Instructions for Porcel-line Metal-Clad Switchgear

Type DH-P Housings Indoor and Outdoor

Westinghouse Electric Corporation

Assembled Switchgear & Devices, East Pittsburgh, Pa.
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INTRODUCTION

Porcel-line metal-clad switchgear with type DH-P horizontal draw-out air circuit breakers controls and protects high voltage circuits up to 15 KV. The switchgear assembly is composed of housings that are arranged to suit the customer's requirements. Housings are, in turn, composed of equipment such as buses, instrument transformers, relays, secondary control devices, and a DH-P air circuit breaker.

Porcel-line metal-clad switchgear is designed, manufactured, and tested in accordance with industry standards. The 5 KV class is rated at 4.16 KV and the 15 KV class is rated at 13.8 KV.

Porcel-line metal-clad switchgear is available for both indoor and outdoor installations. A typical indoor assembly is shown in Fig. 1. An outdoor Shelterfor-M assembly is shown in Fig. 2 and an outdoor Aisle-less assembly is shown in Fig. 3. The type DH-P air circuit breaker is shown and described in I.B. 32-253-1.

This instruction book has been prepared to familiarize the Purchaser's engineering, installation, and operating staffs with the metal-clad switchgear supplied by Westinghouse. Personnel responsible for supervision, operation or maintenance should become well acquainted with the appearance and characteristics of each piece of equipment contained in or mounted on the switchgear.

The following descriptions apply to standard metal-clad construction and wiring. Extra features and special control schemes are often incorporated when specified by the Purchaser's order. These special features are evident on the drawings and diagrams for the switchgear assembly. Instructions on standard apparatus such as relays, instruments and circuit breakers are included elsewhere in the complete instruction book for a particular metal-clad assembly.

DESCRIPTION

Porcel-line metal-clad switchgear is an assembly of housings arranged to suit the Purchaser's requirements. There are circuit breaker housings and auxiliary housings.

The circuit breaker housing has provisions for a removable type DH-P air circuit breaker. It also includes high voltage equipment, primary connections, low voltage equipment, and control devices. A hinged instrument panel is located on the front of the circuit breaker housing.

The auxiliary housing has no provisions for a circuit breaker. It does include miscellaneous equipment and such equipment that cannot be contained in a circuit breaker housing. A hinged instrument panel is also located on the front of the auxiliary housing.

Porcel-line metal-clad switchgear is available for both indoor and outdoor applications. The circuit breakers and design features are similar whether the installation be indoor or outdoor. In general, outdoor metal-clad switchgear is constructed by assembling a weatherproof enclosure onto and around standard indoor housings.

Indoor Construction

Figure 4 is a section drawing of a typical breaker housing. It is composed of bolted together modules: the breaker/bus module, the line module, the control module, and an upper rear module (if required). Figure 1 is a photograph of an indoor Porcel-line metal-clad assembly viewed from the front. Figure 8 is a view of the same assembly from the rear.

The breaker/bus module is made of left and right side pans, a floor pan, primary and secondary contact mounting plates, vertical and cross members, all welded together to form the basic module. Moving and mating parts such as the levering-in assembly, shutter, interlocks, and auxiliary switch mountings are located in this module. The breaker/bus module contains major functioning equipment such as the breaker itself, stationary disconnect contacts, main bus, and current transformers. The supports for the main bus and main contacts are a part of this module.

The line module is two side pans bolted onto the rear of the breaker/bus module along with a roof cover and rear sheet. This provides space for line terminations such as cable connectors or potheads.

The control module is made of left and right side pans and vertical and cross members, all welded together. The control module is bolted onto the top of the breaker/bus module.

The upper rear module is made of a left and right side pan to which cross members may be welded or bolted to form a self-contained enclosure for bolting onto other modules. The module may be used for apparatus such as rotating disconnect transformers, lightning arresters, special buses, etc. When it is used for rotating disconnect potential transformers the 5 KV class of transformers may be accessible from the breaker drawout side: the 15 KV class of transformers are rear accessible only.

Referring again to Fig. 4, note that the combination of modules forms the actual breaker housing. Internal compartments provide metal isolation between secondary control devices, the type DH-P air circuit breaker, the main bus, and the primary line terminations. Access to primary equipment is provided by bolted-on metal covers which should not be removed unless the circuits to be exposed are de-energized.

Figure 5 is a section drawing of a typical auxiliary housing. It is composed of bolted together modules similar in construction and assembly to those modules in the breaker housing without provisions for a breaker.

Figure 5 depicts an auxiliary housing with rotating disconnect potential transformers and a rotating disconnect control power transformer. It is typical only and could instead include equipment, such as a battery tray, surge equipment, or motor field equipment.

Outdoor Shelterfor-M Construction

Figure 6 is a section drawing of a typical Shelterfor-M assembly including a breaker housing. Figures 2 and 9 are photographs of Shelterfor-M viewed from the front and rear. Figure 11 is a side view of an assembly with the aisle door open. Outdoor Shelterfor-M switchgear is an assembly of a weatherproof enclosure onto and around indoor housings and including an operating or maintenance aisle where equipment is accessible without exposure to weather. The aisle permits interchanging type DH-P circuit breakers. A weatherproof door is located at each end of the aisle and each is equipped with "crash" mechanisms permitting quick release from the inside when the door is padlocked on the outside. Aisle lights, switches, and service receptacles are provided. Shelterfor-M is basically:

1. The indoor housing shown in Figs. 4 and 5.

2. A welded base to which the indoor housing is securely bolted.

3. Weatherproof covers which are bolted to the rear and sides of the indoor housing.

4. A weatherproof roof bolted to the indoor housing.

5. An aisle floor which is bolted to the base and to the front mounting channel.

6. Weatherproof covers forming an aisle enclosure.

7. A weatherproof roof completing the aisle enclosure.

The side covers and aisle covers are formed in such a way that bolts are installed from the inside: the vertical seams are internal. The rear covers are bolted externally but the sheets are crimped and overlapped to form a weatherproof seal. The horizontal seams on all of these covers are at the top within the roof overhangs forming a weatherproof arrangement. The roof seams are flanged and turned back so that a seam cover may be simply locked in place. Foundation requirements are simple -- the structure is supported by three base channels. Pier mounting is possible. No breaker drawout pad is required and indoor accessories are supplied.

Outdoor Aisle-less Construction

Figure 7 is a section drawing of a typical Aisle-less assembly including a breaker housing. Figures 3 and 10 are photographs of Aisle-less viewed from the front and rear. Outdoor Aisle-less switchgear is an assembly of a weatherproof enclosure onto and around indoor housings but not including an operating or maintenance aisle. Weatherproof doors are located on the breaker drawout side of each housing. A light and service receptacle is available in each housing. Aisle-less switchgear is similar to Shelterfor-M without the aisle but with a weatherproof front module. Foundation requirements are simple -- the structure is supported by two base channels. Pier mounting is possible but requires a breaker drawout pad. Outdoor accessories, including a transport truck, are supplied.

Ventilation: Indoor

Refer to Figs. 4 and 8. The rear sheets have grillwork at the top and bottom to allow ventilating air to pass through the line module as shown. A chimney and grillwork over the breaker allows for expansion of gases resulting from breaker interruption and ventilation of the breaker compartment.

Ventilation: Shelterfor-M

Refer to Figs. 6 and 9. The outdoor rear sheets have no grillwork, louvers, or openings and are identical to the Aisle-less rear sheets. Ventilating air enters through a screen at the bottom of the line module (see Fig. 12), passes through it, and is expelled through a screen under the rear roof overhang. Ventilating air also enters through a screen in the breaker module or aisle floor (see Fig. 13) and is expelled through a labyrinth under the peak of the roof. A chimney over the breaker allows for expansion of gases resulting from breaker interruption and ventilation of the breaker compartment.

Ventilation: Aisle-less

Refer to Figs. 7 and 10. The outdoor rear sheets have no grillwork, louvers, or openings and are identical to the Shelterfor-M rear sheets. Ventilating air enters through a screen at the bottom of the line module (see Fig. 12), passes through it, and is expelled through a screen under the rear roof overhang. Ventilating air also enters through a screen in the breaker compartment floor (see Fig. 13) and is expelled through a screen under the front roof overhang. A chimney over the breaker allows for expansion of gases resulting from breaker interruption and ventilation of the breaker compartment.

Instrument Panels: Indoor and Shelterfor-M

The standard breaker housing includes two front panels located on the breaker drawout side of the housing. The upper panel is hinged to the control module and is for mounting instruments, meters, and relays such as those shown in Fig. 14. The lower panel is hinged to the breaker/bus module and is not an instrument panel. An access port in the lower door permits levering the breaker between the operating and disconnected positions with the door closed.

The alternate breaker housing includes one full height instrument panel located on the breaker drawout side of the housing. The full height panel is hinged to both the control and breaker/bus modules. The panel is spaced forward by a front extension compartment.

The standard auxiliary housing includes a full height instrument panel. This panel may or may not be spaced forward.

Instrument Panels: Aisle-less

The standard breaker and auxiliary housing includes a full height front panel located on the breaker drawout side of the housing. This instrument panel is immediately behind the weatherproof door and is hinged to permit insertion and removal of the circuit breaker from the same side. It is for mounting instruments, meters, and relays such as those shown in Fig. 15.

Control Equipment

Figure 16 is a view looking into a 5 KV breaker housing. A knife switch for control power cutoff and terminal blocks for customer's control leads are furnished as standard equipment in the control module. As required, additional control equipment may be mounted in the control module, such as: capacitor trip devices, instantaneous or time delay undervoltage trip devices, control and transformer fuses, resistors, auxiliary or interposing relays, and AB

breakers. Frequently some of the aforementioned control equipment is mounted on the back of the instrument panel. Heaters, to prevent condensation, are furnished as standard equipment on outdoor orders. One heater is mounted in the lower rear of the breaker module and another in the lower part of the line module. (These heaters are visible in Figs. 13 and 12.) Note that Fig. 16 shows the closed door of a 5 KV rotating disconnect potential transformer compartment mounted in an upper rear module. Figure 17 is the same view with the door open. The 15 KV transformer compartment is not front accessible.

Shutter and Barrier

Mounted in front of the main contact supports are molded polyester barriers and a glass-mat polyester shutter. Figure 18 is a view of a 5 KV breaker housing showing the shutter position with the breaker removed. An operating arm is pivoted to the side of the module and linked into the shutter. The shutter is automatically raised by the action of a roller on the breaker against the cam surface of the shutter arm when the breaker is levered into the connected position. When the breaker is levered out of the connected position the shutter drops by gravity. The barriers and shutter (when closed) provide a physical barrier to the main contacts which may be "alive". Removing the shutter as in Fig. 19 exposes the molded polyester barriers. DO NOT REMOVE OR MANUALLY LIFT SHUTTER UNLESS MAIN CONTACTS ARE "DEAD".

Current Transformers

Ring-type current transformers are positioned around the main contact supports as shown in Fig. 20. They are removable from the front and may be located on upper and/or lower main contact supports. If necessary, special current transformers may be mounted in the line module.

Main Bus, Main Bus Taps, and Ground Bus

The main bus, main bus taps, and ground bus contact are shown in Fig. 20. The ground bus itself is shown in Fig. 24. The conductors are of either aluminum or copper as required. The main bus, main bus joints, and taps are insulated. The bolted connections are silver-plated. The main bus supports are of porcelain.

Main Disconnect Contacts and Supports

The main disconnecting contacts and supports are shown in Fig. 20. The main disconnecting contacts are round, silver-plated studs located within the cylindrical porcelain supports. The rear of the contact is brazed to the tap to the main bus and is insulated. The contact assembly is secured within the bottle by a spanner nut threaded onto the front of the contact. A special tool is used to remove or replace the spanner nut.

These main disconnecting contacts (in the housing) engage with the main disconnecting contacts of the breaker. The breaker contacts are self-aligning finger clusters.

Levering-In Screw

The levering-in screw shown in Figs. 21 and 22 is a stainless steel, heat-treated round bar which has a 1/2-13 thread on one end and an Acme thread on the other. The end with the finer thread is screwed into the rear of the breaker module. The screw is secured in place with a locking-screw arrangement. The end with the Acme thread is positioned and "aimed" toward the levering-in nut which is a part of the

breaker. When the levering-in screw and nut are engaged and when the nut is rotated the breaker is pulled into the connected position.

See circuit breaker instructions I.B. 32-253-1 for further description and operation of the LEVERING DEVICE.

Guide Rail and Floor Trippers

The guide rail and floor trippers are welded to the floor of the breaker module and shown in Figs. 21 and 22.

The guide rail is a fabricated steel bar that fits into the guide channel on the breaker and operates a latch on the guide channel. The guide rail positions and guides the breaker laterally into the module. It is notched at the front to provide a positive latch for the breaker in the test position and to prevent the levering-in screw in the module and the levering-in nut on the breaker from bumping one another when the breaker is pushed into the module.

The rear floor tripper is a machined bar that operates the floor interlock and automatic tripping lever on the bottom of the breaker. As a result the breaker may be electrically operated in either the connected or test positions but is electrically trip-free in any intermediate position.

The front floor tripper is a machined channel. The right leg operates the floor interlock and automatic tripping lever on the bottom of the breaker. As a result, should it be closed, the breaker is tripped as it is either being inserted into the test position or withdrawn from the test position. The left leg operates the automatic floor closing spring release lever on the bottom of the stored-energy type of breaker. As a result, should it be charged, the spring is discharged as the breaker is either being inserted into the test position or withdrawn from the test position.

See circuit breaker instructions I.B. 32-253-1 for further description and operation of the RAIL LATCH and FLOOR INTERLOCKS and TRIPPERS.

Truck-Operated Cell Switch (TOC Switch)

The TOC switch shown in Figs. 21 and 22 is an assembly of one 4-pole switch but space is available for two more. Each switch has two make and two break contacts. The TOC switch is mounted at the rear of the breaker module. It is operated by a lever mounted on the levering-in screw and this lever is, in turn, operated by the breaker frame or truck when the breaker is levered into the connected position. As a result, the TOC switch electrically indicates whether or not the breaker is in the connected position.

Breaker Position Interlock

The breaker position interlock is a mechanical, manually operated assembly mounted on the lower right hand side of the breaker module. The main part of the assembly is a formed and machined round bar which is spring-retained in the unlocked position. This bar may be rotated into a notch in the guide rail and held by means of a padlock or Kirk lock. As a result, the breaker is locked out of the connected position. Figure 18 shows the interlock in the unlocked position while Figs. 19 and 20 simulate its position if it were padlocked. Figures 21 and 22, which are closeups, show the position interlock in the unlocked and locked positions using a Kirk lock. Note that the Kirk lock key is held in the unlocked position but is removable in the locked position.

Mechanism-Operated Cell Switch (MOC Switch)

The MOC switch shown in Fig. 23 is an assembly of one 9-pole switch but space is available for two more. Each switch

has five make and four break contacts. The MOC switch is mounted on the right hand side of the control module. It is operated by a lever to which is connected a vertical rod. The vertical rod extends down into the breaker module and connects to a pantograph which is an assembly of a channel and levers. The pantograph is operated by a pin on the breaker mechanism. As a result, the MOC switch electrically indicates whether the breaker is closed or tripped.

Secondary Disconnect Contacts

The secondary disconnecting contacts are the socket-type and are mounted in a block at the lower rear of the breaker module. A similar secondary disconnecting contact but of the plug-type is mounted on the breaker. They provide connections for the control leads between the removable breaker and the stationary housing. The plug-type block on the breaker has two different size guide pins while the socket-type block in the module has two different size guide holes that match the pins. This method of assembly polarizes the contacts and aligns the blocks. The secondary disconnecting contacts are shown in Figs. 18, 19, 20, 21, and 22.

See circuit breaker instructions I.B. 32-253-1, under BASIC OPERATING INSTRUCTIONS for description and operation of how TO ENGAGE SECONDARY CONTACTS WITH BREAKER IN TEST POSITION.

Line Conductors and Customer's Connections

The line conductors and customer's connections are shown in Fig. 24. The line conductors are copper and are insulated. The bolted connections are silver-plated. The connection between the line conductor and the lower main disconnecting contact is brazed and insulated.

In the 5 KV gear the line conductor supports are polyester as shown in Fig. 24. However, the 15 KV gear (not shown) uses porcelain standoff supports.

Space is available in the line module for the customer's primary connections and ground connections. Shown are solderless cable terminals. However, the line module, depending upon requirements, may be equipped with potheads or connections to a bus run.

Rotating Disconnect Transformers

Rotating disconnect potential and control power transformers are enclosed within their own compartments. Generally these compartments are in an auxiliary housing. A set of potential transformers is shown in Figs. 25 and 26. They are mounted upon a cradle which is linked to the compartment side-hinged door. With the door closed both the primary and secondary disconnecting contacts are engaged. Upon opening the door the cradle and transformers are automatically rotated around a horizontal axis; both the primary and secondary contacts are disconnected; and the fuses and high voltage winding of the transformers are grounded. A catch secures the door in the open position. In this position the fuses may be readily removed. Figures 16 and 17 show a 5 KV rotating disconnect potential transformer compartment mounted in a rear superstructure in a breaker housing. The 15 KV transformer compartment is not front accessible.

Rotating Disconnect Fuses

Rotating disconnect fuses are enclosed within their own compartment. The fuses are mounted upon an insulating plate which

is fabricated to simulate a cradle which is in turn linked to the compartment side-hinged door. With the door closed the primary disconnecting contacts are engaged. Upon opening the door the cradle and fuse assembly is automatically rotated around a horizontal axis; the primary contacts are disconnected; and both ends of the fuses are grounded. A catch secures the door in the open position. In this position the fuses may be readily removed. Generally rotating disconnect fuse compartments are in an auxiliary housing as shown in Figs. 25 and 26. The fuses have been removed in Fig. 26.

Miscellaneous Equipment

Depending upon customer requirements additional equipment may be furnished. Generally this equipment will be in its own compartment and, if it is connected to high voltage circuits, it will be isolated from other circuits and personnel by grounded metal barriers and covers. Some of the various types of high voltage equipment are: lightning arresters, surge capacitors, gang-operated disconnect switches, and stationary control power transformers. Some examples of additional low voltage equipment are: tripping batteries, battery chargers, and motor and generator field control apparatus. Some lightning arresters and motor field equipment are shown in Figs. 27 and 28.

Type DH-P Air Circuit Breaker

See circuit breaker instructions I.B. 32-253-1.

Accessories

Each new Porcel-line switchgear installation is provided with a set of accessories. Depending upon customer requirements and the nature of the installation accessories will consist of one or more of the following:

1. A maintenance handle (Fig. 29) for manually closing the circuit breaker. It is to be used for maintenance and inspection of such things as the breaker mechanism and contacts outside of the housing only. DO NOT USE WHEN BREAKER IS IN SWITCHGEAR.

2. A levering-in crank (Fig. 30) for moving the breaker between the test and connected positions. This crank is used for rotating the levering-in nut which is a part of the breaker.

3. A spanner nut wrench (Fig. 31) for removing, replacing, or checking tightness of the main contact in its porcelain support (or bottle). DO NOT USE WHEN MAIN CONTACTS ARE ALIVE.

4. Test plugs (Fig. 32) for use with Flexitest relays and meters.

5. A test cable (Fig. 33) generally furnished with outdoor installations for electrically operating the breaker out of its housing. One end is a plug that connects into the secondary disconnect contacts in the breaker module while the other end is a socket that connects into the secondary disconnect contacts on the breaker itself.

6. A test cabinet (Fig. 34) generally furnished with indoor installations for electrically operating the breaker out of its housing. The cabinet includes control power connections, a cutoff switch, necessary control equipment, and a cable which has one end connected to terminals in the test cabinet. The other end of the cable is a socket that connects into the secondary disconnect contacts on the breaker itself.

7. A turning dolly (Fig. 35) furnished with indoor and Shelterfor-M installations to facilitate turning the breaker when it is outside the housing. It should not be used to insert or remove the breaker from the housing.

8. A transport truck (Fig. 36) furnished with outdoor Aisle-less installations to facilitate handling the breaker when it is outside the housing. The floor of the truck is the same height as the floor of the outdoor Aisle-less switchgear. However, the truck height automatically compensates for some variations in the customer's concrete pad up to plus or minus 1/4 inch. The transport truck must be aligned and secured to the Aisle-less base when removing or inserting the breaker. In addition the breaker must be secured to the transport truck during transportation.

9. An arc chute lifter (Fig. 37) assists in tilting back the chutes on the 15 KV type DH-P air circuit breaker. In addition the hinged leg of the lifter serves as a brace or support to hold the chute in tilted position. No arc chute lifter is required for the 5 KV breaker.

10. A manual spring-charge handle (Fig. 38) is furnished for manually charging the spring of a stored-energy type DH-P air circuit breaker. It may be used for maintenance purposes or in an emergency should the electrical charging source fail.

RECEIVING, HANDLING, STORING

Porcel-line metal-clad switchgear is shipped in groups of one or more housings. The shipping group, depending upon the size of the order, may be the complete order or only part of it. Indoor shipping groups are bolted to wooden skids and enclosed in a covering to protect them from the weather. Outdoor shipping groups do not require skids. For single-row Shelterfor-M installations the aisle wall is located on wall shipping brackets across the front of the shipping group so as to protect the instrument panels. For double-row (or common-aisle) Shelterfor-M installations, since there is no aisle wall, a covering is located across the front of the shipping groups so as to protect the instrument panels. The roof, floor, and end sections of the aisle are shipped separately and field constructed. Aisle-less is enclosed completely in its own weatherproof enclosure. DH-P breakers, accessories, aisle parts, and installation materials are packed and crated separately from the housings. Appendages such as bus runs and synchronizing panels and large internal equipment such as oil-filled transformers may also be packed and crated separately.

Receiving

When the switchgear reaches its destination, the purchaser should check the material actually received against the shipping list to be sure that all parts have been received. If damage is found or suspected, file claims as soon as possible with the transportation company and notify the nearest representative of the Westinghouse Electric Corporation. If the switchgear is to be installed as soon as received, it is recommended that the unpacking and handling be done as outlined in the paragraphs that follow. If the switchgear is to be stored or held for some time it is advisable to unpack sufficiently to check the shipment for completeness and condition.

Handling: Indoor

Each shipping group is equipped with a lifting angle for handling by a crane. Figure 39 shows a typical shipping group of 5 KV indoor housings with its lifting angle. A balancing chain should be added as shown by dotted lines, as the single lifting angle is located slightly off the center of gravity of the group.

Indoor switchgear shipping groups are provided with a dual purpose jack support and shipping brace at each end of the group when shipped by rail. During ship-

ment they are used for cross bracing to the freight car. During installation they can be removed and bolted in the lower set of tie bolt holes (as shown in Fig. 39) to make a handy jack support for removing skids and lowering the group to the floor. When the switchgear is not shipped by rail a simple jack support can be fabricated by the purchaser from angle iron or wooden timbers.

It is preferable to lift the groups into position by a crane. However, if no crane is available they can be skidded into place on rollers. Timbers should be placed between the switchgear and the rollers to protect the switchgear from damage. Jacks may be placed under the jack support of the first group. However, in moving in subsequent groups, the jack support must be removed in order to place two groups next to one another. A method of lowering subsequent groups is the use of long wedges fabricated from 4 x 4's cut on the diagonal. With a large crow bar each corner may be lowered alternately a fraction of an inch.

Handling: Outdoor

Each group of Shelterfor-M or Aisle-less switchgear is equipped with lifting lugs for slings or hooks as shown in Fig. 40. Slots or notches are provided in the spreader or shipping brace through which the cables or slings are spread and positioned. THE SPREADERS MUST BE USED TO PREVENT THE POSSIBILITY OF UPSETTING THE GROUP WHEN IT IS LIFTED. THE SPREADER MUST NOT BE USED ALONE FOR LIFTING.

During rail shipment the spreader or shipping brace is used for cross bracing to the freight car. The lifting lugs may be used as handy jack supports for removing skids and lowering the group to the floor.

The first shipping group may be lifted into position by a crane or skidded into place on rollers. Timbers should be placed between the outdoor base channels and the rollers for front to back movement; no timbers are required for sidewise movement. Jacks may be placed under the lifting lugs of the first group. However, in moving in subsequent groups, the lifting lugs must be removed in order to place two groups next to one another. A method of lowering subsequent groups is the use of long wedges fabricated from 4 x 4's cut on the diagonal. With a large crow bar each corner may be lowered alternately a fraction of an inch.

Storing: Indoor

Indoor switchgear which cannot be installed and put into service immediately should be stored in a dry, clean place preferably indoors in a heated building. Conditions such as dampness, changes in temperature, cement dust, and corrosive atmosphere should be carefully guarded against. If necessary to store outdoors special precautions will be required to keep it clean and warm enough to prevent condensation. It will be necessary to cover the switchgear and install temporary heating equipment. During storage the shipping groups should be placed on level surfaces to prevent unnecessary strain and possible distortion.

Storing: Outdoor

Outdoor switchgear which cannot be installed and put into service immediately should be stored with certain precautions. Conditions such as dampness, changes in temperature, cement dust, and corrosive atmosphere should be carefully guarded against. Temporary power must be made available for the operation of the space heaters provided in the switchgear in order to prevent condensation. During storage the shipping groups should be placed on level surfaces to prevent unnecessary strain or possible distortion.

Miscellaneous Equipment

There may be other equipment besides switchgear which will require special attention. (For example: storage batteries.) THE DESCRIPTIVE MATERIAL SUPPLIED WITH THE EQUIPMENT OR ELSEWHERE IN THE COMPLETE INSTRUCTION BOOK SHOULD BE CAREFULLY FOLLOWED IN RECEIVING, HANDLING, OR STORING.

INSTALLATION

Proper installation of Westinghouse Porcel-line metal-clad switchgear is of prime importance. Too much emphasis cannot be placed upon this operation. For this reason, and to assist the customer's installation, Westinghouse has prepared a series of standard installation and field assembly drawings. One or more of these standard drawings is supplied on each shop order in addition to the shop order assembly drawings. The standard installation and field assembly drawings will be referred to extensively in the text of this section. Following is a tabulation and description of them:

505A863 - Floor Plan - 5 KV Indoor
505A864 - Floor Plan - 15 KV Indoor
508A050 - Foundation - Shelterfor-M
508A051 - Base Plan - 5 KV Shelterfor-M
508A052 - Base Plan - 15 KV Shelterfor-M
508A061 - Base Plan - 5 KV Aisle-less
508A062 - Base Plan - 15 KV Aisle-less
509A796 - Aisle Section Assembly: Shelterfor-M
509A797 - Aisle End Assembly: Shelterfor-M (Single Row)
509A798 - Aisle End Assembly: Shelterfor-M (Double Row)
509A799 - Aisle Light Assembly: Shelterfor-M
509A800 - Roof End Trim Assembly: Aisle-less
510A998 & 510A999 - Insulating or Taping Instructions
657A222 - Test Cabinet Outline

Foundation: General

Westinghouse Porcel-line metal-clad switchgear is accurately built upon true and level bedplates to insure ease of operation and interchangeability. Equal care by the customer in laying out and preparing the foundation will result in reduced installation costs as well as good switchgear performance.

The foundation upon which the switchgear is to be mounted may be a concrete floor, pad, footers, or pillars depending upon the type of gear. It must have sufficient strength to withstand the weight of the structure plus the shock or impact resulting when circuit breakers open under short circuit conditions. Table No. 1 tabulates the approximate dead weights for the various ratings of indoor and outdoor switchgear. Actual weights will vary depending upon the type and amount of equipment in the individual housings. Adequate safety factors must be used. See I.B. 32-253-1 for weights of DH-P breakers.

Foundation: Indoor

Careful preparation of the foundation is vitally important for simplicity of erection, ease of operation, and good performance. The foundation should consist of rugged floor steel channels imbedded in an accurate and true concrete floor. The entire concrete floor upon which the switchgear will be erected must be true and flat (preferably level) and in no place should it vary more than 1/8 inch in any square yard, and MUST NOT PROJECT ABOVE THE LEVEL OF THE SUPPORTING FLOOR CHANNEL STEEL.

TABLE NO. I - APPROXIMATE WEIGHTS OF DH-P HOUSINGS

Type of Housing		Rating Kv	Rating Amps.	Weight (Lbs.)	
Indoor	Breaker	5	1200	1600	
	Breaker	5	2000	1800	
	Auxiliary	5		2200	
	Breaker	15	1200	2000	
	Breaker	15	2000	2200	
	Auxiliary	15		2800	
Shelterfor-M Single-Row	Breaker	5	1200	2150	(1)
	Breaker	5	2000	2350	(1)
	Auxiliary	5		2750	(1)
	Breaker	15	1200	2700	(1)
	Breaker	15	2000	2900	(1)
	Auxiliary	15		3500	(1)
Shelterfor-M Double-Row	Breaker	5	1200	4000	(2)
	Breaker	5	2000	4400	(2)
	Auxiliary	5		5200	(2)
	Breaker	15	1200	5000	(2)
	Breaker	15	2000	5400	(2)
	Auxiliary	15		6600	(2)
Aisle-Less	Breaker	5	1200	1950	(3)
	Breaker	5	2000	2150	(3)
	Auxiliary	5		2550	(3)
	Breaker	15	1200	2400	(3)
	Breaker	15	2000	2600	(3)
	Auxiliary	15		3200	(3)

NOTES: (1) Includes One Indoor Housing Plus Weatherproofing Plus Aisle.
(2) Includes Two Indoor Housings Plus Weatherproofing Plus Aisle.
(3) Includes One Indoor Housing Plus Weatherproofing.

Special attention should also be paid to the accurate leveling of the floor adjacent to the housings on the breaker drawout side since the rapidity and convenience in installing and removing the circuit breaker elements will be facilitated by a smooth hard floor surface.

Standard drawings 505A863 and 505A864 show the recommended method of installing the floor channel steel. Welding to floor steel is preferred to eliminate the need for accurate lining up of bolts. The steel supporting channels used in the floor should be brought to the true plane of the finished floor, leveled, and held there until the concrete is set.

When installing metal-clad switchgear on existing floors, it will usually be desirable to pour a new finish floor with embedded channels, or to cut slots in the floor for embedding and leveling the supporting channels.

Foundation: Outdoor

Outdoor switchgear has an integral base frame of steel channels. Therefore, it is only necessary to install a suitable foundation upon which to bolt down the switchgear. The foundation for Shelterfor-M may be a simple concrete pad, footers, or pillars as shown on Drawing 508A050. The recommended foundation for Aisle-less is a full concrete pad under the assembly and in front of it for breaker drawout. The Aisle-less foundation also could be footers or pillars but a breaker drawout pad would still be required.

Foundation bolting details are similar for Shelterfor-M or Aisle-less and are shown on standard drawings 508A051, 508A052, 508A061, and 508A062.

Floor Plan and Conduit Layout

Provisions must be made in the foundation for the conduits which carry the main cables, control wiring, and ground cable when such conduits enter the switchgear from below. A floor plan or base plan drawing is made for each metal-clad switchgear shop order. This shop order drawing must be used for determining the final conduit layout, spacing of floor channels,

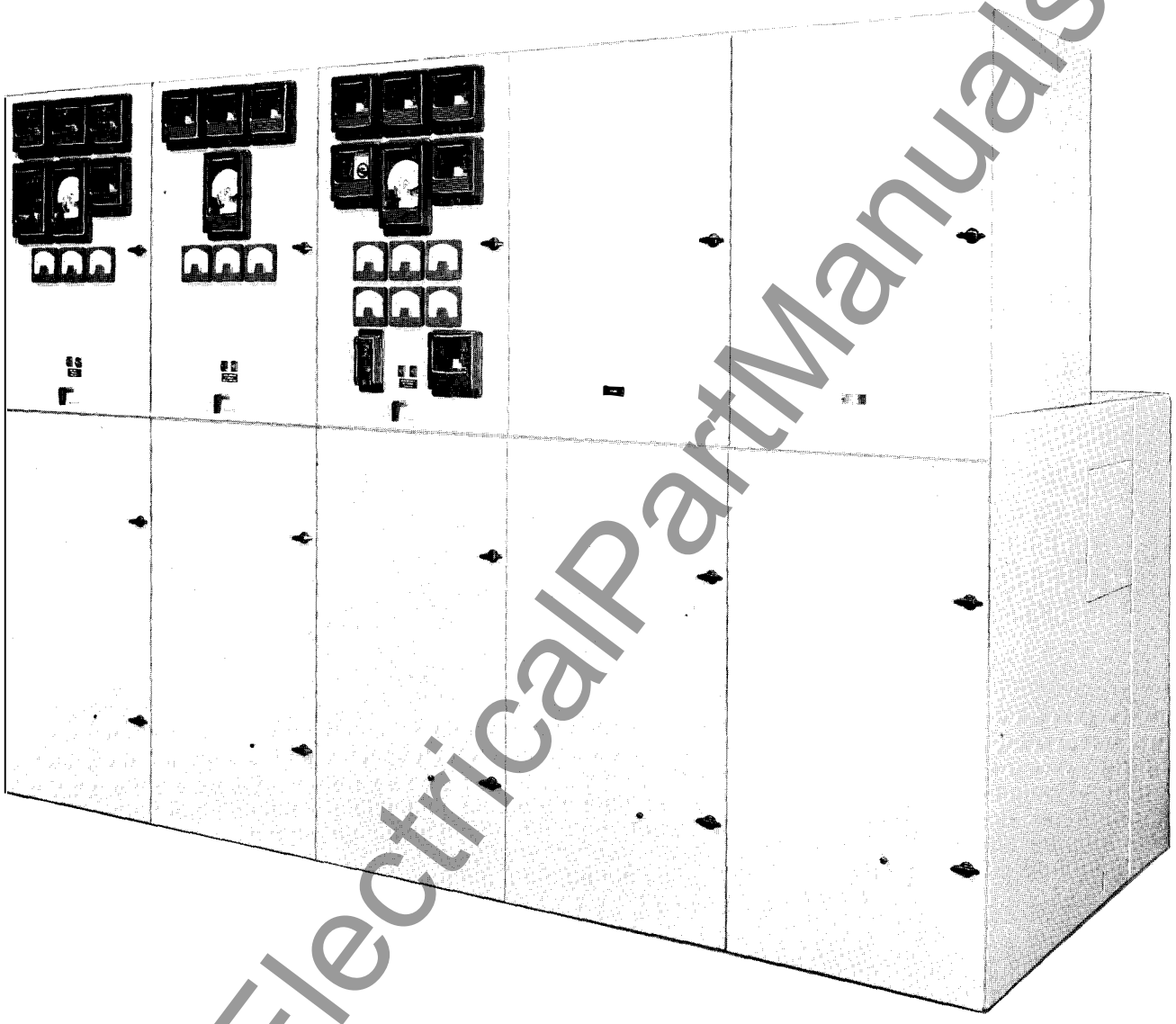


Fig. 1. Indoor: Front View

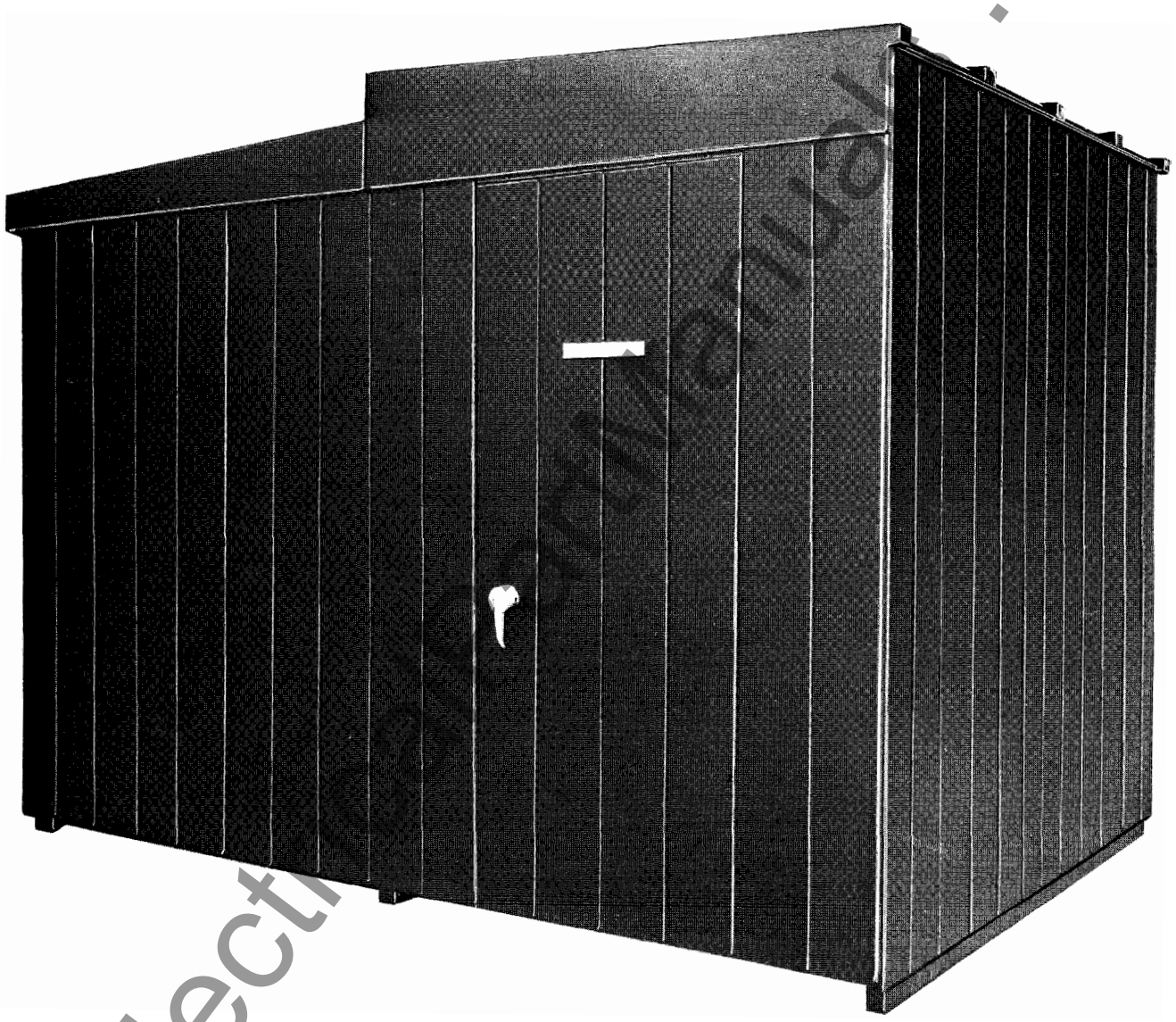


Fig. 2. Outdoor Shelterfor-M: Front View

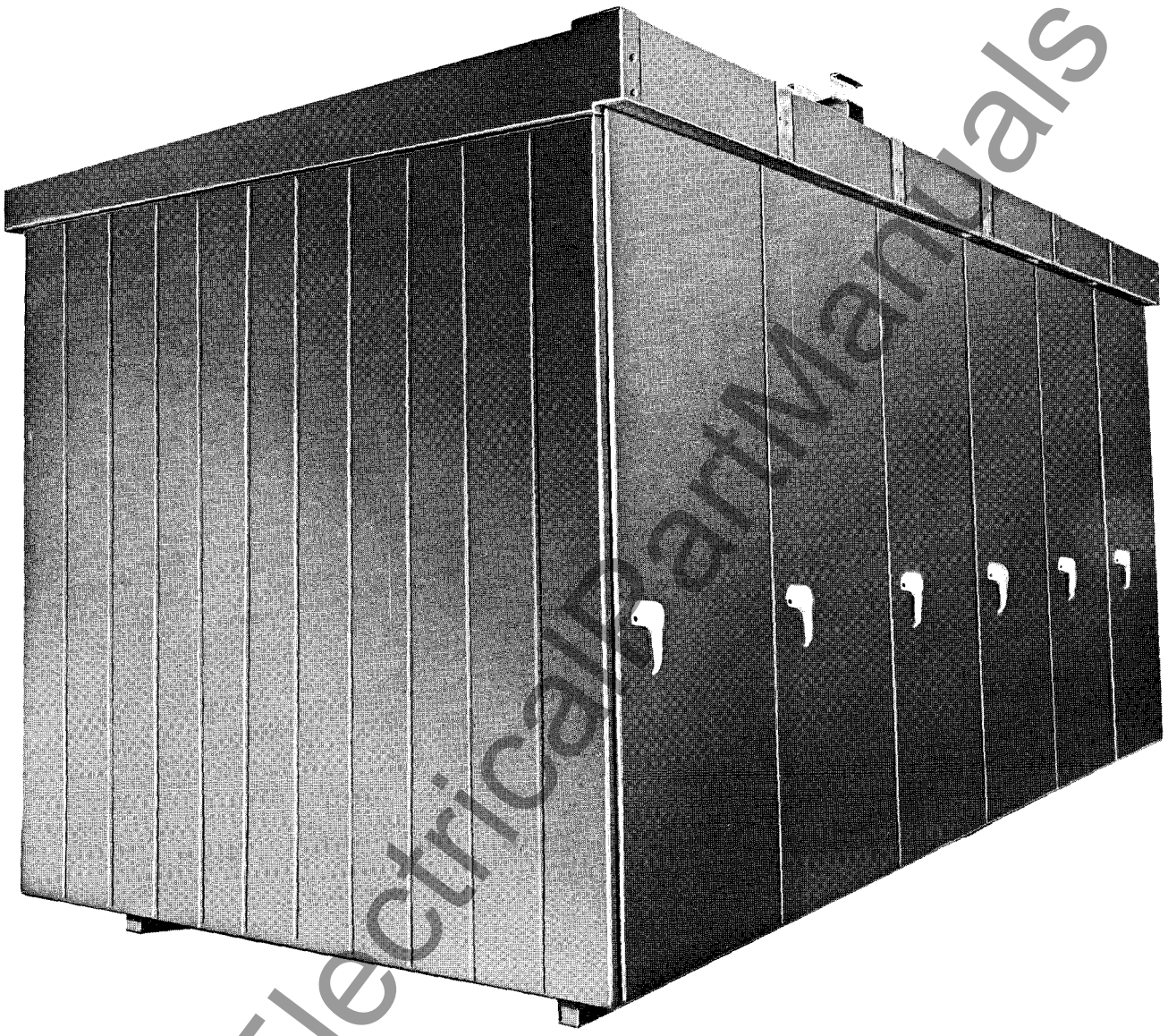


Fig. 3. Outdoor Aisle-less: Front View

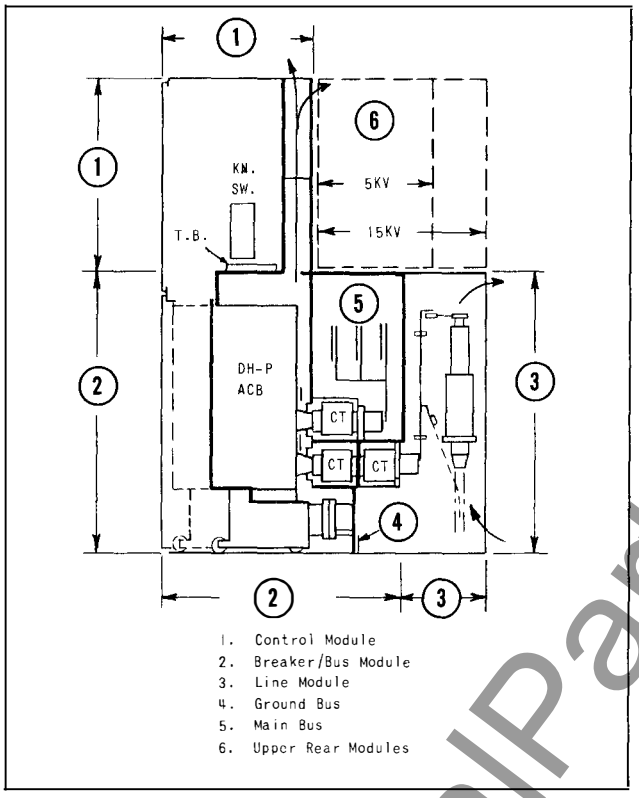


*Fig. 4. Indoor: 5 KV Breaker Housing**

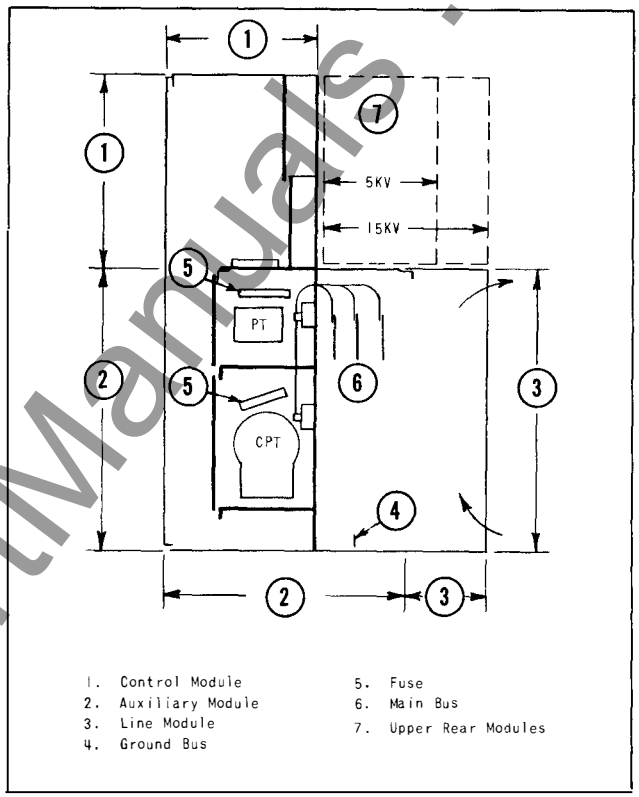


*Fig. 5. Indoor: 5 KV Auxiliary Housing**

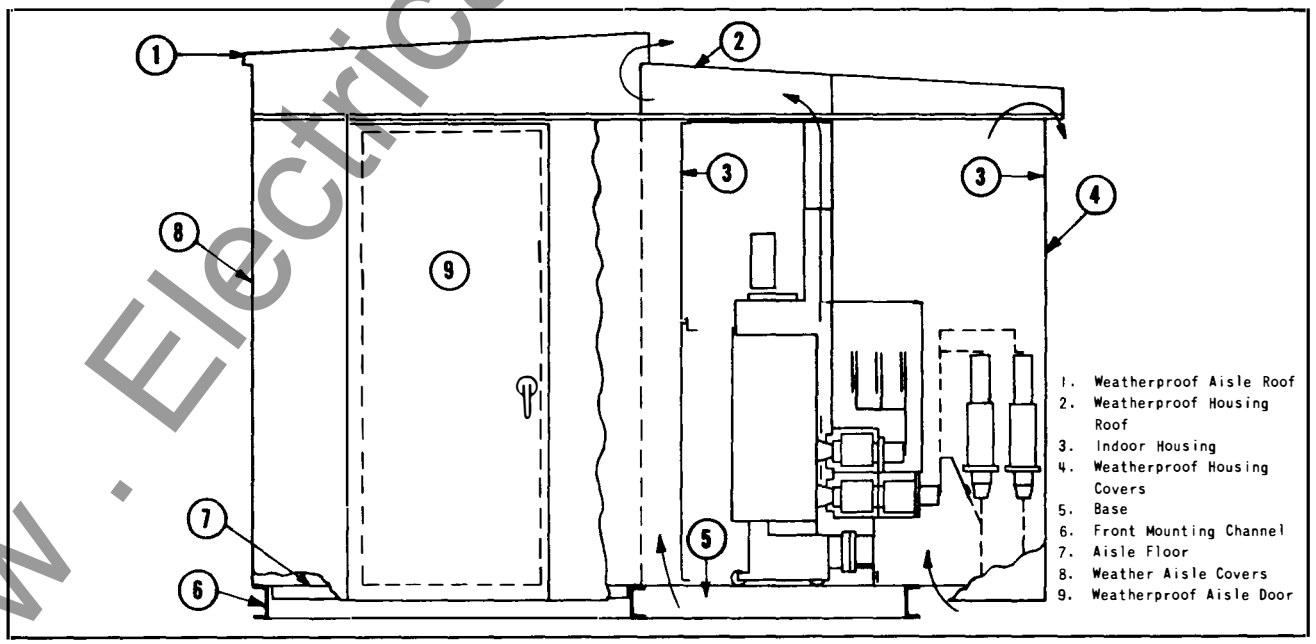


*Fig. 6. Shelterfor-M: 5 KV Breaker Housing**

**(Ventilation indicated by arrows)*

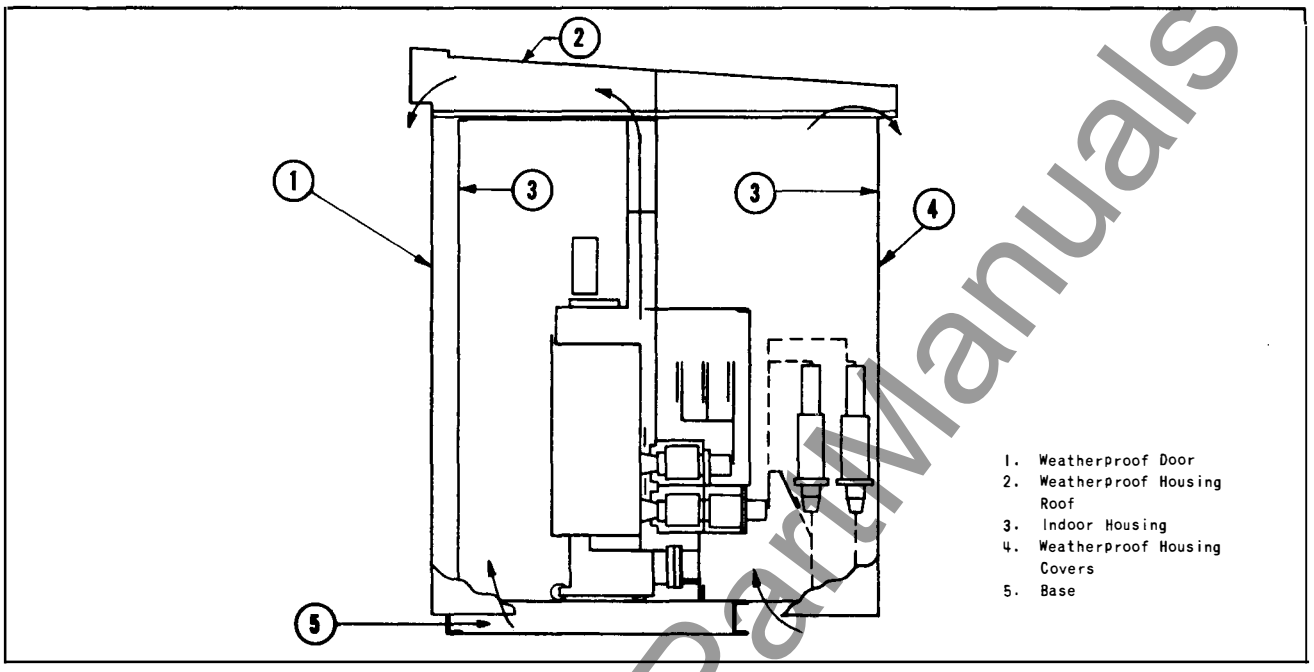


Fig. 7. Aisle-less: 5 KV Breaker Housing (Ventilation indicated by arrows)

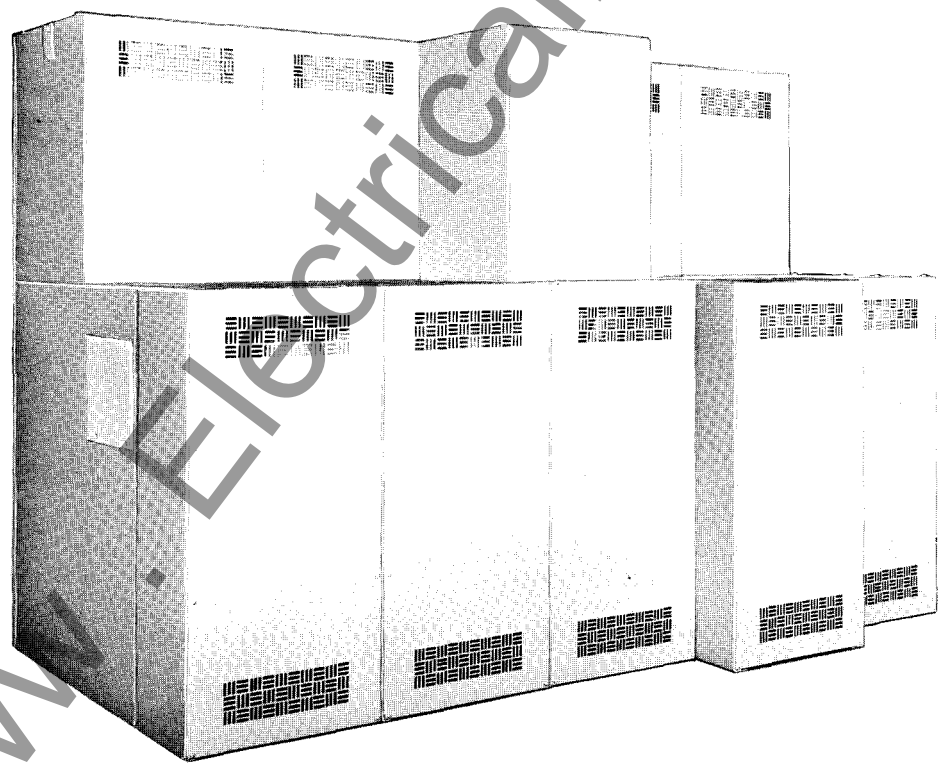


Fig. 8. Indoor: Rear View

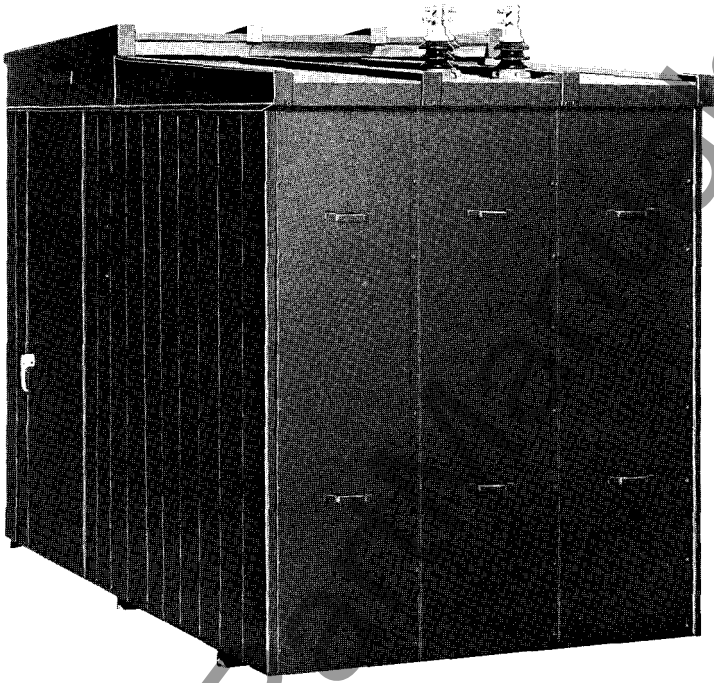


Fig. 9. Shelterfor-M: Rear View

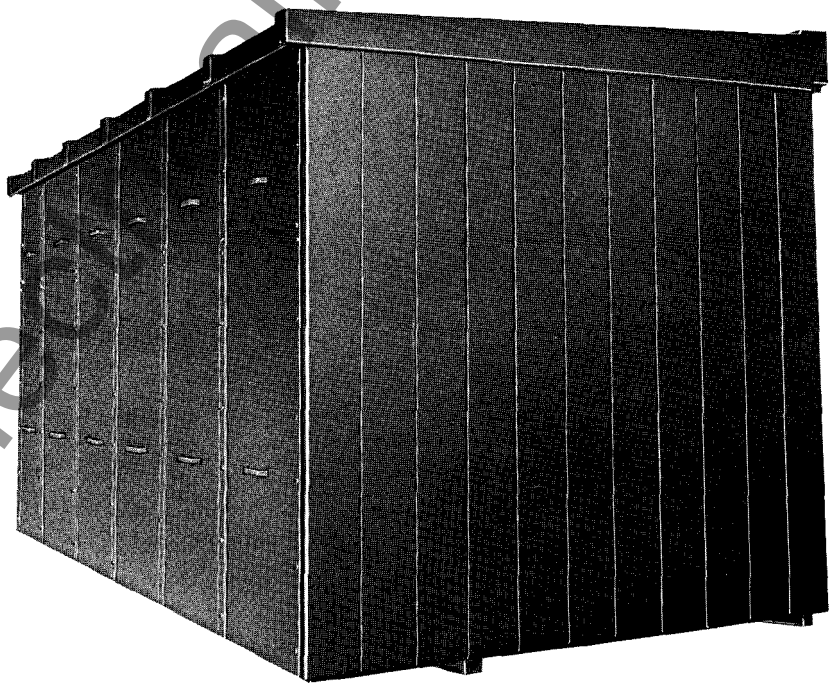


Fig. 10. Aisle-less: Rear View

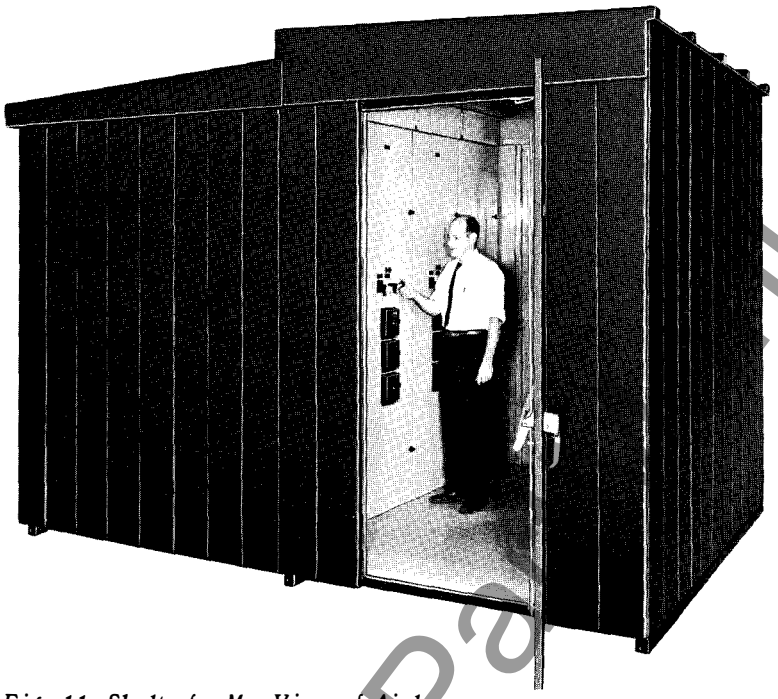


Fig. 11. Shelterfor-M: View of Aisle

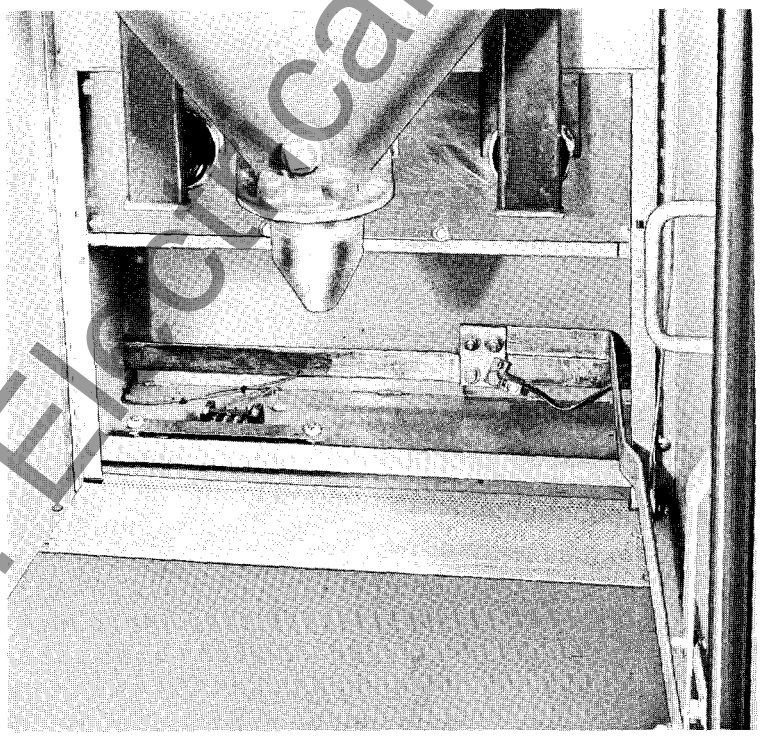


Fig. 12. Outdoor: Line Module with Rear Sheet Removed

Fig. 13. Outdoor: F.V. Close-up showing Ventilating Screen and Transport Truck Clips

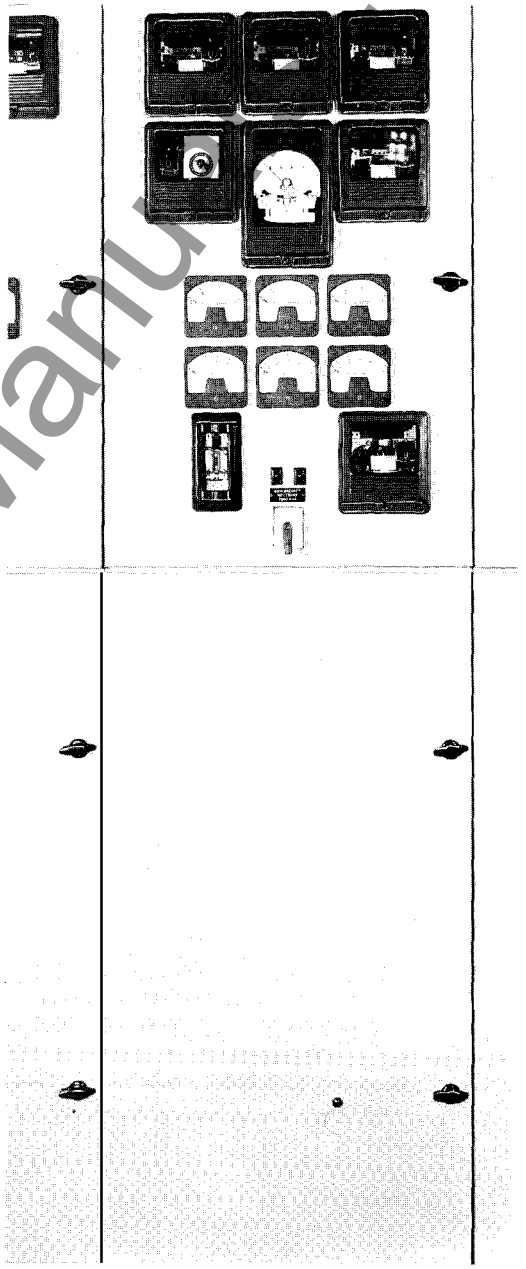


Fig. 14. Indoor and Shelterfor-M: Standard Instrument Panel

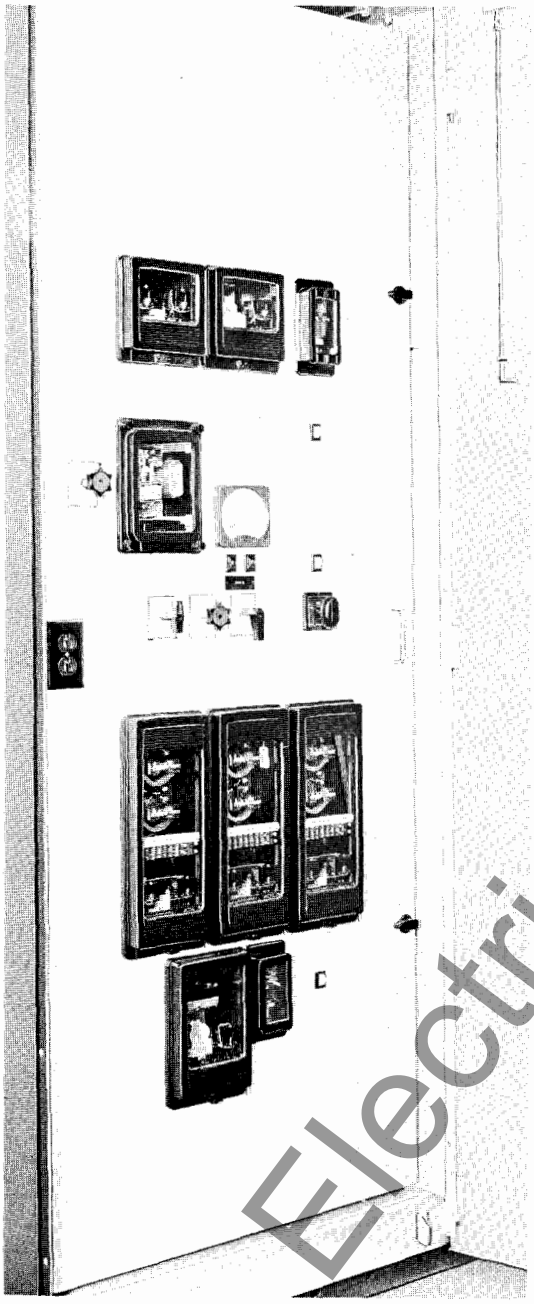


Fig. 15. Aisle-less: Standard Instrument Panel

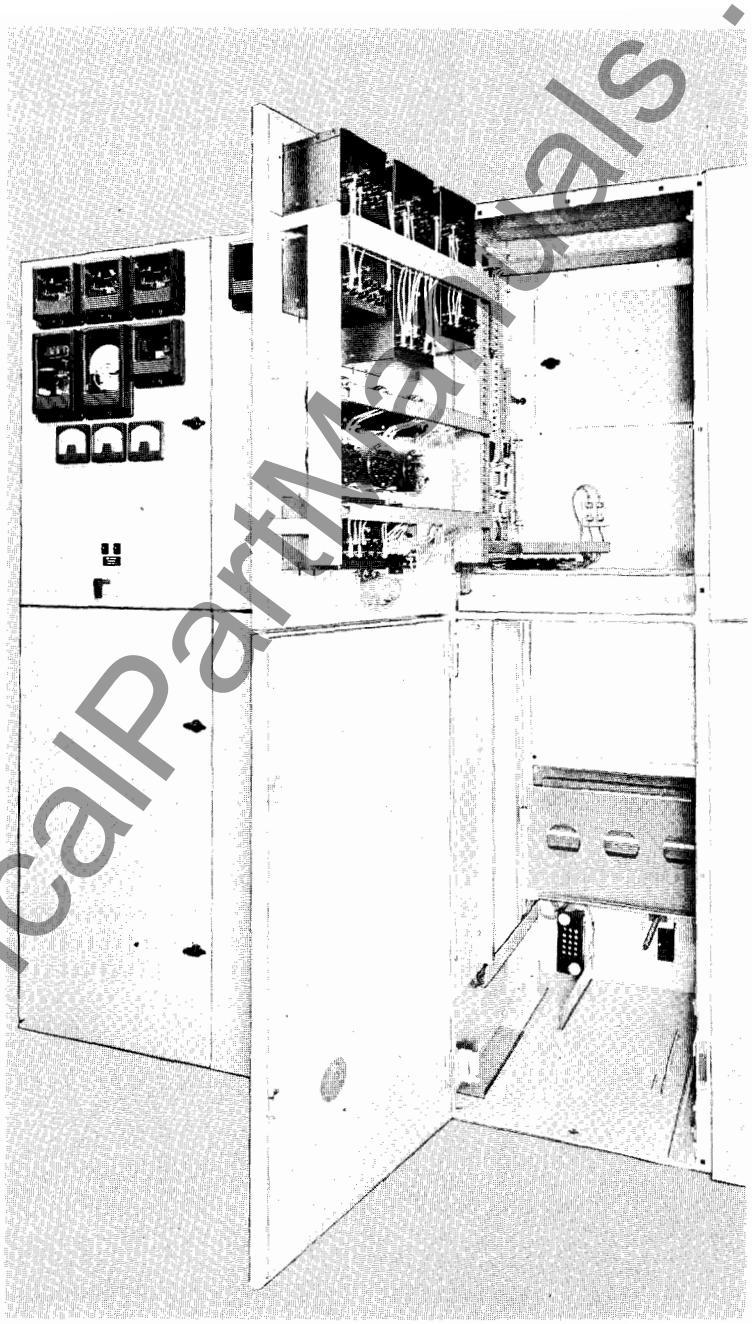


Fig. 16. Indoor and Outdoor: 5 KV Breaker Housing with PT Compartment Door Closed

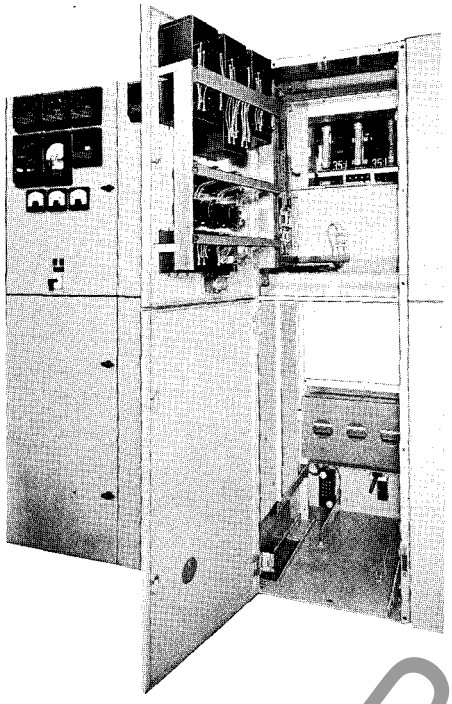


Fig. 17. Indoor and Outdoor: 5 KV Breaker Housing with PT Compartment Door Open

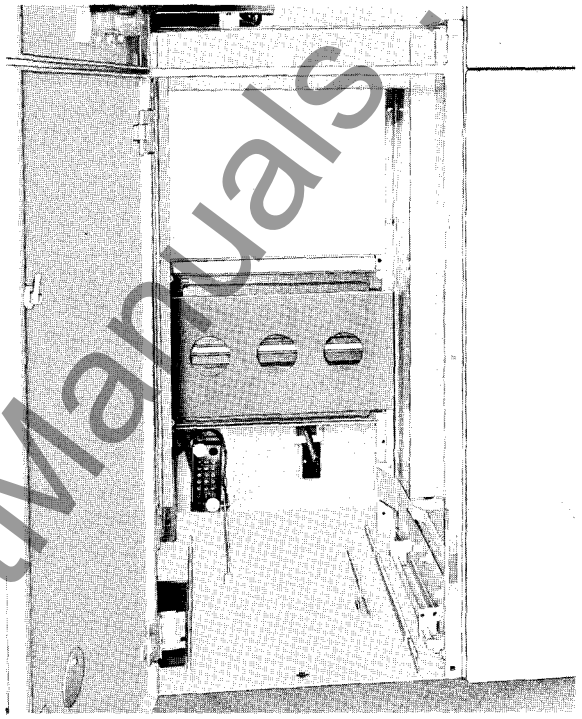


Fig. 18. Indoor and Outdoor: 5 KV Breaker Housing with Shutter and all Barriers in Place

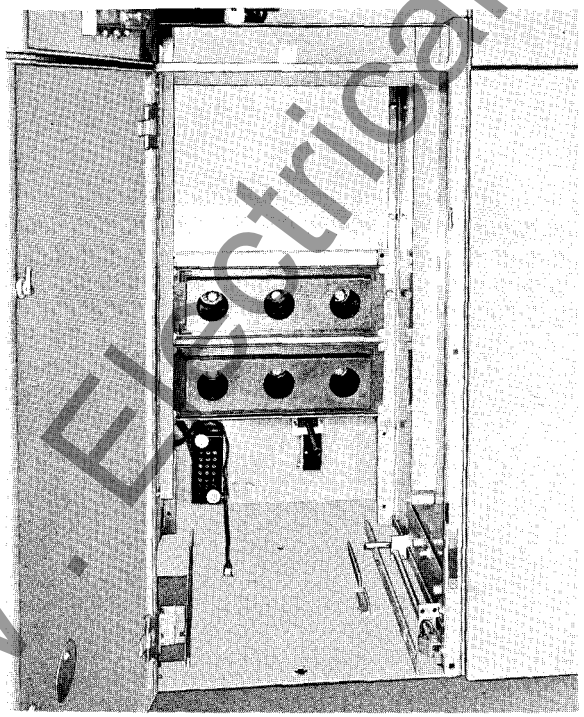


Fig. 19. Indoor and Outdoor: 5 KV Breaker Housing with Shutter Removed

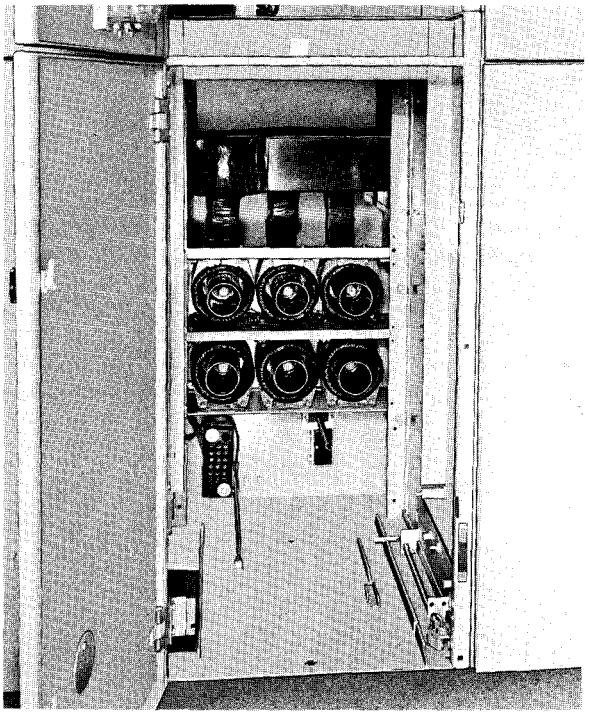


Fig. 20. Indoor and Outdoor: 5 KV Breaker Housing with Shutter and Barriers Removed

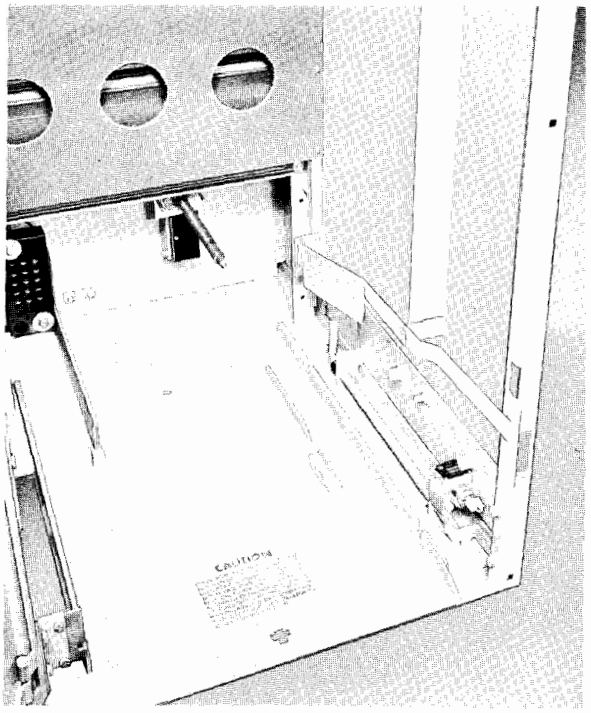


Fig. 21. Indoor and Outdoor: Close-up, Position Interlock (Unlocked)

Fig. 22. Indoor and Outdoor: Close-up, Position Interlock (Locked)

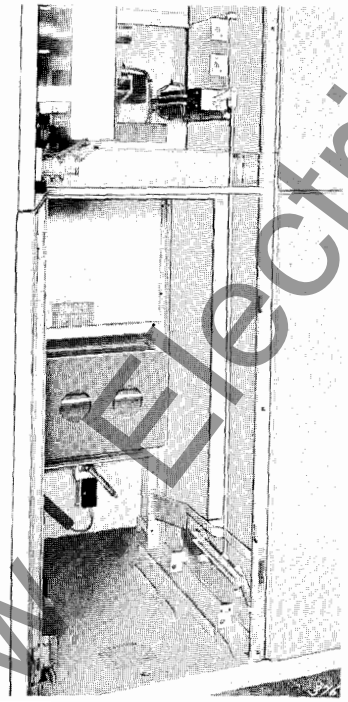


Fig. 23. Indoor and Outdoor: 5 KV Breaker Housing with MOC Sw

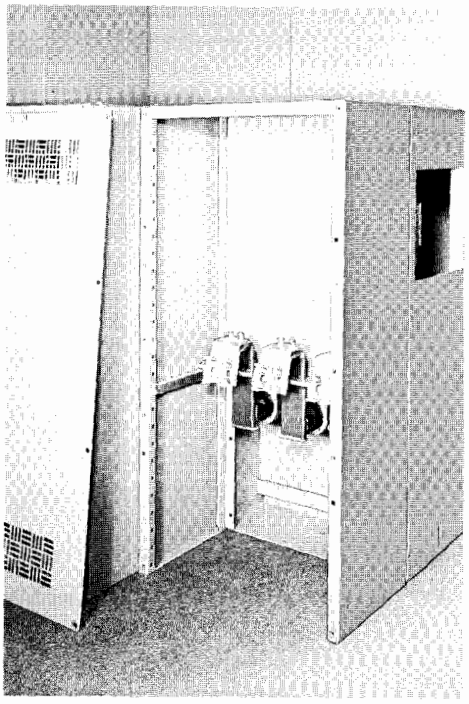


Fig. 24. Indoor: Rear View of 5 KV Breaker Housing with Rear Sheet Removed

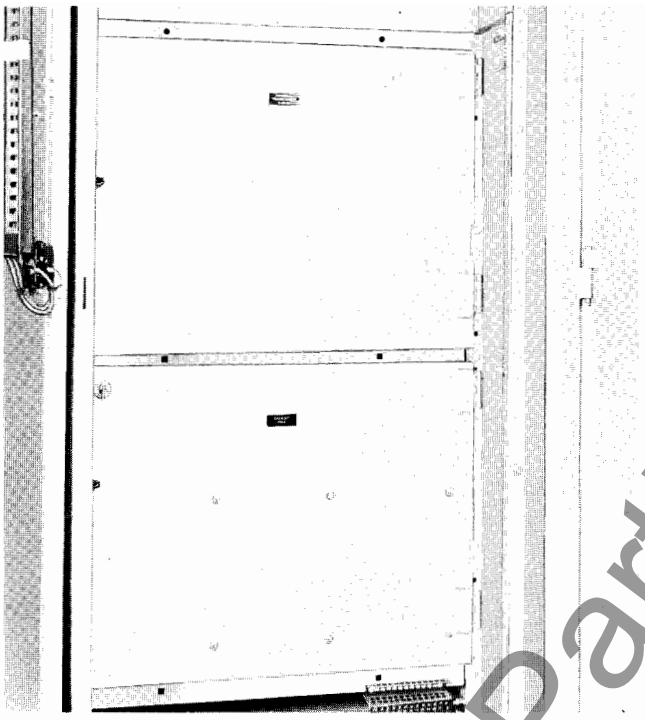


Fig. 25. Indoor and Outdoor: 15 KV Auxiliary Housing with PT and Fuse Doors Closed

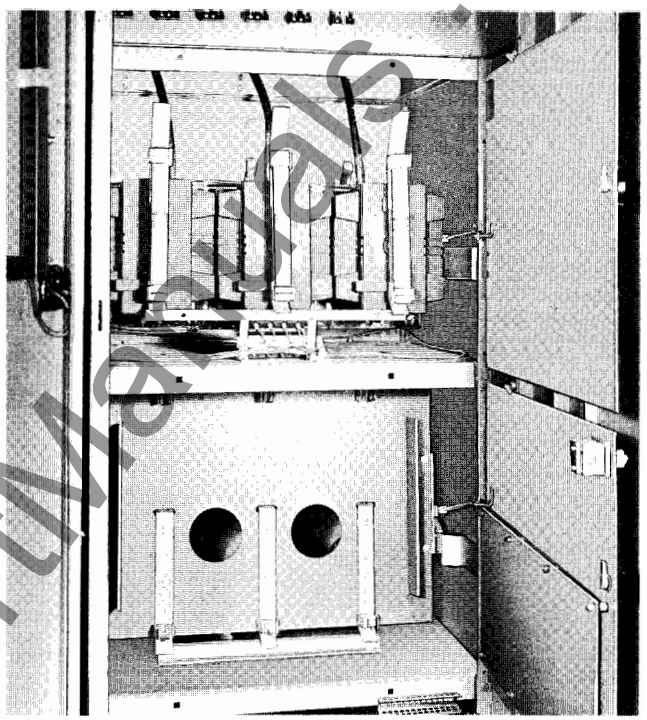


Fig. 26. Indoor and Outdoor: 15 KV Auxiliary Housing with PT and Fuse Doors Open

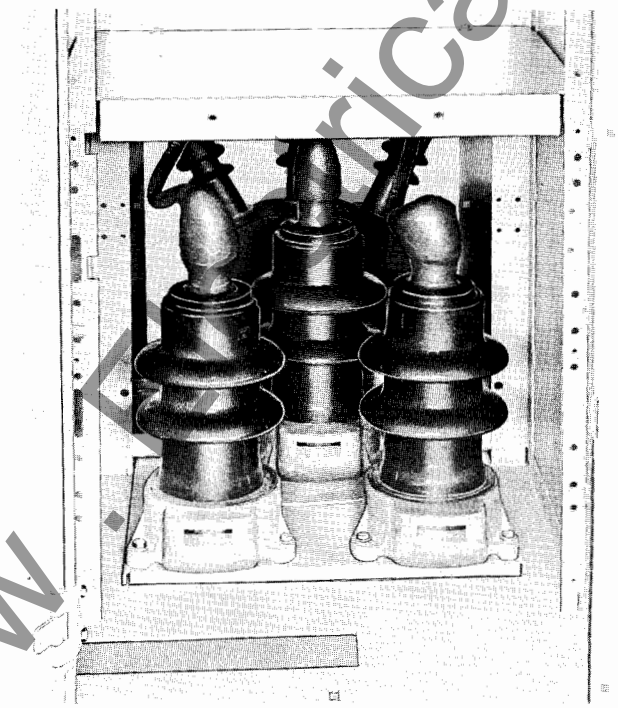


Fig. 27. Indoor and Outdoor: Lightning Arresters

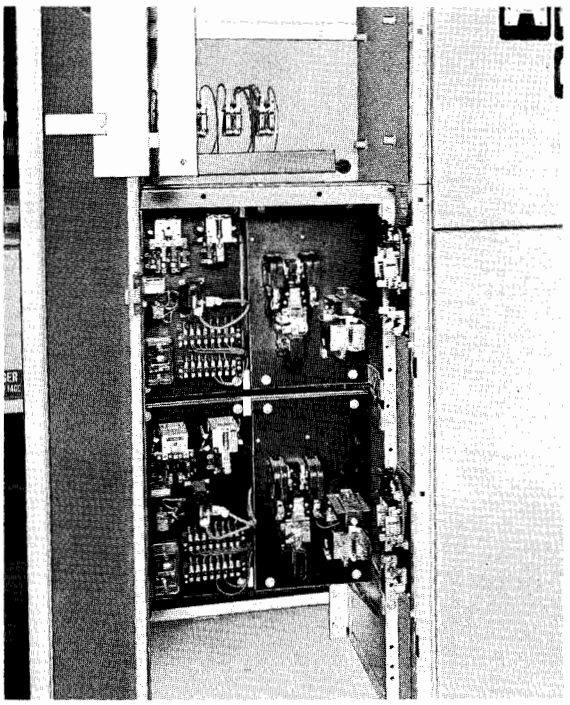


Fig. 28. Indoor and Outdoor: Field Control Equipment

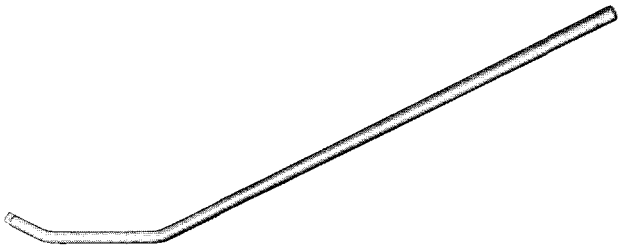


Fig. 29. Maintenance Handle

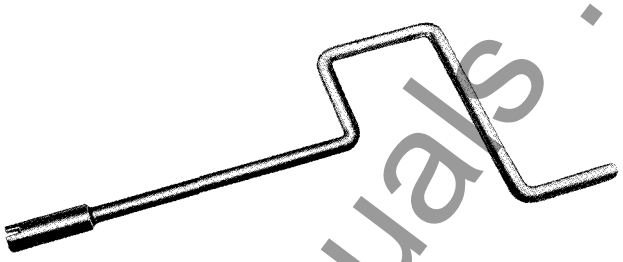


Fig. 30. Levering-In Crank

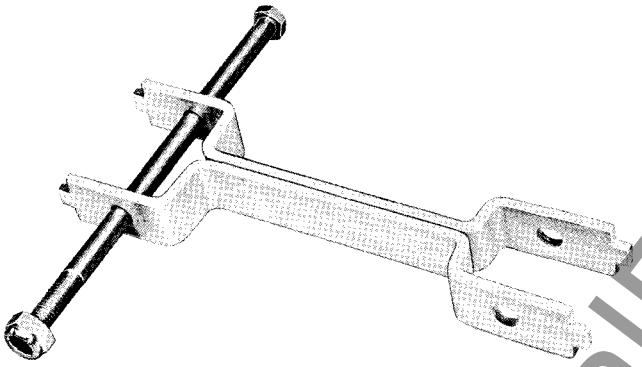


Fig. 31. Spanner Nut Wrench

Fig. 32. Test Plugs

Fig. 33. Test Cable

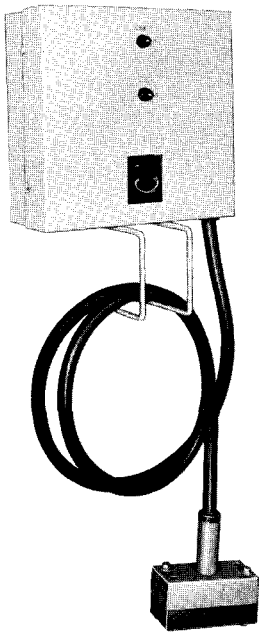


Fig. 34. Test Cabinet

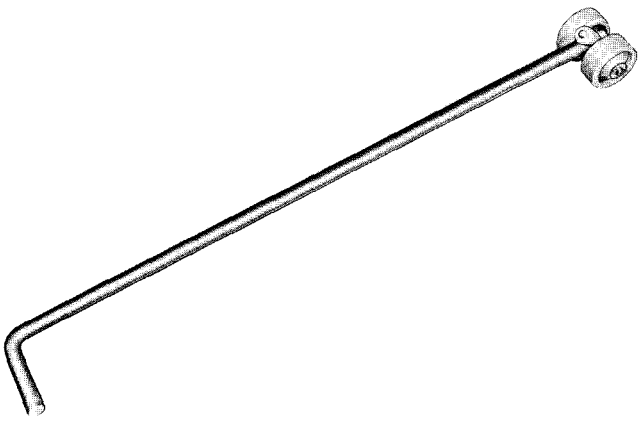


Fig. 35. Turning Dolly

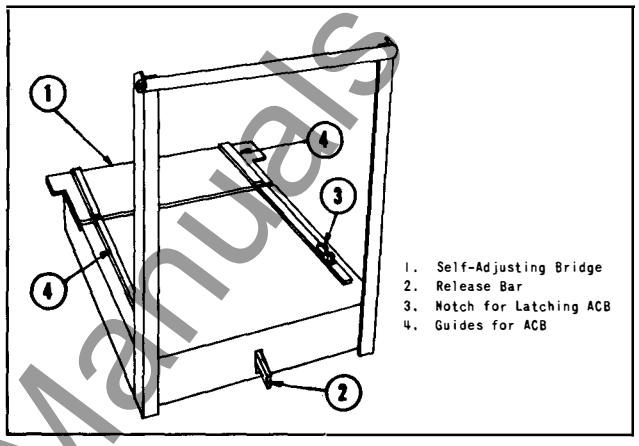


Fig. 36. Transport Truck

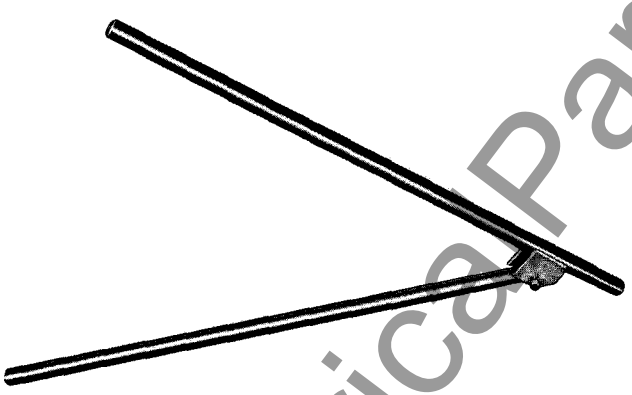


Fig. 37. Arc Chute Lifter

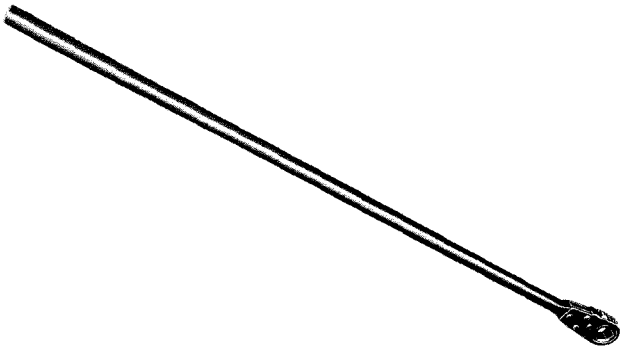


Fig. 38. Manual Spring-Charge Handle

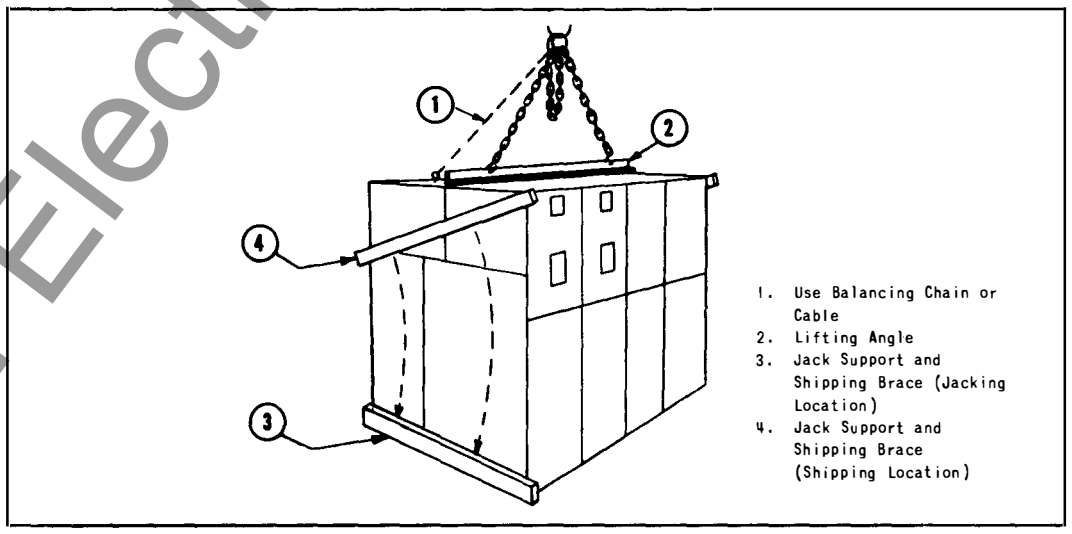


Fig. 39. Handling of Indoor Shipping Group

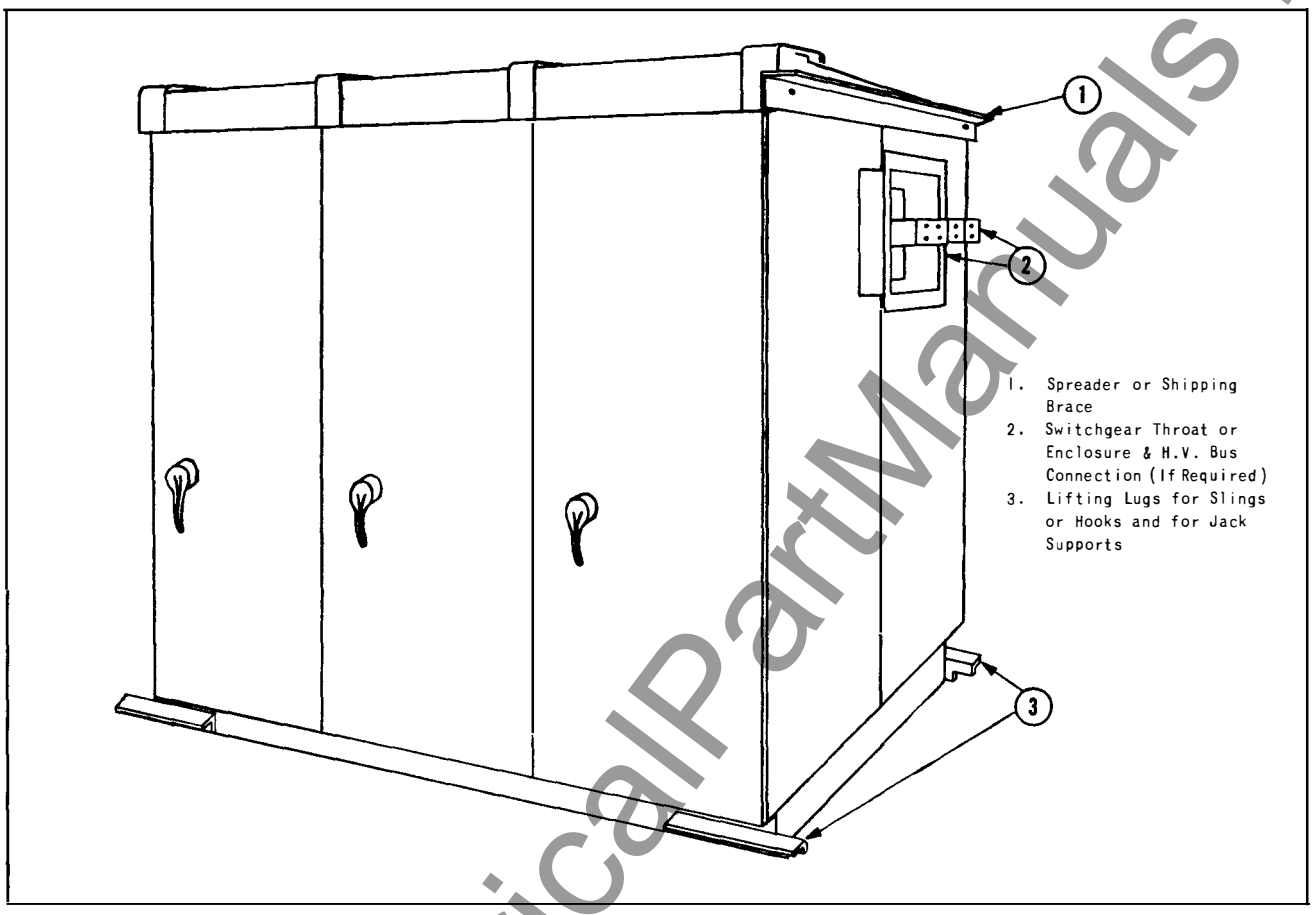


Fig. 40. Handling of Outdoor Shipping Group

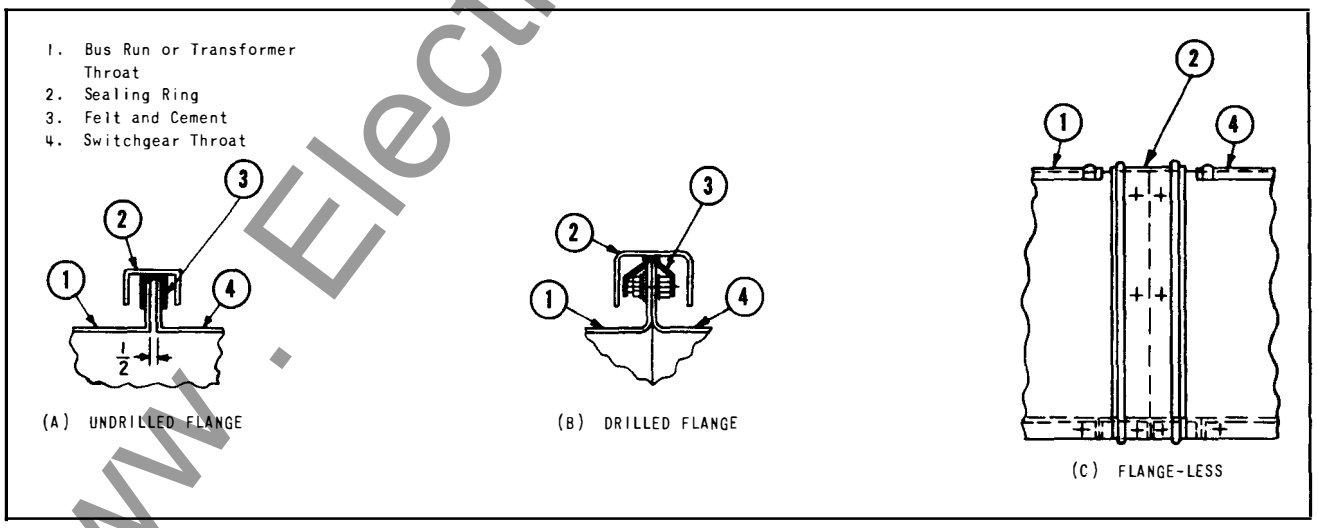
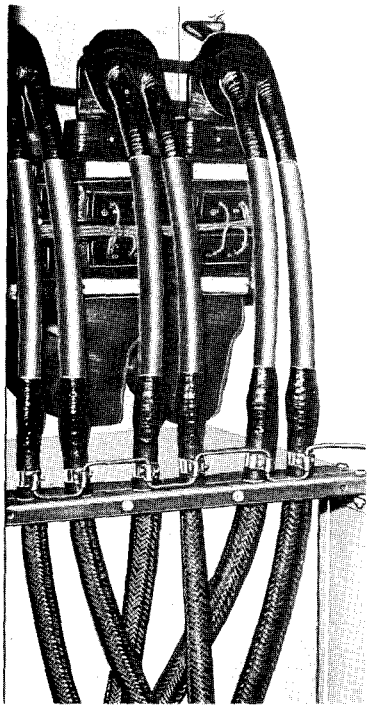


Fig. 41. Sealing Rings for H.V. Enclosures



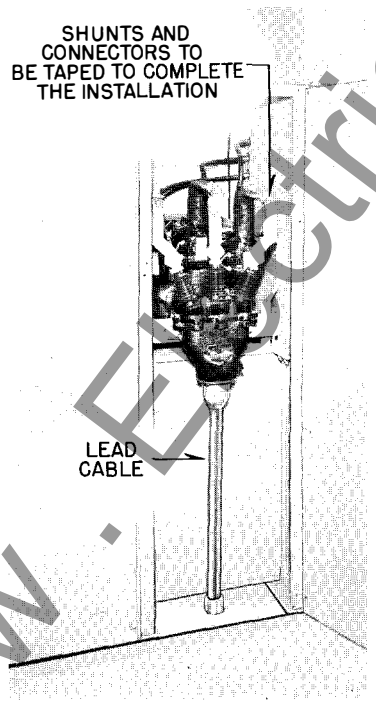


Fig. 42. Typical Main Cable Installation

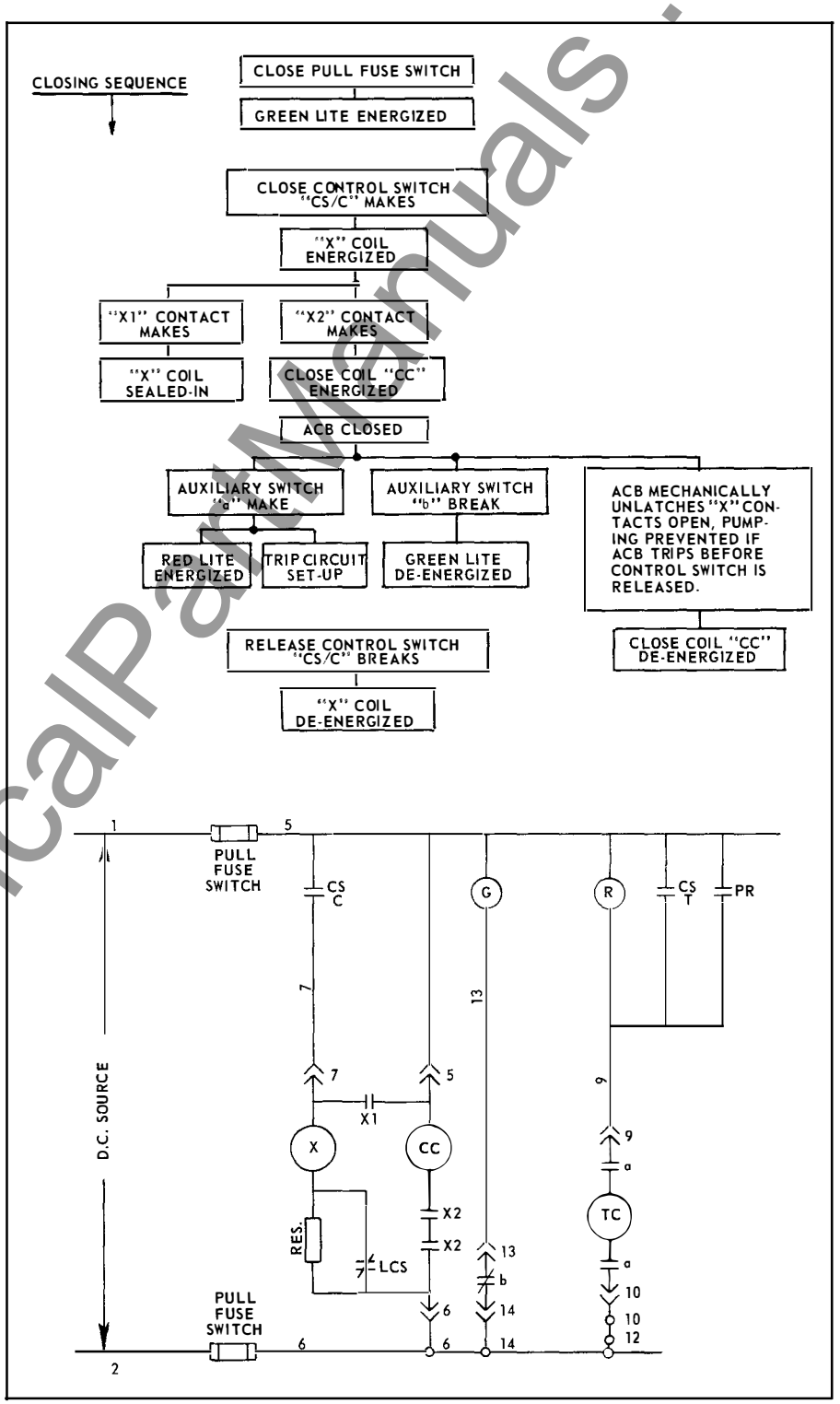


Fig. 43. Solenoid Breaker with DC Control and DC Shunt Trip

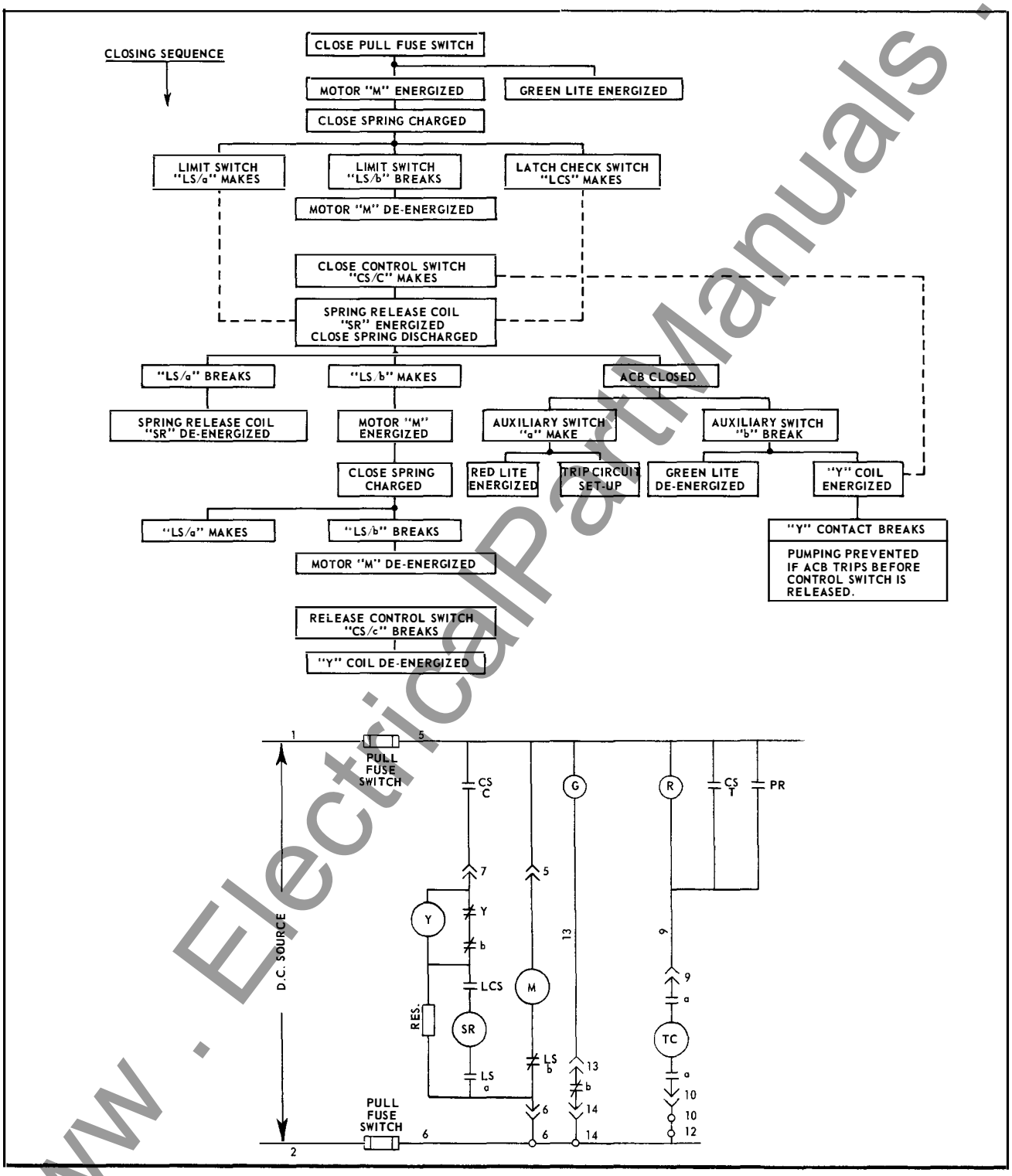


Fig. 44. Stored Energy Breaker with DC Control and DC Shunt Trip

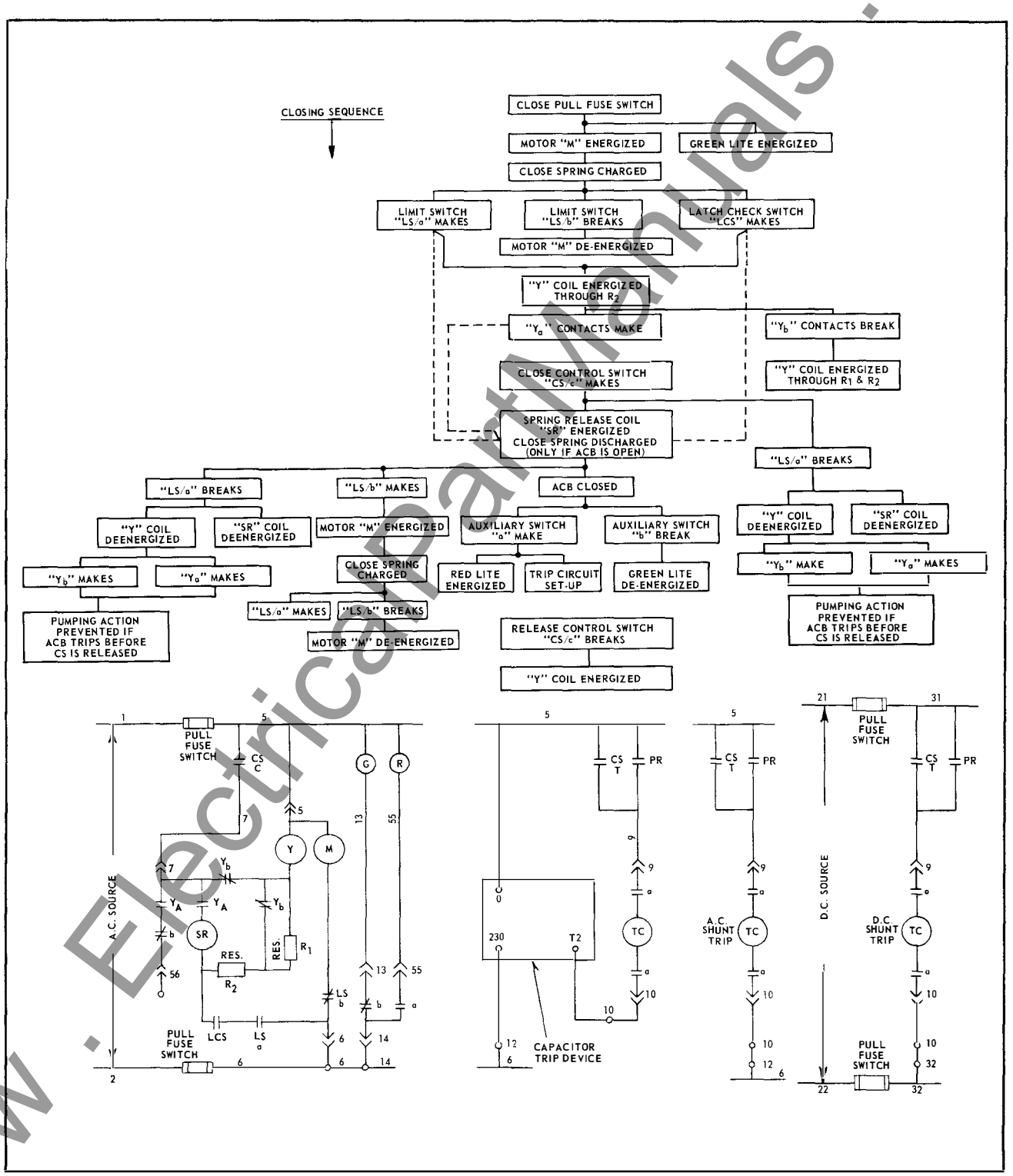


Fig. 45. Stored Energy Breaker with AC Control and Alternate Tripping Schemes

and floor space required for each metal-clad switchgear structure.

Conduits should project above the finished floor approximately two inches for indoor switchgear and approximately 8 inches above the foundation for outdoor switchgear. It will simplify moving the groups into place if the conduits are approximately flush with the concrete, and extension conduits added after the units are in their final location. Otherwise it will be necessary to raise the units on timbers a sufficient height for the pipe rollers to clear the tops of the conduits.

If more than one control conduit is required per housing they must be aligned in the space allotted for them on the floor plan. It is desirable to provide a blocked out slot in the floor or to provide clearance holes around the secondary conduits so that minor bending of the conduits can be made when the switchgear is installed. The space available for the conduits is quite limited and minor bending of the conduits is sometimes necessary to correct for errors in locating the conduits and for accumulated positive tolerances in long switchgear structures.

Standard drawings 505A863, 505A864, 508A051, 508A052, 508A061, and 508A062 present typical floor plans and tables of dimensions for the various ratings of metal-clad switchgear. These drawings are for standard units and may be used for preliminary layouts or for planning future additions. For final layouts only the properly identified floor plan or base plan supplied by the factory should be used.

Encircling loops of reinforcing or building steel around single phase conductors should be avoided in the areas for main cables - when these circuits are rated at 600 amperes or above.

Shipping Groups

The following recommendations and general order of operations will assist in the installation of the Porcel-line metal-clad shipping groups:

1. When three or more shipping groups of the switchgear are to be arranged in one continuous assembly, THE CENTER SHIPPING GROUP SHOULD BE THE FIRST LOCATED. The other shipping groups should then be installed in successive order in each direction from the center of the structure.

When installing a unit substation or power center, the power transformer and the adjacent metal-clad group should first be lined up and set in position in accordance with the dimensions on the base plan drawing for the installation. The additional groups should then be installed. (Also see section on POWER TRANSFORMER ENCLOSURES.)

2. Remove crating and packing material from the groups to be erected. For single-row Shelterfor-M installations remove and set aside the aisle wall with attached base channel from across the front of the shipping group and discard wall shipping brackets. For double-row Shelterfor-M installations remove the protective covering from across the front of the shipping group. The skids should not be removed from indoor groups if rollers are to be used.

3. Move the first group into position either by crane or by pipe rollers. (Refer to the section on HANDLING). The rollers, if used, should be high enough to allow the switchgear to pass over the conduits projecting above the floor. If main cables enter at the bottom of any of the outdoor groups, it will be necessary to remove the rear sheet and the rear floor sheet. As the bottom rear cable entrance

compartment will then be completely open, the units may be moved over the projecting conduits.

4. Establish a base line a few inches in front of the group and parallel with the desired front of the structure. Equalize the distances from the front of the housings to the base line, thus making the face of the group parallel to the base line.

5. Using an accurate level, check the levelness of each housing both laterally and longitudinally. These checks should be made on the floor of the housing on the paths upon which the circuit breaker wheels travel. Using a plumb line, also check each housing for plumbness. If the housings are not level or plumb, it may be the result of poor leveling of the foundation members. Poor indoor foundation leveling may be corrected by inserting shims at the points where the individual housings are fastened to the floor steel channels. Poor outdoor foundation leveling may be corrected by inserting shims at the points where the integral base frame is fastened to the concrete foundation. As can be seen, level foundations are desirable since they automatically produce true, level, and plumb switchgear installations. However, switchgear will operate satisfactorily on a true and flat foundation which has a uniform slope of no more than 1/8 inch in three feet. When installing switchgear housings on a foundation with a uniform slope, the floor of the housings should be parallel to the foundation and the vertical center line of the housings should be perpendicular to the floor instead of level and plumb.

6. Subsequent shipping groups should be moved into position and the procedure outlined in paragraphs 3, 4, and 5 for the first group repeated. The groups should then be bolted together with tie bolts and given a final check for levelness and plumbness. The complete installation should then be fastened to the foundation by bolting or welding.

7. For double row Shelterfor-M installations it is important that the groups facing one another be accurately spaced so that the aisle parts will fit properly. Refer to the shop order drawings for proper spacing.

8. All lifting angles, lugs, and shipping angles should be removed.

Shelterfor-M Aisle Section

After completing the installation of SHIPPING GROUPS as outlined, the Shelterfor-M Aisle Sections should be erected. Refer to standard drawing 509A796 and assemble parts in the order that follows and in the numerical sequence shown on the standard drawing.

1. Aisle wall with attached base channel: Furnished for single row installations. Locate and level the wall assembly in relation to the previously installed shipping groups. Brace temporarily with 2 x 4's between the top of the wall and the main structure. Loosen (do not remove) bolts between adjacent wall sections and between wall sections and base channel.

2. Tie down clip: Use to secure wall base channel to foundation. Tighten bolts.

3. Floor plates: Set in place and bolt tightly to appropriate channels.

4. Floor filler: Furnished for installations without front extensions. Set in place.

5. Aisle roof: Remove temporary wooden braces and bolt on the individual roof sections loosely.

6. Aisle seam cover: Lock in place and loosely bolt down at rear.

7. Aisle seam cover cap: Loosely bolt on as shown.

8. Housing seam cover: Furnished for installations of more than one shipping group. Lock in place and tightly bolt down over each shipping break.

9. See Shelterfor-M Aisle Adjustment for final installation operations.

Shelterfor-M Aisle Ends

After completing the assembly of the Shelterfor-M Aisle Section as outlined, the Shelterfor-M Aisle Ends should be erected. Refer to standard drawing 509A797 for single row installations and standard drawing 509A798 for double row installations and assemble parts in the order that follows and in the numerical sequence shown on the standard drawings.

1. Door and frame: Loosely bolt on as shown.

2. Aisle end filler: Furnished for single row installations. Loosely bolt on as shown.

3. Roof end trims: Lock in place and loosely bolt down.

4. See Shelterfor-M Aisle Adjustment for final installation operations.

Shelterfor-M Aisle Adjustment

After completing the assembly of the Shelterfor-M Aisle Section and Shelterfor-M Aisle Ends as outlined, the aisle should be adjusted and bolts tightened in a sequence so as to properly weatherproof the aisle. Always work from the aisle ends toward the middle wall sections or roof sections. Line up and adjust the relationship between the roof end trims, aisle end fillers, door frames, roof sections, and wall sections so as to eliminate gaps along the line between roof end trims and roof sections and between aisle end fillers and wall sections.

As the relationships are being adjusted proceed to tighten bolts in the following sequence:

1. Roof end trims.
2. Aisle end fillers.
3. Door frames.
4. Roof and wall sections adjacent to end fillers.
5. Intermediate roof and wall sections.
6. Aisle seam covers and caps.

Shelterfor-M Aisle Lights

After completing the assembly and Adjustment of the Shelterfor-M Aisle Section and Ends as outlined, the Shelterfor-M aisle lights should be installed. Refer to standard drawing 509A799 and assemble parts in the order that follows and in the numerical sequence shown on the standard drawing.

1. L.H. switch assembly: The two voltage source wires from the housing must first be run in their trough and connected to the un-mounted L.H. switch assembly. Now bolt on the L.H. switch assembly (to the latch side of the aisle door) in the vertical position shown. Run the four wires vertically and lay in their trough for connecting to the first light assembly in paragraph 2.

2. Light assembly: Bolt the assembly to the aisle roof laying the wires in the channels. Note that the light assembly closest to the L.H. switch assembly should have one wire removed. Match-up and connect wires between L.H. switch assembly and first light assembly and between adjacent light assemblies. The wires from the last light assembly will be connected to the R.H. switch assembly in paragraph 4.

3. Light assembly trim: Bolt on the light assembly trim (or channels) between adjacent light assemblies.

4. R.H. switch assembly: Bolt on (to the latch side of the aisle door) in the vertical position shown. Run the five wires vertically, lay in their trough, match-up and connect to the wires from the last light assembly.

Aisle-less Weatherproofing

After completing the installation of Shipping Groups as outlined, the Aisle-less weather-proofing parts should be assembled. Refer to standard drawing 509A800 and assemble parts as follows.

1. Housing seam cover and cap: For installations consisting of more than one shipping group, lock in place and bolt down over each shipping break. In addition, bolt on cap as shown.

2. Roof end trims: Lock in place over the housing end roof sections and bolt as shown.

Power Transformer and Bus Run Enclosures

Switchgear assemblies are frequently installed adjacent to power transformers to form Unit Substations or Power Centers. (See paragraph #1 under installation of SHIPPING GROUPS.) Switchgear also frequently ties into bus runs. In such cases, the transformer or bus run enclosure is a part of the installation or field assembly.

High voltage enclosures may be divided into five general types. A shop order drawing showing the assembly of these enclosures is normally included on the customer's drawing list.

1. Undrilled-flange type: (See Fig. 41-A) This enclosure is generally used for outdoor installations. The flanges are turned outward and not drilled. A sealing ring assembly with felt and cement is furnished for joining and weather proofing the mating enclosures. To install, align the mating flanges and enclosures and cement the felt to the outside surfaces of both flanges in such a way as to seal any gap between them. Then slide the frame of the sealing ring down from the top and secure in place by bolting on the bottom section.

2. Drilled-flange type: This enclosure may be used for either indoor or outdoor installations. The flanges of the indoor type are turned inward while the flanges of the outdoor type (See Fig. 41-B) are turned outward. To install the indoor type, align the mating flanges and enclosures and simply bolt together. To install the outdoor type, align the mating flanges and enclosures. If gaskets are to be used, insert gaskets between the mating flanges and then bolt together. If a sealing ring assembly (See Fig. 41-B) is to be used, bolt flanges together, cement felt to the outside surfaces of both flanges, and then slide the frame of the sealing ring down from the top and secure in place by bolting on the bottom section.

3. Flange-less type: (See Fig. 41-C) This enclosure may be used for either indoor or outdoor installations. There are no flanges. A crimped and formed band is furnished for joining the mating enclosures. To install, align the mating enclosures, slide the band down from the top and secure in place with bolts. For outdoor weatherproofing, gaskets are furnished as an integral part of the band.

4. Box-enclosure type: This enclosure is limited to outdoor assemblies. It generally encloses connections and transitions between outdoor switchgear and outdoor power transformers. Instruction Leaflet I.L. 48-069-30, which is included with the power transformer instruction book, gives complete assembly instructions.

5. Close-coupled type: This enclosure is limited to indoor assemblies. It generally encloses connections and transitions between indoor switchgear and indoor power transformers. For both dry-type and liquid-type transformers the connection and transition compartment (or enclosure) is an integral part of the transformer. To install, align the adjacent switchgear housing against the transformer transition compartment, butt together, and secure with tie bolts. Generally the front panels of the dry-type transformer are located in the same vertical plane as those on the switchgear.

High Voltage Bus Connections

There are certain high voltage bus joints or connections that must be made in the field. These connections fall into two categories: (1) between switchgear and power transformers or bus runs and (2) between switchgear shipping groups. In general, the connecting procedures are the same for both categories.

The high voltage bus connections within power transformer or bus run enclosures require insulation where metal-clad standards are applicable and where electrical clearances so warrant it. Strict attention must be given to proper insulation of those joints using flexible connectors. Flexible connectors have a tendency to bow or bunch, particularly under short circuit conditions, reducing the electrical clearance between them. Certain high voltage connections (such as the close-coupled type between indoor switchgear and indoor dry-type power transformers) require insulation even though the non-switchgear conductors are bare. In other words, high voltage insulation is required on all metal-clad switchgear conductors and connections up to and including the joint to the non-switchgear equipment.

The switchgear high voltage bus connections (such as the main bus and any transfer bus or tie bus) are completely assembled and fitted at the factory. However, at the shipping group break, sections of bus are removed, identified, packed, and shipped separately and must therefore be connected in the field.

After aligning and bolting together the power transformer or bus run enclosures and the switchgear shipping groups, the following steps should be followed:

1. Clean the silver-plated contact surfaces lightly with crocus cloth and wipe with a cleaning solvent such as Stoddard's Solvent (or Westinghouse #1609-1).

CAUTION:
Keep sparks and flames away. Do not breathe large quantities of vapor. Avoid excess contact with skin.

2. Bolt the bus bars together using the splice plates or flexible connectors and hardware supplied. Recommended tightness for various types of hardware is shown in Table No. 2.

TABLE NO. 2 - BOLT TIGHTNESS FOR BUS AND CONNECTIONS

	Torque in Foot-Pounds for Bolt Diameter				
Bolt Material	1/4	5/16	3/8	1/2	5/8
Heat Treated Steel	5	12	20	50	95
Silicon Bronze	5	10	15	40	55

3. Insulate the joint or connection in line with instructions shown on standard drawings 510A998 and 510A999.

Main Power Connections

Porcel-line metal-clad switchgear is usually provided with either solderless cable con-

nectors or potheads for terminating main power cables. Figure 42 shows installations of both types.

Before making up the connections, the phase of each cable should be determined. Normally metal-clad switchgear is supplied with connections for phase rotation A-B-C unless otherwise required on the particular shop order.

When forming cables for termination within switchgear assemblies, avoid sharp turns, corners, and edges in order to prevent damage to, or weakening of, the cable insulation. The cable manufacturer's instructions should be followed closely in determining the minimum bending radii of cables and the proper tapering of insulation to establish necessary voltage gradients. Such instructions will vary with the type and size of cable involved as well as with the service voltage for which the cable is designed to operate.

Solderless-Type: Solderless connectors are normally furnished for terminating non-leaded cable. In addition insulating clamps may be provided to separate the cables and to support their weight. The cable manufacturer's instructions should be consulted for the exact details required in terminating any given type of power cable. Cable clamps when supplied may be drilled at the factory if the outside diameter of the cable is known. Since it is frequently impossible for the factory to determine the exact outside diameter of the cable that will be used, these insulating clamps will be supplied with 1/4" diameter pilot holes and must be redrilled to exact size in the field. After drilling, the insulating clamps should be saw-cut longitudinally through the center line of the drilled holes to facilitate installation and to provide proper clamping action. The complete connection must be taped in accordance with standard drawings 510A998 and 510A999.

Potheads: Connections of cable into potheads should be made in accordance with the pothead manufacturer's instructions included in supplementary instructions or with the potheads. Flexible connectors are provided to connect the pothead aerial lugs to conductors in the switchgear so as to avoid strain on the pothead insulators. The flexible connectors are to be taped in accordance with standard drawings 510A998 and 510A999 along with the complete joint.

Ground Bus Connections

The ground bus in metal-clad switchgear is assembled in sections with a joint in each housing. The section at a shipping group break is removed, identified, packed, and shipped separately and must be reinstalled in the field.

Terminals of the solderless type are provided on the ground bus in one or more housings as shown on the shop order floor plan drawing. These terminals are for connecting the switchgear ground bus to the station ground. The connection to the station ground should be as direct as possible and should not be in metal conduit.

It is recommended that the connection to the station ground have a cross section of 500,000 circular mils or greater if the soil in which it is buried is of such character as to cause appreciable corrosion. This is especially true where electrolysis from stray currents or contact with dissimilar metals exists. The resistance of the soil surrounding a station ground depends on the condition of the soil as well as its chemical content. Dry, loose, sandy or frozen soils will have a high resistance as compared with moist soils or soils containing ashes, cinders or salt solution. A variety of methods is available for providing the ground, two of which will be described.

Plate Ground: A very effective ground is obtained by using a copper or brass plate

from 10 to 25 square feet area, depending on station capacity, and one-half inch thick. Drill a number of one-half inch holes in this sheet. Place the sheet on a 2-foot layer of charcoal in a pit of sufficient depth to insure contact with permanently moist soil of good conductivity, and deep enough for protection from mechanical damage to plate or cables.

Make permanent connection to the ground plate with stranded cable of at least 500,000 cm area. Fan three feet of the strands over the plate surface and solder or braze them securely. Cover the plate with a two-foot layer of charcoal and fill the pit with earth, settling it with a salt solution.

Pipe Ground: A satisfactory ground can also be made from ten pieces of 1 1/2" galvanized iron pipe of sufficient length to reach moist earth (not less than 12 feet). Drive these pipes into the earth placing them symmetrically over an area at least 25 feet square. Connect all the pipes together by a 500,000 cm cable and clamp connections. Bury the cable a sufficient distance below the surface to prevent mechanical injury.

Secondary Connections

Internal secondary and control wiring on metal-clad switchgear is factory connected as required by the schematic diagrams. Wiring to remote apparatus is factory connected to terminals or terminal blocks. Secondary and control cables from remote apparatus must be field connected to these terminals or terminal blocks. The field connections must be mechanically and electrically strong and should be thoroughly checked before being energized.

Voltage Drop: The control bus for solenoid operated breakers is usually of larger size than the balance of the control wiring to reduce the voltage drop. The feed connection to this bus should be checked for voltage drop at the maximum breaker closing current and sufficiently large cable used to insure proper operating voltage at the breaker solenoid. Make sure that the polarity of all the connections from d-c control sources is correct.

Loading Check: It is suggested that the loading of the control busses be checked with an ohmmeter to insure against short circuits in the control wiring before energizing initially. If an ohmmeter is not available, serious damage to the control wiring may be avoided by temporarily connecting a small fuse in series with the control source for the initial check.

Shipping Groups: Openings in the sides of control modules provide access for control connections between housings. When shipment is made in groups, the cross connections are factory-installed in one group, coiled, and identified for connecting in the field to the adjacent group.

Power Transformers and Bus Runs: Openings or couplings in the housings provide access for control connections between switchgear and power transformers and for heater connections between switchgear and bus runs when required. Where no conduit is supplied, the cross connections are factory installed in one assembly, coiled, and identified for connecting in the field to the adjacent assembly. Where conduit is supplied, the conduit and wire between adjacent assemblies must be installed and connected in the field as shown on the shop order assembly drawings.

Rotating Disconnect Transformers and Fuses

For shipment, the operating links of the rotating disconnect transformers and fuses are disconnected from the hinged door and laid inside the compartment. The cradle is

bolted to its support on both sides with the contacts disconnected to prevent wear and possible damage due to vibration during transit.

Before placing the switchgear in operation, the rotating assemblies should be prepared as follows:

1. Remove shipping bolts.

2. Connect operating link to bracket on door.

3. Make rough check of engagement between all moving and stationary contacts in both the connected and disconnected (or grounded) positions. This contact engagement may be checked simply by "lighting-out" or "ringing-out" with a flashlight or bell. Contact engagement is factory adjusted and under normal circumstances will check out properly. However, undue stresses from shipping or handling, or improper leveling may result in poor contact engagement. If adjustments are required, they may be made through the link itself which has an adjustable length.

4. Check fuses to be sure they are good and make proper contact in clips.

Key Interlocks

Key interlocks are often supplied in conjunction with disconnecting switches, dummy breakers and special compartments where access is to be denied unless the circuit breaker is withdrawn to the test position. The operation of key interlock schemes is generally described by a note or keying chart on the shop order assembly drawings.

To facilitate manufacture and installation procedures, extra keys are supplied with each lock. The extra keys will also provide a set of spares for the Purchaser, but should be kept where they will not be accessible to operating personnel.

CAUTION: Before placing switchgear with key interlocks in operation, the key scheme must be carefully checked and only the proper keys left in the locks. All extra keys must be removed and destroyed or stored where not available to operating personnel.

Moving Parts

There are few moving parts in Porcel-line metal-clad switchgear and, in general, they do not require installation as they are factory-installed. However, it is recommended that all moving parts be operated by hand (even if normally operated automatically) to assure that no binding or damage has occurred during shipment or handling. In addition, foreign matter may have accumulated during long periods of storage under unfavorable conditions.

Type DH-P Circuit Breaker

Refer to Instruction Book 32-253-1 for complete installation instructions for the type DH-P Porcel-line air circuit breaker.

Accessories

Other than the test cabinet, none of the standard accessories listed in the "Description" section of this instruction book require field installation. It is recommended that all the accessories be stored and the test cabinet installed in a clean and dry location convenient to the switchgear.

The test cabinet is designed for wall mounting as shown on standard drawing 657A222. The cabinet also has provisions for conduit entrance of control power.

Separate Equipment

As mentioned under "Receiving, Handling, and Storing", appendages such as bus runs

and synchronizing panels and large internal equipment such as oil-filled transformers may be packed and crated separately. They should be un-crated and installed per the shop order assembly drawings.

Un-blocking

Many pieces of equipment are blocked or braced for shipment. As an example, refer to the "Rotating Disconnect Transformer and Fuses" previously discussed. Other apparatus, such as meters and relays, must be scrutinized for forms of blocking or bracing which must be removed.

Adjusting and Testing

After the switchgear together with the apparatus which it is to control has been installed and all inter-connections made, it should be given a final check and test before being put into service. Extreme care must be exercised to prevent the equipment to be controlled from being connected to the system while the preliminary tests are being conducted.

The testing equipment will depend on the size and type of installation. Portable voltmeters will be required. For large and complicated installations ammeters should be available in case unexpected trouble develops. Some simple portable device for "ringing" or "lighting-out" circuits should be included in the testing equipment.

Wire connections, accessible bolted bus connections, and insulated joints should be examined to make sure that they have not been loosened or damaged during shipment or installation.

The connections to the equipment apart from the switchgear such as instrument transformers, remote control and interlock circuits, and auxiliary switches should be "lighted-out" to make sure that they are also correct. The extent to which this will have to be done depends on the thoroughness of the installation work. There must be definite assurance that connections are correct before an attempt is made to operate the equipment.

The relays have been checked and adjusted at the factory to a recommended setting commensurate with the system information available. The final settings of the relays should be coordinated with other parts of the system in accordance with the Purchaser's standards or operating practice. If it becomes necessary to modify these relay settings, the instruction leaflet for the relay involved should be carefully studied. These instruction leaflets show typical connection diagrams only and may not necessarily agree with the connections furnished. The schematic diagrams furnished for the shop order should be referred to for the actual connections.

The covers for meters, relays, and other devices which have to be removed during the course of installation and test should be carefully handled when removed. The covers should be put back in place promptly to keep dust and dirt from collecting on the vital relay parts.

After the switchgear has been installed and put into operation, the drawings supplied with the equipment should be gone over and notations made on them of any deviation made during the installation. A set of these should be returned to Westinghouse so that the tracings may be changed for permanent record.

OPERATION

The operation of horizontal drawout Porcelline metal-clad switchgear has the advantages of flexibility, safety, and ease of

maintenance, plus ease of testing and checking out control circuits.

All circuit breakers with the same rating and control wiring are identical and interchangeable so that it is possible to replace any breaker or housing with another of the same rating and control wiring.

During operation, all live parts are enclosed by barriers which permit the operator to perform his work with maximum safety. Separate covers are provided over each different compartment, so that any compartment of a housing may be exposed without exposing other compartments.

All type DH-P air circuit breakers are equipped for electrical operation. A maintenance operating handle is supplied as part of the accessories to permit manual operation of the breaker during maintenance. THIS DEVICE MUST NOT BE USED TO CLOSE THE BREAKER ON ANY ENERGIZED CIRCUIT.

The control circuits may be checked accurately and safely by moving the breaker to the test position where the main circuits are disconnected and the control circuits can be completed by moving the secondary contact assembly to the engaged position.

Insertion and Withdrawal of Breaker from Housing

No attempt should be made to place the circuit breaker in the housing until the housing installation is complete. If attempted earlier trouble may occur from foreign material in the housing, from an un-level foundation, or from distortion caused during shipment or handling.

As a check to prevent the insertion of a breaker into a switchgear housing of a different rating, an interference interlock is provided. The interference interlock consists of a pin on the left side of the breaker frame and a notched plate bolted to the lower left of the housing. The notched plate can be seen in Figs. 16, 17, 18, 19, etc. However, for safety and since the interference interlock does not coordinate control wiring, ALWAYS REFER TO SHOP ORDER INFORMATION, DRAWINGS, OR SCHEMES TO MAKE CERTAIN THAT THE BREAKER AND HOUSING ARE COORDINATED FOR OPERATION TOGETHER.

To prepare the circuit breaker for insertion into the housing, first align the breaker guide channel with the housing guide rail.

For indoor and Shelterfor-M installations, the turning dolly (Fig. 35) may be used to assist the alignment between the breaker and the housing. After aligning, remove the turning dolly so as to eliminate the possibility of defeating the floor tripper interlocks.

For Aisle-less installations, since the breaker must be on the transport truck (Fig. 36), the breaker will automatically be aligned when the transport truck is properly attached to the housing. To properly attach the transport truck to the Aisle-less housing, visually align the truck then push forward slowly but firmly. The truck will be guided into proper position by angled and beveled clips welded to the housing and visible in Fig. 13. In addition, the truck will attach itself as the bridge portion rides up the clips and drops down to lock behind the clips. To release the breaker from the transport truck, simply press down on the rail latch. To detach the transport truck from the housing, simply step on the release bar and pull truck away.

The breaker is now ready for insertion into the test position and then into the fully energized position. This procedure is fully described in the circuit breaker instruc-

tions I.B. 32-253-1, Parts 6 and 7 under BASIC OPERATING INSTRUCTIONS.

To withdraw the breaker from the energized to the test position and from the housing, follow the procedure fully described in I.B. 32-253-1, Parts 8 and 9 under BASIC OPERATING INSTRUCTIONS.

Breaker Operation and Mechanical Interlocks

Refer to circuit breaker instructions I.B. 32-253-1 for detailed operating instructions.

Electrical Operation

General: A one-line or three-line diagram and a schematic diagram is prepared for each metal-clad switchgear assembly. These should be thoroughly studied and completely understood by the operators of the metal-clad switchgear.

The reading of indicating and recording instruments and meters is common knowledge to electrically trained personnel. The use of instrument switches, rheostat control, and governor motor control switches is also common. Synchronizing switches are usually provided on generator and incoming line units with a synchronizing switch contact wired in series with the breaker control switch "close" contact. The synchronizing switch should always be turned "ON" first and the circuits adjusted to be in synchronism as indicated by the synchroscope before the circuit breaker is closed.

Lamp indication is provided by a green light to indicate that the breaker is open, and a red light to indicate that the breaker is closed. For the d-c control schemes, the red light is also arranged to supervise the trip coil and indicate that the trip coil circuit has continuity.

Protective Relays: A large variety of relays may be applied to protect the system during faults or other unusual operating conditions. When such applications are made, pertinent descriptive literature on each type of relay is included in the switchgear instruction book. FINAL SETTINGS OF SUCH RELAYS SHOULD BE MADE IN THE FIELD to coordinate with the other parts of the power system in accordance with the Purchaser's standards and operating practices.

Breaker Control Schemes: The details of circuit breaker operating schemes may vary widely on different metal-clad switchgear installations. However, all schemes are derived from basic control schemes which are shown in their simplest form in Figs. 43, 44, and 45. They comply with requirements formulated and approved by AEIC, IEEE, NEMA, and ASA. A comparison between the basic schemes and the schematic diagram for any particular assembly will reveal which basic scheme has been employed to meet the requirements for that particular application. All of the schemes are designed to electrically co-ordinate with the mechanical design of the breaker.

Combination schemes, such as closing and tripping on different voltages, and schemes with a-c closing and d-c tripping are in common use. Sequence interlocking with other equipment, various arrangements of local and remote control, and automatic reclosing schemes are frequently encountered.

Breaker Tripping Schemes: A variety of circuit breaker tripping schemes may be used with the basic control schemes;

1. D-c shunt trip coils are most frequently used with the d-c control scheme or more generally, where a reliable source of tripping power is available. The d-c shunt trip is included in Figs. 43, 44 and 45.

2. A-c shunt trip coils are sometimes supplied with a-c control schemes where the tripping power is derived from the same control source as the closing power. However such trip coils are only relied upon to trip the breaker under normal operating conditions and are usually backed up by some additional tripping means to open the breaker should a fault occur. The a-c shunt trip is included in Fig. 45.

3. On schemes using a-c control where no separate reliable tripping source is available a capacitor tripping device is often employed. On this type of device a-c power is continuously supplied to a Rectox which charges a capacitor. In such cases the energy stored in the capacitor is discharged through a special trip coil when the control switch is operated to the tripping position or when one of the protective relays closes its contact to trip the breaker. The capacitor trip device is included in Fig. 45.

4. Additional tripping schemes using under-voltage release coils or transformer trip coils are occasionally supplied. In such cases the use of these devices will be clearly indicated on the schematic supplied with the equipment.

INSPECTION AND MAINTENANCE

Safety Precautions

When inspecting, repairing, and performing maintenance on metal-clad switchgear the fact that dangerous voltages may exist must be kept in mind and precautions taken to insure that no personnel come in contact with a "live" high-tension part. Common general precautions for high voltage work are:

1. All connections should be considered "alive" until the crew expecting to work on them is assured that the circuits are "dead", and until every possible precaution has been taken to see that there is no chance of a circuit being energized while the crew is working.

2. Switches which have been opened to de-energize a circuit to permit work on equipment should be locked or blocked open and a suitable visible warning device placed thereon.

3. Do not work on parts normally carrying current at high voltage until these parts have been disconnected from the system and connected to the ground bus. Provision should, therefore, be made by the Purchaser for connecting adequate flexible ground leads so as to reach every part of the switching equipment.

4. A good and reliable ground connection is necessary for every switchgear installation. It should be of sufficient capacity to take care of any abnormal condition that might occur on the system and should be independent of the grounds used for any other apparatus. See GROUND BUS CONNECTIONS.

Access to Switchgear Parts

High Voltage Parts: Porcel-line metal-clad switchgear is designed so that internal compartments provide metal isolation between the DH-P circuit breaker compartment, the main bus, and the primary line terminations. Access to high voltage parts is provided by removable covers and barriers WHICH SHOULD NOT BE REMOVED UNLESS THE PARTS TO BE EXPOSED ARE "DEAD". Figures 20 and 24 are photographs in which covers have been removed to expose the main bus and the primary line terminations.

Main Contacts and Current Transformers: Both the stationary main disconnecting contacts and the ring-type current transformers are located just behind

the insulating shutter and molded barriers as shown in Fig. 20. Upper and/or lower contacts and transformers are easily exposed. For this reason CAUTION MUST BE EXERCISED. DO NOT EXPOSE ANY CONTACTS OR TRANSFORMERS UNLESS ALL UPPER AND LOWER HIGH VOLTAGE PARTS ARE "DEAD".

Rotating Disconnect Transformers and Fuses: Figures 16, 17, 25, and 26 are pictures of rotating disconnect transformers and fuses. Simply opening the hinged door automatically disconnects and grounds the moving high-voltage parts. The cable and stationary contacts are accessible either by removing back covers or by removing the complete transformer and cradle or fuse and cradle assembly. DO NOT ATTEMPT REMOVAL UNLESS CABLE AND CONTACTS ARE "DEAD".

Control Equipment: With the exception of apparatus such as current transformers and rear mounted heaters, control equipment and wiring is in general accessible without exposing high voltage parts.

Inspection and Maintenance Schedule

To assure high quality service, a definite maintenance schedule, systematically followed, is essential. Plant, operating, and local conditions vary to such an extent that the schedule must be prepared to suit the conditions. However, the following general requirements should be helpful in setting up the program.

Individual Devices: The maintenance schedule for individual devices such as circuit breakers, relays, meters, etc. should be based upon recommendations contained in the individual instruction book for the device. These operations should be coordinated with the overall program to result in the least operating inconvenience and circuit shutdown.

Overall Installation: The switchgear installation should be given a thorough overall maintenance check at least annually, when plant, operating, and local conditions are normal. Where conditions are abnormal, more frequent inspection and maintenance is necessary. The following items require attention:

1. Buses and connections: De-energize primary circuits and remove cover plates from the primary compartments. Before cleaning take "megger" readings between phases and to ground. Inspect for symptoms which might indicate overheating or weakened insulation. Remove dust from buses, connections, supports, and enclosure surfaces. A vacuum cleaner with a long nozzle will be of assistance. Wipe clean with a solvent such as Stoddard's Solvent (or Westinghouse #55812CA).

CAUTION: Keep sparks and flames away. Do not breathe large quantities of vapor. Avoid excess contact with skin.

After buses have been dusted and wiped clean, take "megger" readings again between the buses and ground and between phases. Keep a record of these readings for future reference in determining when trends occur that would indicate a lowering of the insulation resistance.

Periodic high potential tests are not required and are recommended only after repair of high voltage buses or insulation, or when the trend of megger readings indicates it to be advisable. Such a high voltage test should not exceed 75% of the factory test values given in AIEE Standard No. 27 for new switchgear. Transformer primary fuses should be removed during high potential tests.

2. Main Disconnecting Contacts and Supports: Remove each breaker from its housing. De-energize primary circuits and expose primary contacts and their por-

celain supports (or bottles). Wipe clean with a cloth moistened in Stoddard's Solvent. (See preceding paragraph.) Inspect for abnormal wear or overheating. Discoloration of the surfaces is not harmful unless corrosion due to atmospheric conditions is severe, leaving deposits on the surface. If necessary, these can be removed by a light application of crocus cloth. Check each breaker while it is out of the housing for all items recommended in the instruction book applying to that particular type of breaker. (See I.B. 32-253-1)

3. Other Disconnecting Contacts: Inspect all primary and secondary disconnecting contacts (such as those on rotating transformers) for abnormal wear, fatigue, or overheating. Replace if necessary. Otherwise treat the same as Main Disconnecting Contacts above.

4. Control Contactors: Contacts should be inspected and dressed or replaced when the surface becomes seriously pitted. Unless repetitive duty has been experienced, little attention should be required.

5. Instruments, Relays and Other Panel Mounted Devices: Individual devices should be maintained according to the specific instructions supplied for each device. Remove all relay covers and inspect the interiors for dust or dirt. This operation can most readily be performed by relay test personnel during periodic relay tests. Control switches, transfer switches, and instrument switches should have their contacts inspected and dressed when necessary.

6. Secondary Wiring: Check all wiring connections for tightness including those at the current and potential transformers and at the terminal blocks where circuits leave the switchgear. Make sure that all secondary wiring connections are properly connected to the switchgear ground bus where so indicated.

7. Mechanical Parts: Visually check and manually operate mechanical moving parts such as the shutter, TOC and MOC switch assemblies, the position interlock, hinged doors, and the rotating features of the transformers and fuses. Examine mechanical mating parts such as the levering-in screw, the guide rail and floor trippers.

8. Ventilation: Check all labyrinths, grillwork, and air passages for obstructions and accumulations of dirt. The air space under outdoor switchgear, which is necessary for the entrance of ventilating air, should be cleaned of leaves and other possible debris.

9. Battery and Charging Equipment: The control battery is such an important item in switchgear operation that it must be given special periodic attention if it is to have a long life of reliable service. Periodic inspections and tests are recommended in the battery supplier's instructions. At the same time the battery is checked, inspect the battery charger and remove accumulations of dust and dirt. On all chargers having a manual transfer switch for setting the charging rate, check carefully to be sure that the selector switch is returned to the value appropriate for a floating charge at the end of the periodic inspection. Serious damage to the control battery can occur if the charger is left on a high charging rate for an extended period of time.

10. Records: The condition of each switchgear unit at the time of inspection should be listed in a permanent record to become a guide for anticipating the need for replacements or for special attention between the regular maintenance periods. Megger tests are suggested for checking the insulation. A series of these tests will indicate any tendency toward a reduction in dielectric strength of the insulation. Megger readings should be taken before

and after cleaning the equipment and, insofar as possible, under similar conditions at successive periods. Records should include the megger reading, the temperature and the humidity (either by definite reading or description). These limits will vary with the extent and design of the bus structure. In contrast with a small installation, the longer switchgear assemblies will have a more extensive bus structure with a greater number of insulators and, thereby, a larger number of parallel insulation resistance paths to ground which will tend to decrease megger readings. This variation in insulation resistance between different switchgear assemblies emphasises the value of a series of readings which can be charted to establish a normal insulation level so that progressive weakening of the insulation can be recognized.

11. Abnormal Conditions: Local conditions such as high humidity, salt-laden atmosphere, corrosive gases, heavy dust, or severe circuit operating conditions, are considered to be abnormal; and will require more frequent inspections.

It should be emphasized that a series of inspections should be made at quarterly intervals until the progressive facts of the local conditions can be analyzed to determine a schedule which will maintain the equipment in satisfactory condition.

In some locations local conditions may be so bad that the frequency of maintenance will interfere with operating and production schedules. In such cases, consideration should be given to the possibility of enclosing the switchgear equipment in a relatively tight room and to supplying a sufficient quantity of clean air so as to maintain a positive pressure in the room. Under such conditions maintenance schedules may then be established on a more normal basis. Such an arrangement might also provide for cooling the air where the ambient temperature is relatively high, thus further improving operating conditions.

Lubrication

Porcel-line metal-clad switchgear is designed so that lubrication is not required under normal conditions. However, abnormal local conditions such as high humidity, salt-laden atmosphere, corrosive gases, or severe circuit operating conditions may demand the use of lubricants. In such cases a dry or powder lubricant should be used on moving or mating mechanical parts and a thin film of vaseline on disconnecting contacts. The application of the lubricants should be held to a minimum to reduce the accumulation of dust and dirt.

Renewal Parts

When ordering renewal or spare parts include as much information as possible. In many cases the style number of the new part can be obtained from identification on the old part. Always include a description of the part. Specify the rating, housing number, and shop order number of the metal-clad housing in which the part is to be used.

The following parts are suggested as spares for a typical installation. The size and complexity of the particular installation will cause variations. As a further guide, spare parts lists are usually included in the specific instructions for individual devices.

1 - Set of primary fuses for potential and control power transformers.

1 - Package of indicating lamps.

1 - Package of secondary fuses.

1 - Set of contacts for control, instrument, and auxiliary switches.

1 - Set of contacts and coils for auxiliary relays.