (white) to control the speed governor on the remote generator prime mover where the unit has control of a remote generator. Control power shall be connected through the transfer switch item (k), of the remote EPCP, and the indicating light shall be energized when the transfer of control to the remote station is accomplished.

(m) One control switch with circuit breaker closed indicator light (blue) for control of each local generator circuit breaker.

(n) One control switch with circuit breaker closed indicator light (blue) for control of each bus tie circuit breaker.

(o) One control switch with circuit breaker closed indicator light (blue) for control of each electrically operated distribution circuit breaker.

(p) One control switch with space heater on indicator light (white) for control of generator space heater (when provided with the generator) for each local generator (see 6.2.1).

(q) Test receptacle with test plugs for connecting portable instruments to the metering current and potential circuits. Removal of the receptacle protective cover shall automatically short circuit the secondary of metering current transformers, so that only the meters are electrically removed from the secondary circuit.

(r) One transfer switch with two white indicator lights for connecting the switchboard control bus to the local 450 volt ship's service bus, or the 450 volt emergency supply. The transfer may be accomplished automatically, however, and in such cases one source of power shall be the local 450 volt ship's service bus and the second source shall be a 450 volt bus tie supply.

(s) One set of three indicator lights with a test switch to indicate ground conditions on the main bus.

(t) Fuse panel for fusing the control circuits.

(u) One mimic bus system (dark type) simulating the generator and bus tie connections shall be provided and shall consist of the following: Indication lights (white) for each generator to indicate generator running and voltage available. Indication lights (yellow) for each generator and bus tie circuit breaker. Single pole, double throw switches shall be provided for each circuit breaker light. These switches shall be combined with their respective yellow lights and so arranged that when the switch handle indication and the circuit breaker position (open or closed) are the same, the light shall be out. When the circuit breaker position and the switch handle indication are different, the light shall be lit. For indicator light power supply, see 3.11.7. Mimic bus material shall be 1/8-inch thick, 1/4-inch, 3/4-inch, or 1/2=inch wide, as specified (see 6.2.1). Mimic bus material shall be laminated plastic conforming to type NDP or GCP-H of L-P-387, aluminum alloy conforming to ASTM B 209, alloy 5052, commercial brass conforming to ASTM B 36 and B 121, corrosion resisting steel conforming to type 316 of ASTM A 167, A 240, and A 666, or nickel-copper alloy conforming to ASTM B 127, B 164, and B 564.

(v) One ammeter to indicate current in the bus tie.

(w) One ammeter for each remote generator for reading one phase of generator current.

(x) One shore power circuit breaker control switch for each shore power station to simultaneously operate all circuit breakers for that station. One indicator light (blue) for each shore power circuit breaker to indicate breaker closed. One indicator light (white) per shore power receptacle to indicate the shore power feeder energized. One indicator light (white) to indicate the bus feeder energized. These indicator lights shall be mounted near the shore power circuit breaker control switch.

(y) One control switch with one blue and one white indicator light for each electrically operated circuit breaker feeding an emergency switchboard.

(z) One ammeter for reading the shore power current.

(aa) One switchboard type phase sequence indicator with a multi-position selector switch, for use in checking phase rotation and orientation of shore power connections.

(bb) One reference switch for use in checking phase orientation of shore power connections. Two indicator lights (green) to indicate phase orientation.

(cc) One local/remote control transfer switch for the purpose of transferring control from the local station to the EPCC. Monitoring and indicating circuits shall not be transferred except as noted below. This is required only on ships provided with a centralized machinery control system including an EPCC (see 6.2.1). Circuits transferred by this switch shall include:

(1) Generator starting and stopping. Remote generator starting shall be transferred by the switch. Remote generator stopping shall be locked out when the switch is in the local position. Local stopping and remote emergency stopping shall be effective regardless of the position of the switch.
(2) Generator output voltage control.
(3) Prime mover governor manual control.
(4) Voltage regulator mode selection.
(5) Governor mode selection.
(6) Circuit breaker control of all circuit breakers which are controlled at the EPCC. This shall include control of the synchronizing control system. Local automatic protection of the local/remote transfer switch.
(7) Elements of the generator green light circuit which are duplicated locally and at the EPCC.
(8) Local/remote transfer switch position indication on the EPCC.

(old) One synchroscope and one set of synchronizing lights with selector switch for synchronizing with the main bus, the main bus with the bus tie circuit and the bus tie with shore power for switchgear group containing shore power connection. Where the switchgear group has control of two generators and two bus tie circuits, the synchroscope and synchronizing lights shall be connected for synchronizing either generator with the bus and the bus with either bus tie circuit.

(1) For synchronizing monitor devices (type I) and automatic paralleling devices (type II):

a. System selector switch for selecting the system to be paralleled. This switch may be combined with the synchroscope selector switch.
b. An indicator light (white) to indicate that the synchronizing control system is energized.

(2) For synchronizing monitor devices the following applies:

a. Synchronizing control monitor operating mode selector switch having operating, test, and off positions.

(3) For automatic paralleling devices the following applies:

a. One operating mode selector switch having Automatic, Manual Permissive, Test, and Off positions.
b. One pushbutton control switch for initiation of the automatic paralleling operation.
c. An indicator light (red) to indicate that the synchronizing control equipment is unable to close the circuit breaker when in the automatic mode.
d. A pushbutton to interrupt the automatic paralleling cycle to completion of paralleling.
e. Indicating devices as required by MIL-S-24188.

3.4.1.5.5 Submarine EPCP. The following shall be mounted on submarine EPCP'S :

(a) For each ship's service turbine generator: items (a), (b), (e), (j), (m), (P), (q), and (z) of 3.4.1.5.4
(b) For each ship's service motor generator: items (a), (b), (m), and (p) of 3.4.1.5.4 and the following additional devices:
(1) Control switches, rheostats, and similar devices as required in conjunction with speed regulating equipment (see 6.2.1).
(2) One control switch with indicator light (blue) for control of each motor circuit breaker.
(3) One ammeter, zero center scale for reading dc current.
(c) For a diesel generator:
(1) Control switches, rheostats, and similar equipment that are for panel mounting and as required in conjunction with the voltage regulator equipment mounted in the generator unit shall be mounted on and operated from the EPCP (see 6.2.1).
(2) One control switch with indicator light (blue) for control of the diesel generator circuit breaker.
(3) One ac ammeter for reading one phase of the generator current.
(4) One polyphase wattmeter for reading the generator power output l
(5) One control switch or other control devices as required, for control of the governor on the generator prime mover (see 6.2.1).
(d) For the battery:
(1) Two zero center scale dc ammeters, one high range and one low range, to measure battery charge and discharge currents.
(2) One battery float charge measuring device.
(3) One hydrogen detector remote indicator.
(4) One control switch with indicator light (blue) for control of each battery circuit breaker.
(5) One battery exhaust fan control switch with indicator light (green).
(6) One battery ventilation flow indicator.
(7) One control switch with ammeter to control and indicate operation of battery recirculating fans.

(e) For the system:
(1) One synchroscope with synchronizing selector switch for synchronizing generators with the bus and the bus with bus tie circuits.
(2) Two frequency meters and two voltmeters connected through the synchronizing selector switch for reading frequency and voltage on each side of the point at which synchronizing is being performed.
(3) One dc voltmeter with selector switch for reading battery and dc bus voltages.
(4) One transfer switch with two indicator lights (white) for connecting the ac control bus to a 450 volt normal and alternate source of supply.
(5) One transfer switch with two indicator lights (white) for connecting the dc control bus to a normal and alternate dc supply.
(6) A direct reading ground detector.
(7) Fuse panel for fusing control circuit.
(8) One mimic ks system simulating the generators, bus ties, shore power, and battery connections of the power system (see 3.4.1.5.4(u)).
(9) A transfer device with indicator light (white) shall be installed for supplying each dc control bus from either its respective motor generator dc bus or from the battery side of the battery circuit breaker.
(10) Test receptacles with test plugs shall be provided for connecting portable instruments to all metering and potential circuits on the EPCP. Removal of the receptacle protective cover shall automatically short circuit the secondaries of the metering current transformers so that only the meters are electrically removed from the secondary circuit.

3.4.1.5.6 400 hertz (Hz) EPCP for solid-state frequency changer systems. The following shall be mounted on the 400 Hz EPCP:

(a) One mimic bus system (dark type) simulating the frequency changer and bus tie connections shall be provided and shall consist of the following:
(1) Indicator lights (white) for each frequency changer to indicate frequency changer energized and voltage available.
(2) Indicator lights (yellow) for each frequency changer output contactor and bus tie circuit breaker.
(3) Single pole, double-throw switch for each circuit breaker light. These switches shall be combined with their yellow lights and arranged so that when the switch handle indication and the circuit breaker position (open or closed) are the same, the light shall be out. When the circuit breaker position and the switch handle indication are different, the light shall be on. For indicator light power supply, see 3.11.7. Black mimic bus material shall be 1/8-inch thick, 1/4-, 3/8-, or 1/2-inch wide, as specified (see 6.2.1). Mimic bus materials shall be laminated plastic conforming to type NDP or GCP-H of L-P-387, aluminum alloy conforming to ASTM B 209, alloy 5052, commercial brass

conforming to ASTM B 36 and B 121, corrosion-resisting steel conforming to type 316 of ASTM A 167, A 240, and A 666, or nickel-copper alloy conforming to ASTM B 127, B 164, and B 564.

(b) One current meter for reading one phase of each frequency changer output l

(c) One pushbutton switch combination for actuating each frequency changer input contactor. One indicator light (white) to indicate that the unit is energized.

(d) One control switch with indicator light (blue) for each frequency changer output contactor.

(e) One control switch with indicator light (blue) for control of each 400 Hz bus tie circuit breaker.

(f) One remote control switch with indicator light (blue) for control of each applicable 400 Hz distribution circuit breaker.

(g) One set of three indicator lights (white) with a control switch to indicate ground conditions on the main 400 Hz bus.

(h) Solid state frequency changer failure mode indicators as required (see 6.2.1).

3.4.1.6 ACB circuit breaker distribution unit. This unit shall provide for the distribution of power from the main bus (see 6.2.1). The following shall be provided:

(a) Circuit breakers having current rating and protective features as required.

(b) Indicator lights (blue) mounted on the front panel adjacent to or on the circuit breaker escutcheon to indicate when each of the feeder circuit breakers is closed.

(c) Control switches shall be provided for electrically operated circuit breakers. Where the switchgear group has EPCP or EPCC, or both, these switches shall be located on the EPCP or EPCC, or both.

(d) Necessary disconnecting devices for disconnecting cables between switchgear sections and performing other switching functions.

NOTE : Where a circuit breaker supplies a feeder which may be energized from another source, such as the emergency switchgear group, a white light shall be provided to indicate feeder energized.

3.4.1.7 AQB circuit breaker distribution unit. This unit shall provide for the distribution of electric power or lighting supply (450 or 120 volt) through type AQB circuit breakers (see 6.2.1). Units receiving two sources of supply shall be provided with interlocked NQB or AQB circuit breakers. Where interlocked circuit breakers are installed, an indicator light shall be provided for each power supply to indicate when power is available (see 3.4.4).

3.4.1.7.1 Spaces. Spaces for the future installation of circuit breakers resulting from the use of standardized distribution units shall be blanked off, with busing installed for the circuit breakers. Mounting blocks shall also be installed for AQB circuit breakers. Circuit breaker panel blanks shall be securely fastened in place so that the blanks or the fasteners shall not fall into the interior of the switchboard under any anticipated operating conditions. They may be constructed from conducting or nonconducting material.

3.4.1.8 ACB-AQB circuit breaker distribution unit. This unit shall provide for distribution of power through both ACB and AQB type of circuit breakers (see 6.2.1). It shall contain the devices listed in 3.4.1.6 through 3.4.1.7.1.

3.4.1.9 Load shedding. Distribution units of ship service switchgear groups on ships provided with a centralized machinery control system including an EPCP or an EPCC, or both an EPCP and an EPCC, for which load shedding is required, shall contain a load shedding bus or buses segregated from the main bus by electrically operated nonautomatic circuit breakers. Individual electrically operated ship service distribution circuit breakers shall also be operated by the load shedding system as specified. Each electrically operated ship's service distribution circuit breaker not disconnected from the main bus by the load shedding system shall be provided with means for remote control from the EPCC or the EPCP. Relays energized from EPCC or the EPCP power shall be provided to activate the trip circuit of electrically operated distribution circuit breakers. Shunt trip circuit of manually operated distribution circuit breakers shall be energized from EPCC or the EPCP power. The power sensing relay shall be in accordance with MIL-R-24563.

3.4.2 Emergency power switchgear groups for ships having ac power. Switchgear groups for controlling larger than 100 kW generators shall employ a 3-way type ABT-4A(6,9) circuit breaker type bus transfer equipment and shall be constructed as sectionalized switchgear groups having a separate generator and bus transfer section, and feeder sections. For switchboards controlling emergency generators rated 100 kW and less, the bus transfer equipment, type ABT-4A(6,9) contactor type shall be used. When the contactor type unit is used, the switchboard shall be assembled with the AQB distribution units to form a single section (see figures 5 and 6). Bus transfer equipment shall be in accordance with DOD-S-17773.

3.4.2.1 Ac emergency generator control and circuit breaker type bus transfer section. The following shall be mounted on or within the unit:

(a) One type ABT-4A(6,9) circuit breaker type, 3-way, automatic bus transfer equipment having a current rating not less than the continuous rating of the emergency generator and the current rating of the feeders from the ship's service switchboards, as specified. Associated control switches, indicator lights, and relays for panel mounting shall be mounted on one of the front panels.
(b) Necessary disconnecting devices for disconnecting cables between switchgear sections and performing other isolation functions.
(c) Two potential transformers for metering and relaying.
(d) One type AQB-A or AQB-LF circuit breaker, instantaneous element only, for power supply to the pump supplying cooling (salt) water to the generator diesel as specified (see 6.2.1) connected to the generator side of the generator circuit breaker. A red warning plate shall be provided stating that the circuit breaker shall always be in the closed position when the diesel is set up for starting.
(e) Two current transformers for metering and relaying.
(f) One fuse panel for fusing the potential transformer primary circuits.

(g) One circuit breaker type AQB-A or AQB-LF, 250 ampere frame size. Casualty power circuit breaker shall be connected to the generator side of the generator circuit breaker. When the generator capacity is 500 kW or greater, two casualty power circuit breakers shall be furnished.

(h) One casualty power terminal, riser type conforming to MIL-T-24552 and MIL-T-24552/2, connected through the AQB-A or AQB-LF circuit breaker item (g). When the generator capacity is 500 kW or greater, casualty power terminals, riser type, shall be furnished.

3.4.2.1.1 Front panel. The following shall be mounted on the front of the panel.

(a) One ac ammeter for reading one phase of generator current.
(b) One ac voltmeter for reading one phase of generator potential.
(c) One polyphase wattmeter for reading generator output.
(d) One frequency meter for reading generator frequency.
(e) Instruction plates containing complete operating instructions for the automatic equipment and a single line diagram of the main buses.
(f) One set of three indicator lights with test switch to indicate ground conditions on the 450 volts emergency power bus.
(g) One indicator light with green color cap, so connected as to indicate when all manually operated control devices are set Up for automatic operation. The applicable following functions and conditions shall be included to complete the green light circuit:
  (1) Generator circuit breaker (closed) (when separated from bus transfer).
  (2) Voltage regulator transfer switch (automatic position).
  (3) Ship's service bus transfer equipment (set for automatic operation).
  (4) Emergency bus transfer equipment (set for automatic operation).
  (5) Diesel starting control circuits (set for automatic starting).
  (6) Diesel starting air shut-off valve (open).
  (7) Electrically operated emergency bus unloader switch (if used, set for automatic operation).
  (8) Diesel salt water cooling pump circuit breaker (closed).
  (9) Circuit breaker reset switch closed (set for automatic operation).
(h) Space, mounting, and wiring for the voltage regulator equipment, including associated current and potential transformers, and for the exciter field rheostat, all equipment to be furnished with the emergency generator. The control switches, rheostats, and similar equipment constructed for panel mounting shall be located for front-of-panel operation (see 6.2.1).
(i) Space, mounting, and wiring for equipment, for the control switches and interlocks, furnished with the bus transfer equipment. The control switches and similar equipment constructed for panel mounting shall be located for front-of-panel operation.
(j) One temperature indicator with selector switch and accessories, when temperature detectors are provided with the generator (see 6.2.1).

3.4.2.2 Ac emergency generator control and contractor type bus transfer section. This unit shall be equivalent functionally to the section specified in 3.4.2.1. The devices shall be the same as required in 3.4.2.1 except that the following shall be provided in lieu of 3.4.2.1(a):

(a) One generator circuit breaker, type AQB-A, manually operated.
(b) Two type ABT-4A(6.9), contactor type bus transfer equipments having current ratings not less than the current rating of the feeders from the ship's service switchboards, as specified. One equipment shall be connected for selection of the ship's service supply, the second equipment shall be connected for transfer between ship's service supply and the emergency generator supply.
(c) Four indicator lights (blue) to indicate closed positions of the contractors of the type ABT-4A(6.9) bus transfer equipments. Indicator lights circuit shall be wired through auxiliary contacts provided in the bus transfer equipments.
(d) Two indicator lights (white) to indicate that the ship's service power feeders are energized.
(e) One type NQB circuit breaker, connected to by-pass the bus transfer equipment selecting between ship's service and emergency so that emergency generator power may be supplied to the ship's service switchboards when their generators are secured.
(f) Two control switches, one for each bus transfer equipment, for selecting between manual and automatic control of the equipments.
(g) One electrically operated emergency bus unloader switch with control relay and current transformer. This switch shall be connected between the feeder for the steering power switchboard and the emergency bus to disconnect the emergency bus during periods of high current requirements by the steering gear auxiliaries when energized from the emergency generator. Equipment shall function to hold the unloader switch closed unless the demand on the steering power switchboard exceeds 150 percent of the full load current of two steering motors plus 100 percent of the full load current of all other steering gear auxiliaries, in which case the unloader switch shall open provided the power is being supplied by the emergency generator. This item shall be furnished only when specified (see 6.2.1).

3.4.3 Distribution units. Distribution units of the emergency switchgear group shall be in accordance with 3.4.1.6 through 3.4.1.9.

3.4.4 Load center (see 6.5.7) distribution sections. These sections shall be switchgear unit type of construction. Units comprising the section shall provide for distribution through type ACB or AQB circuit breakers and shall be constructed in accordance with 3.4.1.6 through 3.4.1.9. Distribution units requiring two sources of supply shall be provided with interlocked NQB, AQB, or ACB circuit breakers. Where interlocked circuit breakers are installed, an indicator light shall be provided for each power supply to indicate when power is available.

3.4.4.1 Circuit breakers. Each load center distribution section shall be provided with two type AQB-A or AQB-LF 250 ampere frame size circuit breakers for casualty power supply and two casualty power terminals riser type conforming to MIL-T-24552 and MIL-T-24552/1, connected through the type AQB circuit breakers to the main bus.

3.4.5 Ship's service power switchgear group for dc ships.

3.4.5.1 Dc generator control unit. Generator control unit shall contain the following:

(a) One circuit breaker.
(b) One dc voltmeter and switch for reading bus and generator voltage.
(c) One dc ammeter with shunt for reading generator current.
(d) One indicator light (blue) to show the closed position of the generator circuit breaker.
(e) One set of two ground detector lights and one control switch for indication of ground conditions on dc bus or its connected feeders.
(f) Space, mounting, and wiring for the generator field rheostat and operating mechanism to be furnished with the generator.
(g) One reverse current relay to prevent the generator from motoring on the bus after loss of driving power from the prime mover (only when more than one generator is connected to the dc bus).

Lower section of the unit may be used for the mounting of distribution switches or circuit breakers where the utilization of this space will result in a saving in the overall size of the switchboard. ,

3.4.5.2 Dc bus tie unit. The following shall be mounted within the unit:

(a) One circuit breaker.
(b) Necessary disconnecting devices for performing switching functions as may be required.
(c) Fuse panel for fusing control circuits.
(d) Shunt for bus tie ammeter (in positive bus only).

3.4.5.2.1 Front panel. The following shall be mounted on the front panel of the bus tie unit:

(a) One indicator light (blue) to indicate the closed position of the bus tie circuit breaker.
(b) One ammeter with zero center scale for indicating current flow in the bus tie. The ammeter shall be connected to read to the right for current flowing from the bus to the bus tie.
(c) Voltmeter with transfer switch for reading the voltage of the switchboard bus and of the bus tie.

Lower section of the unit may be used for the mounting of distribution switches or circuit breakers where the utilization of this space will result in a saving in the overall size of the switchboard.

3.4.5.2.2 Bus tie and shore power unit. Bus tie unit of the switchgear group containing the shore power connection shall be designated as a "bus tie and shore power unit". In addition to the equipment specified in 3.4.5.2 and 3.4.5.2.1, this unit shall have the following:

(a) One shore power connection circuit breaker. The shore power circuit shall be connected to the bus tie circuit so that the power may be fed to either the local or remote switchboard through a bus tie circuit breaker. The ammeter shunt (see 3.4.5.2(d)), shall be so located that it is in the circuit when feeding power to the local switchboard.
(b) One indicator light (blue) to indicate the closed position of the shore connection circuit breaker.
(c) One indicator light (white) to indicate when the shore connection feeder is energized.
(d) One indicator light (white) to indicate when the bus tie feeder is energized.
(e) Warning plate adjacent to the indicator lights for the shore connection and bus tie feeder stating "DO NOT CLOSE THIS CIRCUIT BREAKER WHEN THE BUS TIE CIRCUIT IS ENERGIZED".

3.4.5.2.3 ACB distribution circuit. For installations not requiring a bus tie unit, items (a), (b), and (c) of 3.4.5.2.2 shall be mounted on one of the ACB distribution circuit breaker units and the shore power circuit connected to the switchboard bus. In such instances, this unit shall be designated as "ACB distribution circuit breaker and shore power unit", and the following additional equipment shall be provided:

(a) One indicator light (white) to indicate when the switchboard bus is energized.
(b) Warning plate adjacent to the indicator lights to warn against closing the shore connection circuit breaker when the switchboard bus is energized.

3.4.5.3 Dc, AQB circuit breaker distribution unit. Unit shall provide for the distribution of power or lighting through type AQB, 250 volt, dc circuit breakers (see 6.2.1).

3.5 Switchboard construction.

3.5.1 General construction.

3.5.1.1 Standardized switchgear sections (see 6.5.2). Each unit of a switchgear section shall be in accordance with the applicable unit shown on figures 7, 8, and 9 and applicable notes on the figure. Units shall be constructed with a self-supporting, box-like framework for support of the front panels, buswork, circuit breakers, and other devices to be included in the various units which constitute the section. Number and size of circuit breakers and overall dimensions of the unit shall be in accordance with figures 7, 8, and 9. Units shall be bolted together to form sections and shall be connected by transverse buses. Bus locations shall be as shown on

figures 7 and 9, except where bus locations are not so specified, they shall be installed to suit the application. Each unit and enclosure shall be constructed to meet the requirements of MIL-STD-167-1 and MIL-S-901 (see 4.6.3.3 and 4.6.3.4).

3.5.1.2 Special switchgear sections. Each section of a switchgear group shall be constructed with a rigid, self-supporting, box-like framework for support of the front panels, buswork, circuit breakers, and other devices to be included in the various units which constitute the section. Framework for a section may be constructed as an integral frame for all units joining the individual units by bolting and welding to form the section. Where each edge of the unit is formed by welding formed members, the ends joining to form a section shall be welded, including necessary intermediate welding of the joining members to add strength and rigidity to the section. When formed members are used for structural support, their strength shall be equivalent to that of structural members (angles, channels, and so forth) used for the same application. Each unit and enclosure shall be constructed to meet the requirements of MIL-STD-167-1 and MIL-S-901 (see 4.6.3.3 and 4.6.3.4).

3.5.2 Dimensions. Insofar as practicable, the grouping of the various units that comprise a switchgear group shall be such that the length of each section is approximately equal to the height; however, the length of a section shall not exceed approximately 8 feet. In the arrangement of the devices to be located within the structure and the general design of the unit, particular attention shall be given to keeping the center of gravity of the unit as low as practicable.

3.5.3 Framework fabrication.

3.5.3.1 Standardized and special units. Framework shall be fabricated from angles, channels, or other structural shapes, or formed members. Each edge of each unit shall be formed by a length of a structural shape, formed member, or formed members welded to effect a continuous length. When formed members are used for structural support, their strength shall be equivalent to that of structural members (angles, channels, and so forth) used for the same application. Intermediate vertical supporting members shall be provided for the support of such heavy devices as circuit breakers and large disconnecting switches and shall be constructed using structural members welded to the bottom and top horizontal structural members. Gusset plates shall be continuously welded at the corners of the units in both lengthwise and lateral vertical panels so that each corner shall have a strength not less than the bending strength of the weakest adjoining vertical or horizontal member. Typical bottom corner construction is shown on figure 10.

3.5.4 Gusset plates. In the special case where the lengthwise gusset plates at the front of the unit interfere with devices, special consideration shall be given to the construction of the corner to provide maximum strength. Small gusset plates or L-shaped plates may be used in the above special case. Gusset plate shall be not less than 1/8-inch thick. Where the thickness of the gusset is less than 3/16 inch, the diagonal edge shall be bent to form a flange. Three sided forged or formed and heat treated aluminum alloy gussets may be used on aluminum constructed switchboards. Typical gusset plates are shown on figure 11.

3.5.5 Framework assembly. Framework of each standardized unit or special section shall be stiffened to resist bending by the use of diagonal braces or welded sheets, but braces and sheets shall not be secured in such a manner as to restrict access to the front and rear of the units. The framework of each unit or section shall be fabricated by welding all members except those which must be disassembled for replacement of devices. In these cases, bolting shall be employed. Riveting shall not be used in the assembly. Interframe bolting of standardized units to form sections shall be in locations as shown on figure 8. The minimum size of bolt used for this purpose shall be 1/2-inch diameter. Structural shapes that comprise the base members shall be not less than 1/4-inch thick and the horizontal flanges which are bolted to the foundation shall be not less than 2 inches wide. Members in the top of the frame of all switchboards shall have sufficient strength and rigidity for securing top braces. Braces shall not be considered as part of the switchboard.

3.5.6 Foundation channels. Foundation channels shall be supplied with complete switchboard section or sections.

3.5.6.1 Standardized units (see 6.5.1). Foundation channels shall be drilled for the maximum number of mounting holes as shown on the floor plan (see figure 8) regardless of whether they are used for the orginal installation or not. Individual switchboard manufacturers may use all or any combination of these holes for mounting as long as the shock and vibration tests of 4.6.3.3 and 4.6.3.4 are met. Where the thickness of the frame member is less than 3/8 inch, a 1/4-inch thick reinforcing washer approximately 2-inches square shall be provided under each bolt head.

3.5.6.2 Special sections. The frame of each section shall be bolted directly to the channel by 3/4-inch diameter bolts conforming to MIL-S-1222. Bolt holes in channels shall be 0.813 (plus 0.010, minus 0.001) inch. The minimum number of holding-down bolts to be provided for a section shall be based on the total weight of the section, allowing 210 pounds for each 3/4-inch diameter bolt. Not less than four bolts shall be provided per unit. Holding-down bolts shall be located as near the vertical frame members as practicable, but with not more than 3 inches horizontal separation between the vertical member and the center of the bolt hole. Where more than 12 bolts are required, two in each corner, and two adjacent in each intermediate vertical member, and the thickness of the frame member is less than 3/8 inch, a 1/4-inch thick reinforcing washer, approximately 2-inches square, shall be provided under each bolt head.

3.5.7 Side sheets. Ends of each standardized unit or special section shall be enclosed by solid sheets, at least 1/16-inch thick, welded to the switchboard framework, except where the arrangement of switchgear within the section is such as to require side access for maintenance, in which case the side sheet or a portion thereof shall be removable. Removable side or rear sheets are not considered to be structural members, and the tests required shall be made with such sheets removed. The side sheets shall be welded by intermittent welds, spot welds, or plug welds to the vertical and horizontal frame members. The gusset plates in the plane of the sheet may be omitted, provided the sheet is welded to the frame at the corners with the same length of welding that would be normally employed with a gusset plate. When gusset plates are omitted, plug welding shall be used

only on the side sheets at the top corners of the frame. Side sheets shall be cut to provide for interconnecting bus bars and wiring, and insulating spacers shall be employed to close the openings. Location of cutouts for bus bars shall be as shown on figures 7 and 9.

3.5.8 Compartmentation. Each unit shall be internally subdivided by sheet metal barriers to form separate compartments for the circuit breakers to isolate them from the bus work and cable connections. For spraytight units, the barriers shall be perforated with 1/4-inch holes to allow for vertical flow of air. When barriers are installed, insulation distances shall be as specified in 3.6.2. A separate compartment shall be provided for each type ACB circuit breaker, but all type AQB circuit breakers on one unit may be in a common compartment. The compartments shall be constructed to prevent an arc or fault from spreading from one compartment to another or into the area occupied by the bus work. Bus disconnecting devices shall be located outside the circuit breaker compartment. Whether or not the rear enclosure of the AQB circuit breaker compartment is used for support of the circuit breakers, the terminal mounting block shall be bolted through reinforcing angles or channels secured to the vertical structural members. Each type ACB circuit breaker compartment shall be enclosed on the front by a removable panel section. On type AQB circuit breaker compartments over 60-inches high, the front enclosure shall be made by two panels.

3.5.9 Ventilation. Ventilation for compartments within a unit and for the unit itself shall be constructed, and the openings sized, so that the maximum internal, ambient temperature shall not exceed 75 degrees Celsius (“C) for submarines and 65°C for surface ships when the unit is operated in an externals ambient temperature of 50°C. Type ACB circuit breakers shall be vented through the front of the unit or through the rear of the unit. Components and wiring required to be installed in the units shall operate to rated capacity in the above internal, ambient temperature without performance degradation. Ventilating louvers and grill openings shall minimize the probability of entrance of solids and shall protect personnel against injury from electric arcs.

3.5.9.1 Spray baffles. When spraytight units are specified, louvered or other type of ventilation openings shall have spray baffles to meet the requirements of 3.17.4, and these baffles shall be in accordance with figure 12 or an equivalent that meets the spraytight and thermal testing requirements (see 4.6.3.6).

3.5.10 Vibration. Units of all switchgear groups shall be constructed to withstand the type I vibration test as specified in MIL-STD-167-1 (see 4.6.3.3). The maximum frequency of vibration shall be as specified (see 6.2.1).

3.5.11 Materials. Switchboard structure may be either of steel or aluminum construction as specified (see 6.2.1). Steel conforming to ASTM A 131 shall be utilized in the fabrication of switchboard structures. Steel conforming to ASTM A 570 or A 457 shall be used for plates and sheets. Aluminum alloy conforming to ASTM B 221, alloy 5086-Hill or alloy 6061-T6 shall be used for structural pieces. Aluminum alloy conforming to ASTM B 209, alloy 5052-H32, H34 or alloy 6061-T6 shall be used for plates and sheets. Aluminum alloy conforming to ASTM B 209, alloy 3003-H22 or H24 may be used for nonstructural applications. Aluminum alloy conforming to ASTM B 221, alloy 5086-0 shall be used for structural pieces that are bent into shape.

3.5.12 Thread locking devices. Unless otherwise specified in the individual equipment specifications, locking devices shall be provided on the following basis for electrical connections and mechanical assemblies in all switchboards, switchgear units, and in all equipment.

3.5.12.1 Electrical connections. Nuts, bolts, studs, and screws used for electrical connections shall be secured by means of a locking device, except that a locking device need not be provided where solderless types of connectors are used for conductors below 14 American Wire Gauge (AWG) (4000 circular roils (cmils)). Lock washers shall be used with cap screws. See 3.10 for bus bar connections.

3.5.12.2 Mechanical assemblies. Nuts, bolts, studs, and screws used for structural purposes shall be secured by means of an acceptable locking device where continuous satisfactory operation, under the shock, vibration, and heat conditions specified herein, or as specified in the individual equipment specifications, depends on maintaining tight connection of parts, or where a holding screw, nut, bolt, or component part could fall into the equipment. Clip-on type of nuts are not acceptable. Anchor devices for thumbscrews (see figure 13) that are used to attach front and rear panels to the switchboard framing shall use hex head or counter-sunk head bolts and self-locking nuts, or button socket-head or flat socket-head, self-locking screws in tapped holes. Welding, brazing, or riveting shall not be used for anchor devices. Single-thread engaging nuts formed by stamping a thread-engaging impression in a flat piece of metal shall not be used.

3.5.12.3 Acceptable locking devices. The following are considered acceptable types of locking devices:

(a) Nut and jam nut.
(b) Self-locking nut.
(c) Castellated nut with cotter pinning or safety wiring.
(d) External toothed lockwasher may be used where the weight of the part does not exceed 2 ounches per screw.
(e) Split ring lockwashers.

3.5.13 Welding. Welding and allied processes shall be in accordance with MIL-STD-278. Nondestructive testing of MIL-STD-278 does not apply. Commercial welding practices may be used for welding application involving aluminum alloy 6061-T6 used in switchgear units, providing they meet the vibration and shock tests of 4.6.3.3 and 4.6.3.4.

3.5.14 Mechanical shock. Units of all switchgear groups shall withstand the type A shock test as specified in MIL-S-901 (see 4.6.3.4).

3.5.15 Soldering. Soldering and allied processes shall be in accordance with DOD-STD-2000-4.

3.6 Insulation.

3.6.1 Insulating material. In order to restrict the use of material which might catch fire or emit fumes when exposed to flame, the quantity of insulating material shall be kept to a minimum and used only where necessary to provide electrical insulation between live parts and to ground. Insulating material for bus supports and spacers, fuse bases, and other similar parts shall be in accordance with MIL-E-917 a minimum of a class B insulation system.

3.6.2 Insulation distances. Insulation distances in air and surface creepage distances on insulating materials for equipments shall conform to the applicable specifications. For all other live parts, such as bus work, the values shall conform to table I, except the applicable clearances of MIL-E-917 may be used where the bus is connected to the component studs within 4 inches of the component stud.

3.6.2.1 Insulating material. Insulating material used to obtain electrical clearance shall be a minimum of 1/8-inch thick when there is a possibility of impact or abrasion to the insulating material resulting from high impact shock or vibration. Otherwise, it may be 1/16-inch thick. Insulating material shall be secured by through-bolting.

TABLE I. Switchboards.

	Insulation distances to ground or to opposite polarity		
		Surface creepage	
Voltage	In air (inches)	Bottom and side surfaces (inches)	Top and flat surfaces 1/ (inches)
125 ac or dc	0050	0.94	1.13
230 ac	.63	1.20	1.50
500 ac or dc	.78	1.56	2.00
1000 ac	1.31	2.50	3.34

1/ Values for top creepage apply to flat surfaces or to curved surfaces presenting sufficient irregularities to permit accumulation of dust and moisture. 'Values are not intended to apply to simply cylindrical surfaces having a radius of 3 inches or less where side creepage values will apply.

3.7 Hinged and removable enclosing panels.

3.7.1 Structure. Panels shall be made from sheet 3/32- to 1/8-inch thick of U.S. Gauge number 11 (commercial tolerances acceptable). Panels shall be formed with bent angle or channel edges. Flanges of panels shall be welded at the corners and ground smooth. There shall be no butt joints on the panel surfaces. Where the strength of the paneling is materially weakened by cutouts, it shall be reinforced by stiffening members. Front enclosure panels for type AQB and NQB feeder circuit breakers shall be drilled with 5/16-inch diameter holes so that the contact prong of the megger testing equipment may be inserted to make contact with the circuit breaker terminal for making the insulation tests of the feeder cables. Type NQB and AQB circuit breakers that are interlocked to form a bus transfer switch, casualty power circuit breakers and motor operated type AQB circuit breakers, or any AQB circuit breakers which may have their load side energized from another source shall not be provided with megger holes. Size of the cutout for type AQB and ACB circuit breaker operating handles and escutcheons shall be in accordance with MIL-C-17361 and MIL-C-17587, respectively. Mounting and alignment devices shall be provided to facilitate installation and removal of removable enclosing panels. When installed, the panels shall be electrically grounded to the unit framework. Electrical ground may be achieved by the panel mounting or fastening devices, as long as positive metal-to-metal conductive surfaces are provided for by the addition of other devices that do not interfere with panel removal.

3.7.2 Panel hinging. Panels shall be hinged to provide access to electrical equipment mounted thereon. Means shall be provided so that these hinged sections may be opened without removing the guard rail. Hinged panels shall be provided with door stops or positioning devices to stop the door in its opening swing and to hold it in the open position. The preferred side for hinging panels is the left-hand side when facing the front of the panel. A typical panel hinge assembly is shown on figure 14. Hinged panels shall be electrically grounded to the unit framework by a separate conductor. Hinges are not considered to be an acceptable grounding path.

3.8 Mounting of equipment.

3.8.1 Securing of equipment. Equipment shall be secured to the panels of framework in order to insure against dislodgement caused by shock. Brackets and mounting lugs or feet shall have fully enclosed holes or slots. Open end slots shall not be acceptable. Devices mounted on the unit side sheet or internal partitions shall be easily removable from the inside of the unit. Devices mounted on the unit side sheet shall not interfere in any way with the inner-unit bolting to form switchboard sections.

3.8.2 Mounting bolts and screws. Bolts used in the assembly of the framework and for securing the large devices to the framework shall be hexagon head type. Screws for miscellaneous purposes shall be round, fillister, or flat slotted head type.

3.8.3 Arrangement of equipment. No device shall extend beyond the edges of the panel on which it is mounted. Symmetrical arrangements of equipment on the units is desirable, but should not take precedence over arrangements where space may be saved for future or spare equipment.

3.8.4 Polarity. For dc, when facing the front of the switchboard or panels, left-hand contacts shall be of the same polarity (negative) and the right-hand contacts of the same polarity (positive).

3.8.5 Phase rotation. For when facing the front of the switchboard or panel, the phase rotation shall be A, B, and C, respectively, from right to left, top to bottom, or front to back.

3.8.6 Casualty power equipment.

3.8.6.1 Arrangements. For ship's service and emergency switchgear groups the casualty power circuit breaker and casualty power terminal (required herein on the generator units) shall be available for use in the event of damage to the remainder of the switchboard on which the generator unit is located. The lead from the generator bus on generator units for the main bus on power distribution units to the casualty power connection and equipment shall be as short and direct as practicable and the casualty power terminal shall be readily accessible to permit rapid connection of the casualty power cable. Casualty power terminals and circuit breakers are required on load centers as specified in 3.4.4.1.

3.8.6.2 Mounting of casualty power equipment. Casualty power circuit breakers and riser terminals shall be mounted at the rear or on the side of the unit. When mounted within the unit, the casualty power equipment shall be readily accessible from the rear of the unit so that cables may be connected to the terminal without undue exposure of the personnel to live parts. Rear enclosures shall not be used for support of the terminal or circuit breaker, nor shall its removal be necessary for access to the terminal or for operation of the circuit breaker. When mounted on the side of the unit, the riser terminal shall be surface mounted, and the circuit breaker shall be removable without removal of the side sheet. Normally, the circuit breaker and riser terminal shall be located adjacent to one another so that personnel my readily determine that the breaker is open and the terminal not energized before making connections. Allow approximately a 14-inch diameter area about the centerline of the terminal for installation of cables into terminal.

3.8.6.3 Casualty power circuit breaker rating. Circuit breaker type AQB-A or AQB-LF shall be provided with an element rated at 250 amperes. Unless otherwise specified in the contract or order (see 6.2.1), instantaneous trip settings shall be as follows: AQB-A circuit breaker - 3400 amperes and AQB-LF circuit breaker - 3000 amperes. For generators rated 1000 kW and below, an AQB-A circuit breaker shall be furnished. For generators rated above 1000 kW, an AQB-LF fused circuit breaker shall be furnished.

3.8.7 Voltage regulator equipment. Where voltage regulator equipment conforming to MIL-R-2729 is required to be installed in the switchboard, the space and arrangement of this equipment shall allow for accessibility for maintenance and provide the specified electrical insulation distances (see 6.2.1).

3.8.8 Accessibility, Equipment, bus work, fasteners, and electrical connections that may require servicing, repair, or replacement during the life of the switchboard shall be readily accessible for servicing, inspection, tightening, repair or replacement. Access shall be maintained after all bus work, switchboard wiring, and ship cabling are installed.

3.9 Shore power (see figure 2).

3.9.1 Phase sequence indicator. The phase sequence indicator shall conform to MIL-I-16103. It shall be wired through a multiposition selector switch. The switch shall have one position for each shore power feeder and an off position.

3.9.2 Reference selector switch. The reference selector switch shall be used to establish a reference shore power feeder for checking phase orientation. There shall be one switch position for each shore power feeder. The A and B phases of each feeder shall be connected to the switch terminal and the corresponding switch terminal of the phase sequence/orientation test switch. The phase sequence/orientation test switch shall be used to check that the A and B phases of the incoming shore power are connected to the A and B phases of the other shore power feeders. There shall be one switch position for each shore power feeder. The wiper arm of the reference switch shall be connected to one terminal of the indicator. The other terminal of the indicator shall be connected to the phase sequence/orientation test switch wiper arm. Both green indicators shall light if the phases are the same. The indicator shall be located next to the reference selector switch and the phase sequence/orientation test switch.

3.9.3 Circuit breaker control switch. Circuit breaker control switch shall be a momentary contact, new position indicator with a close contact and an open contact for each shore power breaker. The switch shall simultaneously control all shore power circuit breakers. Circuit breakers shall be type AQB-LF 400, motor operated with a 400 amp element. Instantaneous shall be at the maximum setting. Breaker shunt trip shall be wired through the shore power receptacle interlock switch so the circuit breaker trips when the shore power receptacle cover is open or the cable is not connected.

3.10 Bus bars and connectors.

3.10.1 Bus connections. Bus connections shall be made with solid copper or aluminum alloy bus bars, except as specified for certain circuit breaker connections (see 6.2.1).

3.10.2 Copper bus bars. Rectangular copper bus bars with rounded corners or round edges, hard temper in accordance with ASTM B 187 shall be used for bus bars. Bars shall be silver surfaced at the contact areas as specified herein.

3.10.3 Cable connector sizes. On switchboards having an ac bus structure designed for short circuit currents of 15,000 amperes or less, single conductor insulated copper cable, in accordance with MIL-W-16878 and type D4 of MIL-W-16878/3, shall be used for connections to 100 amperes frame size type AQB circuit breakers. On switchboard buses having a total connected dc generator capacity of not more than 150 kW at 120 volts, similar cable connections shall be provided for 100 ampere frame circuit breakers.

3.10.4 Aluminum bus bars. Rectangular aluminum alloy 6101, T61, or T63 temper with rounded corners or round edges in accordance with ASTM B 317 shall be utilized for bus bars. Bars shall be silver-surfaced at the contact areas as specified herein.

3.10.5 Cable connector sizes for casualty power. Cable connecting a casualty power circuit breaker to the line side of an ac generator circuit breaker shall be type D 1/0 of MIL-W-16878/3. Cable connecting the casualty power circuit breaker and the riser terminal shall be type D4.

3.10.6 Bus bar sizes. Size of the bus bars shall be selected on a basis of the current carrying ratings shown in table II. In no case shall the bus bar sizes be smaller for a given current than the corresponding sizes listed in table II.

TABLE II. Ampere rating of rectangular bus bars placed on edge.

Number of bars parallel	Size of bars (inches)	Cross-sectional area (square inches)	Ac ampere rating 60 Hz		Dc ampere rating
			Copper bus, silver surface	Aluminum bus, silver surface	Copper bus, silver surface
1	1/2 X 1/8	0.063	140	100	140
	5/8 X 1/8	.078	175	120	175
	3/4 X 1/8	.094	210	140	210
	1 X 1/8	.125	285	190	285
	1-1/2 X 1/8	.188	425	280	425
	2 X 1/8	.250	555	370	355
	3/4 X 3/16	.140	265	175	265
	1 X 3/16	.188	355	235	355
	1-1/2 X 3/16	.278	550	360	550
	2 X 3/16	.375	700	450	710
	3/4 x 1/4	.188	295	200	295
	1 x 1/4	.250	410	300	410
	1-1/2 x 1/4	.375	600	420	600
	2 x 1/4	l 500	780	550	800
	2-1/2 x 1/4	.625	1,000	660	1,050
	3 x 1/4	.750	1,140	800	1,185
	4 x 1/4	1.000	1,425	1,000	1,490
	5 x 1/4	1.250	1,760	1,250	1,850
	6 x 1/4	1.500	2,100	1,500	2,190
2 (1/4-inch apart)	1 x 1/4	0.500	650	480	650
	1-1/2 x 1/4	.750	950	660	950
	2 x 1/4	1.000	1,350	900	1,370
	3 x 1/4	1.500	1,825	1,250	2,000

TABLE II. Ampere rating of rectangular bus bars placed on edge. - Continued

Number of bars parallel	Size of bars (inches)	Cross-sectional area (square inches)	Ac ampere rating 60 Hz		Dc ampere rating
			Copper bus, silver surface	Aluminum bus, silver surface	Copper bus, silver surface
	4 x 1/4	2.000	2,280	1,600	2,530
	5 x 1/4	2.500	2,740	1,900	3,100
	6 x 1/4	3.000	3,140	2,250	3,630
3 (1/4-inch apart)	3 x 1/4	2.250	2,200	1,600	2,620
	4 x 1/4	3.000	2,660	2,000.	3,110
	5 x 1/4	3.750	3,200	2,400	3,830
	6 x 1/4	4.500	3,600	2,800	4,560
4 (1/4-inch apart)	3 x 1/4	3.000	2,650	— -	3,130
	4 x 1/4	4.000	3,020	— -	3,870
	5 x 1/4	5.000	3,450	— -	4,750
4 (2 pairs/ phase 3/4-inch between pairs)	6 X 1/4	6.000	4,000	— .	---
4 (2 pairs/ phase 2-1/2 inches between pairs)	5 x 1/4	5.000	4,200	3,200	---
	6 X 1/4	6.000	5,000	4,000	---
	8 x 1/4	8.000	6,400	5,200	— -

3.10.7 Grouping and arrangement of bus bars. Particular attention shall be given to the grouping and arrangement of buses for ac (60 Hz and above) currents near magnetic material, since proximity of such material will create additional heating, thereby interfering with the dissipation of heat from conductors and reducing their capacity.

3.10.8 Cabling for circuit breakers. Where single conductor cable is used for connection to circuit breaker, cables shall be securely bound together with nonflammable cord and secured to the supports as necessary to prevent distortion under short circuit conditions. Cable runs shall not come in contact with the bus bars except at the bus bar terminating end of the cable. Binding shall be applied in such a manner that it will not cut into the cable insulation due to the forces exerted under short circuit conditions. Binding shall be especially heavy where cables turn out of the pack. Terminal lugs shall be used for terminating cable at the circuit breaker terminals and at the bus bar. Through-bolts shall be used for securing the cable terminal to the bus bar. Not more than two cable terminals shall be clamped by one bolt and when two are used they shall be placed on the opposite sides of the bus. Cables shall be neatly formed and where their length exceeds approximately 12 inches they shall be supported by the switchboard structure and not by the bus bars.

3.10.9 Bus bar forming. Flat bends shall have an inside radius of not less than the thickness of the bus bar, and the ends of the bus bars shall be neatly finished. Edgewise bends of copper bars Up to 2 inches in width may be made on an inside radius of 1 inch and those over 2 inches, but not exceeding 4 inches in width may be made on an inside radius of 2 inches. Bars shall be free from cracks or flaws at bends. In general, aluminum bars shall not be bent edgewise, except for minor bends resulting in a brief change of direction (jog) with the maximum offset limited to one half the width of the bus bar.

3.10.10 Silver surfacing of buses. Silver surfacing of buses and connections shall be accomplished by plating using 99.9 percent pure silver. Plating shall conform to the requirements specified in QQ-S-365, with the exception that the silver plate shall be not less than 0.0002-inch thick. Contact surfaces of bus bars shall be silvered up to 1 inch past the joint area. The entire bus may be silver-surfaced at the discretion of the contractor. Threaded surfaces shall have silver thickness of at least 0.0002 inch.

3.10.10.1 Holes in bus bars. Holes in bus bars for bolting may be either punched or drilled, but the contact area shall be smoothed by belt sanding or other equivalent method before silver surfacing. Where punching is used, the operation shall not appreciably indent the surface of the bus bar in the vicinity of the hole. Slotted holes are not permitted. Contact surfaces of bus bars and contact nuts shall be finished true to give adequate contact. Contact nuts and contact spacer nuts for copper stud contacts shall be of rolled brass and shall be of sufficient size to provide the necessary area for contact surface. Contact nuts and contact spacer nuts for silvered contacts shall be silver-surfaced, as specified in 3.10.10 for threaded surfaces. Holes in bus bars for standard bolts shall have the following dimensions:

Bolt size (inch)	Hole size (inch)
3/8	7/16
1/2	9/16
5/8	11/16

When 5-inch or larger bus bars are joined together, the bolt hole size may be enlarged to provide 1/8-inch clearance.

3.10.10.2 Preparation of joints. Joints of all bus bars shall be specially prepared before bolting. Method of preparation shall be as follows:

(a) Apply a thick film of high viscosity paste conforming to MIL-C-16173, grade 2.
(b) Bolt joints together without removing the paste.
(c) After joints are bolted together, remove paste from all exposed surfaces with clean, dry cloth.
(d) On aluminum bus bars where only the joint or contact area is silver plated, the paste shall be applied approximately 1 inch beyond the silver plated area.

3.10.11 Bolts and nuts used in bus bar joints. Bolts and nuts used in bus bar joints shall be of the coarse thread series made of a 300 series corrosion-resistant steel (CRES) conforming to QQ-S-763, silicon bronze conforming to ASTM B 98, B 411, or B371, or zinc plated steel conforming to MIL-S-1222 (a minimum of grade 2 or 5 depending on stress on the bolts and nuts). Silicon hardware shall be used in bus bar joints 4000 amperes and above. Flat washers of material similar to the nuts and bolts shall be used under all bolt heads and nuts adjacent to the conductors. Securing bolts shall be fitted with nuts conforming to figure 15. For typical bus bar mountings, see figure 16. Locking devices listed in 3.5.12.3(a), (b), and (c) shall be used in bus bar joints for surface ships. Locking devices listed in 3.5.12.3(a) shall be used in bus bar joints for submarines. Bus bars may be joined by welding; however, welding shall be restricted to assemblies where disassembly will not be required for maintenance or repair of underlying assemblies. All welders and weld procedures for copper bus bars shall be qualified in accordance with MIL-STD-248.

3.10.12 pressure of bus bars. Bus bar joints shall be made in accordance with table III and figure 15. Bolts for bus bar joints shall be lubricated and tightened to the following torques:

Bolt size (inches)	Torque (foot-pounds)			
	Steel		Silicon bronze	
Maximum	Minimum	Maximum	Minimum	Maximum
3/8	14	16	10	11
1/2	30	33	15	17
5/8	50	55	35	39

For connections made to circuit breaker studs, the following torque requirements shall apply:

Copper stud size	Steel cap screw size	Torque (foot-pounds)	
		Minimum	Maximum
3/8 - 16	- — -	7	8
1/2 - 13	- - -	15	17
3/4 - 16	- - -	25	28
1-1/8 - 12	— -	40	44
----	5/8 - 11	50	55
----	1 - 8	130	145

TABLE III. Bolting of connection bars - diameter and number of bolts.

Size bars (inches	Diameter and number of bolts 3/4 (inch)	1 (inch)	1-1/2 (inch)	2 (inch)	2-1/2 (inch)	3 (inch)	4 (inch)	5 (inch)	6 (inch)	8 (inch)
3/4	One 3/8	---	—--	---	---	—--	---	----	----	----
1	One 3/8	One 1/2		---	---	---	-- —	----	----	----
1-1/2	One 3/8	One 1/2	One 5/8	—--	---	---	----	----	----	-- —
2	Two 3/8	Two 3/8	One 5/8	One 5/8	---	-—-	----	----	----	----
2-1/2	Two 3/8	Two 3/8	Two 1/2	Two 1/2	Two 1/2	---	----	----	----	----
3	Two 3/8	Two 1/2	Two 1/2	Two 1/2	Two 5/8	Two 5/8	--—	----	----	----
4	Two 3/8	Two 1/2	Two 5/8	Two 5/8	Two 5/8	Two 5/8	Four 5/8	----	----	—--
5	Two 3/8	Two 1/2	Two 5/8	Two 5/8	Two 5/8	Three 5/8	Five 5/8	Five 5/8	-—-	--—
6	Two 3/8	Two 1/2	Two 5/8	Two 5/8	Two 5/8	Three 5/8	Five 5/8	Five 5/8	Five 5/8	—--
8	Two 3/8	Two 1/2	Two 5/8	Two 5/8	Two 5/8	Three 5/8	Five 5/8	Five 5/8	Five 5/8	Six 5/8

3.10.12.1 Nuts. When jam nuts and regular nuts are used as fasteners, the jam nuts shall be seated and torqued to 100 percent of 3.10.12 values, then the regular nuts installed. While holding the lock nut stationary, the regular nut shall be torqued to 110 to 115 percent of 3.10.12 values.

3.10.13 Bus supports. The construction, number, spacing, and mounting of the bus bar supports shall be in accordance with calculations based on the magnitudes of forces and stresses encountered on the buses being supported when subjected to maximum rms asymmetrical short circuit currents (see 6.2.1). Values of maximum stress in the outside fibers shall be based on the strength of the bus bar and not upon the tensile strength of the bus bar. Support shall prevent contact of live parts with each other or ground during short circuit, high impact shock, or vibration. Any permanent deformation or displacement of the bus bars following a short circuit shall not reduce the specified clearance distances by more than 30 percent of their original values. A short circuit test may be performed in lieu of calculations.

3.10.14 Bus bar capacity. Main bus bar rating shall be not less than the largest rated current capacity of the power source supplying the main bus. Units shall accept the maximum bus size required for standardized units as shown on figure 9. Either main bus taps or branch bus taps feeding three or more AQB circuit breakers shall be sized based on 75 percent of the sum of the active and spare circuit breaker frame sizes (maximum current rating) supplied, but not exceeding the" main bus rating. Main bus taps and branch bus taps feeding one or two circuit breakers shall be sized based on 100 percent of the active and spare circuit breaker frame sizes supplied, but not exceeding the main bus rating.

3.10.15 Bus bar insulation. When specified (see 6.2.1), bus bars shall be insulated with materials in accordance with MIL-E-22118 or other specified compounds to improve creepage distances. Joints, except those required for final shipboard installation, shall be insulated after assembly. Installation instructions shall include a list of joints requiring insulation so that all current carrying parts will be insulated upon completion of final shipboard installation.

3.10.16 Cable lug terminals. Cable lug terminals installed on all cables entering or within the switchboard shall be solderless in accordance with MIL-T-16366. Lug terminals shall be tin plated. Style LP07 and LP08 cable lug terminals of MIL-T-55156 shall be used with type AQB circuit breakers except where multiple cables are used, style LP02 of MIL-T-55156 or type CLC or CLCG cable lug terminals of MIL-T-16366 may be used. CLC or CLCG lug terminals shall be used with ACB circuit breakers or bus bar applications. Cable lug terminals shall not be installed on spare circuit breakers to which a cable is not attached. For all cables of 14 AWG (4000 cmils) and larger, cable lug terminals shall be secured by means of locking devices in accordance with 3.5.12.3. Cable lug terminals for cables entering a switchboard may be furnished by the installing activity (see 6.2.1).

3.10.17 Connections between buses. Connections between the buses of adjacent sections of a switchgear group may be made by cables instead of solid bus bars to permit relative movement of the sections under shock without rupturing . the switchboard main bus circuit. A means for readily disconnecting the cables from the bus shall be provided in all sections having a source of power other than from the connecting cables. The disconnecting device shall have a rating equal to the main bus. Cable connections shall be made by the installing activity. Switchboard arrangement shall include means to provide for the entrance of the connecting cable into the switchboard structure and for connecting the cables to the switchboard bus. Connecting cables shall have a current rating equal to that of the smaller of the two connected buses. Consideration shall be given to facilitate connection (by the installing activity) for the ship's cable to the switchboard so that these cables will not result in restriction of access features. Recommended locations and routing of cables to be installed by the shipbuilder shall be shown on the drawings to demonstrate that adequate clearance for the cables and access to the switchboard have been provided. Armor shall be removed from the portion of ship’s cables inside the switchboard. Instructions for interconnecting wiring shall be shown on the switchboard drawings.

3.10.18 Cables entering switchboards. Cable shall enter the switchboard through the top dripshields, with standard terminal tubes or multi-cable transit devices. Terminal tubes or multi-cable transit devices shall be shipbuilder-furnished. Switchboard arrangement shall provide for proper cable connections without restrictions of access features (see 6.2.1).

3.11 Wiring of control and instrument circuits.

3.11.1 Control and instrument cable types. Cables used for control and instrument circuits, ground detector and indicator lights, and other parts shall conform to MIL-W-16878 and MIL-W-16878/3. Control and instrument wiring shall be not smaller than type D-16(19) of MIL-W-16878/3, but may be larger, if necessary, for current carrying capacity requirements. NAVSEA 0362-LP-235-2000 shall be used as a guide for the rating of bundled cables. Current rating of cables and bundles shall be based on a switchboard internal, ambient temperature of 65°C for surface ships and 75°C for submarines. The flexible 19-strand wire shall be used for wiring between hinged panels and the stationary structure. Cables within each unit shall be of the same solid color.

3.11.2 Cable end connectors. Ends of each wire shall be connected to the apparatus studs by means of an accepted solderless terminal or by forming a wire loop around the apparatus stud or terminal screw and retaining the loop in a cup or crimped washer. Wire loop shall be soldered to secure the strands together. Locking devices in accordance with 3.5.12 shall be used to secure the nuts or screws connecting wire loops to the apparatus connection point. See figure 17 for illustration of wire connections.

3.11.3 Forming and securing cable groups. Wires shall be neatly formed into groups which shall be laced or corded and supported or clamped in a manner that will prevent chafing of the insulation caused by vibration. Cable shall not be supported by bus bars, and a minimum 1/4-inch clearance shall be provided between cables and bus bars to prevent abrasion under conditions of vibration, except at the bus bar terminating end of the cable. Commercial nylon cable straps or metal clamps may be used, but where metal is used it shall be covered with a flame-retardant material which will prevent chafing of the wire insulation. Lacing material shall be either nylon straps, nonflammable cord, glass fiber tape conforming to type SR-1 of MIL-I-3158, or pressure sensitive adhesive plastic tape conforming to MIL-I-24391. The last two materials are specifically adapted for serving switchgear control wiring in locations subject to abrasion. Glass fiber tape may be coated with adhesive on one side, but when used with this adhesive coating, it shall be covered with pressure sensitive adhesive plastic tape for permanent adhesion. There shall be no splices in the wire and connections shall be made at the terminal studs of the devices or terminal boards. Wire groups running from hinged panels shall be formed and clamped so that sharp bends do not occur with the panel in either the open or closed position and shall be connected to terminal blocks on the fixed portion of the switchgear structure. Where wires run from one section of a switchboard to an adjacent one, and these sections are separated for shipping or installation purposes, a terminal board shall be provided on one of the units and located in order to facilitate completion of the interconnections during installation of the switchboard on the ship.

3.11.4 External control cable connections. External control cable connections to the switchboards shall terminate at terminal boards accessibly located near the top or bottom of the switchboard, corresponding to ship's cable entrance. Where calibrated shunt leads are required, they shall terminate on the instrument studs. An excess length of shunt leads shall be neatly coiled and secured to prevent interference with access to other equipment. Small wiring to circuit breaker trip coils shall run directly to the coils and associated contact circuits and shall not be routed through terminals of other apparatus. Taps from bus bars shall be made by through-bolting terminals to the bus bars.

3.11.5 Synchronizing control circuits. The synchroscope shall be supplied by the phase A-B transformers, and the synchronizing lights shall be supplied by the phase B-C transformers provided for metering, synchronizing, and relaying potential as shown on figure 18. The loss of one transformer shall not disrupt both synchronizing facilities. Closing control circuit of electrically operated circuit breakers (ac generators, bus ties, and shore power) shall be connected through contacts of the corresponding synchronizing switch. Synchronizing control equipment shall be provided as specified in MIL-S-24188 to electrically prevent closing of the generator circuit breakers, bus tie circuit breakers, or shore power circuit breaker, as applicable, unless the energized systems to be

connected are properly synchronized. Control circuitry external to the synchronizing protective equipment shall be arranged so synchronizing and paralleling can be accomplished after failure of the synchronizing protective equipment. Automatic paralleling devices shall be as specified (see 6.2.1).

3.11.6 Space heater circuits. When space heaters are provided with the associated generator, the heater circuit shall be supplied through a heater control switch from a local lighting circuit for 120-volt space heaters or from a power source having emergency supply for 450-volt space heaters. An indicator light (white) shall indicate when generator heaters are energized. This heater circuit shall be wired through a normally closed contact (closed when breaker is open) of the associated generator circuit breaker auxiliary switch.

3.11.7 Indicator light power. On surface ships, the indicator lights of the mimic bus shall be supplied from a local lighting system that has available both normal and emergency power. On submarines; power for the indicator lights shall be taken from the ac or dc control power buses.

3.11.8 Control transformers. Control transformers shall be supplied in number as required for supplying governor motor control circuits, temperature indicator, and generator running and up to voltage relay.

3.11.9 Ground detector lights. Ground detector lights shall be connected as shown on figure 19.

3.11.10 Voltage regulator connections. Voltage regulator equipment shall be connected in accordance with the drawings provided with the regulator equipment.

3.11.11 Wire and terminal marking. Internal wiring of equipment shall be marked on both ends by fiber tags or by synthetic resin tubing type F, grade A of MIL-I-631. Markings shall agree with the designation shown on the switchboard drawings to facilitate checking of connections. It shall not be necessary to mark the terminal studs on instruments and control switches, but wiring diagrams shall clearly indicate the studs or contacts to which marked wires are connected. Terminal blocks shall be equipped with marking strips. These marking strips shall be permanently marked at each terminal with a number (for example, 1 to 12) and also to agree with the corresponding number on the wiring diagram. Terminal blocks in each unit shall be numbered TB1, TB2, and so forth.

3.11.12 Shunt trip coil circuits. Shunt trip coil circuits (both ac and dc) for tripping type ACB and AQB circuit breakers shall be routed through a normally open contact (open when the breaker is open) of the circuit breaker auxiliary switch, so that the trip coil cannot remain energized after the circuit breaker is open.

3.11.13 Control voltage. Control voltage within the switchboard shall normally be 120 volts ac or dc. Where 450 volts control circuits are used for circuit breaker control, they shall be clearly identified.

3.12 Circuit breakers. Circuit breakers shall conform to MIL-C-17587 (for type ACB), MIL-C-17361 (for types AQB and NQB), and MIL-C-17588 (for type ALB). Unless otherwise specified (see 6.2.1), type ACB circuit breakers 1600 ampere frame size and larger shall be electrically operated and circuit breakers 1600 ampere frame size and smaller may be manually operated. Circuit breakers controlled from an EPCP, EPCC, or controlled by the synchronizing protective equipment specified in 3.11.5 shall be electrically operated.

3.12.1 Mounting (AQB and NQB). Types AQB and NQB circuit breakers for switchboard use shall be equipped with removable contacts on both line and load side, connections being made by use of terminal mounting blocks in accordance with MIL-C-17361 for AQB and NQB. Distribution type, horizontal panel mounting of AQB and NQB circuit breakers is permitted. When circuit breakers requiring panel megger holes are mounted vertically, the line side terminals shall be at the top and the operating handle shall be in the downward position when the breaker is intentionally open. When interlocks are required for types AQB and NQB circuit breakers, they shall be mounted in front of the panel and shall be suitable for use with circuit breakers of any make by no further modification than possible reassembly of the interlock. Circuit breaker escutcheon shall be centered in its panel cutout on the switchboard.

3.12.2 Mounting (ACB). Type ACB circuit breakers shall be of a removable assembly construction. Each circuit breaker shall be supplied as a complete removable switchboard assembly consisting of circuit breaker, separable disconnects and associated control wiring, circuit breaker drawout mechanism, assembly structural supports, back plate including stationary main bus connections, and stationary terminal for connection of the necessary external control wiring. Circuit breaker stationary assembly shall be secured to the vertical member or the horizontal structural member or both. ,

3.13 Switches, disconnecting devices, and transfer switches. Control and instrument switches shall be in accordance with MIL-S-18396. For applications below 125 volts, style JR switches as specified in MIL-S-21604 and MIL-S-21604/5 may be used. Control and instrument switches shall have gray or natural light tan escutcheon plates with black lettering. Switches shall be provided with four styles of handles to identify the function for which the switch is provided.. The handle styles and corresponding function shall be as follows:

(a) Round	- governor control (spring return).
(b) Oval	- synchronizing and voltage regulator, synchronizing monitor, and field flashing.
(c) Round (knurled)	- instruments (voltmeter, ammeter, frequency meter, temperature indicator).
	- test (emergency switchboard, spring return).
(d) Pistol-grip	- circuit breaker and ground lamps (spring control).
	- control bus selector.

Control switches installed within the enclosure (such as relay defeater switches) shall be sufficiently close to the access opening to minimize personnel exposure to energized components.

3.13.1 Disconnecting devices. Disconnecting devices and associated tools for performing power disconnecting functions shall conform to MS17831. With full rated current through the disconnect devices, the maximum temperature rise of the devices shall not exceed 50°C. Disconnect devices shall be mounted inside the switchboard and shall be readily accessible after removal of the rear enclosure. Tools conforming to MS17832 (if required) for operation of the devices shall be mounted outside of the switchboard enclosure adjacent to the panel that must be removed for operation of the device. A warning plate shall be provided near the disconnect device to read: "DO NOT OPERATE WHEN ENERGIZED". The plate may be constructed in accordance with the requirements of 3.20 with letters not less than 3/16 inch.

3.14 Fuses and terminal blocks. Fuses shall be in accordance with MIL-F-15160. Fuses for 450 volt applications shall be characteristic C of MIL-F-15160.

3.14.1 Fusing of transformers. Each metering potential transformer shall be fused on the primary side with a separate fuse in each leg of each transformer. Fuse size shall be 250 to 400 percent of transformer rated primary current. Control transformers shall be fused on the primary side. Transformer secondary circuits shall not be fused, except where a circuit leaves the switchboard. In such a case, the ungrounded portion of the circuit which leaves the switchboard shall be fused, and the fuses shall be located so as not to open any other circuits on the local switchboard. One 6-ampere fuse shall be provided in each primary leg of each indicator light transformer. The control circuits for electric operation of circuit breakers shall be fused for short circuit protection only. Potential circuits for generator voltage regulators on excitation systems shall not be fused.

3.14.2 Fuse mounting. Fuses mounted on switchboards shall be accessibly located for replacement. Dead front fuseholders or clip type fuseholders may be used. Fuses shall be grouped on subpanels insofar as practicable, but the length of leads between fuses and the power circuit taps shall be kept to a minimum.

3.14.2.1 Dead front fuseholders. Dead front fuseholders shall be of the following types in accordance with MIL-F-19207 and shall not be installed for any distribution circuit fuse on power or lighting distribution switchboards or panels:

Type	Specification
FHL10U	MIL-F-19207/1
FHL11U	MIL-F-19207/2
FHL12U	MIL-F-19207/3
FHL14G	MIL-F-19207/5
FHL32W	MIL-F-19207/21
FHL33W	MIL-F-19207/22
FHL34W	MIL-F-19207/23
FHL35W	MIL-F-19207/24

3.14.2.2 Clip type of fuseholders. Clip type of fuseholders shall be enclosed by hinged metal covers. Covers shall be provided with insulating strips that shall hold the fuses in the fuse clips under shock. Fuse clips shall be in accordance with MIL-F-21346 and MIL-F-21346/1.

3.14.3 Terminal boards. To minimize the possibility of breakage of the terminal boards caused by distortion of the mounting support under shock, the length of the terminal board shall not exceed 12 terminal points. Terminal boards shall be in accordance with MIL-T-55164 and MIL-T-55164/2 or MIL-T-55164/3, or the equivalent.

3.15 Instruments. relays. and instrument transformers.

3.15.1 Electrical measuring instruments. Electrical measuring instruments shall conform to MIL-I-1361, MIL-T-15377, MIL-M-16034, MIL-S-16104, MIL-M-16125, MIL-W-19088, MIL-V-23151, and MIL-M-23167 having a 4-1/2 inch, rectangular case with 250-degree scale. Instrument scales shall be white with black markings and lettering and shall be marked to indicate the full load and normal voltage calibration points.

3.15.2 Digital indicators. Digital readout indicators shall be segment readouts in accordance with MIL-R-28803. The height of the indicator characters shall be a minimum of 0.45 inch. Display colors shall be selected in accordance with 3.16, except that red shall be used for alpha-numeric displays.

3.15.2.1 Digital readout circuitry. The need for digital indicators may require that some circuitry be mounted with the digital indicators to reduce the number of connections necessary between the equipment and the digital indicators.

3.15.2.1.1 Digital requirements for digital readout circuitry. Any circuitry that is to be mounted with the digital indicators shall be constructed according to the following guides with the order of importance being the same as the order of the guides:

(a) Minimize the complexity of the indicator component.
(b) Minimize susceptibility.
(c) Minimize the number of connections between the equipment and the digital indicators.

3.15.2.2 Digital indicator flicker. The digital indicators that display the parameter measurements in engineering units shall reduce flickering of the readout equipment. The least significant digit will inherently change from one digit to another at the transfer point. Every effort shall be made to reduce objectionable flicker in the least significant digit.

3.15.2.3 Isolation. Isolation shall be used among the various instrument outputs so that shorting or opening any digital output circuit will not produce a change in any other output in excess of the specified accuracy requirements.

3.15.3 Instrument transformers.

3.15.3.1 Transformers for metering and relaying. Instrument transformers for metering and relaying shall conform to MIL-I-1361 having an accuracy for Navy secondary standard rating. Transformer type of devices used to provide phase angle for single phase wattmeters on 3-phase circuits or similar functions shall conform to MIL-I-1361. Instrument transformers provided for voltage regulators shall not be used to supply any other burden. For each group of instruments, relays and synchroscope, one set of instrument transformers shall be used unless the burden on one set would be too great for the accuracy required. Potential

transformers for each group of instruments, relays, and synchroscope shall not be used for other potential devices. Where two potential transformers are used for 3-phase operation, they shall be connected open delta on the primary and secondary. One transformer shall be connected across phase A-B and the other across B-C. Where current transformers are required to supply 3-phase current, two transformers shall be used, one connected in phase A, one in phase C. Their secondaries shall be connected open delta. Current transformer secondary circuits that extend beyond the section containing the current transformers shall be provided with protective devices conforming to MIL-I-1361 to prevent high voltage in the event of an open circuit. Protective devices shall be connected so that their operation will not shunt out protective relays that may be connected in the circuit. A short circuiting switch shall be connected in parallel with the protective device for manually short circuiting the remote part of the current transformer circuit. Connections shall be as shown on figure 20. Current transformer secondary circuits, which supply both metering and electric governor input, shall be wired so that when the metering test receptacle cover is removed, the current transformer secondary is short circuited through the electric governor so that performance of the electric governor will be unaffected. Current transformers shall not be used as bus bar supports.

3.15.3.2 Grounding of secondary terminal. One secondary terminal of each metering and relaying (potential and current) transformer shall be grounded, except for the following:

(a) For 3-phase connections where one ground connection shall be made to the common or B phase of the two transformers.
(b) For current and potential transformers used in voltage regulator circuits.

3.15.4 Inductive relays. Inductive relays, both protective and auxiliary types, shall conform to MIL-R-2033 and shall be of types that have been tested for class A high impact shock. Auxiliary relays shall be in accordance with MIL-C-2212 and MIL-R-19523. Solid-state relays shall be in accordance with MIL-R-28750. Relays used in the circuit breaker control circuits shall be selected so that under switchboard shock they will not cause the circuit breakers to change state.

3.15.5 Transformers. Transformers shall conform to MIL-T-15108 and MIL-T-16315, as applicable.

3.15.6 Resistors and rheostats. Resistors and rheostats shall conform to MIL-R-15109. Power dissipation shall not exceed 50 percent of the rated value after ambient temperature and other applicable derating factors are applied in accordance with the part specification.

3.15.7 Reverse power monitor. Reverse power monitors shall be in accordance with MIL-M-24350.

3.16 Indicator lights. Indicator lights shall conform to MIL-L-3661, MIL-L-3661/38, MIL-L-3661/62, MIL-L-3661/63, MIL-L-3661/64, and MIL-L-3661/65, as applicable. Indicator lights shall be furnished with lamps. For position

indication of circuit breakers, blue indicator lights shall be used to show that the circuit breaker is closed. Other indicator lamps have color caps as specified for the particular application. The color code shall be as follows:

(a) Red. . . . . danger or emergency condition requiring immediate attention or corrective action.
(b) Green. . . . . normal condition.
(c) White. . . . . power available or power on.
(d) Blue . . . . . closed, advisory.
(e) Clear (not etched) . synchronizing or ground detector lights.
(f) Yellow . . . . . abnormal, but not requiring immediate attention.

3.17 Switchboard enclosures.

3.17.1 Rear enclosures. The rear of each unit shall be provided with a removable enclosure. These rear enclosures shall be made of expanded metal (rolled flat), perforated sheet, or solid sheets. Rear enclosures shall be sectionalized into not less than two horizontal parts to facilitate handling. When solid sheets are used, ventilation openings shall be provided at the top and bottom with louvers or openings similar to those in expanded metal or perforated sheet. Enclosures shall be adequately secured but shall not be used for structural strength. Openings in expanded metal or perforated sheet shall not pass a rod having a diameter greater than 3/8 inch. Provision shall be made for removal of fuses without removing the rear enclosure of a unit. On bench type of control units having equipment mounted on the rear enclosures, the rear enclosures shall be a hinged, solid sheet. Clearances between live bus work and disconnect devices, or both, and rear enclosures shall be adequate, in order to prevent these nonstructural strength panels from coming into contact with live bus work, if the panels are buckled inward.

3.17.2 Top enclosure. The top of each section shall be enclosed by a sheet cover. The top shall prevent dripping water or falling objects from entering the switchboard enclosure or damaging instruments on the front panels. It shall extend approximately 4 inches out over the face of the front panels and 4 inches beyond the rear of the switchboard structure. Clearance between the upper edge of the front panels and the underside of the top sheet, where it extends over the front, shall be at least 1/4 inch. Front and rear edges of the top sheet shall be turned up to form a l-inch flange along the entire length of the section or switchboard to prevent water from spilling over the front or rear. To ensure watertight integrity at the corners, the turned-up front and rear flanges shall be extended around the corners and along the end of the top sheet approximately 8 inches. The edge of the top sheet shall be turned down to form a flange and shall overlap the side sheets of the switchboard to allow drainage over the end in a manner that prevents water from seeping down the inside of the side sheet.

3.17.3 Panel fastening. Hinged and removable panels on the front and rear of the unit shall be secured by thumb screws (see figures 21 and 22). See 3.5.12.2 for thumbscrew anchoring devices.

3.17.4 Protection of enclosure from waterspray for submarine applications. When specified (see 6.2.1), switchgear shall be protected on all sides from waterspray from any angle (see 4.6.3.6.1). Protection shall be obtained by means of transparent, gasketed, quick opening covers mounted over circuit breaker handles, fuses, meters, or other devices subject to water damage and by installing baffles (see figure 12) over louvers to exclude waterspray. An operator's view of instruments and his ability to operate equipment shall not be impaired.

3.18 Guard rails. Each switchboard unit, except for distribution units, shall be provided with a vertical grab rod located on the right-hand side, facing the unit (see figure 23). Rod shall be of smooth hardwood supported with a sufficient number of brackets to provide adequate support for personnel under all operating conditions of the ship. The rod shall be attached in such a manner that all panels can be removed and hinged panels opened without removal of the rod from the member to which it is attached. These rods shall be located so that they will not interfere with operation of the equipment and shall not extend more than 4 inches from the front of the panel.

3.18.1 Removable guard rails. Removable guard rail sections shall be provided on the rear framework of the switchboard when the rear enclosure is removed (see figure 24). In general, two horizontal rails shall be required at proper levels to prevent personnel from being thrown against live buses caused by the motion of the ship. Rails shall be made of smooth hardwood. Rails shall be mounted on the inside of the rear vertical members so as not to protrude beyond the rear or ends of the structure. Guard rail sections shall be easily removable for maintenance access but shall be provided with securing bolts or other locking means to prevent dislodgement caused by shock.

3.19 Painting

3.19.1 General. Exterior and interior surfaces of enclosures shall be painted. The order of operations shall be as follows:

(a) Complete fabricating operations such as welding, machining, drilling, and tapping.
(b) Remove rust and other visible corrosion products.
(c) Remove grease, oil, and dirt by solvent wiping, vapor decreasing, or caustic washing and rinsing.
(d) Apply primer pretreatment coating or chemical treatment and primer.
(e) Apply enamel.

3.19.2 Painting shall be in accordance with method I (see 3.19.2.1) or method 11 (see 3.19.2.2).

3.19.2.1 Method 1.

3.19.2.1.1 Primer. Primer (TT-P-645) shall be applied at a thickness of 0.0015 - 0.0025 inch to hand tooled (SSPC-SP2) or power tooled (SSPC-SP3) surfaces.

3.19.2.1.2 Enamel. One coat of gray enamel conforming to class 2, type II or III of MIL-E-15090 shall be applied as a continuous film, each approximately 0.001-inch thick. A second coat of enamel shall be applied to the outside of the switchgear.

3.19.2.2 Method II.

3.19.2.2.1 Primer. A phosphate treatment shall be applied conforming to type I of TT-C-490, 0.0001 - 0.0002-inch thick.

3.19.2.2.2 Enamel. Enamel shall be applied in accordance with the following:

(a) First color coat - Parts shall be coated with one coat of a light gray, modified epoxy enamel applied by electrodeposition, at 150 to 300 volts for 1 to 3 minutes at a paint temperature of 65 to 120°F and a solid content of the electrocoating level of 5 to 15 percent. Dry film thickness shall be at least 0.001 inch. This shall be followed by a tap water and deionized water rinse and then baked for 20 to 25 minutes at 350°F.

(b) Second color coat (exterior) - Exterior surfaces shall receive one coat of a thermosetting acrylic enamel, light gray, semigloss meeting MIL-E-15090 appearance, applied to a 0.001-inch minimum dry film thickness. This shall be applied by spraying over the first color coat. This coating shall then be baked and completely cured in 15 minutes at 400°F or in 20 minutes at 375°F, or in 25 minutes at 350°F.

3.20 Identification plates, information plates, and marking.

3.20.1 Identification and information plates on the outside of the switchboard shall conform to types A, B, C, F, or H of MIL-P-15024 and MIL-P-15024/5. Plastic identification and information plates shall be light gray except beveled edges are not required. Inscriptions or markings for all type plates shall be black, except for danger, warning, and caution plates which shall have words in red for emphasis or be red with white markings. Identification and information plates inside the switchboard shall conform to type F of MIL-P-15024 and MIL-P-15024/5.

3.20.2 Location. Identification and information plates shall be placed in close proximity to the equipment to which it refers and, generally, either directly above or directly below it.

3.20.3 Size. In general, identification and information plates shall be of the size as listed in MIL-P-15024 and MIL-P-15024/5.

3.20.3.1 Thickness. Thickness of identification and information plates shall be in accordance with MIL-P-15024 and MIL-P-15024/5.

3.20.3.2 Shape. Information plates for rheostat handwheels and other rotary devices where required shall be circular or some other shape to suit the equipment.

3.20.4 Information. Identification plates with information consistent with the following shall be provided at or near the top of the front enclosure of each switchgear section or for each unit, if required individually:

(a) Name or functional designation of item.
(b) Manufacturer's name.
(c) Manufacturer's drawing number (front view).
(d) Year manufactured.
(e) NAVSEA drawing number (front view), if assigned.
(f) Stock number if assigned.
(g) NAVSEA number of manual, if assigned.
(h) Serial number.

3.20.5 Abbreviations. Unless lack of space prevents spelling out the word, abbreviations of words on identification and information plates shall be avoided except in the case of words which have abbreviations in common use in accordance with MIL-STD-12.

3.20.6 Installation. Identification and information plates shall be fastened securely to such parts of the equipment as ordinarily will not be renewed during its service life. Identification and information plates shall be attached in accordance with MIL-P-15024 and MIL-P-15024/5. Metal identification and information plates and mimic bus may be attached with an adhesive.

3.20.7 Detail application requirements. Information plates shall be installed immediately above each circuit breaker and shall contain the following information:

(a) Circuit name.
(b) Circuit designation and number.
(c) Circuit breaker element rating.

3.20.8 Blank plates. Information plates without markings shall be provided for mounted spare circuit breakers.

3.20.9 Instrument identification. Instruments shall be marked with the name of circuits; marking may appear on instrument or on a separately mounted information plate. Switchboard devices and component assemblies shall be provided with identification sufficient to identify each component from the information contained on the applicable switchboard drawings.

3.20.10 Fuse marking. Fuses for each switchboard control circuit, instrument, and instrument transformer shall have an information plate showing name or designation of circuit, phase (if applicable), fuse ampere rating, and type designations.

3.20.11 Marking switchboard buses. Buses shall be clearly marked in a visible location with their polarity or phase identification. If marking is accomplished by painting (stencil) application, the ink shall conform to A-A-208, type III. Information plates for buses may be similar to the warning plates specified in 3.20.14.

3.20.12 Polarity. Positive and negative polarities of dc buses shall be indicated with + and - signs, respectively.

3.20.13 Phase identification. Phase identification of ac buses shall be indicated by the capital letters A, B, or C, as applicable. A neutral bus of a four-wire, 3-phase circuit where used shall be indicated by the capital letter N. Letters A, B, C in that order shall indicate the phase sequence.

3.20.14 Bus bars. Bus bars facing and closest to the rear of the unit shall be stenciled "DANGER_____VOLTS". Applicable voltage shall be entered. Letters shall be white and not less than 3/4-inch high. As an alternative to stenciling, bus bars may be provided with a warning plate bearing the same legend. Letters shall be not less than 3/4-inch high. Plate shall be pressure sensitive adhesive backed elastomeric film with a carrier or separator sheet applied over the adhesive. Film shall consist of a white printed opaque polyvinyl fluoride film 0.002-inch thick laminated to a 0.001-inch clear polyethylene terephthalate film. Plate adhesive shall consist of an acrylic base vinyl polymer of a pressure sensitive type. A minimum of two warning stencils or plates per unit shall be provided, one in the upper and one in the lower section.

3.21 Tools. Ordinarily no tools are required to be furnished with switchboards. Where the construction of the switchboards or any of the devices installed thereon requires the use of certain special tools for their proper service maintenance, the quantity required shall be as specified (see 6.2.1). Special tools are defined as those tools not listed in the Federal Supply Catalog (copies of this catalog may be consulted in the office of the Defense Contract Administration Service Management Area (DCASMA)). Storage for any tool furnished shall be provided and labeled on the switchboard enclosure.

3.22 Government furnished material. The Government will furnish material as specified (see 6.2.1).

3.23 Maintainability. The switchgear shall facilitate trouble-shooting, fault isolation, and repair down to the lowest nonrepairable part or nonrepairable assembly (see 4.6.3.2).

3.24 Electromagnetic interference (EMI). The switchgear components shall fully meet the EMI requirements of class A4 of MIL-STD-461 for below deck equipment (see 4.6.3.8).

3.25 Dielectric strength. Switchgear shall be constructed to withstand for a period of 1 minute a dielectric test voltage of twice the rated voltage of the equipment plus 1000 volts rms between separate circuits and to ground.

3.26 Ambient temperature. The switchgear shall meet all the specification requirements when operating in an ambient temperature of 50°C and have no more than a 15°C temperature rise for surface ships and a 25°C rise for submarines (see 4.6.3.6.2 and 4.6.3.7).

3.27 Drawings. When specified in the contract or order, drawings shall be prepared (see 6.2.2 and appendix A).

3.28 Workmanship.

3.28.1 General. Workmanship shall be in accordance with the requirements herein applicable to soldering, marking of parts and assemblies, wiring, welding and brazing, plating, riveting, finishes, machine operations, screw assemblies, and freedom of parts from burrs, sharp edges, or any other damage or defect that could make the part (or equipment) unsatisfactory for the purpose intended.

3.28.2 Threaded parts or devices. Screws, nuts, and bolts shall show no evidence of cross threading, mutilation, or detrimental or hazardous burrs.

3.28.2.1 Tightness. Screw-type fasteners shall be tight. The word tight means the screw shall be firmly secured and that there shall be no relative movement possible between the attached parts.

3.28.3 Wiring. Insulated wire shall be formed into cables or ducted wherever practicable. Wires and cables shall be positioned or protected to avoid contact with rough or irregular surfaces and sharp edges.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.1.2 Terms and definitions. Quality assurance terms and definitions shall be in accordance with MIL-STD-109.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

(a) First article inspection (see 4.4).
(b) Quality conformance inspection (see 4.5).

4.3 Inspection conditions. Unless otherwise specified in the detailed inspections, all inspections shall be performed in accordance with the test conditions specified in 4.6.2.

4.4 First article inspection. One switchgear cubicle of each type shall be submitted for the examination and tests specified in table IV.

TABLE IV. First article and quality conforming inspection.

Inspection	First article	Quality conformance	Requirement paragraph	Inspection paragraph
General examination	x	x	3.4	4.6.3.1
Maintainability	x	---	3.23	4.6.3.2
Vibration	x	---	3.5.10	4.6.3.3
Shock	x	---	3.5.14	4.6.3.4
Dielectric strength	x	x	3.25	4.6.3.5
Waterspray	x	---	3.17.4	4.6.3.6.1
Ambient temperature and heat	X	---	3.26	4.6.3.6.2 and 4.6.3.7
Electromagnetic comparability	x	---	3.24	4.6.3.8

4.5 Quality conformance inspections. Quality conformance inspections shall be as specified in table IV.

4.5.1 Sampling for quality conformance inspection.

4.5.1.1 Inspection lot. Equipment of the same type and size identified for inspection at one time shall be considered a lot for quality conformance inspection.

4.5.2 Classification of defects. Classification of defects shall be as listed in table V. In addition, failure to satisfy any test of 4.6 shall be counted as a defect. Defects resulting from failure to satisfy tests of 4.6.3 shall be classified as major.

TABLE V. Classification of defects.

Classification	Defects
Critical:	
1	Enclosures, panels, compartmentation not provided to prevent injury from electric shock; rear enclosure perforations, ventilating louvers exceed size limit.
2	Grab rails and guard rails not located or mounted as specified to insure safe operations.
Major:	
101	Type, number, or section arrangement nonconforming.
102	Section unit not complete, devices or component parts missing.
103	Evidence of use of unauthorized material.
104	Parts broken, cracked, distorted, or chipped.
105	Control benchboard (if required) dimensions, arrangement of devices nonconforming.

TABLE V. Classification of defects. - Continued

Classification	Defects
Major:	
106	Structure not in accordance with drawing; not framed, bolted, welded, or dimensioned as required; gusset plates nonconforming.
107	Framework bracing not as specified; bolt size less than minimum; unauthorized use of rivets.
108	Standard units or special sections not bolted to foundation channel in accordance with drawing; number and size of bolts nonconforming.
109	Side sheets less than specified thickness; welding to frame nonconforming, bus bar cutouts not located in accordance with applicable drawing.
110	Compartmentation not as specified; circuit breakers not isolated; insulation distance not as specified.
111	Ventilation not adequate; openings not size for circuit breaker load; openings not screened.
112	For submarine applications, enclosure does not meet spray-tight requirements; construction of equipment impairs operator's view of instruments or restricts its operation.
113	Locking devices not acceptable type; not provided where required.
114	Panel thickness, size, forming, stiffening, or location nonconforming.
115	Panel megger holes not provided for type AQB and NQB circuit breaker panels; not hinged as specified, when required.
116	Equipment brackets, bolting, or arrangement nonconforming; switches not mounted in specified plane; phases not disposed as required.
117	Casualty power connection, if required, not accessible; mounting nonconforming; casualty power circuit breaker not as specified.
118	Voltage regulator mounting nonconforming.
119	Bus bars not size, cross section required by A rating; not silver surfaced formed as specified; ends not neatly finished; bolt hole contact areas not flat; bolt size and number not as specified.
120	Cable connectors not specified type and size for required load and use.
121	Bus bar assemblies not marked with specified warning.
122	Evidence that bus bar supports not spaced in accordance with short circuit current available, high-impact shock and vibration requirements.
123	Evidence that bus bar capacity nonconforming.
124	Cable connectors not specified type; solder, if authorized, not as specified.
125	Means not provided for connecting cables from other units or sections; cable connection arrangement restricts access.

TABLE V. Classification of defects. - Continued

Classification	Defects
Major:	
126	Instrument and control wiring nonconforming; not connected as specified; not grouped and strapped as specified.
127	Terminal boards not provided where required.
128	Synchronizing circuits, where required, not connected in specified manner; synchronizing control equipment not as specified.
129	Indicator lights, space heater circuits, transformers, voltage regulators and trip circuits for ACB circuit breakers not connected or arranged in accordance with applicable specifications or drawing.
130	Wiring not marked or tagged.
131	Circuit breakers not type specified; location and mounting nonconforming; drawout mechanism (for type ACB only) not operable as specified.
132	Switches not in accordance with specification; instrument control switches not type or not marked as specified; handle not required shape.
133	Disconnect devices not specified type; not mounted as required; tools if required, not located properly.
134	Fuses not in accordance with specification; location identifications and mounting nonconforming.
135	Fuseholders, where required, not enclosed or not in accordance with drawing.
136	Terminal boards exceed allowable length.
137	Instruments not in accordance with specification; case, scale, and mounting nonconforming.
138	Transformers not in accordance with applicable specifications; not provided; not connected as specified; not protected where required.
139	Relays not as specified; not accepted type.
140	Indicator lights nonconforming; not color required by code; resistors not as specified; lamps not provided.
141	Rear and top enclosures not secured firmly to frame; will not clear live bus work if buckled; top flanges do not prevent water from seeping into the enclosure; panel fastening not as specified method employed for making thumbscrews captive inadequate.
142	Top enclosure shape, form, and flanges nonconforming; corners not welded watertight.
143	Buses not marked to indicate polarity or phase.
144	Devices, where so required by applicable specification, not qualified for listing on Qualified Products Lists.

TABLE V. Classification of defects. - Continued

Classification	Defects
Minor:	
201	Painting procedure specified not followed; primer not applied as specified; enamel not specified type.
202	Identification and information plates not specified shape, size, thickness, location, letter, and fastening.
203	Special tools, if required, not furnished.
204	Switchboard not cleaned following construction, loose parts, dirt, or metal shavings not removed from unit.

4.6 Examination and test methods.

4.6.1 Test equipment. Test equipment shall be as specified in MIL-E-917, except that the shock machine shall be in accordance with MIL-S-901.

4.6.2 Test conditions. Unless otherwise required in the detailed test herein, the inspection and tests of 4.6 shall be performed under the following conditions. Ambient conditions within the specified ranges need not be controlled:

(a) Temperature from 10 to 50°c.
(b) Attitude: Normal operation position.

4.6.3 Detailed inspection.

4.6.3.1 General examination. The completed unit shall be given a thorough examination to determine that it conforms to the applicable specifications and drawings with respect to safety, material, finish, workmanship, construction, assembly, electrical parameters and function of electrical components, dimensions, weight and marking of identification and description plates. This examination shall be limited to those that can be performed without disassembling the unit in such a manner that its performance, durability or appearance would be affected. This examination shall include a check of operating controls, circuit functions and adjustments as applicable. Defects shall be as specified in table V.

4.6.3.2 Maintainability demonstration. When required in the contract or order (see 6.2.1), compliance with 3.23 shall be verified through a maintenance demonstration procedure, maintenance task selection, and maintenance task performance in accordance with test method 1-A of appendices A and B of MIL-STD-471.

4.6.3.3 Vibration test. A vibration test shall be conducted in accordance with the type I requirements of MIL-STD-167-1 (see 4.6.3.4.1) to determine failure of test. One unit from each group specified in table VI and the EPCP shall be tested, as applicable. Tests on EPCPS of similar design may be extended (see 4.6.3.4.3). If the unit satisfactorily passes the vibration test, the other units within that group need not be tested. Any major redesign of the tested

unit which might alter the ability of the units to withstand this test shall require a retest to determine conformance to these requirements (see 4.6.3.4.3). Separate tests shall be conducted on steel and aluminum switchgear units (see 3.5.10).

TABLE VI. Vibration and shock test grouping of switchgear units.

Group number					
1	2	3	4	5	6
G1	G2 (ACB)	G3	G5	D80	D85
G2 (AQB)	G11 (ACB)	B21	G7	D81	D86
G10	D50	B22	B25	D82	D87
G11 (AQB)	D60	D51	B26	D83	D95
E40	D61	D52	D56	D88	
E40A	D62	D55		D89	
	D63	D70		D90	
	D64	D71		D91	
	B20	D72		D92	
	E41	D73		D93	
		D74		D96	
		E42		D97	

4.6.3.4 High-impact shock test. Equipment required by this specification to be installed in the switchgear units shall have passed the high-impact shock test, as applicable, in accordance with the various equipment specifications. Equipment shall be installed on the switchboard during the shock test. Equipments which have not been previously shock tested individually will be accepted when installed within the switchgear unit and found to pass the shock test of that unit. High-impact shock tests in accordance with MIL-S-901 shall be conducted on one unit of each group in table VI and the EPCP, as applicable. Tests on EPCPS of similar design may be extended (see 4.6.3.4.3). If the unit satisfactorily passes the high-impact shock test, the other units within that group need not be tested (see 4.6.3.4.3). Separate tests shall be conducted on steel and aluminum switchgear units. The test shall include mounting on a 30 degree incline and be conducted with the unit de-energized. The features of the test shall be as follows (see 3.5.14):

(a) Type -A.
(b) Weight designation - medium.
(c) Class - I, deck mounted.
(d) Grade -A.

4.6.3.4.1 Definition of failure to perform principal function. Sufficient electrical tests and visual examinations shall be made to determine that components installed within the switchgear unit perform their intended function. Hair line cracks are permitted in the framework, but no separation of parts shall result. Any resulting distortion shall not be of sufficient magnitude to impair the operation of the equipment contained within or prevent the circuit breakers

from being withdrawn. The enclosure shall not distort to an extent which might result in contact with any electrically conducting part within the unit. The bus work shall not be mechanically damaged nor the bus clearance distances reduced below the minimum requirements. Insulation resistance shall not be reduced below that specified in table V. The unit shall pass the dielectric strength test of 4.6.3.5 at 65 percent of the specified voltage. Circuit breakers shall not change position during the test. Circuit breaker control relays shall not cause the circuit breakers to change state.

4.6.3.4.2 Disposal of shock tested equipment. Equipment which has been subjected to class high impact shock may be accepted as a production of the contract or order only under the following conditions:

(a) That the order of performing tests shall be such that the vibration test follows the shock test to aid in discovery of loose or weakened parts.
(b) That damaged parts are replaced.
(c) That damaged structural members are repaired or replaced.
(d) That post shock and vibration electrical tests and inspections show conformance to specified performance.
(e) That the unit is subjected to the same guarantee by the manufacturer as other production units.
(f) That the shock tested unit shall not be accepted if there is any distortion of the frame members or enclosure that would prevent its being bolted to the deck or to other switchgear units to form a switchboard section. Measurements shall be made to detect any misalignment of bolt holes or bent framework.

4.6.3.4.3 Extension of shock and vibration tests. A file shall be maintained of detailed drawings, shock tests and vibration test reports (see 4.6.4) for each unit tested in the groupings of table VI and EPCP tests. Shock and vibration test reports shall reference by number, date, and revision the applicable drawings for that unit tested. Requests for extension of satisfactory test results to other units of the groups in table VI, EPCPS, or to subsequent similar units shall be accompanied by copies of detailed drawings of tested and untested items, copies of the shock and vibration test reports upon which the requested extension is based, and a detailed comparison of the differences in materials and design showing that the untested unit has equal or greater shock and vibration resistance than the unit tested. The following items, among others, shall be included in the determination for test extension:

(a) Change in weight.
(b) Change in center-of-gravity.
(c) Change in circuit breaker frame sizes.
(d) Change in materials or size and location of structural members.
(e) Changes in method of circuit breaker mounting.
(f) Changes in bus bar arrangement or method of support.

4.6.3.5 Dielectric strength. Equipment shall withstand, for a period of 1 minute, a dielectric test voltage of twice the rated voltage of the equipment plus 1,000 volts rms value. The frequency of the test voltage shall be not less than 60 Hz. It shall approximate a true sine wave. The source of the test potential shall have a rating of at least 1 kW (see 3.25).

4.6.3.6 Waterspray and heat tests for spraytight switchgear (see 6.2.1).

4.6.3.6.1 Waterspray test. Switchgear shall be subjected to the waterspray test requirements of MIL-STD-108 for spraytight enclosure with the following exceptions (see 3.17):

(a) Direct a stream of fresh water against the enclosure at representative covers, handles, seams, plates, and so forth. The stream of water shall be directed at the front, back, sides, and top of the enclosure for not less than 15 minutes on each of the above surfaces. At a 90 degree position to each of the above enclosure surfaces, the water nozzle shall be slowly rotated in an arc from 45 degrees right to 45 degrees left, and 45 degrees up to 45 degrees down from the perpendicular axis. If under the above spray test procedure on the front and rear surfaces of the enclosure, the stream of water cannot strike the intakes to the lowest ventilation louvers or openings when the nozzle is positioned at 45 degrees below the perpendicular axis, then the entire enclosure shall be first tilted 30 degrees from the top toward the rear, and then 30 degrees from the rear toward the front and the above spray test procedure performed on these two surfaces.

(b) Dielectric test shall be conducted on the complete switchboard within 30 minutes after the completion of the test at the voltage specified in 3.25. Readings of less than 10 megaohms shall constitute a failure. When the contractor has developed a design for making switchgear enclosures spraytight, the waterspray test shall be conducted on one representative unit of this construction. If the methods employed by the contractor to achieve spraytight construction in a design are modified, a retest shall be conducted to reestablish that the spraytight requirements are met.

4.6.3.6.2 Heat test. Heat run tests shall be conducted to verify that the maximum air temperature within any switchgear enclosure does not exceed 75°C when operating within an ambient temperature of 50°C. Circuits shall be loaded to their designed full load (element rating) to simulate the heat dissipation characteristics the switchboard will have under actual operating conditions. Turbine generator control units shall be tested at 75 percent load. The bottom of the switchgear enclosure shall be sealed off and the maximum temperature of any component or wiring mounted on or within the enclosure shall not exceed the temperature rating of the component or wire. The test shall be conducted on one complete switchgear group of a spraytight construction under conditions simulating a shipboard installation. Dummy type resistive loads shall be used to simulate voltage regulator components in the spaces allocated to these. These dummy loads shall be equal to the maximum heat dissipation ratings of the regulator components. Switchboard bottoms shall be sealed off. Sufficient temperature detectors (thermocouples or other methods) shall be installed to determine the maximum temperature of the switchboard components, as well as the ambient temperatures of the various compartments within the units. Each compartment shall have a temperature detector located 2 inches from the top and another close to the bottom. Bus compartments shall have an additional temperature

detector located half way from the top to bottom of the compartment. The test shall be of sufficient duration to allow stabilization of the measured temperatures to a rate of rise within 2°C per hour. This test will be extended to subsequent units manufactured which use the same basic methods to achieve spraytight construction and ventilation (see 3.26).

4.6.3.7 Heat tests for non-spraytight switchgear. Heat tests for non-spraytight switchgear shall be similar to heat tests for spraytight switchgear with the exception that the maximum air temperature within the switchgear enclosure shall not exceed 65°C. Spraytight construction shall not apply.

4.6.3.8 Electromagnetic interference. The switchgear shall be tested for conformance to MIL-STD-462 (see 3.24).

4.6.3.9 Short circuit tests. Switchboards shall be subjected to short circuit tests if calculations are not done (see 3.10.13). The maximum rms asymmetrical short circuit current shall be as specified (see 6.2.1).

4.6.4 Test reports. When specified in the contract or order, vibration and shock test reports, a first article inspection report, and a first article inspection procedure shall be prepared (see 6.2.2).

4.7 Inspection of packaging. Sample packages and packs, and the inspection of the preservation-packaging, packing and marking for shipment and storage shall be in accordance with the requirements of section 5 and the documents specified therein.

5. PACKAGING

(The packaging requirements specified' herein apply only for direct Government acquisition. For the extent of applicability of the requirements of referenced documents listed in section 2, see 6.6.)

5.1 Preservation, packing, and marking. Equipment, accessories, replacement devices, stock repair parts, and manuals shall be preserved level A, C, or commercial, packed A, B, C, or commercial as specified (see 6.2.1), and marked in accordance with MIL-E-17555.

6. NOTES

6.1 Intended use. Switchgears covered by this specification are intended to provide protection, control, and distribution of electrical power on Naval ships .

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

(a) Title, number, and date of this specification.
(b) When first article inspection is required (see 3.1).
(c) Type, number, and arrangement of units comprising the switchgear sections (see 3.4.1 to 3.4.3, inclusive).

(d) Sections comprising a switchgear group (see 3.4.1 to 3.4.3, inclusive).
(e) Power, current, and voltage rating of generators controlled and quantity of casualty power equipment (see 3.4.1.1, 3.4.1.2, 3.4.2.1, 3.4.2.2, and 3.4.4.1).
(f) Space, mounting and wiring requirements for the voltage regulator equipment including associated current and potential transformers (see 3.4.1.1(g), 3.4.1.1.1(g), 3.4.1.2.1(i), 3.4.1.5.4(a), 3.4.1.5.5(c)(1), 3.4.2.1.1(h) and 3.8.7).
(g) Space, mounting and wiring and associated control equipment for electric governor equipment (see 3.4.1.1(m), 3.4.1.1.1(0), 3.4.1.1.1.1(j), 3.4.1.2.1(f), and 3.4.1.5.5(c)(5)).
(h) If load sensing relays are provided (see 3.4.1.1.1(i)).
(i) When automatic paralleling devices are required (see 3.4.1.1.1(q), 3.4.1.2.1(m), and 3.11.5).
(j) If generator space heaters and temperature detectors are provided with the generators (see 3.4.1.1.1.1(i), 3.4.1.1.1.1(n) 3.4.1.2.1(h)(o), 3.4.1.5.4(g)(p) and 3.4.2.1.1(j).
(k) Disconnect devices (see 3.4.1.1.2(c) and 3.4.1.3(c)).
(l) Rating for shore power connection circuit breaker (see 3.4.1.3(h), 3.4.1.4.2(a), and 3.4.5.2.2).
(m) When a chair for EPCP is required (see 3.4.1.5.1).
(n) Space for internal communications (IC) equipment (see 3.4.1.5.1.1).
(o) Whether desk type or vertical type EPCP is required (see 3.4.1.5.3).
(P) Whether or not ship has a centralized machinery control system including EPCP (see 3.4.1.5.4(cc)).
(q) Control switches, rheostats and similar devices required in conjunction with speed regulating equipment (see 3.4.1.1.1.1(f) and 3.4.1.5.5(b)(1)).
(r) Solid-state frequency changer failure mode indicators (see 3.4.1.5.6(h)).
(s) Feeders, breakers, and switches (see 3.4.1.6, 3.4.1.7, 3.4.1.8, and 3.4.5.3).
(t) Requirement for type AQB circuit breaker on emergency switchgear for diesel cooling water pump (see 3.4.2.1(d)).
(u) Requirement for electrically operated emergency bus unloader switch (see 3.4.2.2(g)).
(v) Maximum frequency of vibration (see 3.S.10).
(w) Material to be used in construction of switchgear structure and switchgear buses (see 3.4.1.5.6(a)(3), 3.5.11 and 3.10.1).
(x) If instantaneous trip settings are other than as specified (see 3.8.6.3).
(Y) Buses to be provided in each switchgear section (see 3.10.1).
(z) Maximum available rms short circuit current (see 3.10.13 and 4.6.3.9).
(aa) Bus bar insulation (see 3.10.15).
(bb) Cable lugs (see 3.10.16).
(cc) Location of cable entrance (see 3.10.18).
(dd) Circuit breaker frame size (see 3.12).
(ee) Circuit breaker trip element ratings and tripping characteristics (see 3.12).

(ff) Spraytight enclosure and heat run test for submarine applications (see 3.17.4 and 4.6.3.6).
(gg) Quantity of special tools (see 3.21).
(hh) List of Government furnished material (see 3.22).
(ii) Whether a maintainability demonstration is required (see 4.6.3.2).
(jj) Level of preservation and packing required (see 5.1).
(kk) If switchboard manuals do not contain the specified information (see appendix B, 30.1).
(ll) The following items are not a part of any individual standard unit. They will be supplied by the contractor only when complete switchgear sections are ordered. Otherwise they will be supplied by the Command or agency assembling the standard units into switchgear sections:

(1) Foundation channels.
(2) Top sheet and drip shield.
(3) Main bus bars.
(4) Main bus supports, main bus spreaders and bus opening cover on end units.
(5) Cable and wiring between units.
(6) End trims.

(mm) When Mimic bus material is required (see 3.4.1.5.4).

6.2.2 Data requirements. When this specification is used in an acquisition and data are required to be delivered, the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (CDRL), incorporated into the Contract. When the provisions of DoD FAR Supplement, Part 27, Sub-Part 27.475-1 (DD Form 1423) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this specification are cited in the following paragraphs.

Paragraph no.	Data requirement title	Applicable DID no.	Option
3.27	Drawings, engineering and associated lists	DI-E-7031	Level 3 Design activity
Appendix B	Manuals, power switchboard	UDI-M-23484	----
4.6.4	First article inspection procedure	DI-T-4901	----
4.6.4	First article inspection report	DI-T-4902	----
4.6.4	Report, vibration testing	UDI-T-23762	----
4.6.4	Reports, equipment shock test	UDI-T-23753	----

(Data item descriptions related to this specification, and identified in section 6 will be approved and listed as such in DoD 5010. 12-L., AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.2.2.1 The data requirements of 6.2.2 and any task in sections 3, 4, or 5 of this specification required to be performed to meet a data requirement may be waived by the contracting/acquisition activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for identical item acquired to this specification. This does not apply to specific data which may be required for each contract regardless of whether an identical item has been supplied previously (for example, test reports).

6.2.2.2 Technical manuals. The requirement for technical manuals should be considered when this specification is applied on a contract. If technical manuals are required, military specifications and standards which have been cleared and listed in DoD 5010.12-L (AMSDL) must be listed on a separate CDRL (DD Form 1423), included as an exhibit to the contract. The technical manuals must be acquired under separate contract line item in the contract.

6.2.3 Acquisition management systems. acquisition documents should specify the degree to which any of the following acquisition management systems are to be invoked in the acquisition:

(a) Human engineering program: MIL-H-46855
(b) Maintainability program: MIL-STD-470
(c) Reliability program: MIL-STD-785
(d) Safety program: MIL-STD-882

6.3 First article. When a first article inspection is required, the item should be a first article sample. The first article should consist of one unit. The contracting officer should include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract.

6.4 Provisioning. Provisioning Technical Documentation (PTD), spare parts, and repair parts should be furnished as specified in the contract. Quantities of on board repair parts should be as shown in table VII.

6.4.1 When ordering spare parts or repair parts for the equipment covered by this specification, the contract should state that such spare parts and repair parts should meet the same requirements and quality assurance provisions as the parts used in the manufacture of the equipment. Packaging for such parts should also be specified.

TABLE VII. On board repair parts.

Item	To determine the quantity of on board repair parts to be furnished for ship or on an order, multiply the quantity of identical installed replaceable parts times the assigned multiplying factor and round the product to the nearest whole number. For numbers less than one, furnish one item. Multiplying factor
Fuseholder, each size and type	0.05
Fuses, each size and type (except for AQS-LF circuit breaker (see MIL-C-17361))	.500
Lens, indicator light, each size and type	.10
Light, indicator (where transformer or resistor are integral)	.05
Lamps, incandescent, each size and type	2
Relay coils, each size and type	0010
Relay contacts, each size and type	.10
Relay springs, each size and type	.10
Resistor, each size and type	.10
Rotary switch contacts, stationary and movable	.5
Rotary switch springs, each size and type	l 10
Transformer protective device, each size and type	1
Special tools (one set furnished for each ship’s service and emergency switchboard)	
ACB and AQB/AQB-LF circuit breaker repair parts should conform to MIL-C-17587 and MIL-C-17361, respectively	
Bus transfer equipment repair parts should conform to DOD-S-17773	

6.5 Definitions. The definitions specified in 6.5.1 through 6.5.2 apply to terms used in this specification.

6.5.1 Standardized unit. A standardized switchgear unit is a vertical subdivision of a section complete with separate front panels and all required devices designed to be mechanically and electrically interchangeable between switchboard manufacturers. It should be constructed in accordance with the basic dimensions shown on figures 7, 8, and 9.

6.5.2 Section. A switchgear section is a self-contained assembly of switchgear units consisting of a complete framework with all required enclosures and with a common base mounting.

6.5.3 Switchgear group. A switchgear group is synonymous with the term switchboard; however, switchboard groups may consist of two or more individual sections rather than all units being assembled together into a single structure.

6.5.4 Desk type EPCP. A desk type EPCP is a switchgear section consisting of switchgear type units and a control desk combined in a single structure with the top of the control desk, either horizontal or inclined, attached to the front switchgear section panels. It is provided with the necessary instruments and controls for centralized operation, monitoring, and control of the electric plant including control of generator, bus tie, and feeder circuits (including battery on submarines) of one or more switchgear groups.

6.5.5 Vertical EPCP. A vertical EPCP is functionally similar to the desk type EPCP except that all necessary instruments, controls, and indicating apparatus are mounted on vertical panels.

6.5.6 EPCC. A desk type EPCC is a console consisting of control desks provided with the necessary instruments and controls for centralized operation, monitoring, and control of the electric plant including control of generator prime movers, generators, bus ties, and feeder circuits of one or more switchboard groups.

6.5.7 Load center. A load center distribution section is a section consisting of one or more distribution units. It serves as a power distribution center in locations requiring power supplies exceeding the capacity of distribution panels.

6.5.8 Nonstandard switchgear. Nonstandard switchgear is switchgear consisting of units, sections, and groups, not conforming to the standardization requirements of figures 7, 8, and 9.

6.5.9 Main bus taps. Main bus taps are bus bars connected to the main bus.

6.5.10 Branch bus taps. Branch bus taps are bus bars connected to the main bus taps.

6.5.11 Switchboard. Switchboard is a large single panel, frame, or assembly of panels on which are mounted on the face, the back, or both, switches, overcurrent and other protective devices, buses, and instruments.

6.6 Sub-contracted material and parts. The packaging requirements of referenced documents listed in section 2 do not apply when material and parts are acquired by the contractor for incorporation into the equipment and lose their separate identity when the equipment is shipped.

6.7 Qualification under referenced specifications. When any specification which forms a part of this specification requires that the product be subjected to and pass qualification tests, only products which are qualified for listing on the applicable Qualified Products List on the date of invitation for bids or date of initiation of purchase action should be utilized. In the event that no Qualified Products List has been issued, the contractor should request instruction as to what testing will be required to determine whether the product meets the requirements of this specification.

6.8 Subject term (key word) listing.

Branch bus tap
Bus bar
Bus connection
Bus tie unit
Cable end terminal
Cable lug terminal
Carcinogens
Circuit breaker
Compartmentation
Digital indicator
Distribution unit
Electric plant control console
Electric plant control panel
Electromagnetic interference
Emergency generator control
Fuse
Fuse mounting
Generator control unit
Insulation
Insulation distances
Load center
Main bus tap
Ozone
Polarity
Switch
Terminal block
Terminal board
Transformer
Ventilation
Voltage regulator
Wire and terminal marking
Wiring

6.9 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Preparing activity:
Navy - SH
(Project 6110-N296)

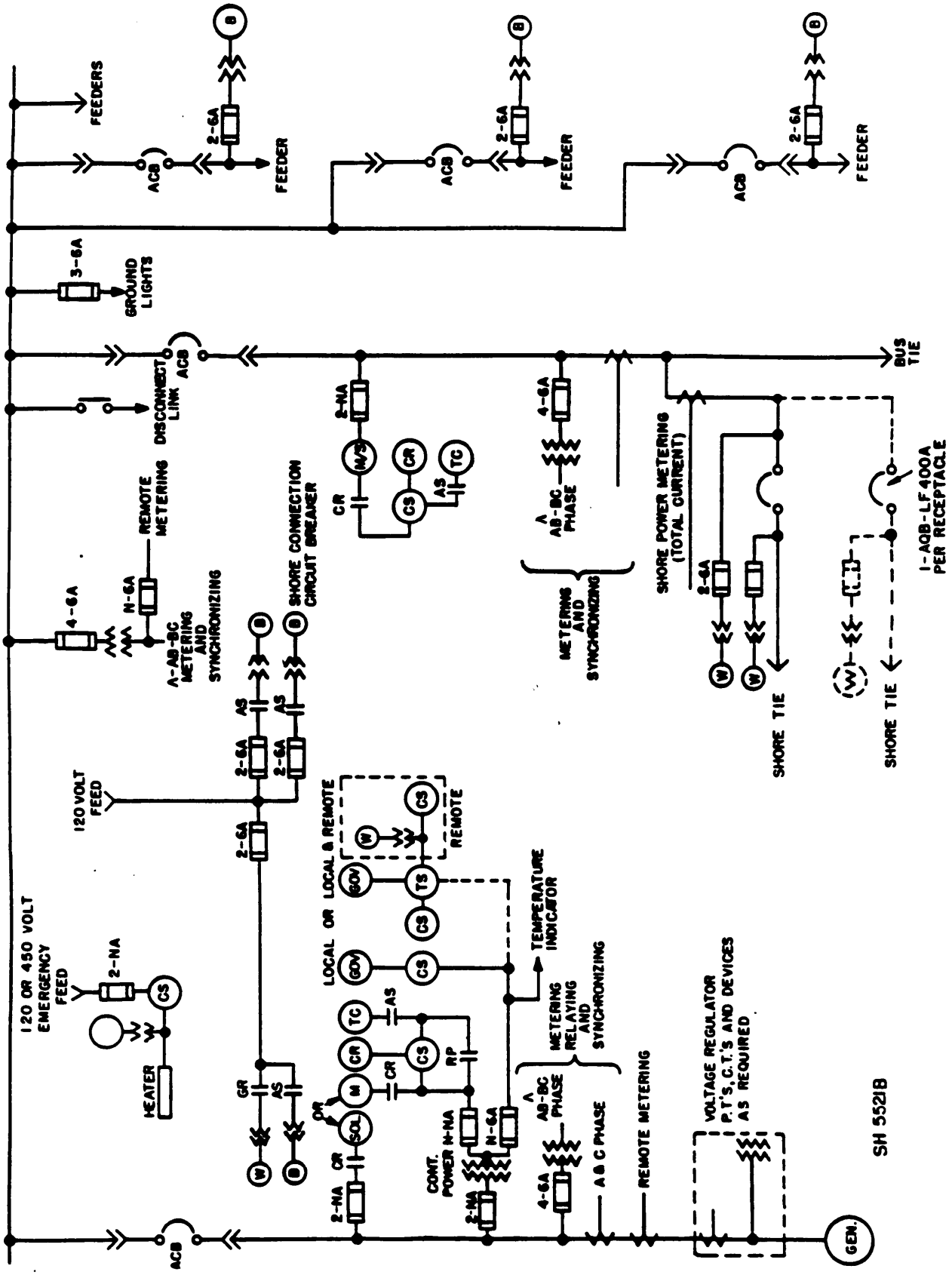
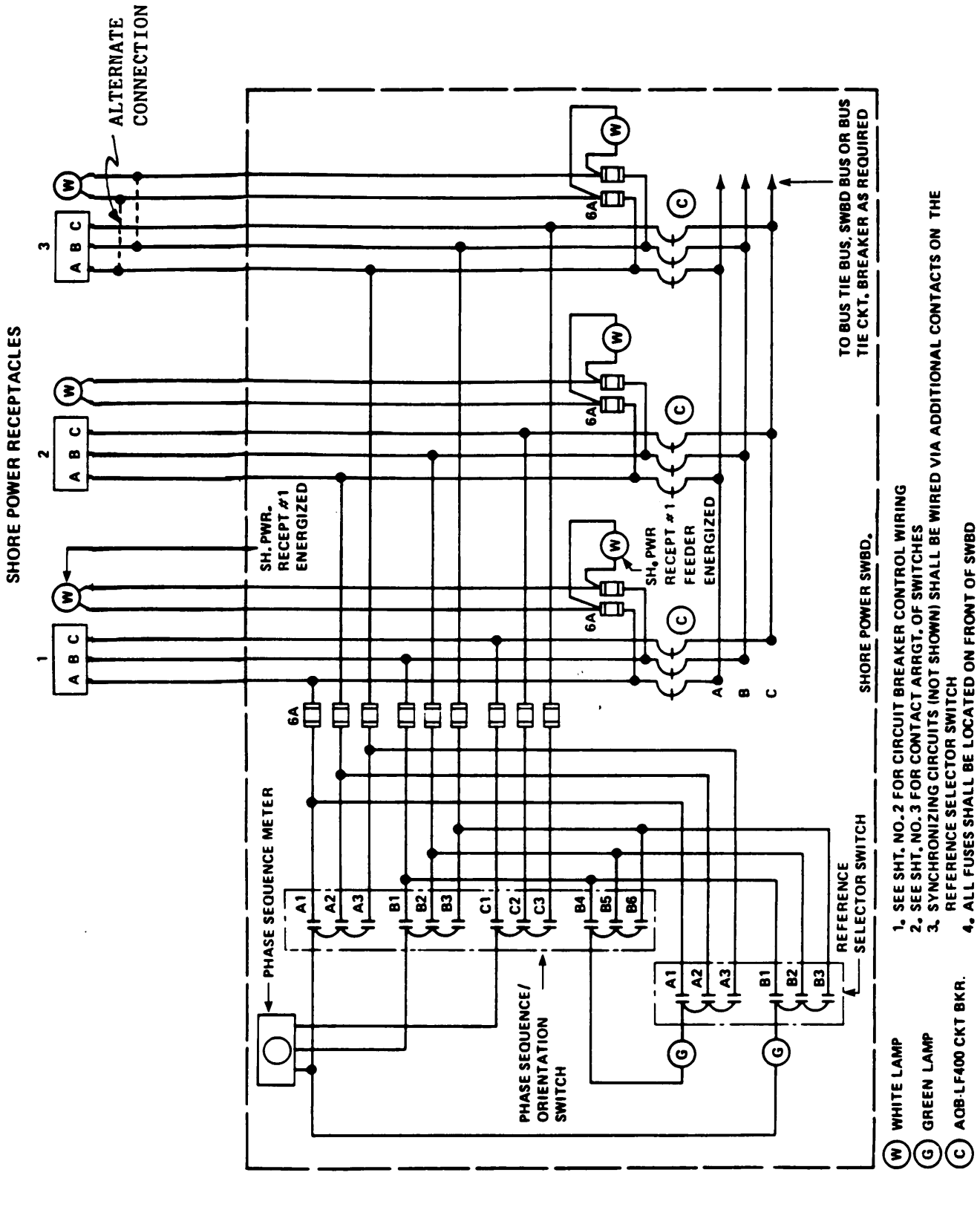
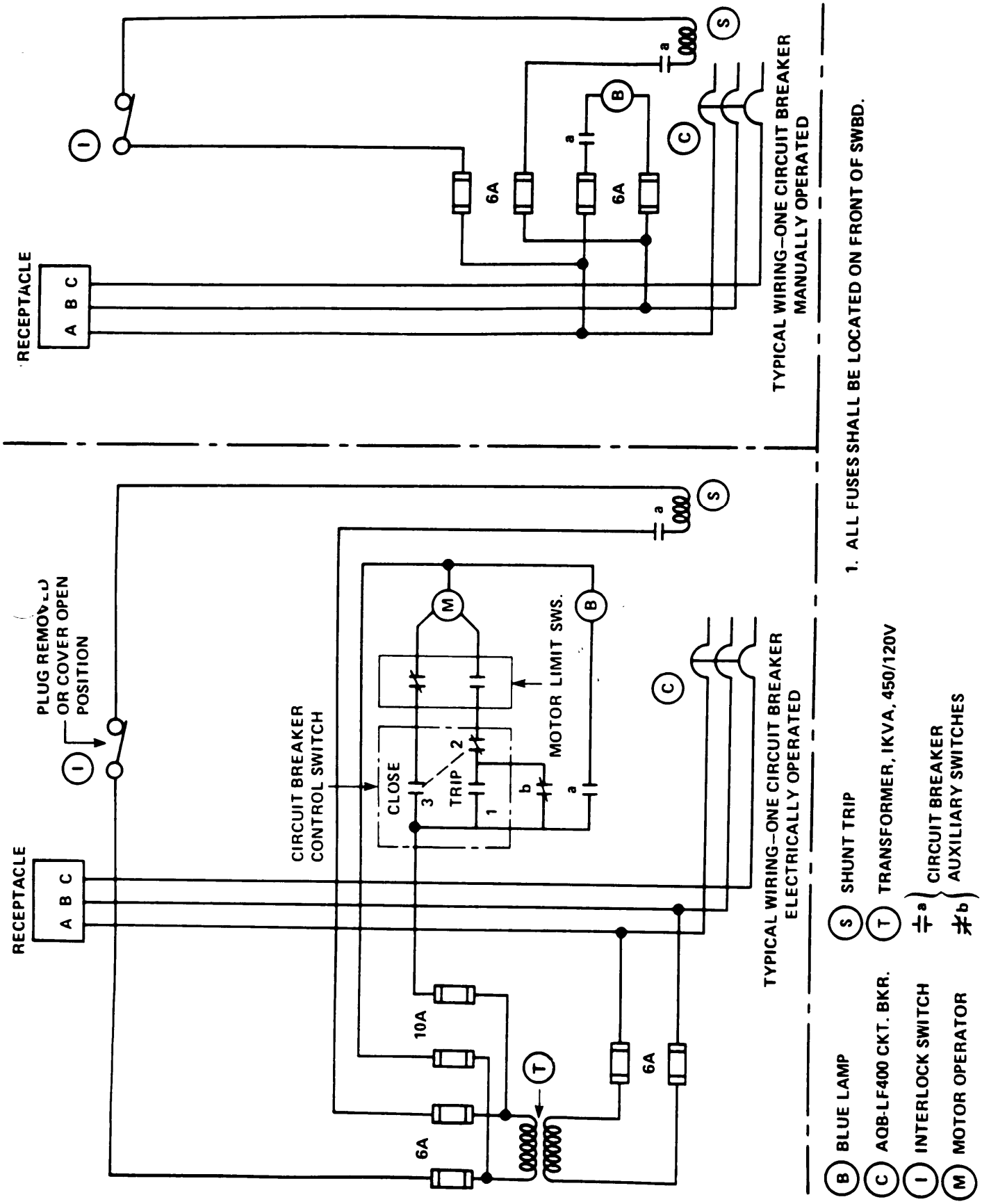


FIGURE 1. Typical one-line control diagram for ship's service ac power switchgear group having an EPCP (see figure 3 for legend).



SH 11483

FIGURE 2. Typical shore power connection diagram (sheet 1 of 3).



SH 11484

FIGURE 2. Typical shore power connection diagram (sheet 2 of 3). - Continued

TYPICAL SWITCH CONTACT ARRANGEMENTS

PHASE SEQUENCE/OREINTATION TEST SWITCH

CONTACT	POSITION			
	OFF	1	2	3
A1		X		
B1		X		
C1		X		
A2			X	
B2			X	
C2			X	
A3				X
B3				X
C3				X
B4		X		
B5			X	
B6				X

REFERENCE SELECTOR SWITCH

CONTACT	POSITION			
	OFF	1	2	3
A1		X		
A2			X	
A3				X
B1		X		
B2			X	
B3				X

CIRCUIT BREAKER CONTROL SWITCH

CONTACT	POSITION		
	TRIP	NORMAL	CLOSE
1	X		
2	X	X	
3			X
4	X		
5	X	X	
6			X
7	X		
8	X	X	
9			X

1. CONTACT ARRGTS. APPLY TO THE 3 RECEPTACLE CIRCUITS SHOWN ON SHT. NO. 1 OF 3

2. ADDITONAL CONTACTS SHALL BE PROVIDED ON THE REFERENCE SELECTOR SWITCH TO SWITCH METERING AND SYNCH. EQUIPT. TO THE RECEPTACLE SELECTED AS THE REFERENCE, AS REQUIRED

SH 11485

FIGURE 2. Typical shore power connection diagram (sheet 3 of 3). - Continued

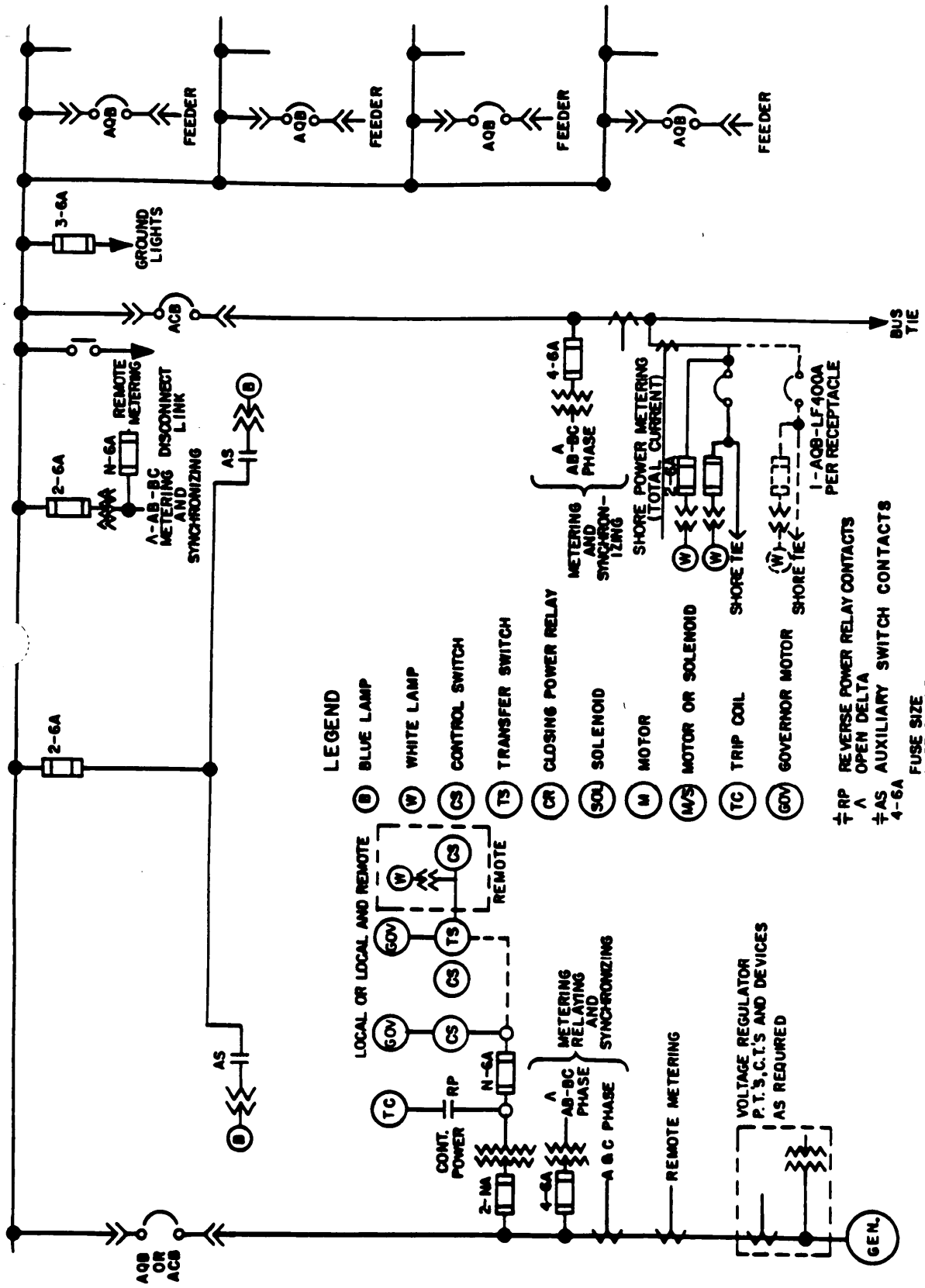
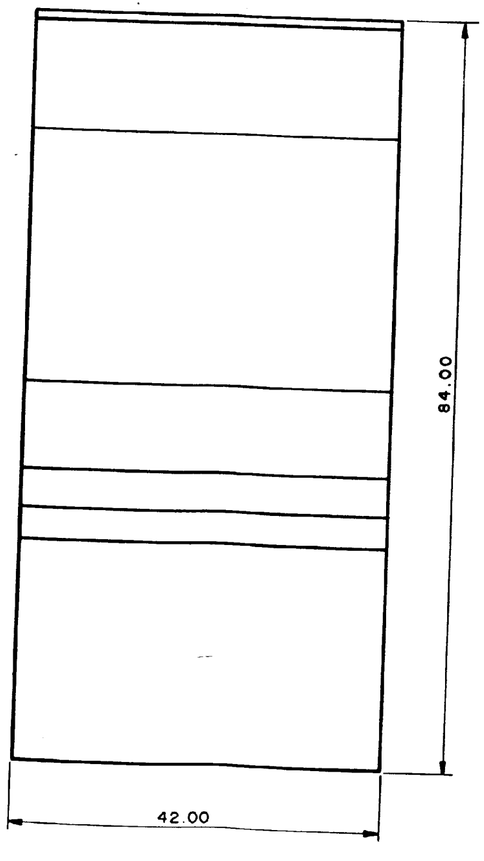
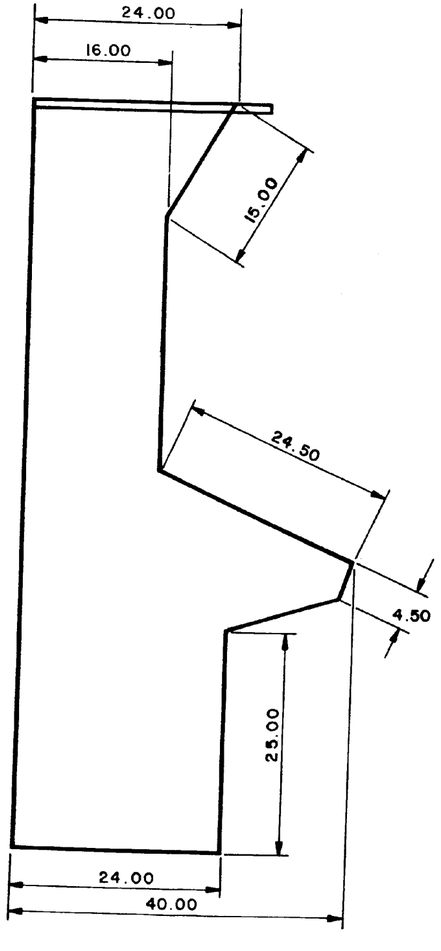


FIGURE 3. Typical one-line control diagram for ship's service ac power switchgear group not having EPCP or EPCC.

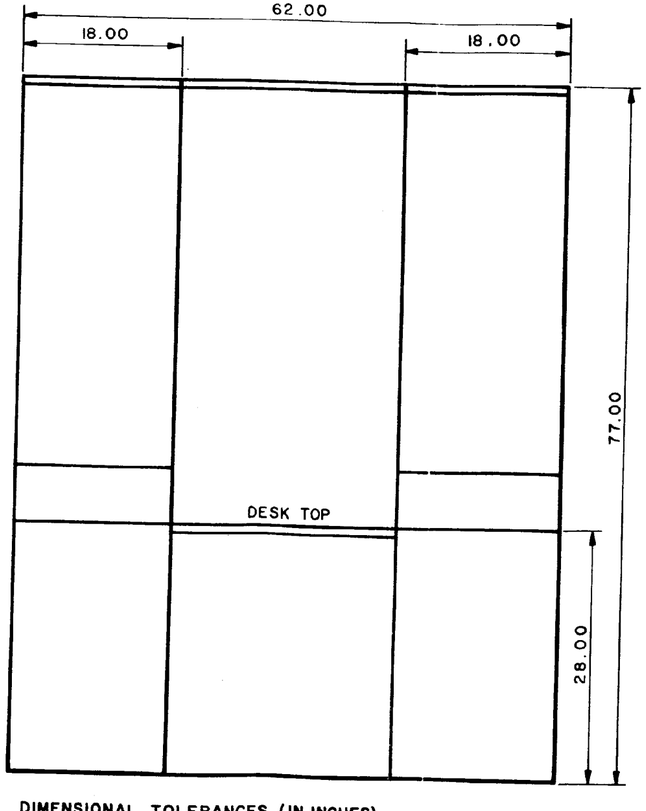
TYPE 1





SH 11481

TYPE 2



DIMENSIONAL TOLERANCES (IN INCHES)

UNDER 6 INCHES	±.01
6 TO 18	±.02
18 TO 36	±.03
36 TO 84	±.04

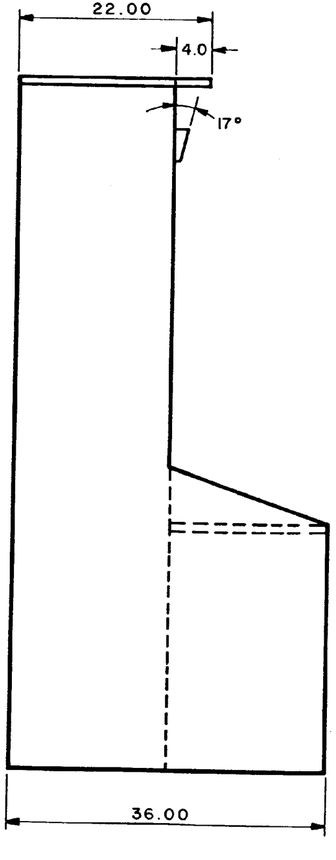


FIGURE 4. Desk types EPCP.

TABLE "A"
STANDARDIZED SWITCHGEAR UNITS

GENERATOR SIZE IN KW	TYPE UNIT	AQB 250 OR 400	AQB 800 OR ACB 640,900,902	ACB 1600	ACB 3200	ACB 4000
30-60-100-200	G1	1				
200-300-500	2		1			
750-1000	3			1		
1500-2000	5				1	
2500	7					1
30-60 (DC)	10	1				
150-200 (DC)	11		1			
	B20		2			
	21			2		
	22			2		
	25				2	
	26				2	
	D50		3			
	51			2		
	52			2		
	55			2		
	56				2	

GENERATOR SIZE IN KW	TYPE UNIT	AQB A101	AQB-A101 FUSED	AQB 250	AQB 400	ACB 640 900,902	ACB 1600
	D60		5			2	
	61			1	or 1	2	
	62		12			1	
	63		12	2		1	
	64		8	4		1	
	70			6			2
	71			2	or 2		2
	72		16				1
	73		12	2			1
	74		6	4			1
	80	14	or 10				
	D81		12				
	82	22	or 15				
	83		18				
	85			10			
	86			15			
	87			15			
	88			5			
	89			5			
	90	24	or 16				
	91		20	2			
	92	16	or 12	4			
	93		12	6			
	95		18	9			
	96	8	or 6	2			
	97		6	3			
100	E40	ABT-A3(ES)					
	40A	ABT-A3(ES) SAME AS E40 EXCEPT HAS UNLOADER					
200-300-500	41	ABT-A3(ES) (ACB-640,900 or 902)					
750-1000	42	ABT-A3(ES) (ACB1600)					

TABLE "A"
STANDARDIZED SWITCHGEAR UNITS, Continued

DIMENSIONS OF UNITS (ALL DIMENSIONS IN INCHES) A	B	C	D	E	F	G	H	K	M	DIAGRAMS FIGURE 8 AND 9
74	20	33 1/2				26 3/4				2,5,7,8
81	20	40 1/2	9	14	13		13 1/8	20 5/8	5 3/16	1,6,7,9
81	27	40 1/2	9	14	13		13 1/8	20 5/8	8 11/16	1,6,7,9
81	33	44 1/2	13	11	16		12 1/4	23 1/2	11 11/16	1,6,7,10
81	39	49 1/2	18	11	16		17 1/4	25 1/2	11 11/16	1,6,7,11 or 12
74	20	33 1/2				26 3/4				2,5,7,8
81	20	40 1/2	9	14	13		13 1/8	20 5/8	5 3/16	1,6,7,9
81	18	40 1/2	9	14	13		13 1/8	21 7/8	3 7/8	1,4,7,9
81	27	40 1/2	9	11	16		13 1/8	21 7/8	8 3/8	1,4,7,9
81	27	44 1/2	13	11	16		12 1/4	26 3/4	8 3/8	1,4,7,10
81	33	49 1/2	18	11	16		17 1/4	26 3/4	11 11/16	1,4,7,11 or 12
81	33	44 1/2	13	11	16		12 1/4	26 3/4	11 11/16	1,4,7,10
81	18	40 1/2	9	14	13		13 1/8	21 7/8	3 7/8	1,4,7,9
81	27	40 1/2	9	11	16		13 1/8	21 7/8	8 3/8	1,4,7,9
81	27	44 1/2	13	11	16		12 1/4	26 3/4	8 3/8	1,4,7,10
81	27	49 1/2	18	11	16		17 1/4	26 3/4	8 3/8	1,4,7,11 or 12
81	33	49 1/2	18	11	16		17 1/4	26 3/4	11 11/16	1,4,7,11 or 12
81	18	40 1/2	9	14	13		13 1/8	21 7/8	3 7/8	1,4,7,9
81	18	40 1/2	9	14	13		13 1/8	21 7/8	3 7/8	1,4,7,9
81	20	40 1/2	9	11	16		13 1/8	20 5/8	3 7/8	1,6,7,9
81	22 1/2	40 1/2	9	11	16		13 1/8	20 5/8	3 7/8	1,6,7,9
81	22 1/2	40 1/2	9	11	16		13 1/8	21 7/8	8 3/8	1,4,7,9
81	27	40 1/2	9	11	16		13 1/8	21 7/8	8 3/8	1,4,7,9
81	27	40 1/2	9	11	16		13 1/8	21 7/8	8 3/8	1,4,7,9
81	27	40 1/2	9	11	16		13 1/8	21 7/8	8 3/8	1,4,7,9
81	27	40 1/2	9	11	16		13 1/8	21 7/8	8 3/8	1,4,7,9
74	14 1/2	33 1/2				26 3/4				2,5,7,8
81	14 1/2	31 1/2				26 3/4				3,5,7
74	20	33 1/2				26 3/4				2,5,7,8
81	20	31 1/2				26 3/4				3,5,7
81	22 1/2	31 1/2				26 3/4				3,5,7
74	32	33 1/2				26 3/4				2,5,7,8
81	32	31 1/2				26 3/4				3,5,7
74	14 1/2	33 1/2				26 3/4				2,5,7,8
81	14 1/2	31 1/2				26 3/4				3,5,7
74	22 1/2	33 1/2				26 3/4				2,5,7,8
81	22 1/2	31 1/2				26 3/4				3,5,7
74	22 1/2	33 1/2				26 3/4				2,5,7,8
81	22 1/2	31 1/2				26 3/4				3,5,7
81	32	31 1/2				26 3/4				3,5,7
74	14 1/2	33 1/2				26 3/4				2,5,7,8
81	14 1/2	31 1/2				26 3/4				3,5,7
74	20	33 1/2				26 3/4				2,5,7,8
74	22 1/2	33 1/2				26 3/4				2,5,7,8
81	36	40 1/2	9	11	16		13 1/8	21 7/8	3 7/8	1,4,7,9
81	54	40 1/2	9	14	13		13 1/8	21 7/8	8 3/8	1,4,7,9

TABLE "B"
SIDE SHEET CUTOUT GROUPS

GROUP	DRAWING	UNITS			
1	8	G1	D80	D88	E40
		10	82	90	40A
			86	96	
				92	
2	9	G3	B20	D50	D64
			20S	51	70
			21	60	71
			21S	61	72
				62	73
				63	74
2A	9	G2	E41		
		11	42		
3	10	G5	B22	D52	
			22S		
			26		
			26S		
4	11	G7	B25	D55	
	12		25S	56	

NOTES:

1. The switchboard unit type numbers shown shall be supplemented with prefix letters as shown below to designate the materials used for the switch gear framework and busbars.

Frame	Bus Bar	Prefix	Typical Type No.
Steel	Copper	None	G1
Aluminum	Aluminum	A	AG1
Aluminum	Copper	CA	CAC1
Steel	Aluminum	AS	ASG1

2. Bus tie units B20-26 used as bus tie and shore power units shall have the letter "S" added to the end of the type designation. e.g. B21S

3. Standardized switchboard units - type number series

Type number	Description of units
G1-7	AC generator
G10-11	DC generator
B20-26	AC bus tie
E40-42	Emergency switchboard
D50-56	ACB distribution
D60-64	AQB and ACB 640, 900, 902 distribution
D70-74	AQB and ACB 1600 distribution
D80-97	AQB distribution 100A or 250A

4. Circuit breaker quantities listed are typical.

5. If necessary, the depth, dimension "C" may be altered on AQB feeder units so the feeder units can have the same main bus as required for the generator and bus tie units.

6. Diagram figure numbers refer to side bolting pattern, floor plan, front plan and side sheet cutout plan.

7. "B" dimension includes side sheets.

8. "A" dimension is without foundation channels.

DIMENSION TOLERANCES (IN INCHES)			
Dim	Decimals 2 PL	3 PL	Fraction
Under 6	± .01	± .005	± 1/64
6 to 18	± .02	± .010	± 1/32
18 to 36	± .03	± .015	± 1/16
36 to 84	± .04	± .020	± 1/8

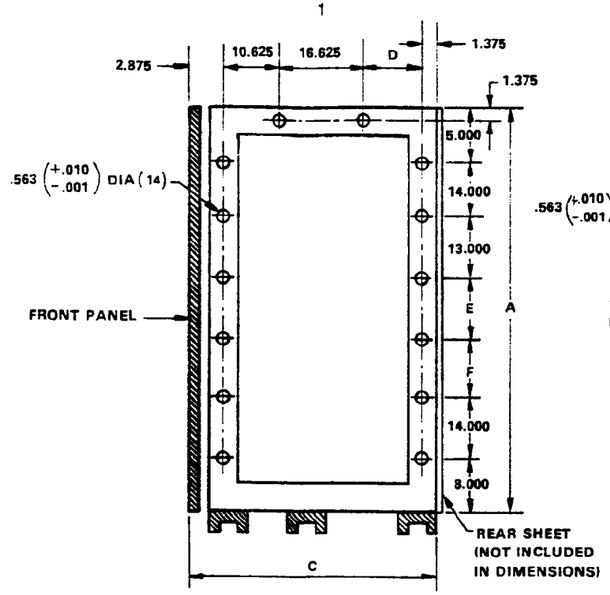
NOTE:

All dimensional tolerances are in accordance with table unless otherwise noted. Tolerances shall be noncumulative.

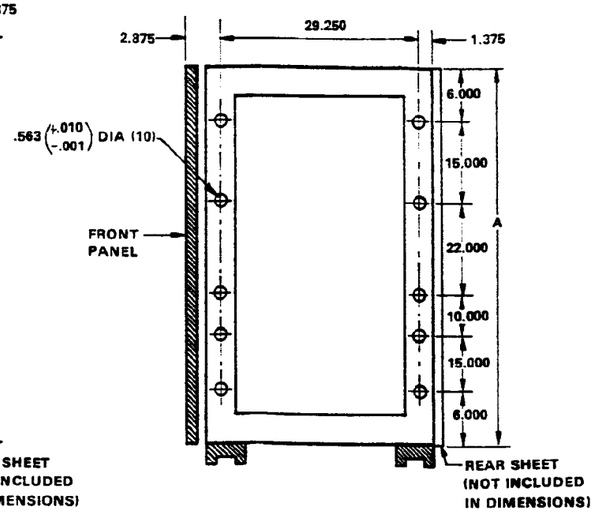
Two place tolerances for dimensions A, B, & C.
Three place tolerances for dimensions D, E, F, G, H, K, & M.

FIGURE 7. Standardized switchgear units.

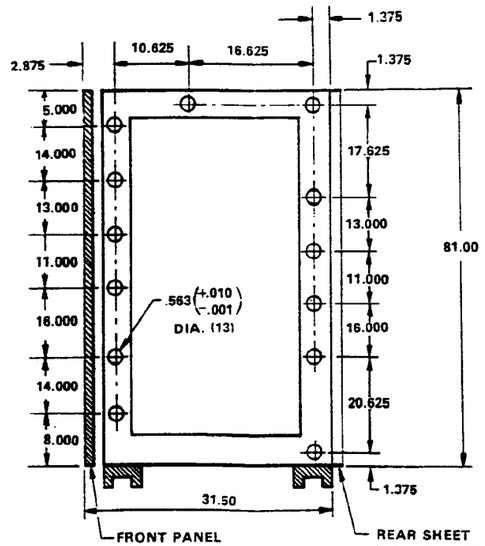
SIDE VIEW
SIDE BOLTING PATTERN
1

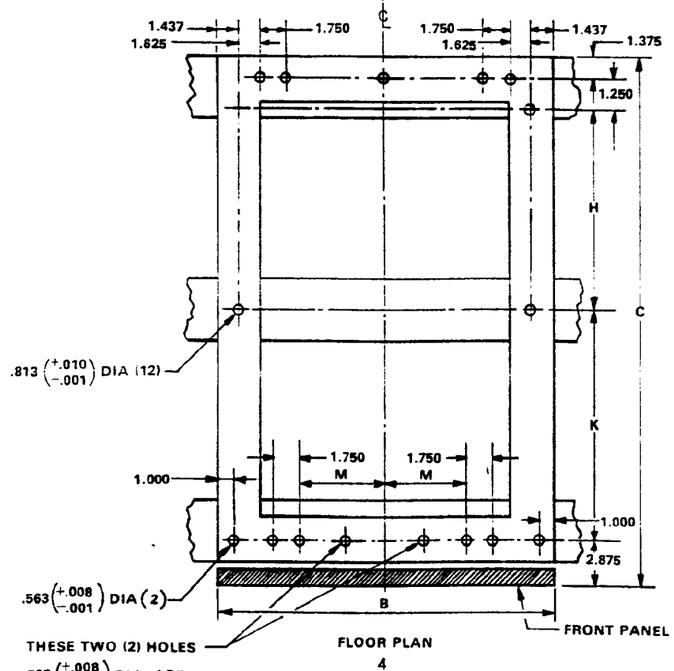


SIDE VIEW
SIDE BOLTING PATTERN
2

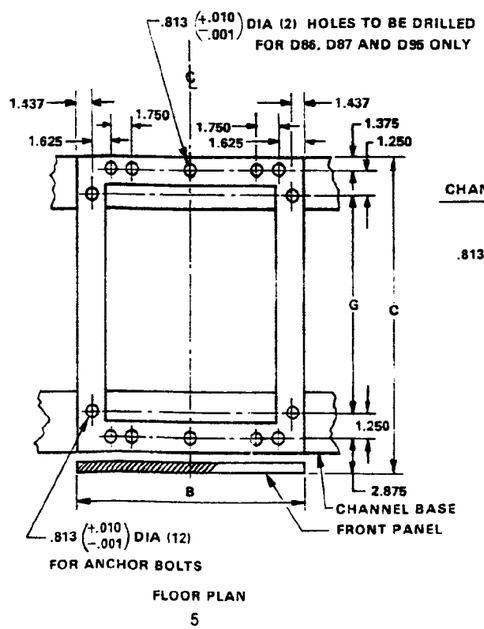


SIDE VIEW
SIDE BOLTING PATTERN
3

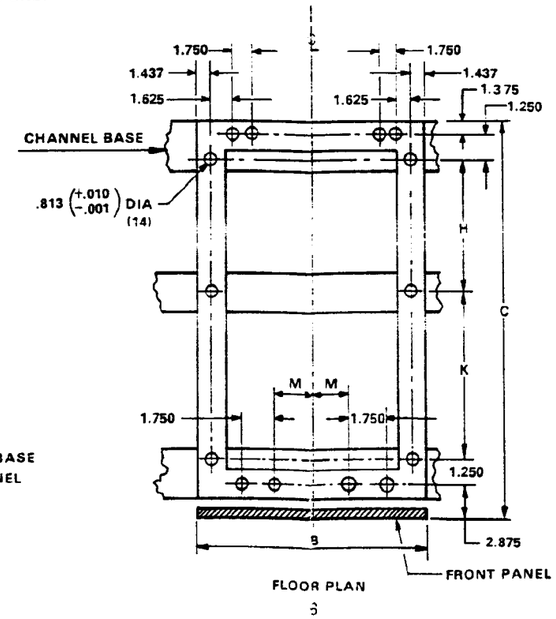




FLOOR PLAN
4

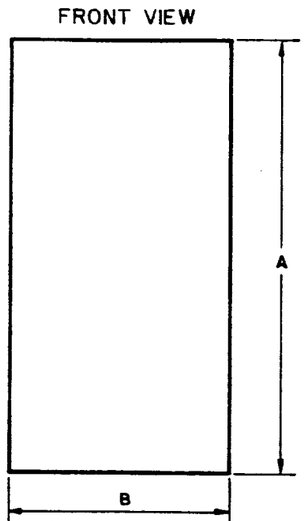


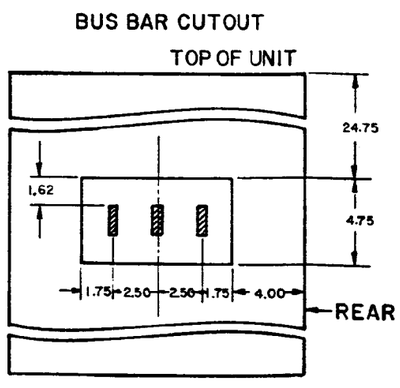
FLOOR PLAN
5

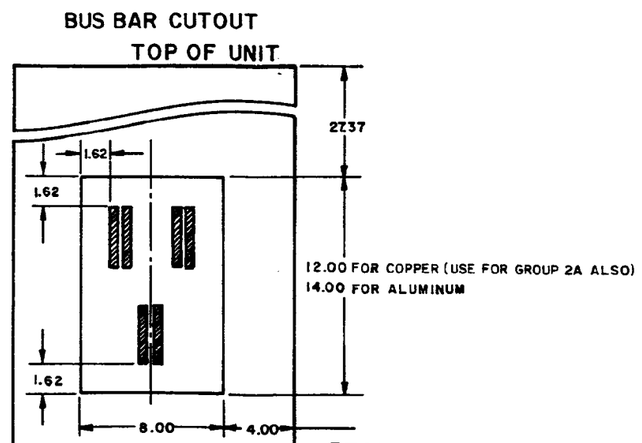


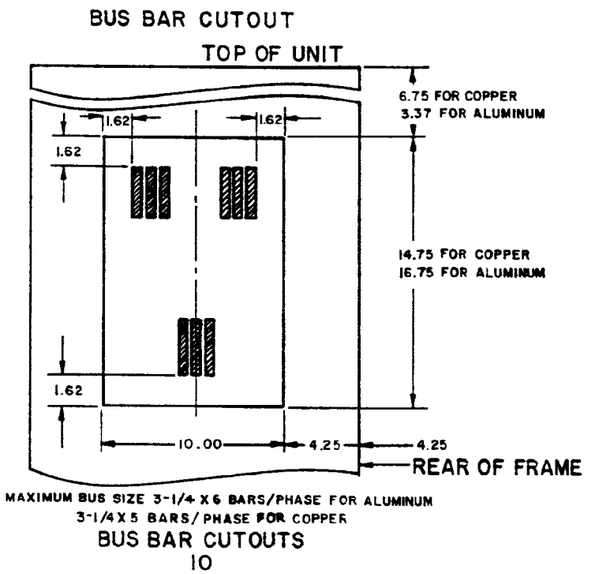
FLOOR PLAN
6

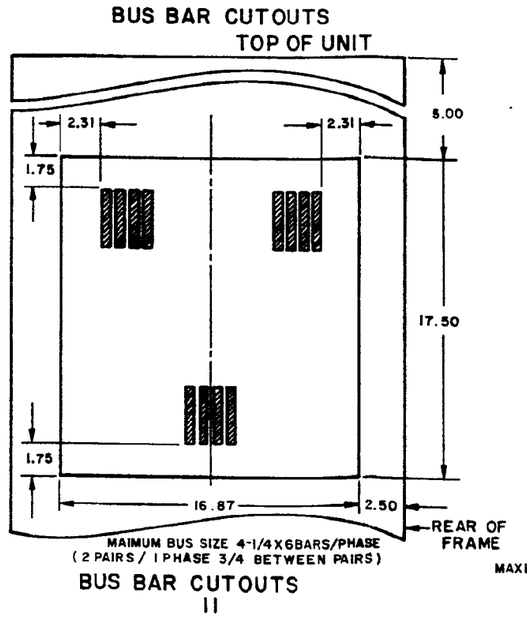
FIGURE 8. Standardized switchboard plans (diagrams 1 through 6).

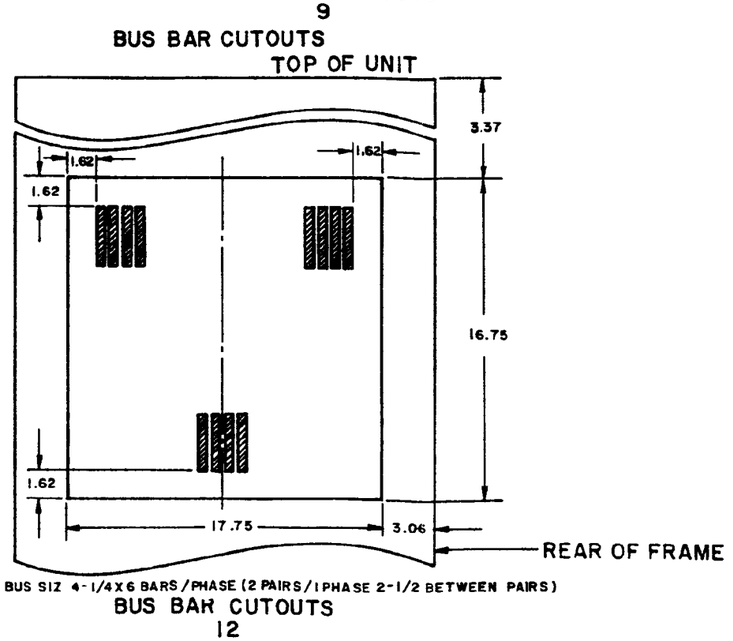






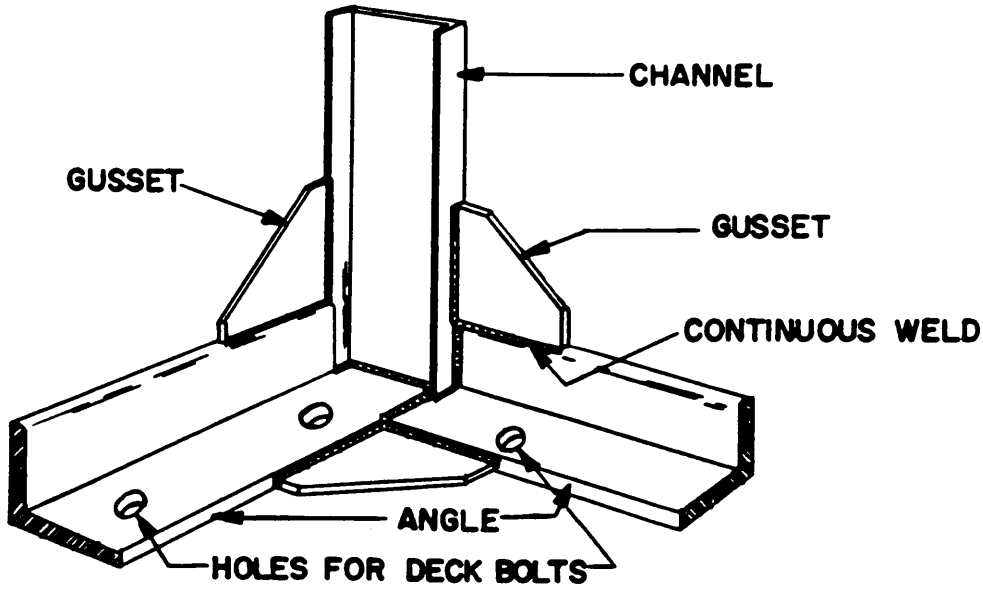






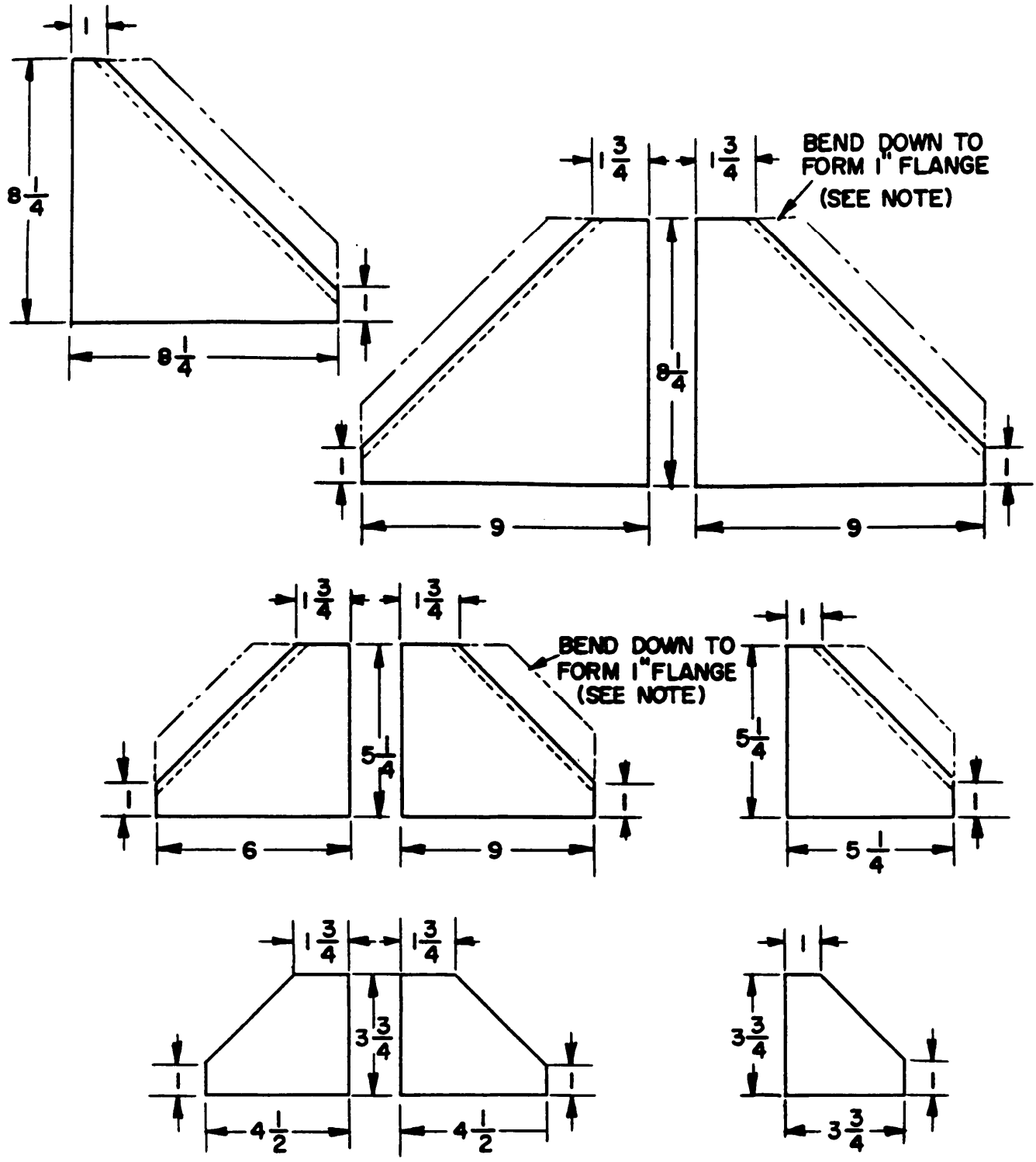
SH 10481

FIGURE 9. Standardized switchboard plans (diagrams 7 through 12).



SH 4266

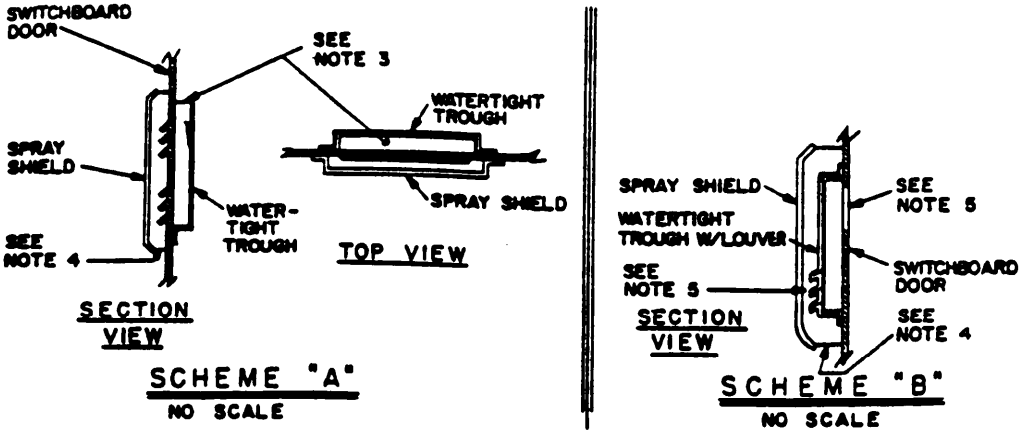
FIGURE 10. Typical bottom, corner construction.



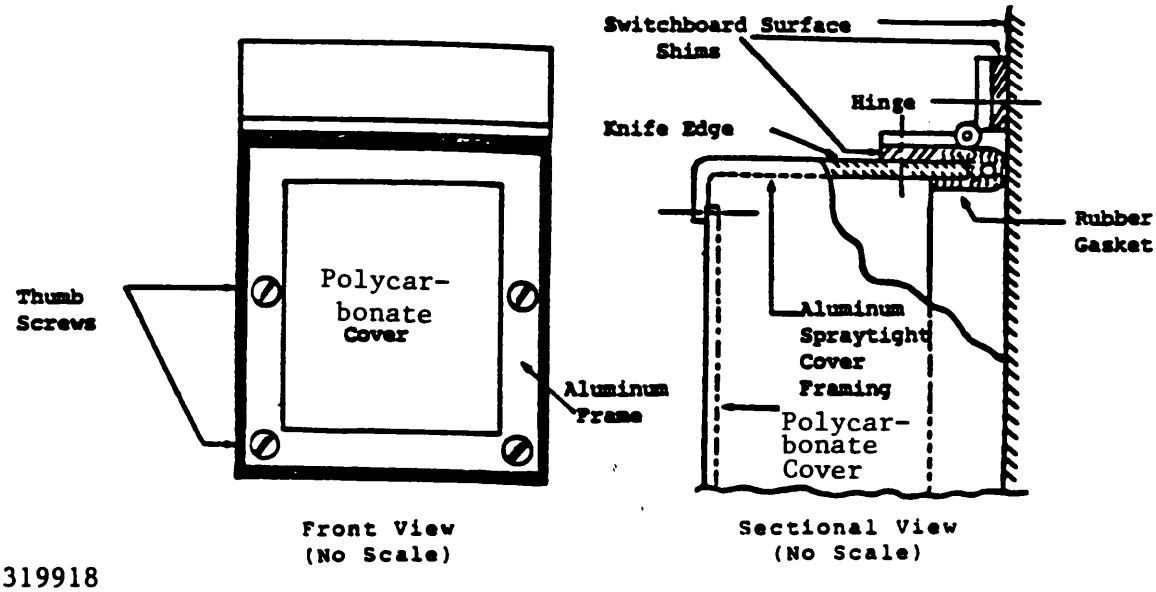
SH 4267

NOTE: Flanges shall be used when thickness of gusset plates is less than 3/16 inch. Gusset plates shall be not less than 1/8-inch thick.

FIGURE 11. Typical gusset plates.



Typical watertight trough mounting



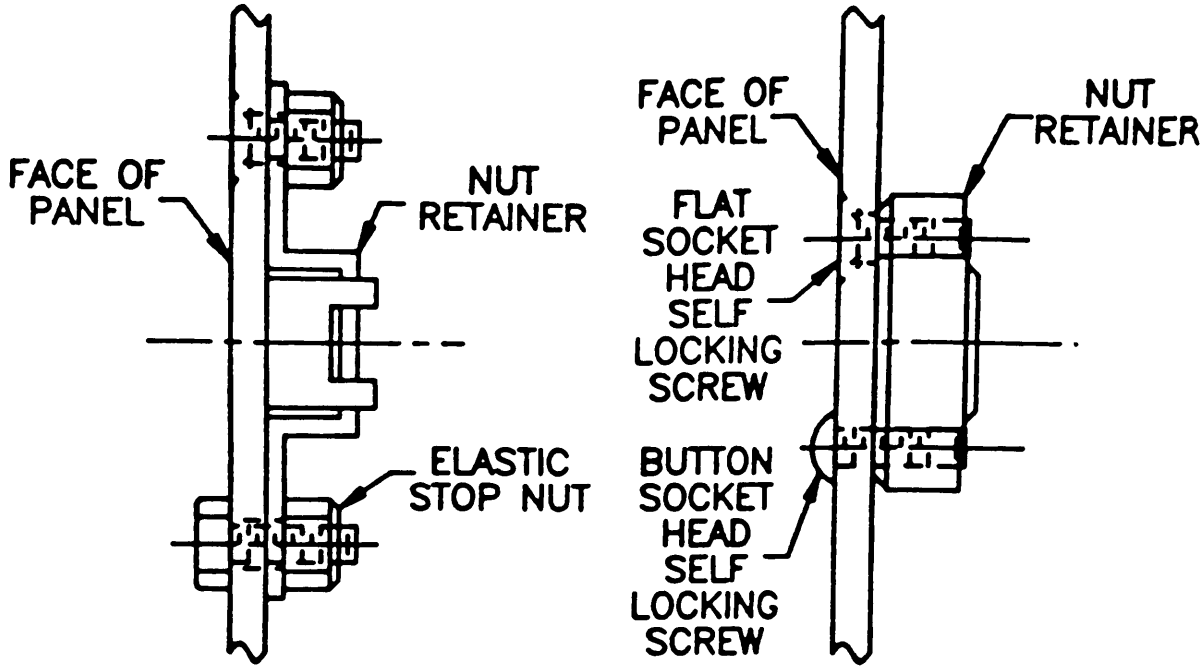
SH 1319918

Typical hinged cover assembly

NOTES:

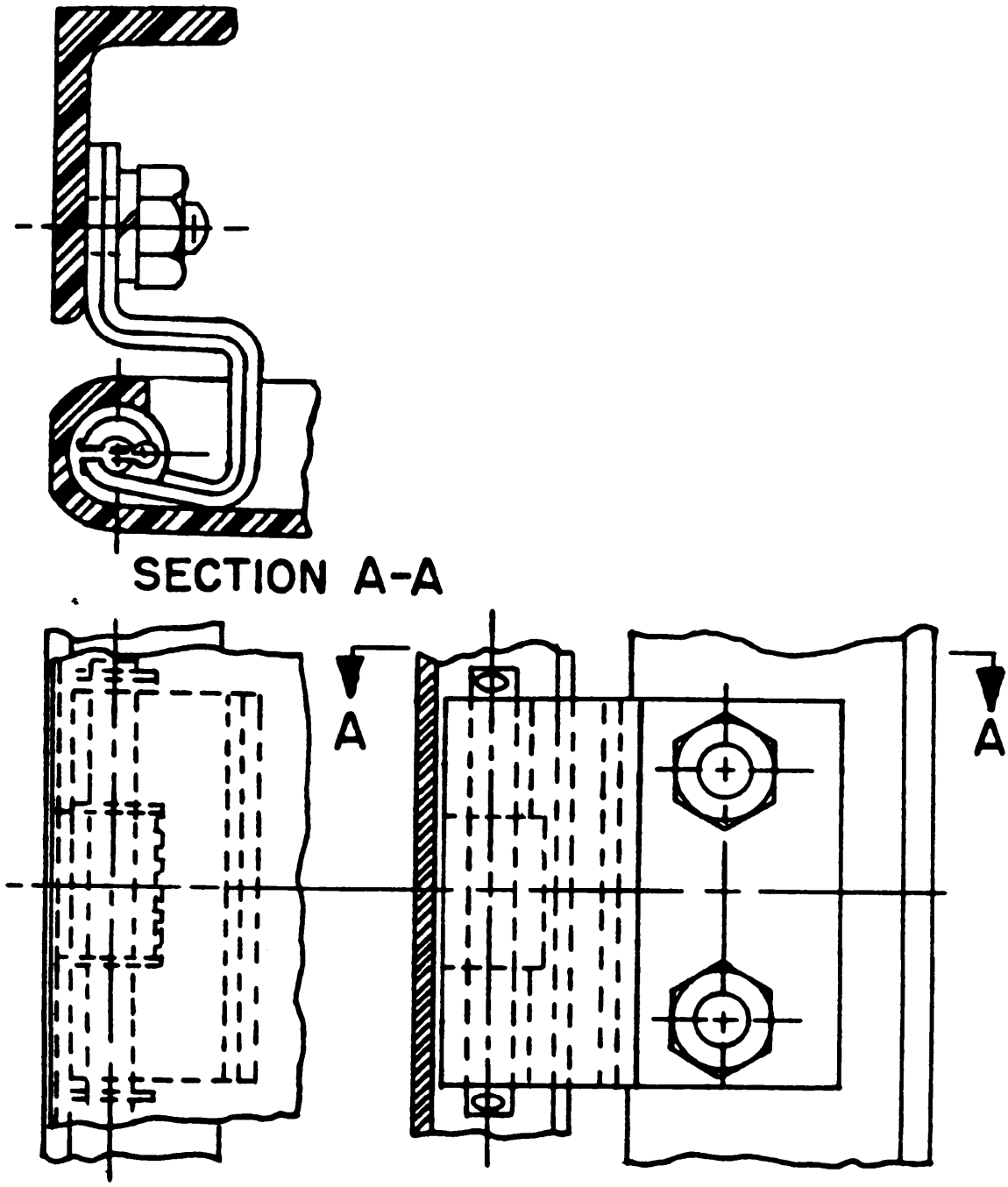
1. Scheme “A” where watertight trough can be mounted behind switchboard door.
2. Scheme “B” where watertight trough cannot be mounted behind switchboard door.
3. Open area at top of watertight trough shall be equal to the area of ventilation provided by the louvers, if spraytight baffle was not provided.
4. The combined open area at the top and bottom of the spray shield shall be equal to the area of ventilation provided by the louvers.
5. Area of ventilation to be provided by louvers on watertight trough and open area on switchboard door shall be equal to the area of ventilation provided by the louvers, if spraytight baffle was not provided.
6. The number of thumbscrews used for the hinged cover assembly shall be the minimum necessary for firm compression.
7. The gasket used for covers and panels assembly shall be class 2, grade 60 and shall conform to MIL-R-6855.

FIGURE 12. Typical spraytight construction.



SH 13231891

Figure 13. Anchor devices for thumbscrews.



SH 1319919

Figure 14. Typical panel hinge assembly.

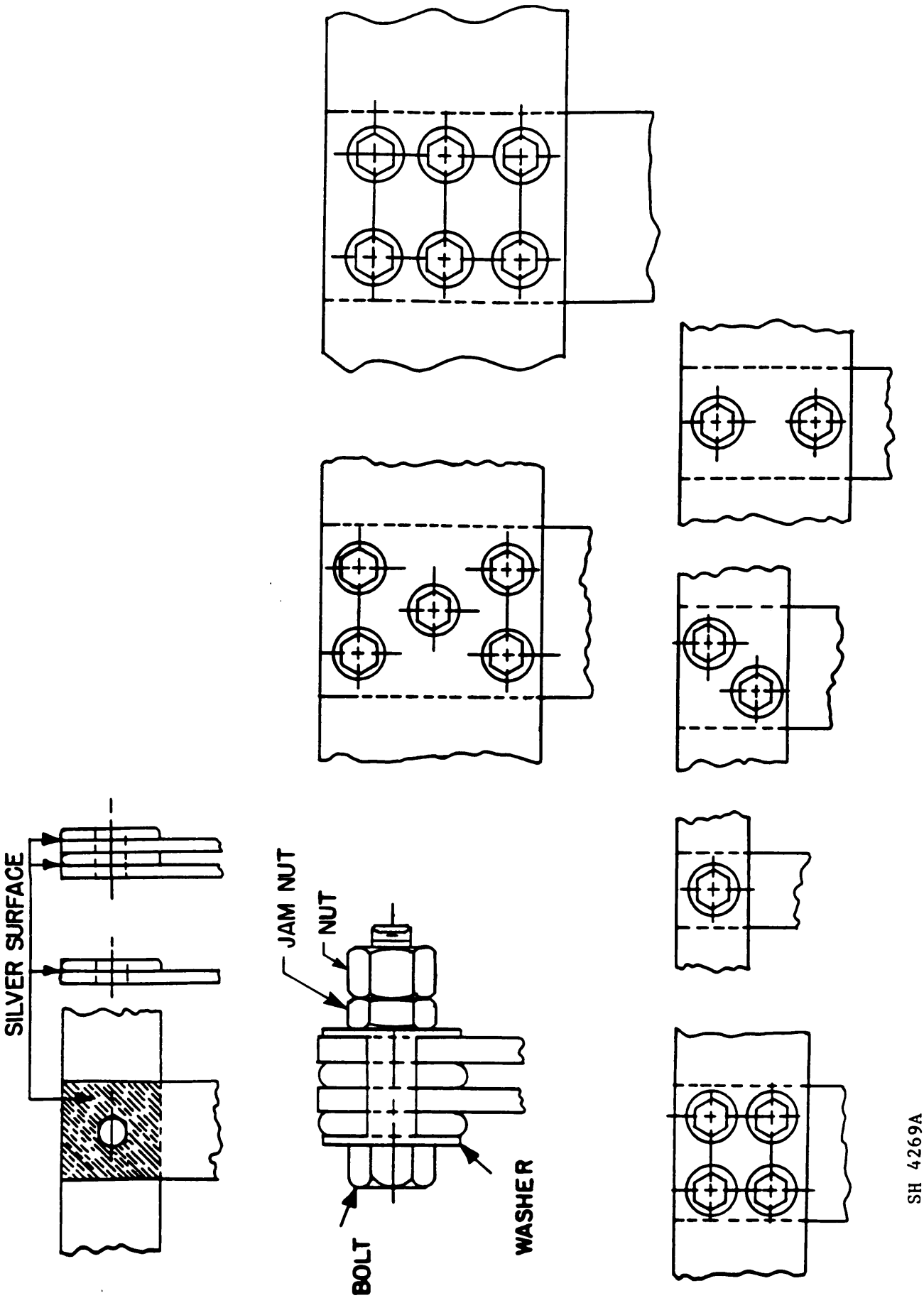


FIGURE 15. Typical arrangement for bolting of bus connections.
(For combination of bolt and bus sizes see table III).

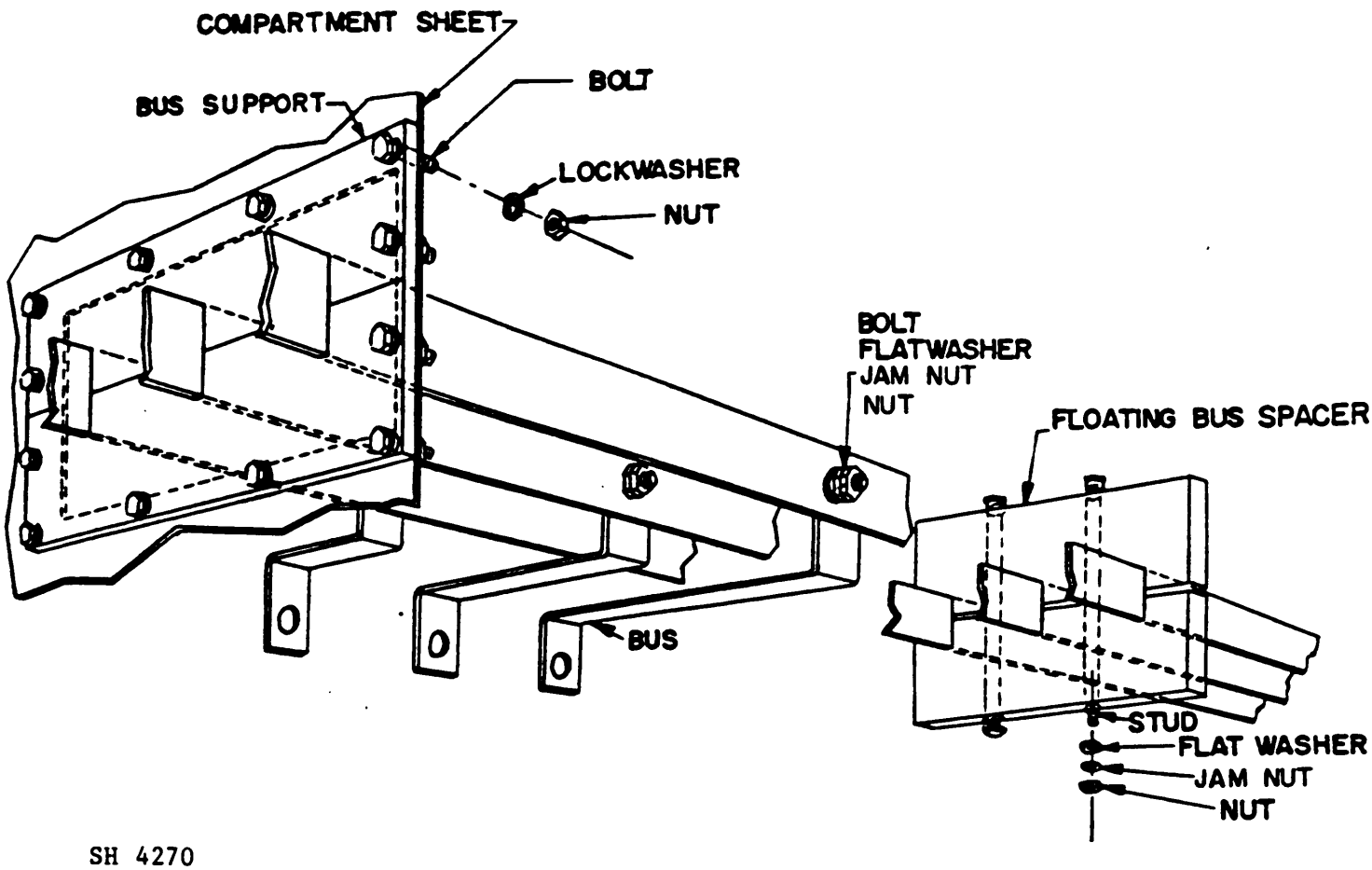


Figure 16 Typical bus bar mounting.

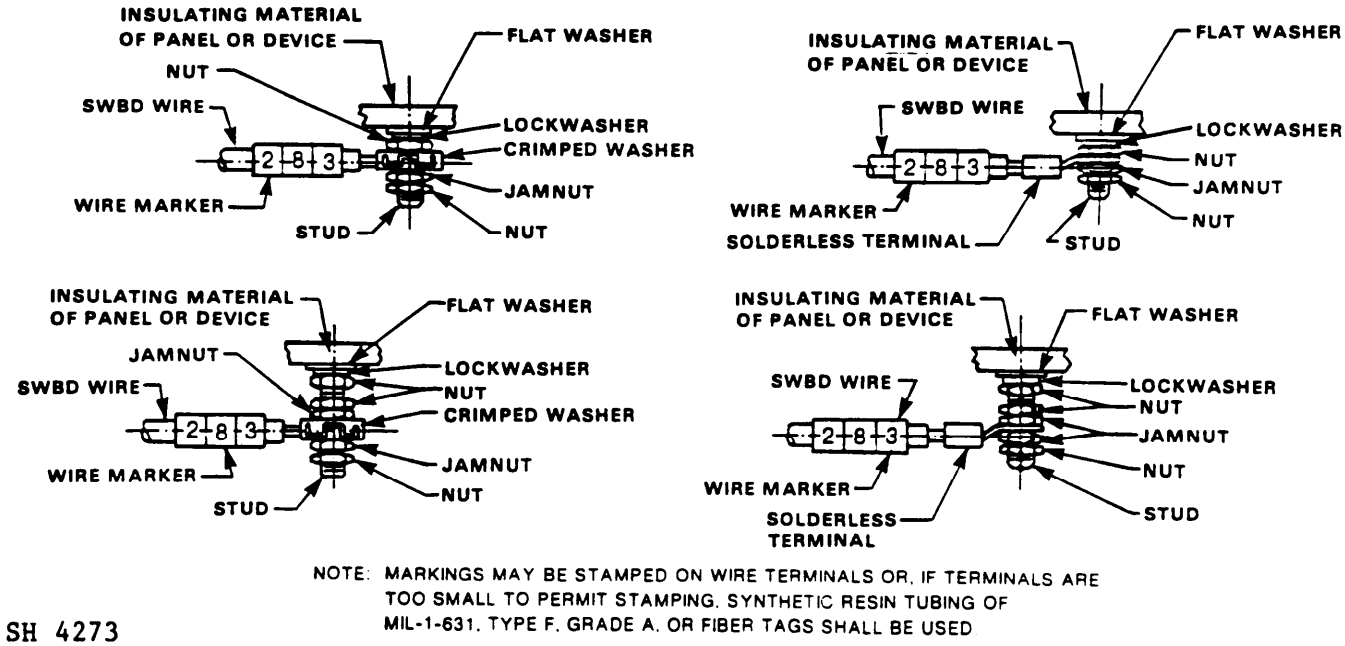
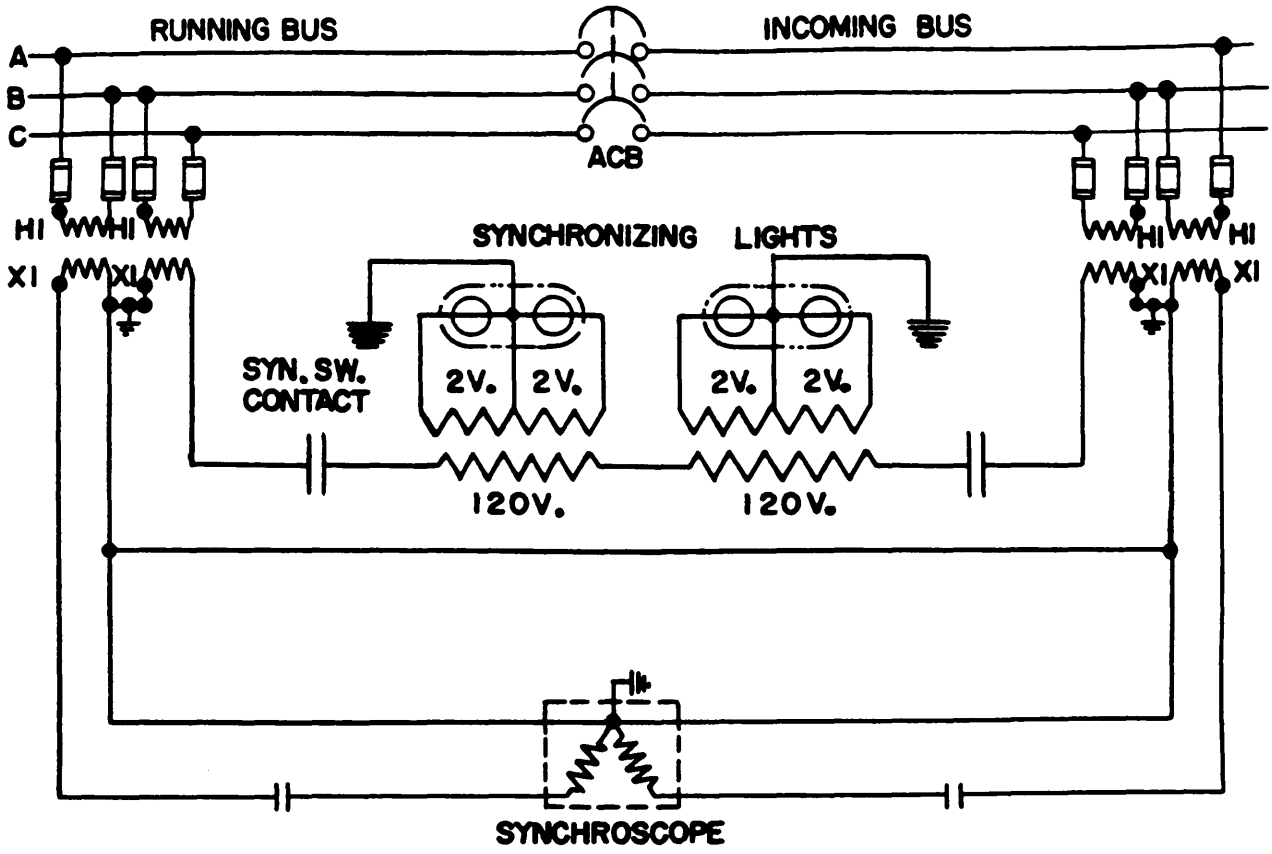


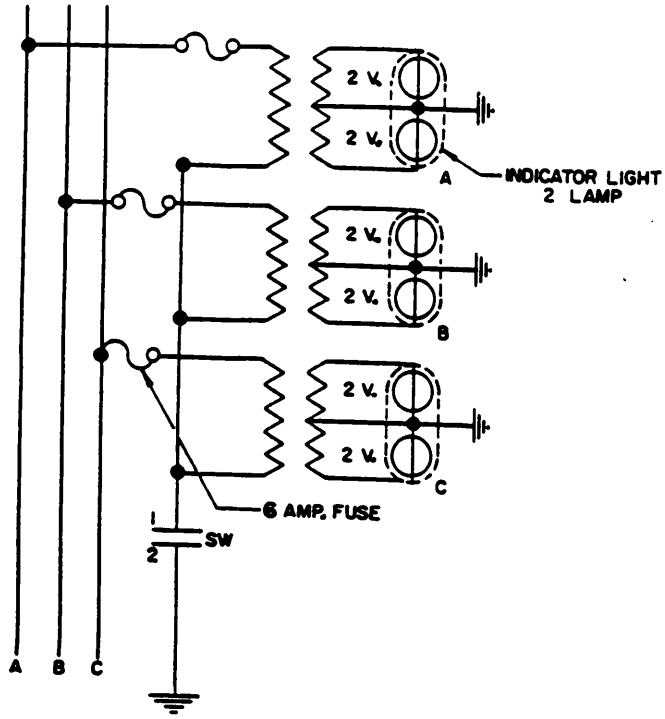
FIGURE 17. Cable marking and detail of connections.



NOTE: THIS DIAGRAM IS TYPICAL ONLY, REPRESENTING A REFERENCE BUS AND A SECOND BUS TO BE SYNCHRONIZED WITH IT. WHERE PROVISION SHOULD BE MADE FOR A THIRD BUS TO BE SYNCHRONIZED WITH EITHER OF THESE BUSES, ADDITIONAL CONTACTS IN THE SYNCHRONIZING TRANSFER SWITCH SHALL BE PROVIDED AS REQUIRED.

SH 99

FIGURE 18. Synchronizing connections.

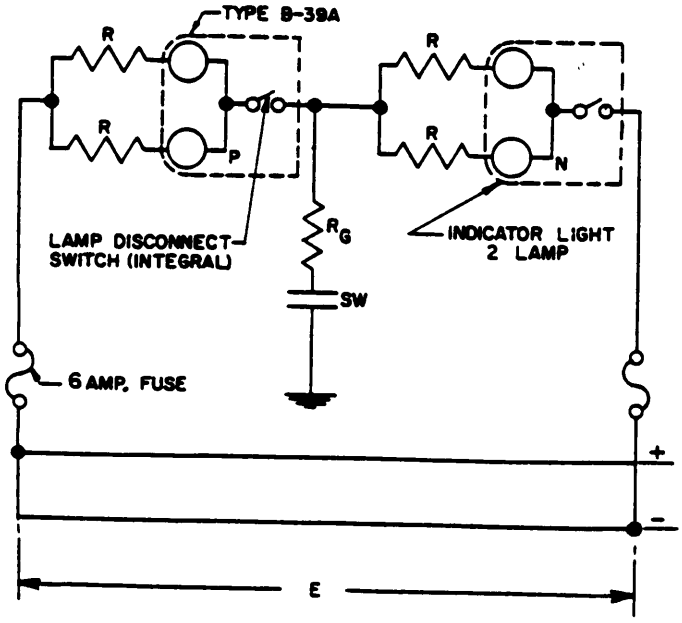


NORMAL – ALL LIGHTS DIM
PHASE A GRD – "A" LIGHT DARK
"B" LIGHT BRIGHT
"C" LIGHT BRIGHT
PHASE B GRD – "B" LIGHT DARK
"A" LIGHT BRIGHT
"C" LIGHT BRIGHT
PHASE C GRD – "C" LIGHT DARK
"A" LIGHT BRIGHT
"B" LIGHT BRIGHT

CONTACTS		POSITIONS	
		TEST	NORMAL
1 — 2	1	X	
	2	X	

SPRING RETURN

A, C. GROUND LIGHTS
3 PHASE



NORMAL – BOTH LIGHTS DIM
POS. GRD. – "P" LIGHT DARK
"N" LIGHT BRIGHT
NEG. GRD. – "N" LIGHT DARK
"P" LIGHT BRIGHT

CONTACTS		POSITIONS	
		TEST	NORMAL
1 — 2	1	X	
	2	X	

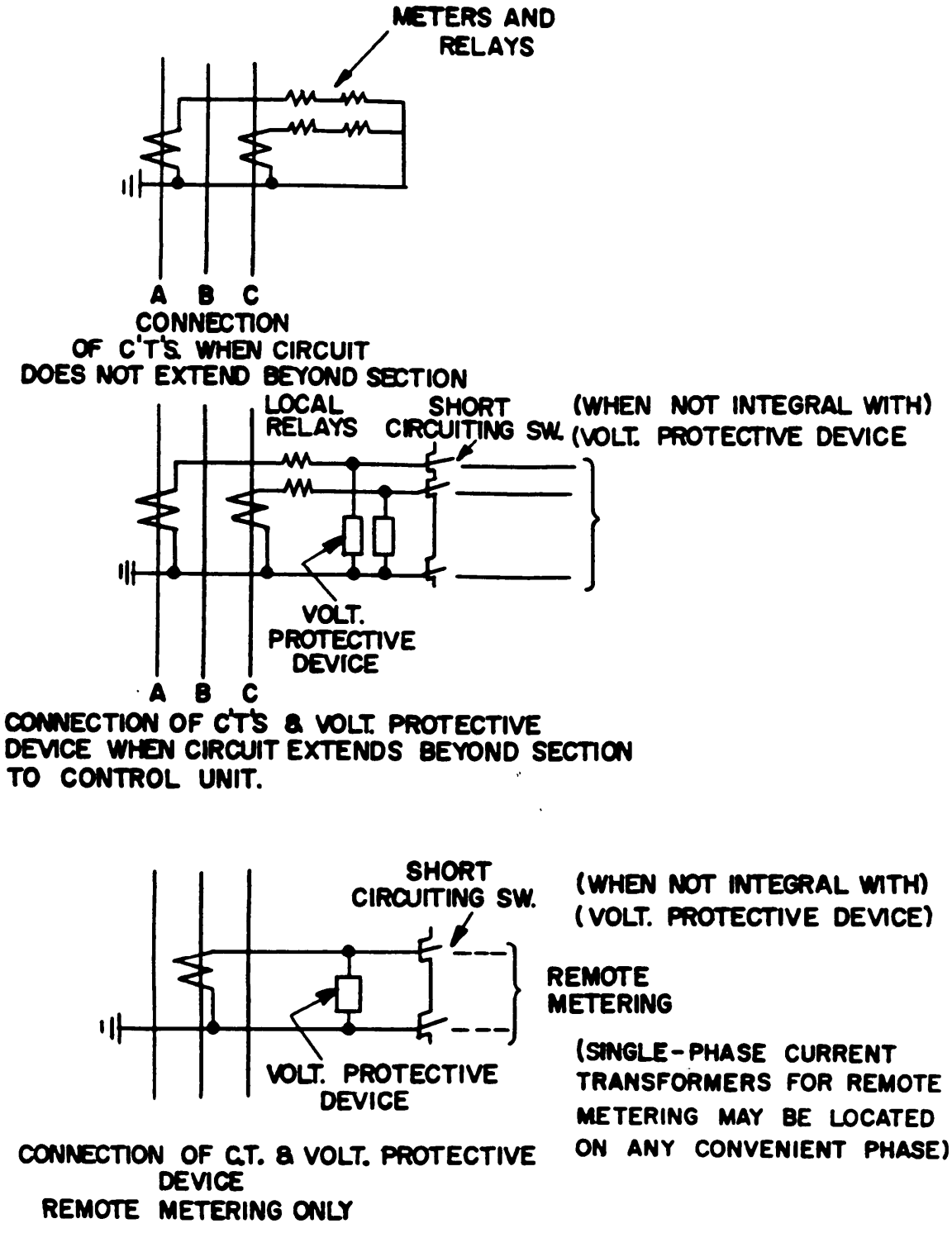
SPRING RETURN

E (VOLTS)	R (OHMS)	R_G (OHMS)
120	1100	630
240	2800	1400

D.C. GROUND LIGHTS
2 WIRE

SH 100B

Figure 19. Ground light schemes.



SH 4276A

FIGURE 20. Connections of current transformers and voltage protective devices.

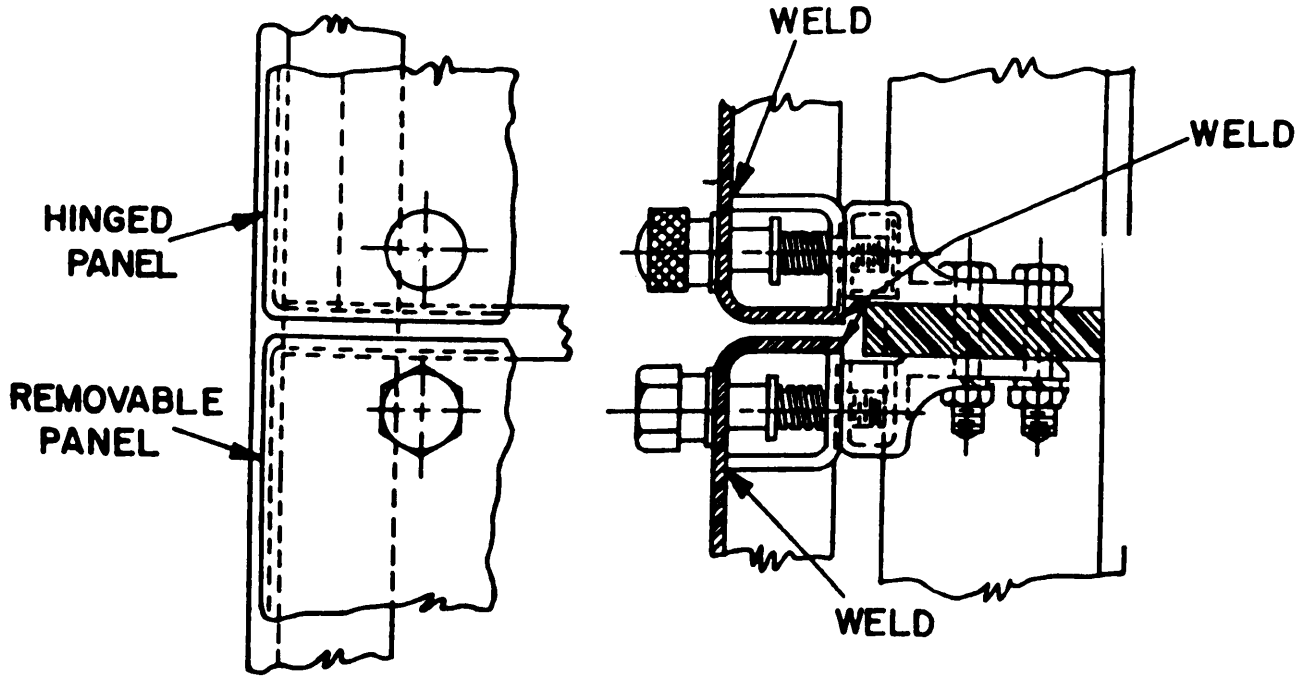


Figure 21. Typical panel latch bolt for hinged and removable panel.

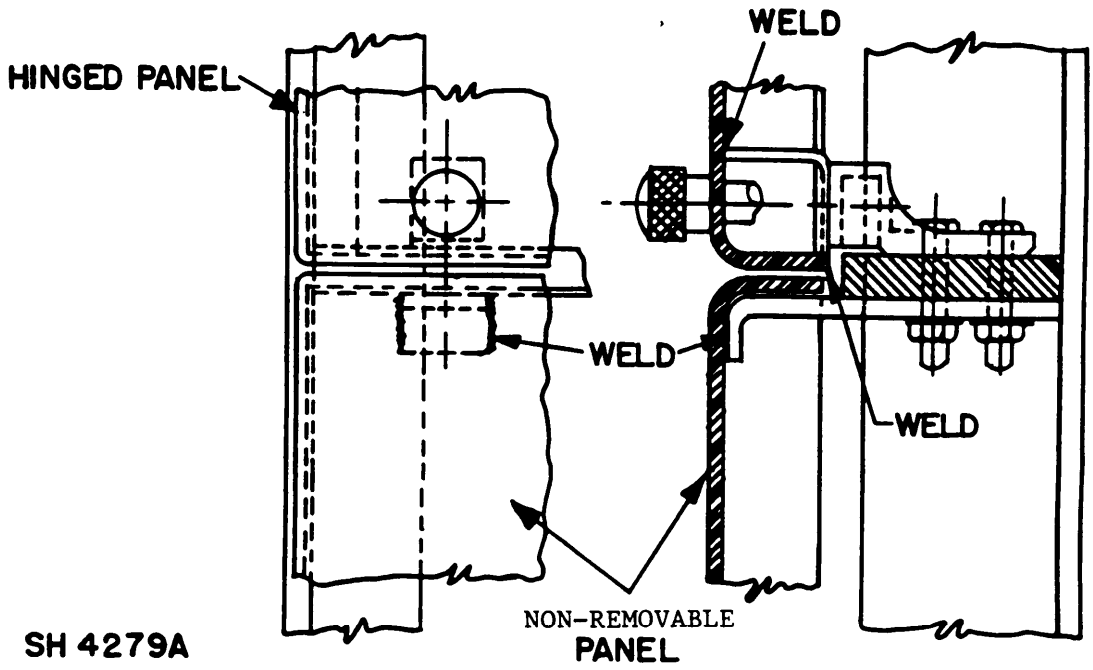
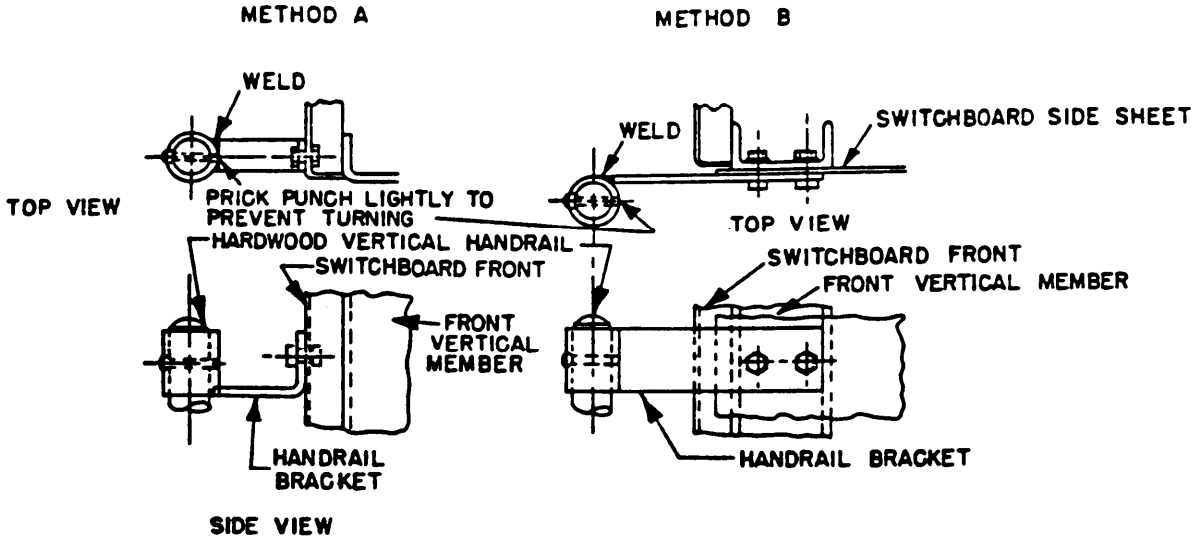


FIGURE 22. Typical panel latch bolt for hinged panel and method of securing stationary panel.



SH 4281A

FIGURE 23. Typical vertical guard rail mounting.

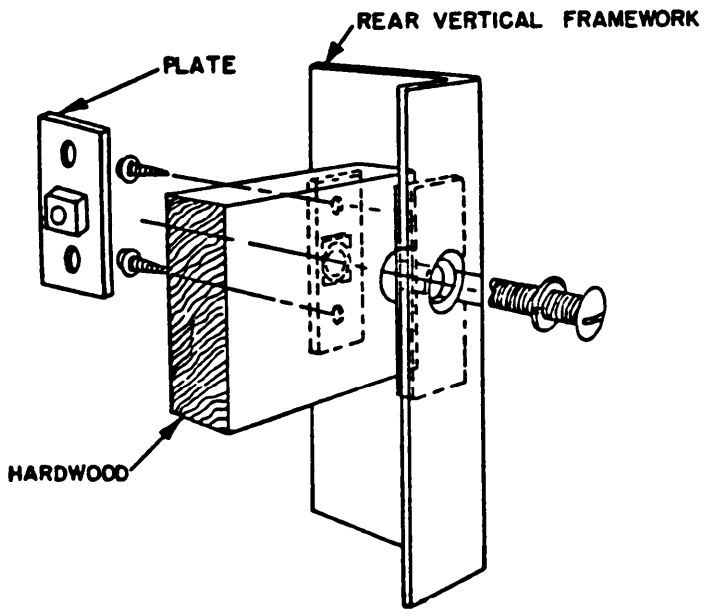


Figure 24. Typical guard rail mounting.

APPENDIX A

APPENDIX FOR DRAWING TECHNICAL REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers the technical requirements for drawings covered by this specification. This appendix is not a mandatory part of this specification. The information contained herein is intended for guidance only.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. DATA CONTENT

30.1 Unit drawings. Unit drawings should contain the following:

(a) Dimensional front, side, and rear views of the switchboard unit showing standardized overall dimensions of the unit; number, size and location of holes for interframe bolting; location of required equipment and; center of gravity location and function of all devices; location and size of main buses passing through the unit and connections thereto.

(b) Dimensional rear elevation view showing casualty power equipment and rear enclosure, where specified.

(c) Dimensional floor or mounting view to show arrangement of anchor bolt drilling.

(d) Supplementary views showing the necessary dimensions and equipment not shown in items (a), (b), and (c) above.

(e) Typical construction methods of the switchboard unit, including details of framework, details of attaching front panels, details of joining structural members, and location and types of welding should be shown or referenced. Total weight of unit with and without circuit breakers should be shown on drawing.

(f) Drawings should show the contractor's recommended method for support of incoming cables.

(g) Drawings should show piece numbers, identification and information plate numbers, and device numbers. These should agree with the corresponding numbers on the identification and information plate list and list of materials.

(h) Detail drawings of devices should be shown or referenced. Where devices are required to be of types for which test record drawings or certification data sheets are funished by the Command or agency concerned, no working or corrected drawings of such devices will be requested. However, each test record drawing or certification data sheet covering the devices, should be referenced and the items in question should conform completely to such drawings or certification data sheets, unless otherwise noted. If supplementary assembly, outline, or detail drawings of such items are necessary in the judgement of the Command or agency concerned, they should be furnished by the contractor.

(i) A one-line wiring diagram of main power circuits. Circuit breakers, disconnect links, main switches, other power circuit switching equipment, and main and interconnecting buses should be shown.

(j) Information plate list of parts having general application; complete list of material with name of parts, part numbers; Command or agency certificate of acceptance, drawing numbers or specification numbers, together with material for parts included in standardized units. Switches, circuit breakers, contractors, fuses, and resistors should be marked to show their current carrying capacity and voltage rating where applicable.

30.2 Switchboard drawings. Switchboard drawings should contain the following:

(a) A dimensional front view of the switchboard showing assembly of units comprising the switchboard, overall diameter of each section, type numbers of units as shown on figure 7, and a single line diagram showing bus sizes. This drawing should show the weight and location of the center of gravity for each switchboard.

(b) Views showing necessary details not shown on drawings of the unit (see spacing of footing or mounting members).

(c) Identification plate list of parts having specific applications; list of material for specific and interconnecting parts not covered by the drawing in 30.1 showing required additional information such as fuse or trip element data.

(d) Complete wiring diagram showing feeder numbers, terminal blocks circuit breakers, switch and fuse sizes, and identification plate numbers. No diagram is required for distribution type switchboards which have no control circuitry or wiring. Electrical devices should be marked or indicated by piece numbers to identify them readily with the corresponding part on the list of materials. Where five or more single lines used to represent several leads parallel to each other on the drawing are together, they should be separated into groups (two or three to a group as convenient), to facilitate following with the eyes instead of having them all uniformly spaced.

(e) An elementary diagram of metering, relaying, and control circuits. This diagram should show the major bus circuits, the number and location of instruments and control transformers, the instruments, relays, and other equipment connected to each transformer, and the location of the instruments in relation to the various switchboards.

(f) Detailed drawings of devices not covered by drawings. Where devices are required to be of types for which test record drawings or certification data sheets are furnished by the Command or agency concerned, no working or corrected drawings of such devices will be required; however, the contractor should reference each test record drawing or certification

data sheet covering the device and the items in question should conform completely to such drawings or certification data sheets, unless otherwise noted. If supplementary assembly, outlines, or detail drawing of each item are necessary in the judgement of the Supervisor of Shipbuilding for the purpose of proper inspection or the identification of repair parts, they should be furnished by the contractor.

(g) A typical construction drawing showing necessary details not covered by 30.2(e) or by other drawings.

(h) Drawings should show piece numbers, identification and information plate numbers, and device numbers. These should agree with the corresponding numbers on the identification and information plate list and list of materials.

30.3 Electric plant control panel drawings. Electric plant control panel (EPCP) drawings should contain the following:

(a) Dimensional front, side, and rear views of the EPCP showing overall dimensions of the EPCP; number, size, and location of holes for bolting; location of required equipment; weight and location of the center of gravity; location and function of all devices.

(b) Dimensional rear elevation view showing casualty power equipment and rear enclosure, where specified.

(c) Dimensional floor or mounting view to show arrangement of anchor bolt drilling.

(d) Supplementary views showing the necessary dimensions and equipment not shown in items (a), (b), and (c) above.

(e) Typical construction methods of the EPCP, including details of framework, details of attaching panels, details of joining structural members, and location and types of welding should be shown or referenced.

(f) Drawings should show the contractor's recommended method for support of incoming cables.

(g) Drawings show piece numbers, identification and information plate numbers, and device numbers. These should agree with the corresponding numbers on the identification and information plate list and list of materials.

(h) Detail drawings of devices should be shown or referenced. Where devices are required to be of types for which test record drawings or certification data sheets are furnished by the Command or agency concerned, no working or corrected drawings of such devices will be required. However, each test record drawing or certification data sheet covering the devices, should be referenced and the items in question shall conform completely to such drawings or certification data sheets, unless otherwise noted. If supplementary assembly, outline, or detail drawings of such items are necessary in the judgement of the Command or agency concerned, they should be furnished by the EPCP.

(i) Information plate list of parts having general application; complete list of material with name of parts, part numbers, Command or agency certificate of acceptance, drawing numbers or specification numbers, together with material for parts included in EPCP. Switches, circuit breakers, contractors, fuses, and resistors should be marked to show their current carrying capacity and voltage rating where applicable.

(j) A diagram of metering, relaying, and control circuits. This diagram should show the main power circuits, the number and location of instruments and control transformers, the instruments, relays, and other equipment connected to each transformer, and the location of the instruments in relation to the various switchboards.

APPENDIX B

APPENDIX FOR MANUAL TECHNICAL REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers the technical requirements for manuals covered by this specification. This appendix is not a mandatory part of this specification. The information contained herein is intended for guidance only.

20. APPLICABLE DOCUMENTS

20.1 Government document.

20.1 Specification. The following specification forms a part of this specification to the extent specified herein. Unless otherwise specified, the issues of this document shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

SPECIFICATION

MILITARY

MIL-D-5480 - Data, Engineering and Technical Reproduction Requirements for.

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

30. DATA CONTENT

30.1 Manuals. Unless otherwise specified (see 6.2.1), switchboard manuals should contain the following information in the order listed. (Note: The above applies where instructions for several switchboards are included in one manual. If any of these switchboards are not furnished, the following numbers shall be rearranged accordingly):

(a) Part 1 - Switchboards and Electric Plant Control Panels (EPCP):
Chapter 1 - General information:
(1) Introduction - Information should include a list of the various switchboards and EPCP furnished and a description of their locations.
(2) Detailed description - Detailed description should include important mechanical details and features which have a bearing on the operation of the equipment.

(3) Principles of operation - Discussion of principles of operation should be based upon a simplified one-line diagram of the ship's service system, emergency system, and other systems, and should include a description of the sources of power, electrical arrangements of the buses, purpose of the various switchboards (that is,ship's service power, emergency power, and others). This chapter should include a discussion of protective device arrangement and operation, selective tripping, and such features as synchronizing, ground detection, and indicating lamps. Illustrations and sketches should be included to clarify the operations of the features discussed.

(4) Maintenance and adjustments - Manual should contain the periodicity and procedure for inspection for loose connections (not less than 3 years), torque values, and the procedure for retorquing and tightening loose connections.

Chapter 2 - Switchgear group - ship's service power - operating instructions.

(1) Include step-by-step procedures for starting generators, synchronizing and paralleling generators, dividing loads, securing generators, and use of ground lamps and indicating lamps.

Chapter 3 - Switchgear groups - emergency power - operating instructions.

Chapter 4 - Miscellaneous operating instructions for other switchboard sections, if supplied.

(b) Part 2 - Air circuit breakers - This part should consist of a chapter for each frame size circuit breaker used on the switchboard, arranged as follows:

Chapter 2A - Type ACB-640R
Chapter 2B - Type ACB-900
Chapter 2C - Type ACB-901R
Chapter 2D - Type ACB-902R
Chapter 3A - Type ACB-1600R
Chapter 3B - Type ACB-1600HR
Chapter 3C - Type ACB-2601R
Chapter 3D - Type ACB-2002HRC
Chapter 3E - Type ACB-5kV-2000RC
Chapter 4 - Type ACB-3200HR
Chapter 5A - Type ACB-4000HR
Chapter 5B - Type ACB-4001R
Chapter 5C - Type ACB-5800HR
Chapter 5D - Type ACB-6400HR
Chapter 6 - Type ACB-ALB-1
Chapter 7 - Type ACB-AQB-A50

Chapter 8A - Type AQB-A101
Chapter 8B - Type AQB-A101F
Chapter 9A - Type AQB-A250
Chapter 9B - Type AQB-LF250
Chapter 10A - Type AQB-A400
Chapter 10B - Type AQB-LF400
Chapter 11A - Type AQB-A600
Chapter 11B - Type AQB-A800
Chapter 13 - Type AQB-A1600
Chapter 13A - Type AQB-1601

These instructions should include that data normally prepared and supplied by the circuit breaker manufacturer for insertion into the manuals.

(c) Part 3 - Miscellaneous switchboard and EPCP devices - Switchboard and EPCP devices should be arranged by sections as follows. (The information should include that data normally prepared and supplied by the contractor.) The pages of each section should be numbered consecutively. The sections should be arranged in alphabetical order, but not necessarily lettered consecutively in the chapter.

Chapter 1 - Instruments, instrument-transformers, and instrument accessories:
- Section A - Dc ammters and voltmeters
- Section B - Ac ammeters and voltmeters
- Section C - Wattmeter
- Section E - Frequency meter
- Section F - Synchroscope
- Section G - Temperature meter equipment
- Section H - Instrument transformers
- Section J - Current transformers protective device
- Section K - Shunts
- Section L - Test blocks
- Section M - Fuses and fuse holders

Chapter 2 - Switches and devices - a general writeup on control switches and indicator lights, test blocks and plugs, and bus disconnecting switches, giving descriptive data, illustrations, rating, without specific reference to any one particular switchboard.

Chapter 3 - Relays:
- Section A - Protective relays
- Section B - Voltage control relays
- Section C - Current control relays (including reverse power relay)
- Section D - Auxiliary relays
- Section E - Bus transfer (where not covered above)

Chapter 4 - Rheostats and miscellaneous.

(d) Part 4 - Maintenance - Maintenance of equipment should be included in the section for each particular piece of equipment. This section should show complete information to enable Navy personnel to perform effective maintenance of equipment, including service inspection, lubrication, and routine maintenance.

(1) Special tools - A list of special tools with their application should be included.

(2) Drawings - Drawings should include the following:

a. A front view arrangement plan of each switchboard showing in simplified fashion the arrangement, part identification, and identification plate number of each device on the front of the switchboard. Identification plate should agree with the switchboard plan. (See part 1, chapters 2 to 4 inclusive, herein.) This plan may be a reduction of the switchboard front view plan.

b. A simplified one-line diagram showing only the arrangement of primary connections for generators, bus ties, buses, typical feeders, and shore connections. Each circuit breaker or device shown on this diagram should be shown except for very simple systems where the inclusions of control and metering circuits will not complicate the drawing. For simple systems, this diagram may be a reduction of the complete wiring diagram.

co Metering and control diagram. This diagram may be a reduction of the switchboard complete wiring diagram. When a specific drawing diagram is furnished, it should show the major bus circuits; the number and location of instruments and control transformers; the instruments, relays, and other equipment connected to each transformer; and the location of instruments in relation to the various switchboards.

d. Drawings included should meet the legibility requirements of MIL-D-5480.

e. Index - An index should be included at the beginning of each part and shall be printed on a heavy paper spacer. The table of contents in the front of the manual should refer to this index.

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NAVSEA (USER) TECHNICAL MANUAL DEFICIENCY/EVALUATION REPORT (TMDER)

(NAVSEA S0005 – AA – GYD – 030/TMMP & NAVSEAINST 4160.3A)

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8. GENERAL COMMENTS

9. RECOMMENDED CHANGES TO PUBLICATION

PAGE NO. A.	PARA-GRAPH B.	LINE NO. C.	FIG. NO. D.	TABLE E.	F. RECOMMENDED CHANGES AND REASONS TYPE OF PROBLEM [INDICATE SAFETY (S), MAJOR (M), OR MINOR (P)]

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