October, 1987

Manual 6055-1

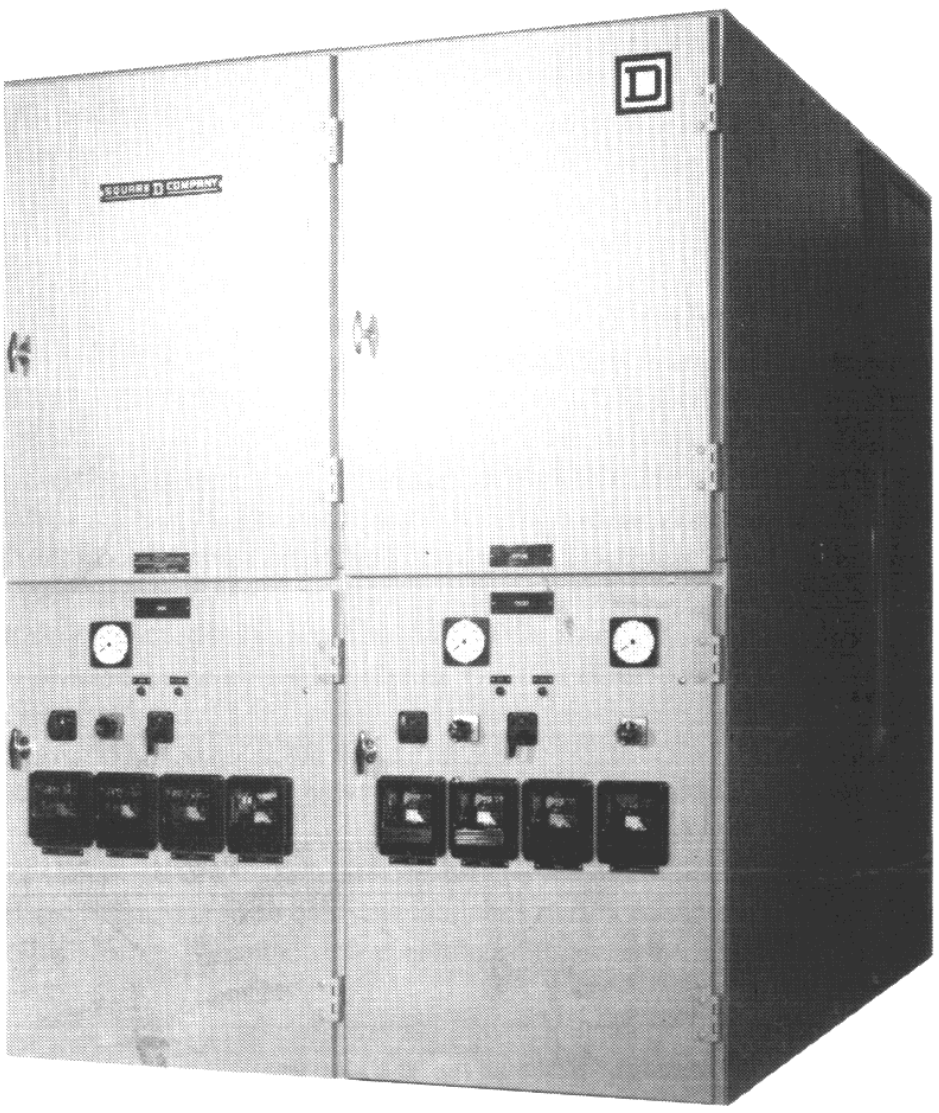
Supersedes Manual 6055-1
Dated September, 1984

Instruction & Maintenance Manual

5-15kV Metal-Clad Indoor Switchgear

Series 2

WITH TYPE FG-2 (SF_6) OR TYPE VAD-2 (VACUUM) AC HIGH VOLTAGE CIRCUIT BREAKERS



SQUARE D COMPANY

CLASS
6055

5-15kV METAL-CLAD INDOOR SWITCHGEAR SERIES 2

CAUTION

SQUARE D TWO-HIGH, 5-15kV, Draw-Out, Metal-Clad Switchgear is heavy duty electrical equipment designed and thoroughly tested to provide high voltage distribution. The assembly consists of sophisticated mechanical and electrical devices that when properly installed, operated and maintained will provide a safe, efficient and durable coordinated electrical system.

1. All personnel involved in the Handling, Site Preparation, Installation, Testing, Operation and Maintenance should be thoroughly familiar with the information in this Instruction Manual and shown on the Customer Drawings provided BEFORE working on this equipment.

2. Do not drop or roughly handle the assembly or the circuit breakers. The shipping skids and crates are more than adequate for normal handling, but the assembly structure, insulation, relays, meters and the circuit breakers could be damaged by abusive handling and could result in costly start-up delays.

3. The Site Preparation should be completed with floor channels, station grounds and conduit stubs in place and the concrete cured and finished before setting the assembly in place.

4. The assembly is mechanically arranged so that all high voltage parts are covered by metal or insulated panels or barriers. All panels and barriers removed for inspection and installation MUST be put back in place before energizing this equipment.

5. "THINK SAFETY"
   a) Always assume all high voltage parts are energized until you yourself have proven them to be de-energized.
   b) Check interconnection circuit diagrams to be sure there is no chance of back feed.
   c) Never disconnect the main trip source of energized equipment.
   d) Do not open a circuit breaker door unless the circuit breaker is tripped.
   e) Remove circuit breakers to the disconnect position before removing rear access panels.
   f) Use OUT of SERVICE tags and padlocks when working on equipment and leave in place when leaving area or until work is completed and equipment is ready to be put back in service.
   g) WHEN IN DOUBT, STOP! Re-read this Instruction Manual or refer to the Customer Drawings before proceeding. Eliminate dangerous and costly human errors!
   h) The complete assembly arrangement determines if the top or bottom contacts are the line side, and both can be energized when the circuit breaker is removed from the compartment.
   i) Disconnect all high voltage to the switchgear before accessing the horizontal bus compartment.

6. Do not use water or liquid fire extinguishers on electrical fires! Be absolutely sure the main source of power is disconnected and the main and all feeder circuit breakers are tripped before trying to extinguish fires within the assembly.

7. Provide adequate ventilation for station battery systems and avoid the use of open flames near the batteries.

This Instruction Manual does not cover all the details or possible combinations of equipment available, or field conditions that may exist, or that may arise during handling, site-preparation, installation, testing, operation or maintenance. If additional information is necessary or unforseen site conditions or problems exist, contact the local Square-D field office.

The standard product covered by this Instruction Manual meets all the requirements of the applicable ANSI, IEEE and NEMA standards; but due to the wide variances possible it is not implied that it will be in accordance with all local codes and ordinances.

5-15kV METAL-CLAD INDOOR SWITCHGEAR SERIES 2

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5-15kV METAL-CLAD INDOOR SWITCHGEAR SERIES 2

INTRODUCTION

TWO-HIGH, 5-15kV, Draw Out Metal-Clad Switchgear provides a unique design that allows the individual use or combined use of Type FG-2 (SF_6) or Type VAD-2 (Vacuum) circuit breakers to give the speed and type of interrupting medium desired to control each high voltage distribution circuit.

The assembly consists of individually grounded steel cells, each compartmentalized and built with doors, barriers and removable access panels to isolate the separate working functions and provide maximum personnel safety. All of the circuit breakers, instrument and control power transformers, relays, meters and other components are factory assembled, wired and tested as an assembly. The user is normally only required to make the external control, ground and power connections at the terminals provided and reconnect the wiring and bus bars at the shipping splits.

Each assembly is custom designed to meet the users specifications using standard cells and bus configurations. These standards are then arranged and combined with the type of circuit breaker and other components necessary to allow the required number of feeders, metering and protective scheme required.

Complete customer drawings are furnished for each assembly including floor plan and elevations, one line diagram, control schematics and wiring diagrams.

DESCRIPTION

Assembly

An assembly consists of one or more basic cells, each with its own complement of compartments. Each cell is a separate, rigid, self-contained structure, fabricated of heavy gauge steel and welded to insure accuracy and interchangeability. Additional bolted-in support members, panels and mechanisms are then added to complete the cell structure.

There are two basic standard cell designs:

a) Auxiliary or combination Auxiliary and Circuit Breaker cell with Main Bus and Cable Compartments.

b) Two-High Circuit Breaker cell with Main Bus and Cable Compartments.

Auxiliary Section (Figure 1)

An auxiliary section may be assembled using a maximum of four auxiliary drawout drawers or two auxiliary drawout drawers and a circuit breaker compartment to provide the circuit arrangement required.

The individual auxiliary drawers may be used for:

a) Control Power Transformer with primary fuses and interlocked secondary breaker (up to 15kVA, single phase).

b) Fused Voltage Transformers.

c) Fuses for fixed mounted Control Power Transformer (above 15kVA or three phase).

Drawout Control Power Transformer Compartment (Figure 2)

A control power transformer is provided to supply A.C. voltage for circuit breaker closing and capacitor trip charging as well as the many miscellaneous station auxiliary power functions. The transformer is sized for the specific order requirements and should not have arbitrary nonspecified loads added after installation.

The control power transformer as well as its primary current limiting fuses and secondary molded case circuit breaker are mounted in the drawer and are withdrawn as an assembly. No tilting or levering is required. The drawer rides on two extension rails. A positive stop limits the travel in the fully withdrawn postion.

The drawer front panel is recessed behind the front door in the connected position and is held in place by an interlock-latch and two thumb screws.

An interlock-latch prevents withdrawing or inserting the drawer while the secondary breaker is in the closed position. To release the latch, push the secondary breaker handle to the left (off position). To engage the latch, push the secondary breaker handle to the right (on position) after returning the assembly to the operate position.

An insulating barrier with openings for the moving primary contacts divides the compartment. The stationary primary contacts and associated high voltage parts are mounted safely behind the barrier. Floating, self aligning, stationary contacts engage the moving contacts as the drawer is inserted into the connected position.

The moving secondary contacts are mounted on the drawer on the front left, and they engage floating, self-aligning, stationary secondary contacts mounted on the compartment side sheet.

A static ground contact is mounted on top of the compartment and grounds the transformer as the drawer is withdrawn.

Drawout Voltage Transformer Compartment (Figure 3)

Voltage transformers are provided to supply voltage indication for metering and relaying purposes. Primary current limiting fuses are mounted on each voltage transformer. No secondary fusing is furnished in the auxiliary compartment or on the drawout drawer.

The front panel, drawout drawer and voltage transformers are withdrawn as an assembly. No tilting or levering is required. The drawer rides on two extension rails. A positive stop limits the travel in the fully withdrawn position. The drawer is recessed behind the front door.

An insulated barrier with openings for the moving primary contacts divides the compartment. The stationary contacts and associated high voltage parts are mounted safely behind the barrier. Floating, self aligning, stationary contacts engage the moving contacts as the drawer is inserted into the connected position.

Secondary sliding finger type contacts are mounted on the front left side of the drawer and engage fixed compartment mounted contacts in the connected position.

Static ground contacts are mounted on a compartment cross bar and engage the load side of the fuses as the drawer is withdrawn.

Drawout Fuse Compartment

Drawout fuses are provided for fixed mounted control power transformers. Fixed mounted CPT's are supplied when three phase control power is required or control power requirements exceed 15 KVA. The front panel, support insulators, current limiting fuses, and secondary molded case circuit breaker are mounted in the drawer and withdrawn as an assembly. No tilting or levering is required. The drawer rides on two extension rails. A positive stop limits the travel in the fully withdrawn position. The drawer front panel is recessed behind the front door in the connected position and is held in place by an interlock-latch and two thumb screws.

An interlock-latch prevents withdrawing or inserting the drawer while the secondary breaker is in the closed position. Push the secondary breaker handle to the left (off position) and slide the latch handle upward to release latch. To engage the latch, push the secondary breaker handle to the right (on position) after returning the assembly to the operate position.

An insulating barrier divides the compartment. The stationary contacts and associated high voltage parts are mounted safely behind the barrier. Floating, self aligning, line and load contacts engage the moving contacts as the drawer is inserted into the connected position.

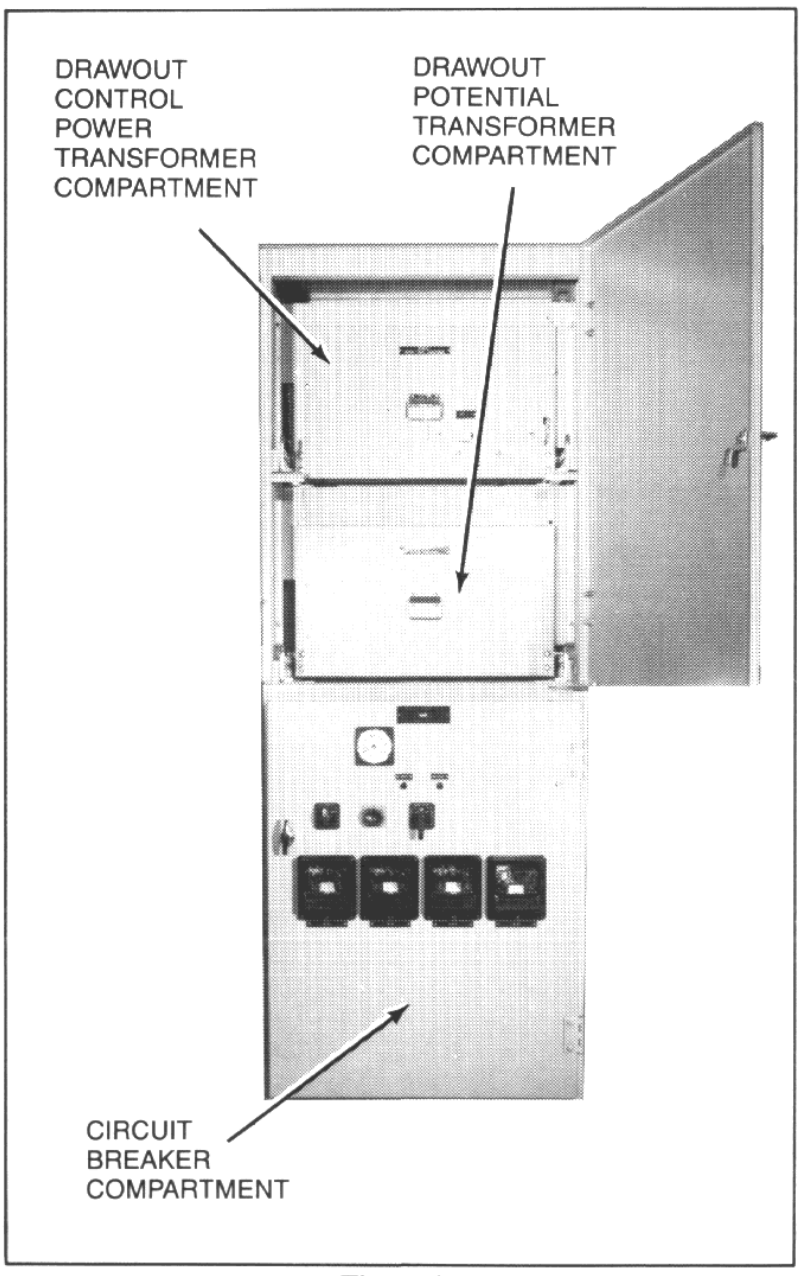


Figure 1
Front View—Breaker/Auxiliary Vertical Section.

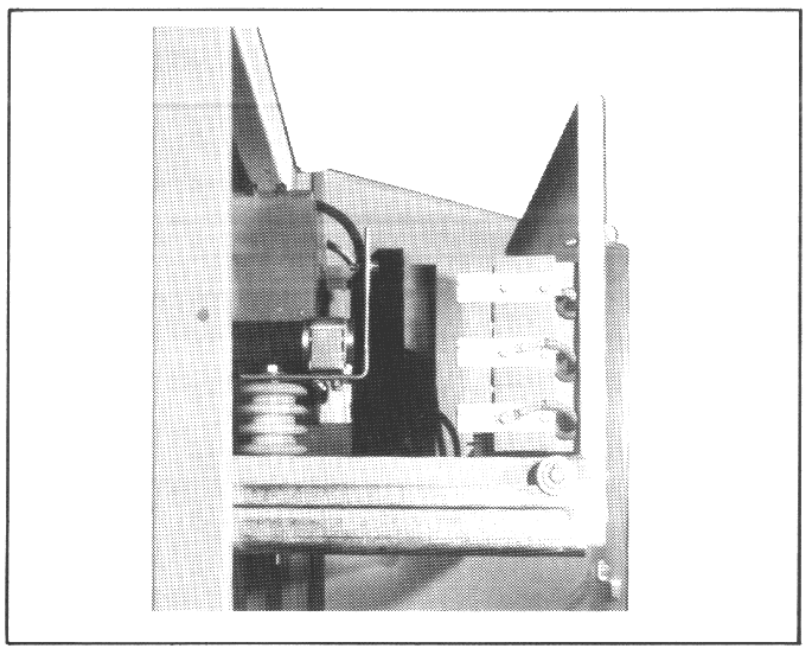


Figure 2
Drawout Control Power Transformer.

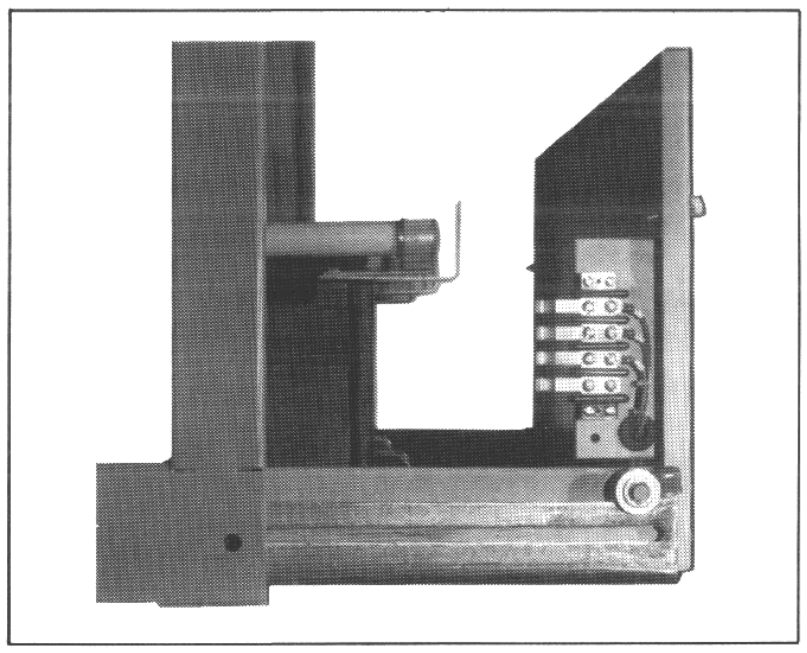


Figure 3
Drawout Voltage Transformers.

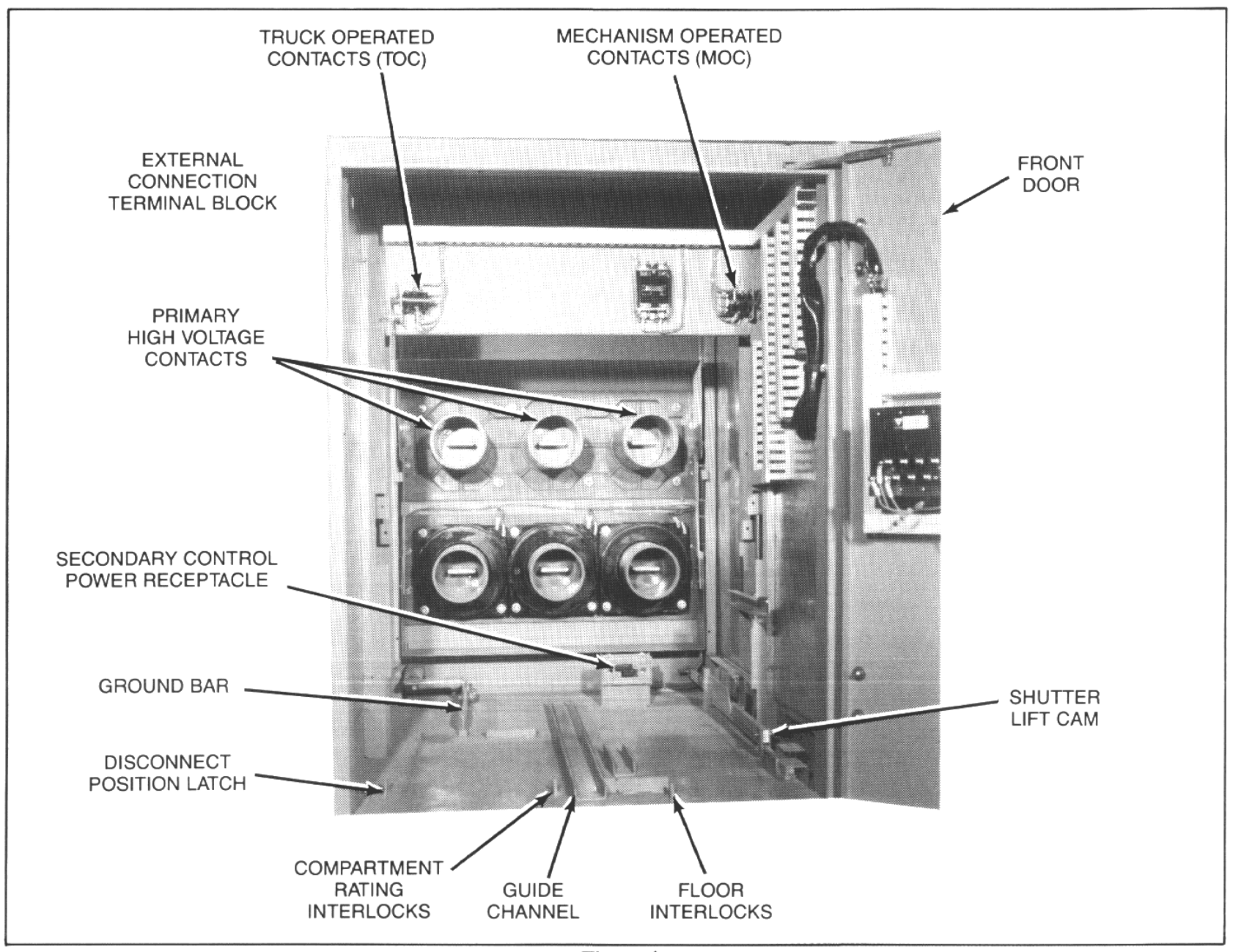


Figure 4
Breaker Compartment—Interior View.

Circuit Breaker Compartment (Figure 4)

Drawout circuit breakers are provided for all main, tie and feeder circuits. Each circuit breaker is a complete device that can be removed from the compartment for inspection and maintenance while the compartment maintains its own electrical, mechanical and safety function integrity.

The circuit breaker compartment contains fifteen separate but coordinated features each necessary for the safe operation of the circuit breaker.

1 Front door
2 Guide channel
3 Floor interlocks
4 Circuit breaker ground bar
5 Racking guide brackets
6 Shutters
7 Primary high voltage contacts
8 Current transformers
9 Secondary control power receptacle
10 Control Wiring
11 Disconnect position latch
12 Compartment rating interlocks
13 Mechanism operated contacts (MOC) (Option)
14 Truck operated contacts (TOC) (Option)
15 Cell interlock

Front Door

The front door is used to mount the normal complement of meters, relays, indicating lights and switches, and to complete the Metal-Clad assembly. A convenient door stay connects between the door and the compartment frame. The door stay allows the door to open to its maximum open position to remove the circuit breaker without interference with the door mounted components. It automatically locks in place when the door is completely open and is released by lifting up on the door stay bar near the compartment.

Guide Channel

The guide channel is a compartment floor mounted channel running from front to back in the center of the compartment. It is used to align the circuit breaker in the compartment. Mating guides are located on the underside of the circuit breaker. The circuit breaker guides slide inside the compartment guide bar when the circuit breaker is properly inserted into the compartment.

Floor Interlocks

Two compartment floor mounted interlock cam systems are provided as safety features.

A COMPARTMENT POSITION INTERLOCK is used to prevent the circuit breaker from being accidentally closed between the test/disconnect and connected positions. The interlock cam mechanically operates the circuit breaker trip mechanism between these two positions so the circuit breaker cannot be closed.

The CHARGED SPRING DISCHARGE INTERLOCK is used to discharge all the springs. If the closing springs are charged and the circuit breaker is inserted into or withdrawn from the compartment, the springs will be automatically discharged approximately one inch from the disconnect position.

Circuit Breaker Ground Contact Bar

A compartment floor mounted circuit breaker ground contact bar is mounted in the back left section of the compartment. It is directly connected to the assembly ground to provide a solidly grounded system. A mating set of sliding contacts are located on the underside of the circuit breaker and engage the circuit breaker ground contact bar in the connected position, all positions between, and in the test/disconnect position.

Racking Guide Brackets

Each circuit breaker has its own internal gear driven mechanism which operates a racking arm with roller on the left and right sides of the circuit breaker. The breaker mechanism is operated by a removable racking crank inserted into the front of the circuit breaker. The racking arms should be down approximately 15° below horizontal with the rollers toward the back of the circuit breaker in the normal withdrawn position.

Compartment mounted racking guide brackets are located on the left and right sides of the compartment: Two guide bracket slots are used on each side. The upper slot is used by the VAD-2 (Vacuum) circuit breaker while the lower slot is used by the FG-2 (SF_6) circuit breaker.

Position indicators are mounted on the floor of the compartment and the front of the circuit breaker. Proper position is obtained by visually aligning the arrow points on the stationary and moving indicators. The circuit breaker is mechanically held in position by the racking mechanism in the connected position. A positive stop is felt when the breaker reaches the connected position.

Shutters

Two grounded steel shutters are mounted directly in front of the primary high voltage contacts. They are appropriately marked DANGER HIGH VOLTAGE. Shutters are used to prevent accidental contact with the primary high voltage contacts if it is necessary to be in an energized compartment for any reason. The shutters move in a rotary motion, and they are stored above the top and below the bottom primary high voltage contact tubes when the circuit breaker is in the connected position. In normal operation the shutters are only open in the connected position and for the short distance required to move the circuit breaker separable contacts into or out of the primary high voltage contact tubes.

Shutter position is controlled by a pivoting lever mechanism on the lower right side of the compartment. A roller on the right side of the circuit breaker rides over the lever mechanism forcing it to pivot and the shutters to open and remain open while the circuit breaker is being racked into the connected position.

The shutters have provisions for locking closed with the breaker withdrawn from the cell or in the test/disconnect position. These provisions are part of the "Cell Interlock" discussed on page 11.

Primary High Voltage Stabs

Each circuit breaker compartment has six primary high voltage stabs. These stabs are used to make the connection between the circuit breaker separable contacts and the main bus in the bus compartment or load terminals.

CAUTION

THE COMPLETE ASSEMBLY ARRANGEMENT DETERMINES IF THE TOP OR BOTTOM CONTACTS ARE THE LINE SIDE, AND BOTH CAN BE ENERGIZED WHEN THE CIRCUIT BREAKER IS REMOVED FROM THE COMPARTMENT!

Two contact designs are used. The 1200 AMP circuit breaker compartment uses flat bus bar type contacts while the 2000 AMP and 3000 AMP use round stud type contacts.

Each contact is mounted in and is partially enclosed by an insulated primary high voltage contact tube. This insulating tube extends well past the front end of the contact, and the open end of the tube is covered by the shutter when the circuit breaker is removed from the operate position.

Current Transformers

Bushing type single or multi ratio current transformers can be mounted around either the top or bottom insulating tubes. A maximum of four model 190 CT's can be mounted per phase, 2 on line, 2 on load.

Secondary Control Power Receptacle

The breaker secondary control power receptacle is located in the lower right floor of the compartment. The molded insulating receptacle contains nineteen contacts and two tapered guide pin holes. A moving mating contact plug is mounted on the circuit breaker and allows the circuit breaker to be used in both the test and connected positions. Engagement is automatic in the connected position.

The stationary secondary receptacle is mounted on two bolts so that it may float approximately 1/8" in each direction. Control wiring is connected to the terminals on the back of the receptacle and is brought forward to the terminal blocks.

Control Wiring

Two terminal block locations are used. A compartment mounted, external connection terminal block is vertically mounted on the left front of the compartment directly above the cut-out in the floor designated for control conduit. All connections necessary for external control are conveniently brought to this terminal block. The second terminal block is vertically mounted on the right front side of the compartment. This terminal block is used for the hinge wiring to door mounted components. Pull-out type control power fuses are mounted in the top sections of this terminal block.

Both terminal block locations are accessible with the circuit breaker in the connected and test/disconnect positions. All interconnecting wiring is enclosed in isolating wire trough to prevent mechanical damage.

Disconnect Position Latch

There are two physical positions of the circuit breaker in the compartment, connected and test/disconnect. There are three functional positions, connected, test, and disconnect.

In the connected position the circuit breaker is racked into the compartment until both the primary high voltage contacts and the secondary control power contacts are made. The circuit breaker is fully operational in this position and it is locked securely in place by the racking mechanism.

In the test position the secondary control power contacts are made and the circuit breaker can be opened and closed electrically. The shutters are closed and cover the primary high voltage contacts isolating the circuit breaker separable high voltage contacts from the main bus and the terminals. The circuit breakers are prevented from accidently moving into the compartment by the racking arms and from moving out toward the door by the disconnect position latch.

In the disconnect position both the circuit breaker secondary control power contacts and separable high voltage contacts are disconnected and the circuit breaker is not operable electrically. The circuit breaker is held in position the same as in the test position.

The disconnecting position latching cam is located on the left front of the compartment floor. A latching lever is located on the left front on the circuit breaker. When the circuit breaker is inserted into the compartment the latching lever rides over the latching cam. Manually raising the latching lever handle allows the circuit breaker to be removed from the compartment.

CAUTION

DO NOT ATTEMPT TO REMOVE A CIRCUIT BREAKER FROM THE TOP CELL WITHOUT A SQUARE D BREAKER LIFT TRUCK HAVING BEEN PUT IN PLACE.

Compartment Rating Interlocks

Each compartment and circuit breaker is provided with a set of fixed mechanical interference compartment rating interlocks. These "go-no go" interlocks prevent accidental insertion of circuit breakers of the incorrect current, voltage, or interrupting rating into the compartment.

The stationary interference pins are mounted on the floor of the compartment and the moving part of the interlock system is mounted on the underside of each circuit breaker.

DO NOT FORCE OR PRY CIRCUIT BREAKERS INTO COMPARTMENTS. DO NOT REMOVE RATING INTERLOCKS.

Mechanism Operated Contacts (Option) (Figure 5)

Mechanism operated contacts (MOC) are compartment mounted auxiliary contacts operated by the circuit breaker mechanism. They indicate the open or closed position of the circuit breaker the same as breaker mounted auxiliary contacts.

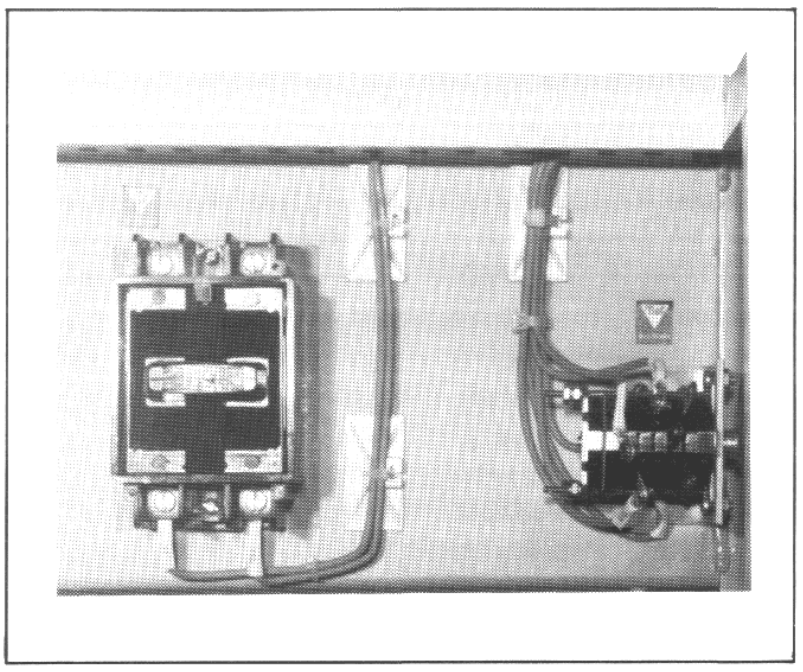


Figure 5
MOC Auxiliary Contact Assembly.

They are operated in both the connected and test/disconnected positions.

MOC contacts are used if more than five auxiliary contacts are needed on one breaker. A maximum of five auxiliary contacts can be mounted on both the FG-2 and VAD-2 breakers.

The MOC is mounted on the right side of the horizontal steel barrier that is located in the top center of the compartment. It is operated by a mechanism in the lower right side of the compartment that is driven vertically by a roller on the right side of the circuit breaker. Gravity and an extension spring hold the mechanism in the open position when the circuit breaker is withdrawn from the compartment.

Truck Operated Contacts (Option) (Figure 6)

Truck operated contacts (TOC) are used to indicate the physical position of the circuit breaker in the compartment. They indicate the breaker is in the connected or test/disconnect position. The TOC contact does not distinguish between the circuit breaker being in the test/disconnect position or withdrawn completely from the compartment.

The TOC is mounted on the left side of the horizontal steel barrier that is located in the top of the compartment. It is operated by a spring loaded lever which in turn is activated by a pin located on the upper left side of the breaker just before the breaker reaches the operating position.

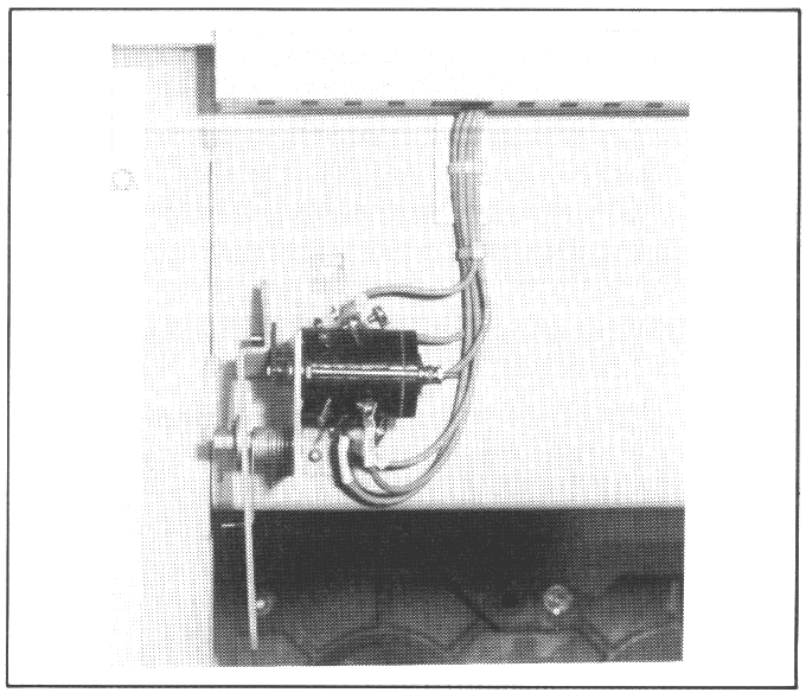


Figure 6
TOC Contact Assembly.

Cell Interlock

An interlock known as "Cell Interlock" is provided in each breaker compartment for locking a breaker out of the connected position.

The cell interlock is located on the lower right side of the compartment and has padlock provisions as standard. It can be equipped with a key interlock when specified by the customer.

The cell interlock works by locking the shutters closed. It prevents racking the breaker into the connected position. A breaker can be stored in the test/disconnect position with the cell interlock locked.

Main Bus Compartment (Figure 7)

The main bus compartment is located in the center of the switchgear. It is isolated from other compartments by removable metal access plates. These removable plates and the main bus compartment are accessible from the back of the cell through the cable compartment.

1200A and 2000A main buses are available in aluminum or copper. The 3000A is always copper.

The vertical riser bus in each vertical section will be sized according to the breakers installed in that section.

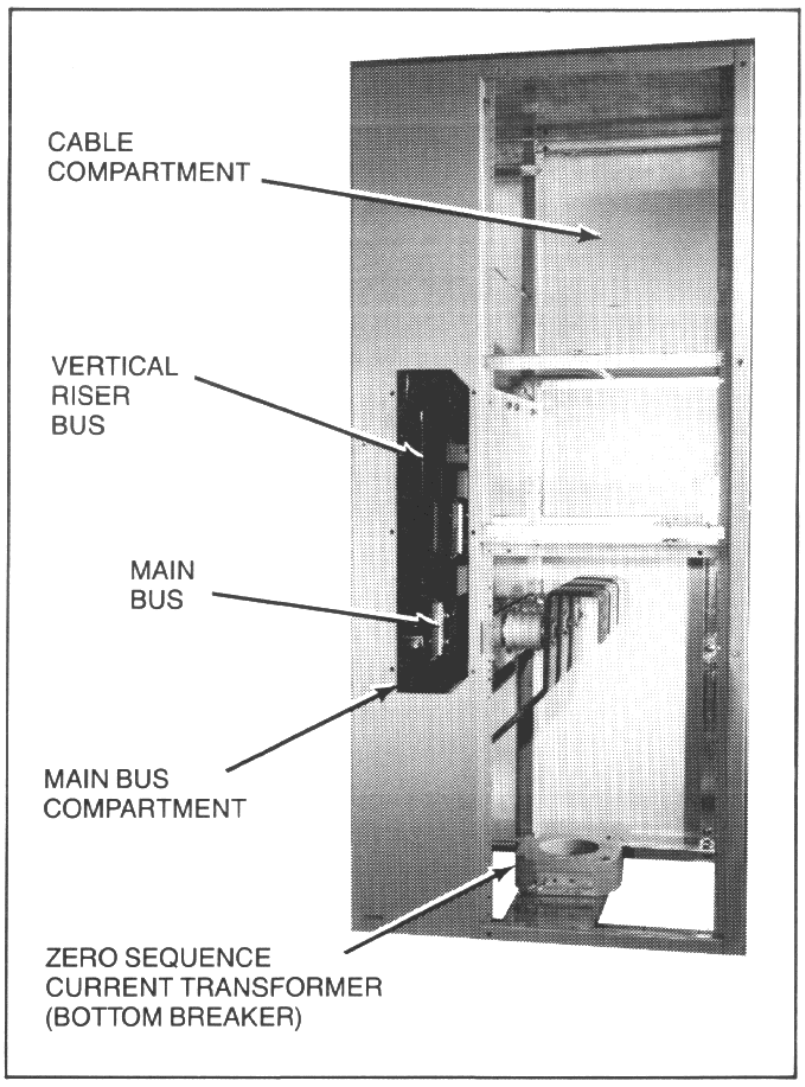


Figure 7
Right Side View—Two-High Breaker Vertical Section.

Each bus bar has fluidized bed epoxy insulation rated for 105°C operation. Flame and track resistant glass polyester barriers are used to separate the bus compartments between adjacent cells. Porcelain inserts are available as an option.

Polyvinyl chloride boots are used to insulate the connection in the main bus compartment. These boots overlap the epoxy insulation on the bus bars.

IT IS NOT GOOD SAFETY PRACTICE AND UNDER NO CIRCUMSTANCES SHOULD THE COVERS OF THE MAIN BUS COMPARTMENT BE REMOVED OR THE EPOXY BUS INSULATION OR THE INSULATING BOOTS BE TOUCHED WHILE THE MAIN BUS IS ENERGIZED.

Cable Compartments (Figure 8)

A separate cable compartment is provided for each breaker in a vertical section. It is accessible by removing a steel cover

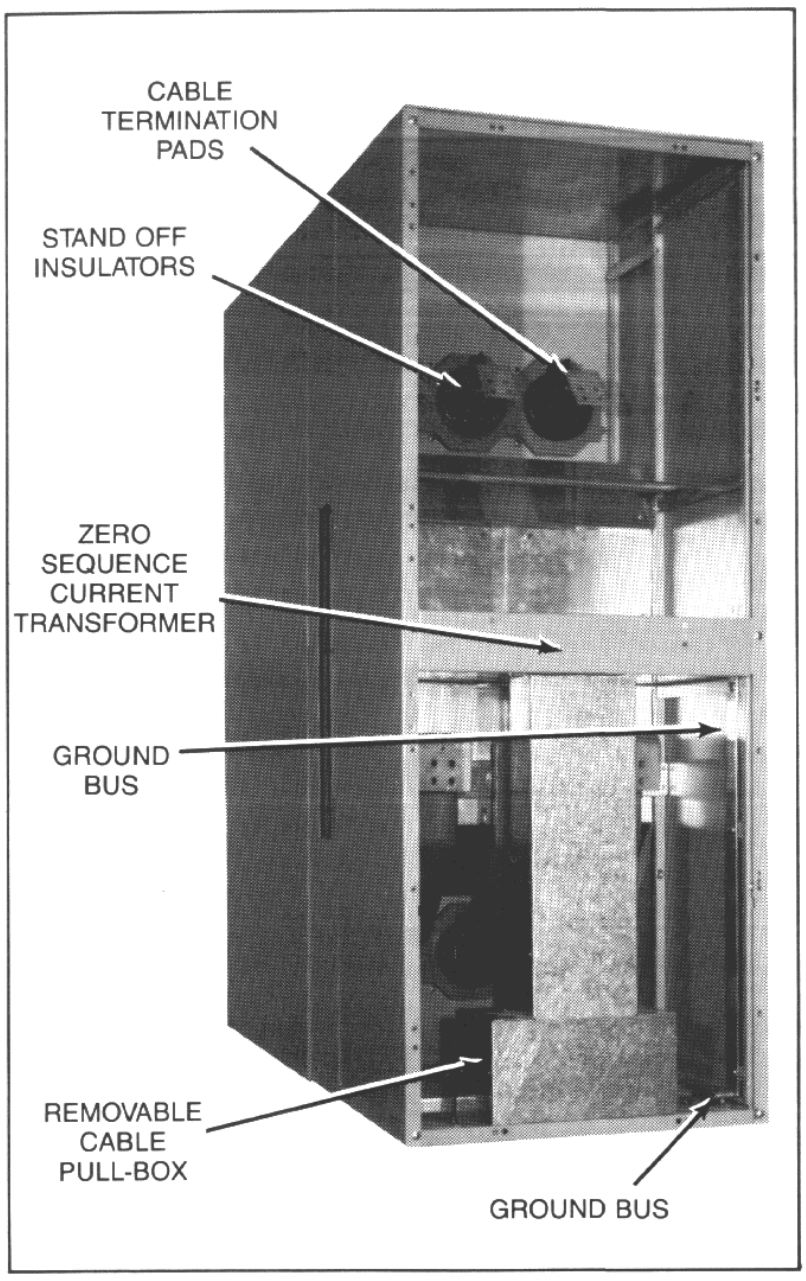


Figure 8
Rear View—Cable Compartments, Two-High Breaker Vertical Section.

on the back. Insulated load connectors are provided for terminating cables. As standard, the load connectors are punched with NEMA 2-hole pattern for terminating two cables per phase. Lugs can be provided by Square D if requested.

Tape and associated material is not supplied as standard for insulating cable terminations.

An assembly ground bus is provided in the cable compartment with lugs on each end for the assembly ground. This ground bus connects to each circuit breaker compartment ground bar, and to the individual ground bar in each cable compartment, and provides a common ground for the assembly. All instrument transformer, metering and relaying grounds are also connected to this common ground system.

Conduit must enter the cable compartments in the areas shown on the customer drawings from either the top or bottom of the cable compartment. NOTE: Conduit should be stubbed in the concrete as part of the site preparation before the assembly is installed, BUT top entrance conduit must be installed after the assembly is put in place. The top covers can be removed, punched to fit the conduit and put back in place.

A removable steel metal cable pull-box is provided to isolate cables when two breakers are installed in one vertical section and cables for both breakers must enter from the same direction, above or below. The front conduit area is for the bottom breaker when all cables enter from below, and for the top breaker when all cables enter from above. This cable pull-box may be removed to permit the rear cables to be installed first.

Zero sequence current transformers are conveniently located in each cable compartment when required.

Various cable termination systems are used and they are specified on the plans and specifications. Solderless or compression lugs can be supplied on the load connectors. Potheads are mounted on grounded support brackets. The compound and tape for their internal connections are shipped in a container with the other miscellaneous parts. **Tape and insulating material necessary for completing the field connection at the bus pad is not normally supplied with the assembly.**

IT IS NOT GOOD SAFETY PRACTICE TO REMOVE THE BACK ACCESS COVERS OF THE CABLE COMPARTMENT WHILE THE CIRCUIT BREAKERS ARE IN THE CONNECTED POSITION OR ENERGIZED.

Surge Protectors (Option)

Surge protectors are provided as standard on all circuits using Type VAD-2 (Vacuum) circuit breakers. They are mounted in the incoming and outgoing cable compartments. Their primary cable connection may be made to the bus pad and the connection is not taped or otherwise insulated when the assembly leaves the factory. Complete the insulation of the surge protector primary cable when installing the power cables (see "INSTALLATION," pages 19-24).

Lightning Arresters (Option)

Lightning arresters are only furnished when specified in the user's specifications. The vulnerability of the incoming and outgoing lines to lightning strikes or other high voltage transient conditions determines their type and justification. They are mounted in the incoming and outgoing cable compartments when furnished. Their primary cable connection may be made to the bus pad and the connection is not taped or

otherwise insulated when the assembly leaves the factory. Complete the insulation of the lightning arrester primary cable when installing the power cables (See "INSTALLATION," pages 19-24.)

SURGE PROTECTERS AND LIGHTNING ARRESTERS (if provided) ARE NOT PERMANENTLY CONNECTED AT THE FACTORY AND MUST BE DISCONNECTED FOR HI-POT OR RESISTANCE TESTING.

SURGE PROTECTORS AND LIGHTNING ARRESTERS (if provided) MUST BE RECONNECTED AFTER HI-POT OR RESISTANCE TESTING BEFORE THE POWER CABLE CONNECTIONS ARE COMPLETED.

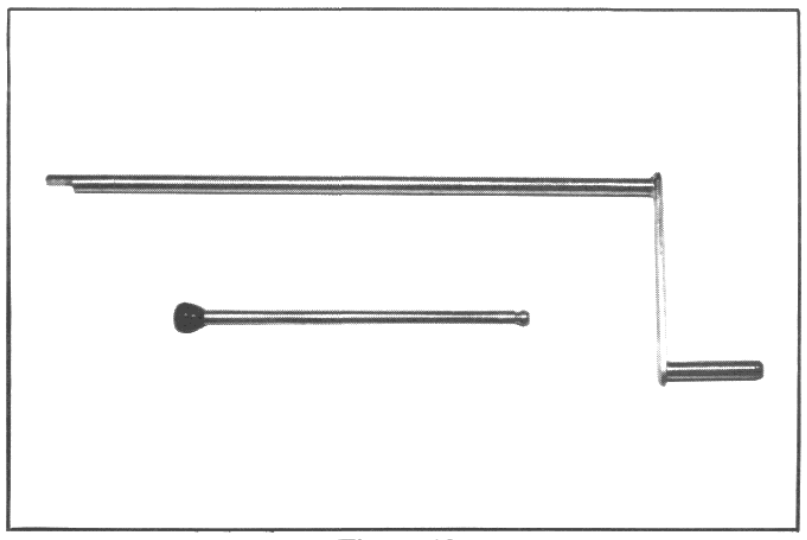


Figure 10
Breaker Racking and Charging Handles.

Circuit Breakers (Figures 9, 10, 11, 12, 13, & 14)

Two different types of circuit breakers are available for use in Two-High, 5-15kV, Metal-Clad, Drawout Switchgear.

Type FG-2 (SF_6) circuit breakers use sulphur hexafluoride gas at a low pressure as the insulating and arc extinguishing medium. They give a quiet, dependable arc interruption of five cycles or less, and have sealed, minimal maintenance, interrupters.

Type VAD-2 (Vacuum) circuit breakers use a high vacuum as the insulating and arc extinguishing medium. They give a high speed, quiet, dependable arc interruption of three cycles or less, and have hermetically sealed, minimal maintenance, interrupters.

The two types of circuit breakers are easily distinguishable:

Type FG-2 (SF_6) circuit breakers have a steel, grounded front panel with a distinctive racking shaft cover box on the left side, and a window insert with the nameplate, open/closed indicator, operation counter, springs charged/discharged indicator, manual close and trip buttons and manual springs charge handle slot on the front. The interrupters are enclosed in large cast epoxy envelopes in back of the operating mechanism. These envelopes serve as their own insulating support structure.

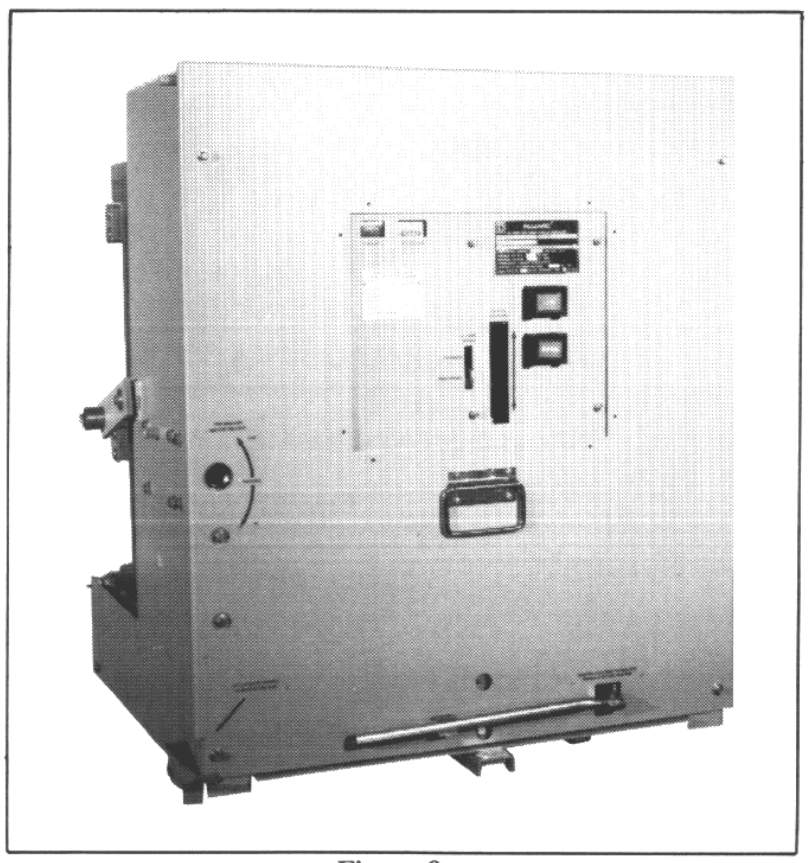
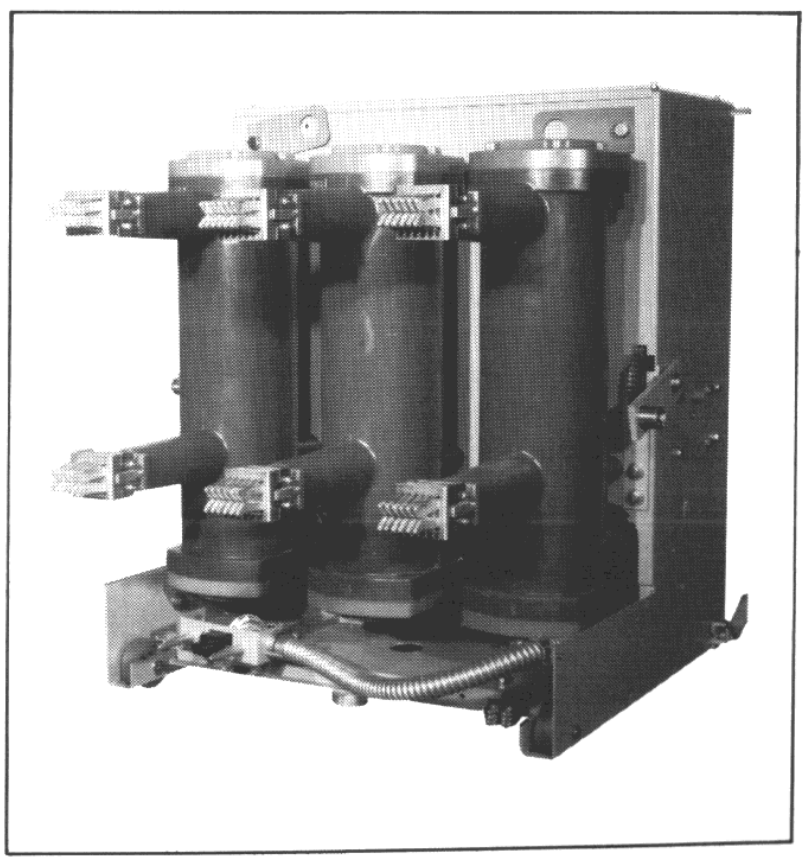


Figure 9
Front View—FG-2 1200A Breaker.



Type VAD-2 (Vacuum) circuit breakers have a steel, grounded front panel with the racking shaft located on the upper right part of the panel. All of the indicators, etc., are visible through openings in the front panel. The interrupters are vacuum bottles which contain the stationary and moving contacts and are located in back of the operating mechanism. Large red insulated interphase and side barriers isolate the interrupters. Two nameplates with complete rating information are provided; one on the front panel and one on the upper right side of the operating mechanism. CAUTION: If Type VAD-2 (Vacuum) circuit breakers of different ratings are used in the same assembly, match the nameplates on the circuit breaker and panel when reassembling after an inspection or maintenance program.

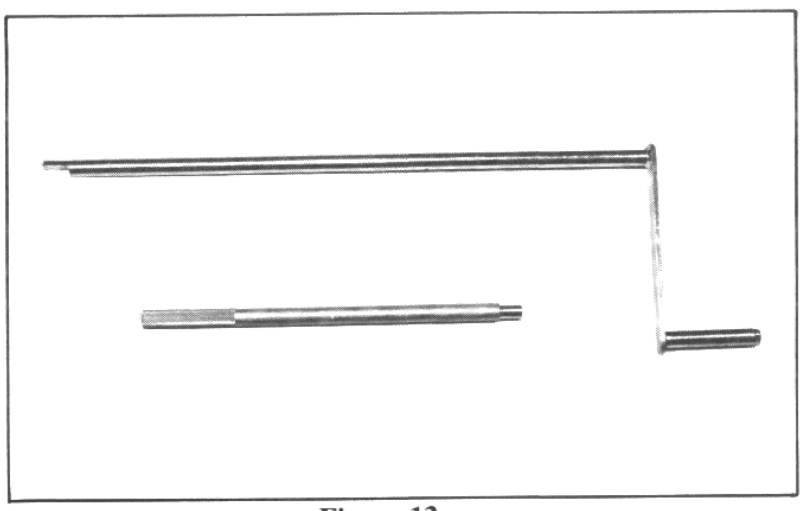


Figure 13
Breaker Racking and Charging Handles.

Figure 12
Front View—VAD-2 1200A Breaker.

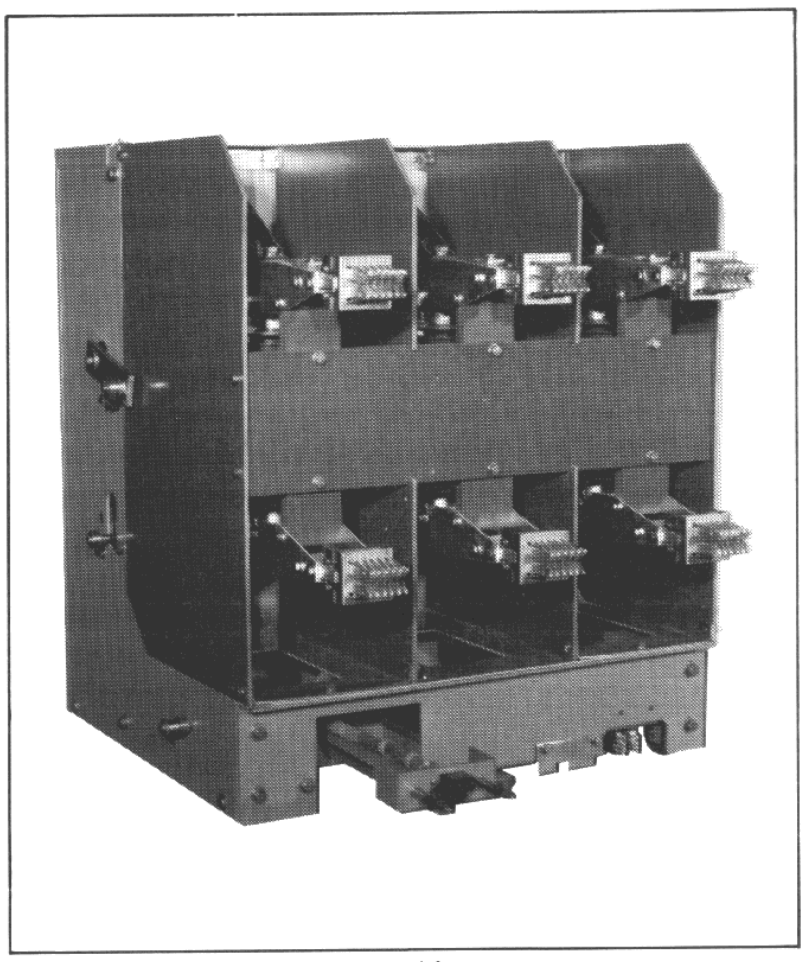


Figure 14
Rear View—VAD-2 1200A Breaker.

OPERATION

FG-2 Circuit Breaker (Figure 15)

Type FG-2(SF_6) circuit breakers have six mechanisms that are manually operated but are coordinated with safety controls built into the circuit breakers and compartments.

(1) Racking mechanism
(2) Secondary control power plug
(3) Disconnect position latch
(4) Manual spring charge mechanism
(5) Manual close pushbutton
(6) Manual open pushbutton

Racking Mechanism

The racking mechanism is only used to move the circuit breaker from the test/disconnect position to the connected position and back to the test/disconnect position.

Push the circuit breaker into the compartment to the test/disconnect position and the disconnect position latch engages. The racking mechanism arm rollers should be aimed to the back of the circuit breaker and they should be down approximately 15° below horizontal.

The racking handle cannot be inserted into a circuit breaker that is in the closed position. Insert the racking handle and rotate clockwise to rack the circuit breaker into the connected position. When the circuit breaker is in the connected position, it will stop its forward motion, the compartment and circuit breaker position indicators will be aligned and a positive stop will be felt when the breaker is in the connected position. The breaker position interlock prevents closing the circuit breaker between the test/disconnect and connected positions or racking a closed circuit breaker onto or off of the primary high voltage contacts.

IT IS GOOD SAFETY PRACTICE TO ONLY OPERATE CIRCUIT BREAKERS IN THE CONNECTED POSITION ELECTRICALLY WITH THE COMPARTMENT FRONT DOOR CLOSED.

IT IS NOT GOOD SAFETY PRACTICE TO OPERATE CIRCUIT BREAKERS IN THE CONNECTED POSITION MANUALLY WITH THE COMPARTMENT FRONT DOOR OPEN.

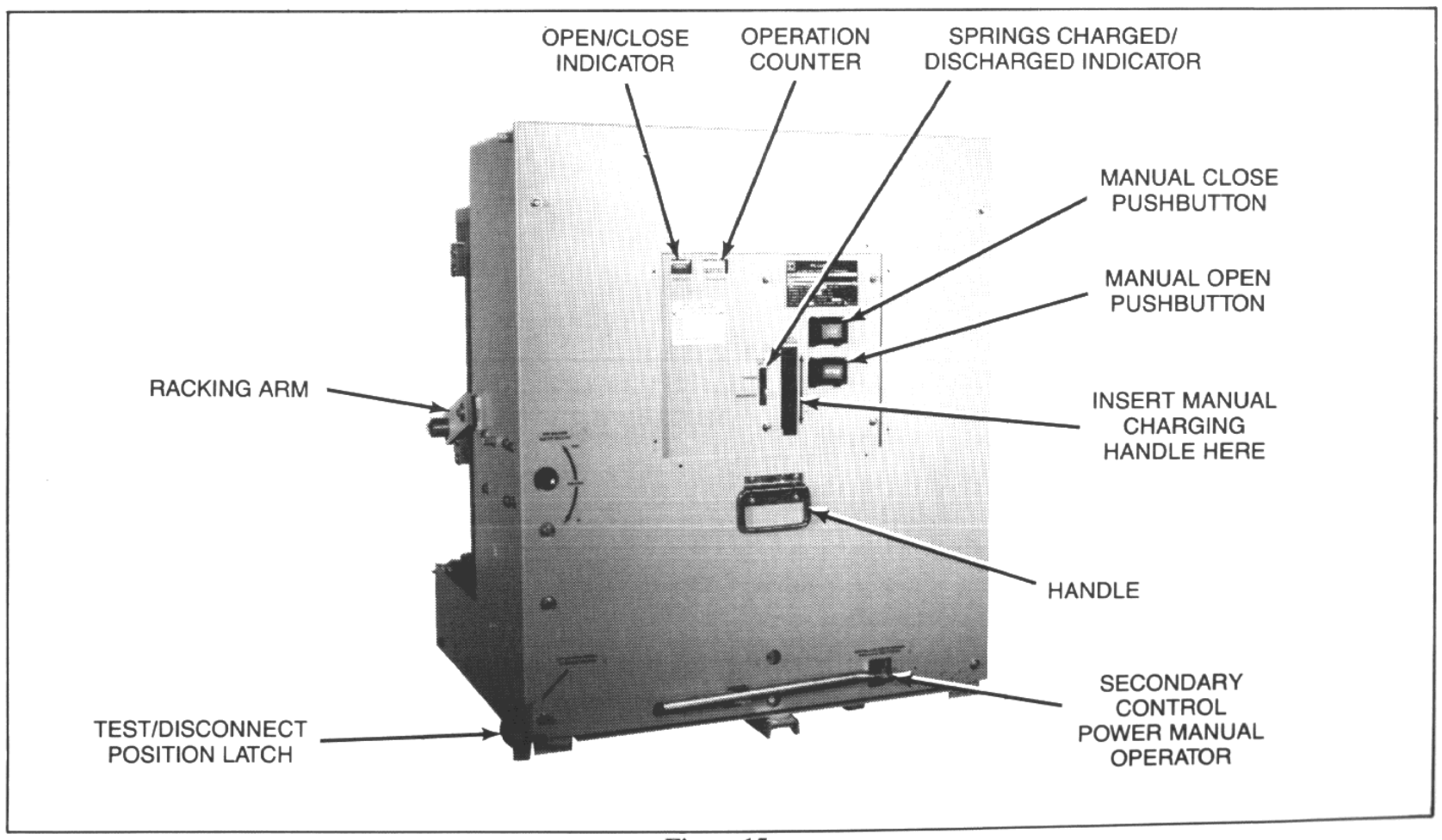


Figure 15
Features—FG-2 Breaker.

To remove a circuit breaker from the connected position to the test/operate position, open the circuit breaker electrically with the compartment door closed. Then open the door and insert the racking handle and rotate counterclockwise until the compartment and circuit breaker position indicators line up.

Through the door racking to move the breaker between the test and operating positions is available as an option.

Secondary Control Power Plug

The secondary control power plug automatically engages the compartment receptacle in the connected position and disengages as the circuit breaker is racked out to the test/disconnect position.

A manual operator is provided to engage the control power plug in the test/disconnect position.

It is possible, if it is left in the manually extended test position, to engage or disengage the secondary control power plug when inserting the circuit breaker into or withdrawing from the test/disconnect position.

Disconnect Position Latch

The disconnect position latch is provided to prevent the circuit breaker from rolling out of the compartment in the test/disconnect position. Simply lift and hold the latch handle up while pulling the circuit breaker out of the compartment.

Manual Spring Charging Mechanism

The circuit breaker closing springs may be charged automatically, by the charging motor, or manually. In normal operation the motor charges the springs.

A manual spring charging mechanism is provided for testing and maintenance purposes and extreme emergency operating conditions. NEVER CLOSE A CIRCUIT BREAKER MANUALLY IN THE CONNECTED POSITION UNLESS THE OPENING SOURCE OF POWER AND PROTECTIVE RELAYS ARE CONNECTED AND OPERABLE. Insert the manual charging handle into the manual spring charging mechanism and pump the handle up and down until a loud "CLICK" is heard and the pumping force is prohibitive. REMOVE THE HANDLE. The closing springs are now charged and the circuit breaker can be closed and opened electrically or manually.

Manual Close Pushbutton

A manual close pushbutton is provided on the circuit breaker for test and maintenance purposes, and extreme emergency operating conditions. NEVER CLOSE A CIRCUIT BREAKER MANUALLY IN THE CONNECTED POSITION UNLESS THE OPENING SOURCE OF POWER AND PROTECTIVE RELAYS ARE CONNECTED AND OPERABLE.

Manual Open Pushbutton

A manual open pushbutton is provided on the circuit breaker for test and maintenance purposes, and extreme emergency operating conditions.

IT IS GOOD SAFETY PRACTICE TO ONLY OPEN CIRCUIT BREAKERS ELECTRICALLY IN THE CONNECTED POSITION WITH THE DOOR CLOSED AND NEVER MANUALLY IN THE CONNECTED POSITION.

Type VAD-2 (Vacuum) Circuit Breaker Operation (Figure 16)

Type VAD-2 (Vacuum) circuit breakers have six mechanisms that are manually operated but are coordinated with safety controls built into the circuit breakers and compartments.

(1) Racking mechanism
(2) Secondary control power plug
(3) Disconnect position latch
(4) Manual spring charge mechanism
(5) Manual close
(6) Manual open

Racking Mechanism

The racking mechanism is only used to move the circuit breaker from the test/disconnect position to the connected position and back to the test/disconnect position.

Push the circuit breaker into the compartment to the test/disconnect position and the disconnect position latch engages. The racking mechanism arm rollers should be aimed to the back of the circuit breaker and they should be down approximately 15° below horizontal.

Insert the racking handle and rotate clockwise to rack the circuit breaker into the connected position. If the circuit breaker is in the closed position it will automatically open as it moves from the test/disconnect position. When the circuit breaker is in the connected position it will stop its forward motion, the compartment and circuit breaker position indicators will be aligned.

The compartment floor mounted interlock prevents accidentally closing the circuit breaker between the test/disconnect and connected positions or racking a closed circuit breaker onto or off of the primary high voltage contacts.

IT IS GOOD SAFETY PRACTICE TO ONLY OPERATE CIRCUIT BREAKERS IN THE CONNECTED POSITION ELECTRICALLY WITH THE COMPARTMENT FRONT DOOR CLOSED.

To remove the circuit breaker from the connected position to the test/disconnect position, open the circuit breaker electrically with the compartment door closed. Then open the door and insert the racking handle and rotate counterclockwise until the compartment and circuit breaker position indicators line up. Through the door racking is available as an option.

Secondary Control Power Plug

The secondary control power plug automatically engages the compartment receptacle in the connected position and disengages as the circuit breaker is racked out to the test/disconnect position.

A manual operator is provided to engage the control power plug in the test/disconnect position for electrical operation.

It is possible, if it is left in the manually extended test position, to engage or disengage the secondary control power plug when inserting the circuit breaker into or withdrawing from the test/disconnect position.

Disconnect Position Latch

The disconnect position latch is provided to prevent the circuit breaker from rolling out of the compartment in the test/disconnect position. Simply lift and hold the latch handle up while pulling the circuit breaker out of the compartment.

Manual Spring Charging Mechanism

The circuit breaker closing springs may be charged automatically by the charging motor or manually. In the normal operation the motor charges the springs.

A manual spring charging mechanism is provided for testing and maintenance purposes and extreme emergency operating conditions. NEVER CLOSE A CIRCUIT BREAKER MANUALLY IN THE CONNECTED POSITION UNLESS THE OPENING SOURCE OF POWER AND PROTECTIVE RELAYS ARE CONNECTED AND OPERABLE. Insert the manual charging handle into the manual spring charging mechanism and pump the handle up and down until a loud "CLICK" is heard and the pumping force is prohibitive. REMOVE THE HANDLE. The closing springs are now charged and the circuit breaker can be closed and opened electrically or manually.

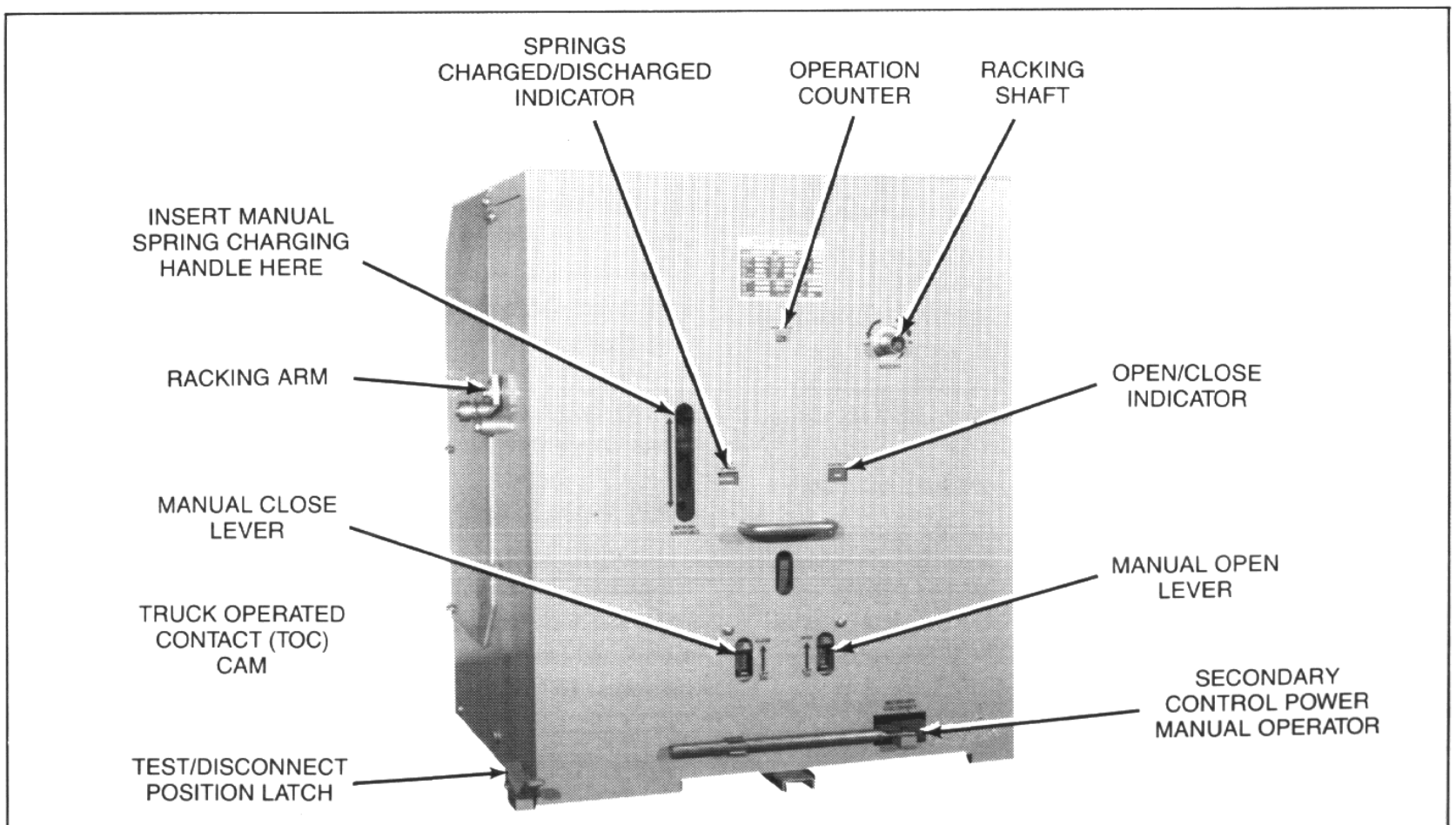


Figure 16
Features—VAD-2 Breaker.

Manual Close Lever

A manual close lever is provided on the circuit breaker for test and maintenance purposes, and extreme emergency operating conditions. NEVER CLOSE A CIRCUIT BREAKER MANUALLY IN THE CONNECTED POSITION UNLESS THE OPENING SOURCE OF POWER AND PROTECTIVE RELAYS ARE CONNECTED AND OPERABLE.

Manual Open Lever

A manual open lever is provided on the circuit breaker for test and maintenance purposes, and extreme emergency operating conditions.

IT IS GOOD SAFETY PRACTICE TO ONLY OPEN CIRCUIT BREAKERS ELECTRICALLY IN THE CONNECTED POSITION WITH THE DOOR CLOSED AND NEVER MANUALLY IN THE CONNECTED POSITION.

RECEIVING, HANDLING, STORAGE

Receiving

Two-high 5-15kV metal-clad indoor switchgear is shipped on skids with appropriate protective crating to prevent damage during normal transit. The drawout control power transformer drawer, voltage transformer drawer and drawout fuse drawer (if supplied) are shipped in place. Circuit breakers are individually skid mounted and crated.

Each crate is individually marked and the packing list will indicate the number of crates and what is in each. The packing list will be in an envelope on the outside of the number one crate.

Inspect each crate for external damage or indication of rough handling before accepting the shipment. If there is any indication of external damage or mistreatment or the correct number of crates have not been received it should be so noted on the shipping papers when signed for. A formal damage claim should be filed immediately with the carrier. Notify the local Square D Field Office of the extent of damage or shortages and attach a copy of the formal damage claim.

The shipping crates should be opened as soon as possible after receipt and the contents inspected and checked in detail against the shipping papers to reduce the possibility of hidden damage.

Notify the local Square D Field Office of any discrepancies, as last minute field improvisions may cause serious operational problems.

If the equipment is going to be stored until being installed it may be practical to leave it on the shipping skids to facilitate moving.

Handling As Received

The individual crates may be lifted by a crane with slings thru the skids or by fork truck. If lifted by slings, be sure there are adequate spreaders used to prevent distortion of the assembly structure or damage to the doors or door mounted components.

The assembly may not have equal weight distribution so the position of the sling lifting point may be important to prevent shifting or swinging. Lifting jacks and rollers under the skids may be used on relatively flat surfaces if other equipment is not available or space prohibits use of other means of moving.

Handling Uncrated Assemblies

Assemblies consisting of more than two cells wide are divided into shipping sections for ease of lifting and handling. Each shipping section is structurally strong enough to be lifted as a unit if properly handled. Four lifting lugs are provided on top of each section. They are located so that the shipping section is approximately in balance if the lift point is midway between the lugs. Use adequate spreaders so the assembly does not tilt or swing. If at all possible, limit the lift height so the assembly just clears the conduit stubs.

Remove the cable compartment cable pull-boxes so that it will be easier to see the conduit stubs and prevent bending the zero sequence current transformer mountings of the bottom circuit breakers.

If rollers are used, remove the back covers and pry the assembly from the skid directly onto the rollers. Place a 2x6 across the back of the assembly and pry against it to apply the force evenly across the frame. Use two pry points at the same time if at all possible.

Circuit breakers should be removed from their skids with a crane. Two lifting plates are suplied on each breaker. DO NOT USE THE PRIMARY SEPARABLE CONTACTS OR BUSHINGS AS HANDLES.

If a fork truck is used to lift the circuit breakers from their skids, space the fork truck lifting arms to match the circuit breaker wheels and carefully roll the circuit breaker directly onto the lifting arms. DO NOT FORCE THE LIFTING ARMS UNDER THE CIRCUIT BREAKER FRAME as the interlocks and secondary control power plug will be damaged.

Lifting eyes are provided on each circuit breaker and should be the only place used for lifting. DO NOT LIFT WITH HOOKS ATTACHED TO THE RACKING MECHANISM ARMS as the circuit breaker weight distribution is not suited for this method and it will tilt and swing and be difficult to maneuver.

TABLE 1—CUBICLE WEIGHTS*

TWO HIGH VERTICAL SECTIONS

TYPE OF CELL	MAIN BUS RATINGS	WEIGHT
Auxiliary/Breaker or	1200	2600
Auxiliary/Auxiliary	2000	2700
	3000	2800
Breaker/Breaker	1200	2500
	2000	2600
	3000	2700

* Weights are in pounds and do not include skids or crates.

TABLE 2—CIRCUIT BREAKER WEIGHTS*

CURRENT RATING	FG-2 (SF_6)	VAD-2 (VACUUM)
1200A	500	530
2000A	550	580
3000A	550	N/A

* Weights are in pounds and do not include skids or crates.
N/A = Not Available

Storage Of Indoor Equipment

It is often impossible to install indoor switchgear immediately after being received. If the assembly is to be stored for any length of time it should be kept in a clean dry, well ventilated area with a mean temperature of approximately 70°F. Loose shipping items should be kept neatly together to prevent being misplaced. The storage area should be closed off to unauthorized personnel to eliminate nuisance tampering or pilfering. Circuit breakers should be loosely covered with dust covers. The assembly doors should be kept closed and all the removable covers kept in place. If space heaters are furnished in the assembly they should be energized from a separate source. Consult the schematic diagrams and wiring diagrams for a logical connection point and the voltage and power requirements.

IF THE SPACE HEATERS ARE NORMALLY ENERGIZED FROM THE ASSEMBLY CONTROL POWER TRANSFORMER OPEN THE CONTROL POWER TRANSFORMER SECONDARY CIRCUIT BREAKER, REMOVE THE PRIMARY CURRENT LIMITING FUSES AND INSTALL AN OUT OF SERVICE TAG BEFORE ENERGIZING THE SPACE HEATERS TO PREVENT BACK FEED TO THE MAIN BUS THROUGH THE CONTROL POWER TRANSFORMER.

If no space heaters are installed in the assembly and the area is cold and damp temporary heating should be used. Avoid greasy smoke type of heaters as the high carbon content smoke can result in carbon deposits on insulation that can cause tracking and eventual insulation failure.

Batteries and battery chargers, when furnished with the assembly, should be put on trickle charge upon receipt.

INSTALLATION

Site Preparation

Good site preparation is absolutely necessary to eliminate costly and time consuming installation problems and insure proper and reliable operation of the assembly. Carefully compare the plans and specifications with the customer drawings provided to be sure there are no discrepancies:

Floor channel sill mounting holes and method of anchoring are important so the assembly can be properly welded or bolted in place.

Conduit runs and size, power and control cable type and size, and assembly ground locations should agree.

Continuous loops of reinforcing rod or structural steel around any single conductor of a three phase power circuit should be eliminated.

Aisle space should be allowed for in the front, back and on the ends of the assembly to open doors, remove and turn circuit breakers, remove access covers, walk and work.

A minimum of 7 feet is required in the front and 3 feet for the back and ends is normally acceptable.

NOTE: A MINIMUM OF THREE FEET IS ABSOLUTELY NECESSARY ON THE RIGHT END FACING THE FRONT OF THE LINE-UP FOR DOOR CLEARANCE TO REMOVE THE CIRCUIT BREAKERS. DO NOT INSTALL BATTERIES IN THIS AREA.

Local building codes may require more space.

Ventilation should be provided at all times so the ambient temperature around the assembly does not exceed 90 °F. Clean, dry filtered air should be supplied.

Adequate lighting and convenience outlets for hand tools should be furnished for both the front and back aisle space.

If control power batteries and charger are used, clear space for the battery rack and charger must be allowed. Typically the charger and battery rack are mounted near the end of the assembly that has the main circuit breaker.

Consult the customer drawings for source of power for the battery charger and inter-connection to the assembly.

Floor drains should be provided to prevent water build up from broken or leaking pipes.

Sewer, water and steam lines should be routed so they do not pass over or near the assembly. Dripping liquids may damage the insulation and cause the switchgear to fail.

Ample head room must be allowed for top entrance or exit conduit and cable bends.

NOTE: BUS PADS AND CABLE TERMINATIONS ARE FOR CONNECTIONS AND ARE NOT INTENDED TO SUPPORT THE DEAD WEIGHT OF LONG VERTICAL CABLE DROPS.

Foundation (Figures 17 & 18)

The switchgear must be installed on a flat and level surface to prevent distortion and assure that the circuit breakers will be interchangeable in all compartments. It is recommended the switchgear be installed on a concrete pad leveled to ±1/16 inch in any square yard and that steel channels be installed in the pad for anchoring the switchgear. See figures 17 and 18.

A seven foot long aisle space should be poured in front of the mounting pad flush with and finished to the same tolerance as the mounting pad. This level surface is necessary for the circuit breaker lift truck and inserting the circuit breakers into the bottom compartment.

The weight of a complete assembly with its breakers in place will depend on the number of cells and circuit breakers. Approximate weights of the individual Two-High cells and the circuit breakers are given in Tables 1 and 2, page 19, RECEIVING, HANDLING AND STORAGE. The circuit breaker does not transmitt impact-load to the foundation on closing or interrupting and need not be considered. The combined assembly and circuit breaker dead weight is all that need be considered.

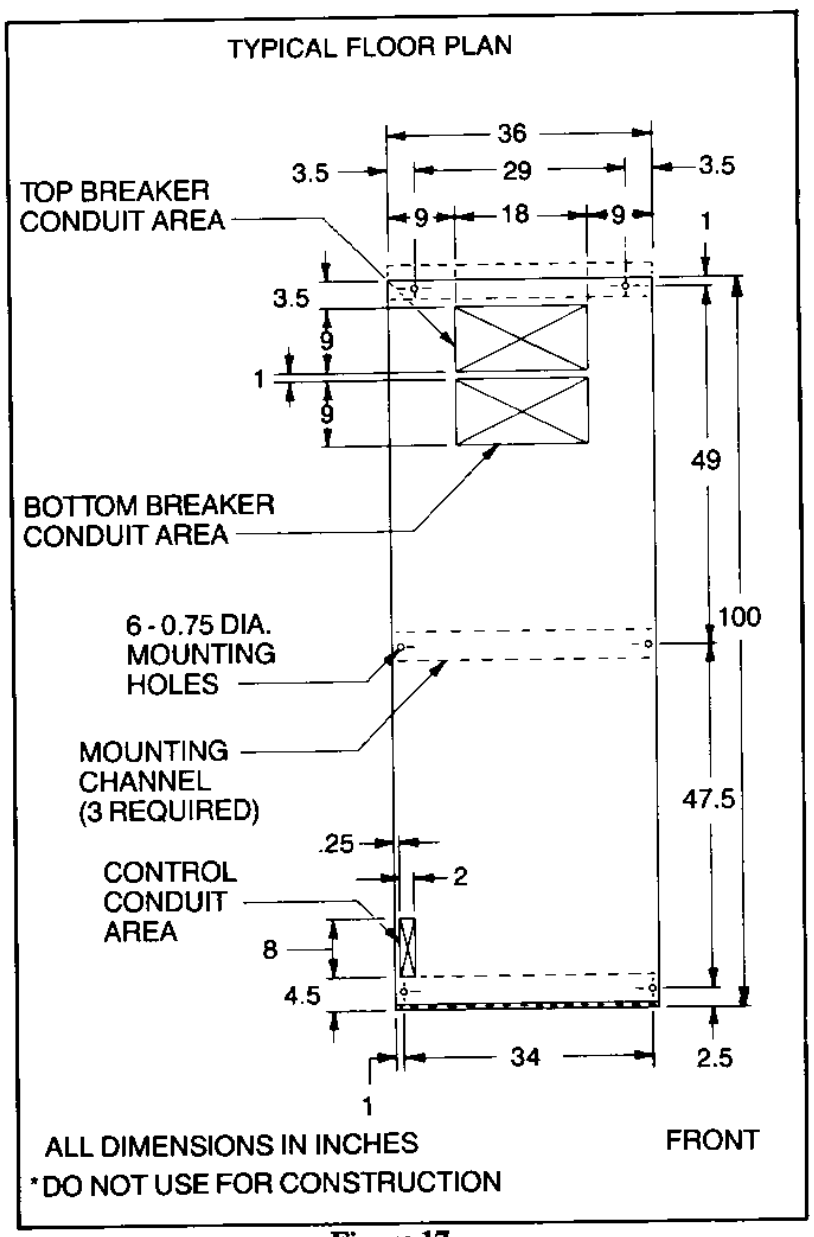


Figure 17
Floor Plan—Two-High Breaker Vertical Section.

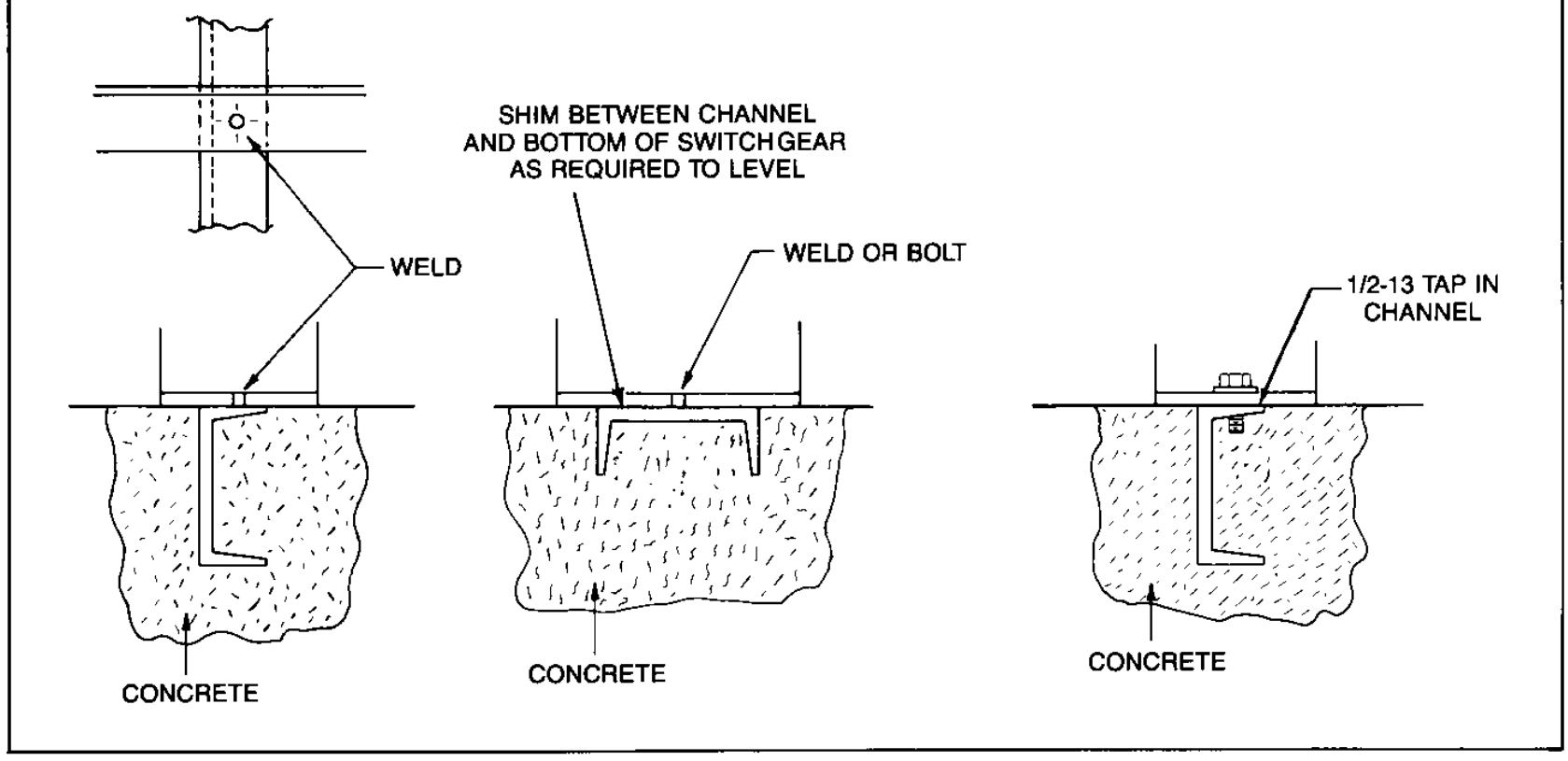


Figure 18
Switchgear Mounting Floor Channels.

If the installation is to be made on an existing concrete floor it is suggested that a new floor with mounting channels be installed over the existing floor. The new floor must not extend in front of the switchgear more than 3″ or it will prevent docking of the Square D breaker lift truck. An alternate would be to cut the existing floor to install the mounting channels and then fill in the low spots with one of the many epoxy surfacing materials available and grind the complete mounting pad to the required tolerance.

Conduits should be stubbed a maximum of 2 inches above floor level so that they do not extend into the Zero Sequenced Current Transformers. The conduit location should be very accurate so that there is no mechanical interference with the assembly frame.

Installation of Assembly

Two-High 5-15kV Metal Clad Indoor Switchgear may be shipped in one or more shipping sections depending on the number of cells in the assembly.

CONSULT THE CUSTOMER DRAWINGS AND SECTION MARKINGS TO INSURE PROPER LINE UP BEFORE INSTALLING EACH SECTION.

If two shipping sections are furnished, install the section first that allows the most maneuverability for the second section.

When more than two shipping sections are involved carefully measure the conduit spacings and compare with the customer drawings. Cumulative error in conduit locations may require starting with the center shipping section and working toward either end. If the conduits are properly located install the end shipping section first that allows the greatest maneuverability for installing the additional sections.

Sweep the pad area before installing sections.

Move the section(s) in place by crane or rollers. When the first section is approximately in the proper position lower onto the pad. Place a 2x6 across the assembly and pry into place. DO NOT PRY DIRECTLY ON THE STRUCTURE, DOORS OR COVERS. The conduits should be in the center of the cut outs, the back of the unit parallel with the pad and with proper clearance, and the mounting holes lined up with the holes in the mounting channels before proceeding.

Level each section before installing the next. Install steel shims, if necessary, between channels and switchgear. After leveling a section, bolt it to the previously installed section(s) before proceeding. If the sections do not fit snugly together, pry together. DO NOT ATTEMPT TO PULL SECTIONS TOGETHER WITH THE HARDWARE.

Move all the shipping sections into place and bolt together before attempting to bolt or weld to the channel sills or installing the horizontal main bus.

After all the sections are level and bolted together, again check that all shipping sections are in their correct position per the job drawings. If they are, weld or bolt the switchgear to the pad. If bolted, 1/2-13 bolts should be used.

THE MAIN BUS AT THE SHIPPING BREAKS SHOULD ONLY BE INSTALLED AFTER THE SHIPPING SECTIONS ARE SECURELY ANCHORED IN PLACE AND NO ADDITIONAL MOVEMENT WILL BE MADE TO THE ASSEMBLY.

The bus bar extensions for the shipping breaks are shipped with the miscellaneous items.

Remove the main bus covers and the removable insulating boots. Install one phase at a time by sliding through the bus barriers and loosely bolting the horizontal bus to the vertical bus. DO NOT BEND OR FORCE THE BUS TO MAKE THIS CONNECTION. The through bushings and the divided insulating barrier may be loosened if necessary. They have sufficient clearance and adjustment to make up for minor field mis-alignment of shipping sections. Tighten the bolts holding the bus bar joints only after all three bus bars are in place and fit properly. Use a torque wrench to insure bolts are tightened in accordance with Table 5, page 24, Installation of Assembly.

Connect the ground bus splice at each shipping section. Remove the hardware and position the splice plate and tighten hardware on both ends.

THE GROUND BUS MUST BE CONNECTED FOR PROPER OPERATION OF RELAYING, INSTRUMENTATION AND PERSONNEL SAFETY.

Consult the customer wiring diagram for reconnection of wiring at the shipping break. Each wire will be identified, and it has been previously connected during assembly and testing at the factory. If the identification is missing or blurred, ring-out before connecting to avoid start up control circuit and instrument panel problems.

With all primary and control power circuits de-energized, insert each circuit breaker into the connected position of its respective breaker compartment and observe the operation of the ground contacts, shutters, secondary control power plug and disconnect position latch operation.

Remove each circuit breaker from its compartment. Open the shutters and check that impressions from main disconnects extend back a minimum of 1/2" from front edge on each bar. Check that ground shoe leaves tracks on breaker ground bus.

DO NOT FORCE CIRCUIT BREAKERS INTO CIRCUIT BREAKER COMPARTMENTS. COMPARTMENT RATING INTERLOCKS PREVENT INSERTING CIRCUIT BREAKERS INTO INCORRECT CELL.

Withdraw the drawout control power fuse drawer and the drawout voltage transformer drawer and observe their operation. Check that the static ground operates properly and that the primary and secondary contacts are making properly.

The bus and circuit breakers should be Hi Pot tested or Resistance tested as an assembly before the external power connections are made.

LIGHTNING ARRESTERS (if provided) ARE NOT CONNECTED AT THE FACTORY.

WITHDRAW THE CONTROL POWER TRANSFORMER DRAWER, THE VOLTAGE TRANSFORMER DRAWER AND DRAWOUT FUSE DRAWER (if provided) BEFORE HI-POT OR RESISTANCE TESTING.

Disconnect the external source (if used) from the space heaters and reconnect the space heaters to their original connection.

Place all of the circuit breakers in their proper circuit breaker compartments in the operate position, charge their springs manually and close by means of the manual pushbutton on each circuit breaker.

CAUTION

VACUUM CIRCUIT BREAKERS MUST BE CLOSED WHILE PERFORMING HI-POTENTIAL TESTS TO ELIMINATE POSSIBLE RADIATION OF X-RAYS. SEE VACUUM CIRCUIT BREAKER MANUAL FOR DETAILS.

Hi Pot testing should only be done with a reliable transformer type tester with a built in voltmeter and miliammeter. Capacitor loaded bench type testers with neon bulb indicators do not have sufficient capacity to give reliable results.

Resistance measurements should be made with a motor driven 1000 or 2500 volt megger with sufficient scale range to read at least 250 megohms on the scale before it indicates infinity.

See Tables 3 & 4 for normal test values for dry, clean, new assemblies. Field high-potential tests are made at 75% of factory test voltages in accordance with ANSI standards.

If satisfactory results are not obtained the trouble should be located, corrected and the test rerun, before proceeding.
The assembly should now be ready for connecting the power cables, ground wires, external wiring and battery (if supplied).

Field Test Levels

Table 3

ONE MINUTE HIGH-POTENTIAL TEST*			
ASSEMBLY RATED MAXIMUM VOLTAGE	FACTORY TEST VOLTAGE	FIELD TEST VOLTAGE	
		AC	DC
4.76kV	19kV	14kV	20kV
8.2kV	36kV	27kV	38kV
15kV	36kV	27kV	38kV

*All Voltages Are 60Hz RMS Symmetrical.

Table 4

PRIMARY INSULATION RESISTANCE MEASUREMENTS*		
ASSEMBLY RATED MAXIMUM VOLTAGE	NUMBER OF CONNECTED CIRCUIT BREAKERS	MINIMUM ACCEPTABLE ASSEMBLY RESISTANCE
4.76kV	1-3 4+	30 Megohms 25 Megohms
8.2kV	1-3 4+	55 Megohms 50 Megohms
15kV	1-3 4+	80 Megohms 75 Megohms

* All measurements are made phase to phase AND phase to ground.

Phasing

All bus within the switchgear is phased A-B-C left to right, top to bottom and front to back when viewing the assembly from the front (the circuit breaker compartment side) per NEMA standards. If for any reason bus must be phased different than noted above, the phase will be identified on the bus with a label.

If the incoming main power source cables are connected to provide the proper phase rotation it eliminates feeder phase rotation problems and reconnecting of metering or relaying that depends on proper phase rotation for operation.

Individual feeder cables can be rung out and tagged before connecting to the bus pads which will assist in keeping the complete system in the proper phase rotation.

ASSEMBLIES THAT HAVE TWO SOURCES OF MAIN POWER AND THAT CAN BE SUPPLIED FROM EITHER SOURCE OR FROM BOTH SOURCES IN PARALLEL THRU A TIE BREAKER MUST HAVE BOTH SOURCES COMPARED AND HAVE NOT ONLY THE PROPER PHASE ROTATION BUT THE SAME ABSOLUTE PHASE (ZERO VOLTAGE DIFFERENCE) ON THE SAME PHASE.

Cable Connections

Extreme care should be taken when making up all types of cable terminations as the successful operation of the electrical distribution system will depend on successful terminations. Avoid sharp turns, edges or corners in order to prevent damage to the cable installation. Follow the cable manufacturer's recommendations for minimum bending radius. These instructions will vary from manufacturer to manufacturer.

The most common method for connecting power cables to metal-clad switchgear is by use of solderless or compression type cable lugs. Follow the cable manufacturer's instructions for making the terminations for each type of power cable. After the cable connections have been made they should be insulated as described below. Place SCOTCHFIL putty (3M Company) around the lugs and bolts to reduce the concentrated field created by their irregular shapes. (See Figure 19.) A layer of #13 semi-conducting tape should be used over the SCOTCHFIL. This tape is to be half-lapped and touch the conductor. It should not extend up over the bus epoxy insulation. Apply Scotch Brand #130C tape over the #13 tape. This tape is to be half-lapped for two layers on 5kV installations and four layers for 7.2kV and 15kV installations. The tape is to extend 1½ inches for 5kV and 2 inches for 15kV up over the bus insulation and cable insulation.

Two layers of Scotch Brand #22 tape are to be applied next and extended up over the #130C tape in all directions. **The tape and other insulating materials for completing these field connections are not normally supplied with the switchgear.**

Table 5

TORQUE—FOOT POUNDS		
BOLT SIZE	SAE #2 STEEL BOLTS①	SAE #5 STEEL BOLTS②
1/4-20	7	10
5/16-18	14	20
3/8-16	21	35
1/2-13	42	70

① For sheet-metal joints and TLD brass lugs.
② For electrical connections, copper or aluminum.

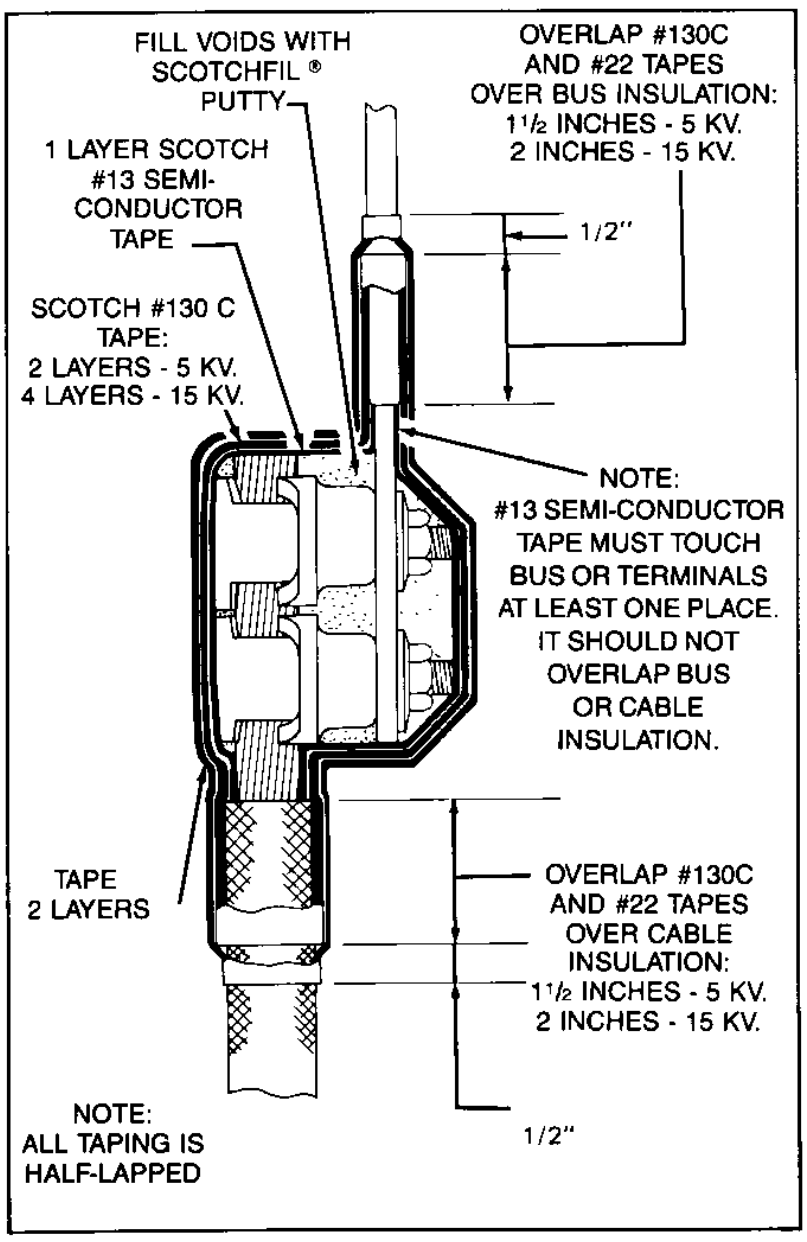


Figure 19
Terminal Insulation, High Voltage Cables.

Potheads

When potheads or terminators are supplied for terminating power cables, the customer should follow the pothead manufacturer's instructions for terminating the cables in these devices. The bus side is not taped to facilitate installation of the power cables. After the cables have been made up, insulate the pothead to bus connections per the instructions previously described for insulating cable lugs.

Flexible Connectors

Occasionally, flexible connectors are provided for relieving the strain on insulators when the switchgear is connected to a transformer. These connectors also facilitate the connections between equipment supplied from various facilities. Flexible connectors used for these applications must be taped to provide adequate insulation. The taping instructions discussed under cable connections should be followed.

START UP

BEFORE THE MAIN SOURCE OF POWER IS CONNECTED TO THE ASSEMBLY, A THOROUGH PRE-START UP NO VOLTAGE CHECK SHOULD BE MADE.

Every compartment should be vacuumed out, all loose parts, tools and miscellaneous construction items and litter should be removed.

All the main bus covers and any other barriers or covers which were removed during installation should be put in place.

The cable compartment back covers should be installed.

The battery charger and batteries (if used) should be connected to the switchgear control bus per the order drawings.

All of the protective relays should be unblocked and set to the relay schedule. A relay test set should be used to verify the settings and electrical operation of each relay.

The Drawout Control Power Transformer (or Drawout Fuse Drawer) should have the current limiting fuses in place. BUT the drawer should be in the withdrawn position.

The Drawout Voltage Transformers should have their current limiting fuses in place, BUT the drawer should be in the withdrawn position.

All the circuit breakers should be in their compartments and in the test/disconnect position.

CONNECT A TEMPORARY SOURCE OF LOW VOLTAGE POWER TO THE STATIONARY SECONDARY CONTACT OF THE CONTROL POWER TRANSFORMER OR ANY LOGICAL POINT. (CONSULT THE CUSTOMER SCHEMATIC AND WIRING DIAGRAM.) **OPEN THE SECONDARY BREAKER AND REMOVE THE PRIMARY FUSES.**

Rack one circuit breaker at a time into the connected position and electrically close and open with the door mounted circuit breaker control switch. Open the circuit breaker by "bumping" the contacts of each protective relay. Reset the targets after each operation.

Electrically operate from remote control locations, check remote indicating lights etc.

Operate all electrical interlocking, transfer schemes, lock out relays and other control functions to insure proper operation.

REMOVE THE TEMPORARY SOURCE OF LOW VOLTAGE POWER AND MAKE THE PERMANENT CONNECTION OF LOW VOLTAGE POWER. RACK ALL CIRCUIT BREAKERS INTO THEIR CONNECTED POSITION. INSERT THE DRAWOUT CONTROL POWER TRANSFORMER, DRAWOUT FUSES, AND DRAWOUT VOLTAGE TRANSFORMERS INTO THE OPERATE POSITION.

Test (again) trip voltage is available at breaker terminals in each compartment.

Energize incoming high voltage circuit(s).

Close breakers to initiate service.

INSPECTION AND MAINTENANCE

Inspection and maintenance should be performed on the basis of operating conditions and experience. Abnormal operation or

conditions may require immediate action while regularly scheduled inspection and maintenance will depend on when "down-time" can be tolerated and qualified personnel are available. Unfortunately "down-time" is usually only available at night, weekends or holidays so maintenance must be properly planned and scheduled well in advance.

Read the entries in the inspection and maintenance log book to help determine the work to be done, replacement parts available and to estimate the "down-time" and personnel required. Do not rush and take unnecessary short cuts or by-pass good safety practices because of poor planning.

INSPECTION AND MAINTENANCE SHOULD ONLY BE DONE WITH THE MAIN SOURCE/SOURCES OF POWER DISCONNECTED AND LOCKED OPEN WITH A WORK LOCK. BE ABSOLUTELY SURE THERE IS NO BACK FEED THRU ANY FEEDER CIRCUIT. GROUND THE MAIN AND FEEDER CIRCUITS BEFORE TOUCHING THE MAIN BUS, BUS PADS OR PRIMARY CONTACTS.

Main Bus Compartment

Remove the covers from each main bus compartment and inspect the bus bars, primary contact supports and the insulating barriers and thru bushings. All insulation should be clean with no indication of carbon deposits.

Track paths or "treeing" indicate areas of high voltage stress and insulation deterioration. All aged insulation should be replaced immediately or scheduled for replacement during the next scheduled maintenance depending on the severity of the deterioration.

Remove the insulating boots from the primary contacts and check the bolts for proper tightness. See Table 5, page 24 for proper torque. Slight discoloration or tarnish of the silver plate is normal and of no concern. Severe discoloration of the silver plate is an indication of an improper or loose contact and overheating. Clean the discoloration from the contact surfaces of the bus bar and primary contact.

Use a commercial silver polish or denatured alcohol to clean the silver plated contact surfaces. CAUTION: Keep away from sparks or flame. Avoid breathing large quantities of vapor and excessive contact with skin. Do not use sandpaper or other abrasive materials that will scar or remove the silver plate.

Vacuum each compartment to remove dust, spiderwebs, etc. Wipe off the insulation with a clean cloth. Replace the insulating boots and the removable covers.

Cable Compartment

Inspect the load connectors, stand-off insulators, primary contact supports and all accessible cable terminations for indication of insulation deterioration.

Remove the insulating boots from the primary contacts and check for discoloration and bolt tightness. Clean the silver plated contact surfaces if necessary and tighten in accordance with Table 5, page 24.

Vacuum each compartment and wipe off all insulation. Replace the insulating boots and the removable back covers.

Drawout Control Power Transformer Compartment

Withdraw the drawer to the fully withdraw position. Inspect the moving and stationary primary and secondary contacts and the static ground contacts. All contacts should be free of burning or pitting marks and of any build up of grease or dirt, and should have bright shiny areas where the contacts have been made. Clean the contact surfaces and remove any burning or pitting marks. Both the stationary primary and secondary contacts have adjustable compression springs that can be adjusted if necessary to increase contact pressure.

Remove the current limiting fuses and inspect the fuse clip and fuse contact surfaces. Clean if necessary. Inspect the control power transformer for indication of insulation deterioration. Tighten all hardware including the secondary contact wiring terminals.

Vacuum the compartment and drawer and wipe off the insulation and control power transformer with a clean dry cloth.

Lightly lubricate the moving primary and secondary contacts with Square D contact grease #PJC-7201. DO NOT USE NO-OXIDE, METALLIC PARTICLE OR LOW TEMPERATURE GREASES. DO NOT GET GREASE ON INSULATION OR ON THE CONTROL POWER TRANSFORMER.

Inspect the molded case circuit breaker and interlock mechanism for proper operation. Replace the current limiting fuses BUT leave the drawer in the withdrawn position until all the inspection and maintenance is completed.

Drawout Voltage Transformer Compartment

Withdraw the drawer to the fully withdrawn position. Inspect the moving and stationary primary and secondary contacts and

the static ground contacts. All contacts should be free of burning or pitting marks and of any build up of grease or dirt, and should have bright shiny areas where the contacts have been made. Clean the contact surfaces and remove any burning or pitting marks. The stationary primary contacts have adjustable compression springs that can be adjusted if necessary to increase contact pressure.

Remove the current limiting fuses and inspect the fuse clip and fuse contact surfaces. Clean if necessary. Inspect the voltage transformer for indication of insulation deterioration. Clean all hardware including the secondary contact wiring terminals.

Vacuum the compartment and drawer and wipe off the insulation and voltage transformer with a clean dry cloth.

Lightly lubricate the moving primary and secondary contacts with Square D contact grease #PJC-7201 or equal. DO NOT USE NO-OXIDE, METALLIC PARTICLE, OR LOW TEMPERATURE GREASES. DO NOT GET GREASE ON INSULATION OR ON THE VOLTAGE TRANSFORMER.

Replace the current limiting fuses, BUT leave the drawer in the withdrawn position until all inspection and maintenance is completed.

Drawout Fuse Compartment (If Supplied)

Withdraw the drawer to the fully withdrawn position. Inspect the moving and stationary line and load contacts and the static ground contacts. All contacts should be free of burning or pitting and any buildup of grease or dirt, and should have bright shiny areas where the contacts have been made. Clean the contact surfaces and remove any burning or pitting marks. The stationary line and load contacts have adjustable compression springs that can be adjusted if absolutely necessary.

Remove the current limiting fuses and inspect the fuse clip and fuse contact surfaces. Clean if necessary. Tighten all hardware including the secondary contact wire terminals.

The control power transformer will be located in the cable compartment of the same cell and should be inspected for insulation deterioration. Clean and have the connections tightened.

Vacuum the compartment and drawer and wipe off stand-off insulators with a clean, dry cloth.

Lightly lubricate the moving primary and secondary contacts with Square D contact grease #PJC-7201, or equal. DO NOT USE NO-OXIDE, METALLIC PARTICLE, OR LOW TEMPERATURE GREASE. DO NOT GET GREASE ON STAND-OFF INSULATORS.

Replace the current limiting fuses, BUT leave the drawer in the withdrawn position until all inspection and maintenance is completed.

Circuit Breaker Compartment

Withdraw each circuit breaker from its compartment and thoroughly inspect each of the moving mechanisms in the compartment.

The shutters, mechanism operated cell switch and truck operated cell switch should raise and lower smoothly with no indication of binding, twisting, hesitation or hang-up. Inspect and tighten their hardware if necessary.

Primary contacts should be free of burning or pitting marks and should have bright shiny surfaces indicating good contact with the circuit breaker separable contacts. Slight discoloration or tarnish of the silver plate on the primary contact is normal and of no concern. Severe discoloration of the silver plate is an indication of excessive heating and should be corrected. Typical causes are: poor contact between the circuit breaker separable contacts and the primary contacts, loose hardware or otherwise improper contact at the bus connection, severe overcurrent operating condition for an extended period of time or internal heating problems in the circuit breaker. Each possible source of trouble should be investigated and corrected. Rated contact force is 5.5 lbs. on each end of each finger of the main separable contact.

Consult the "Installation and Maintenance Log Book" for the condition of the primary contacts in the main bus and cable compartments and for operating history for that particular circuit breaker. If the problem is in the circuit breaker, it should be tagged and given a thorough inspection and maintenance before returning to service. Clean the discoloration and tighten the contact mounting bolts to the proper torque. Inspect the primary contact high voltage mounting tubes and support insulation. All insulation should be clean with no indication of track paths or "treeing", cracks or other mechanical damage. Damaged insulation should be replaced immediately or scheduled for replacement during the next scheduled inspection and maintenance depending on the severity of the deterioration.

The ground contact should be free of burning or pitting marks and should have bright shiny marks indicating good contact with the circuit breaker sliding contacts. Clean the contact surfaces to remove grease and dirt build up and inspect and tighten the hardware. Relubricate with grease #PJC-7201, or equal.

Inspect the stationary control power receptacle. The molding should be free of cracks, the female contacts clean, and the assembly free to move the mounting bolts. DO NOT TIGHTEN THE MOUNTING BOLTS AND PREVENT THE ASSEMBLY FROM FLOATING. Clean the front and back surfaces of the receptacle to prevent contamination build up

Vacuum the compartment and wipe off the primary contact high voltage insulating tubes and support insulation with a clean dry cloth.

Lightly lubricate the primary stab and the ground contacts with Square D grease #PJC-7201. DO NOT ALLOW GREASE TO GET DIRECTLY ON THE PRIMARY HIGH VOLTAGE INSULATING TUBES, SUPPORT INSULATION OR ON THE FRONT AND BACK OF THE CONTROL POWER RECEPTACLE.

Check all terminal block connections for loose hardware and crimp-on terminal condition. The hinge wiring to the door should not be frayed nor have insulation damage, and all wires should be contained in the hinge loop.

Compare the individual protective relay setting with the relay schedule and test each relay with a test set to verify the settings and proper operation. Consult the manufacturers literature for detailed inspection and maintenance procedure for each type of relay.

The batteries and battery charger (if provided) should be given a thorough inspection in accordance with the manufacturer's recommendations. Refer to the manufacturer's instruction manual in the Job Instruction Manual for cleaning, tightening of terminals, water level, etc.

Circuit Breakers

Type FG-2 (SF_6) and Type VAD-2 (Vacuum) circuit breakers are minimal maintenance devices. The interrupters are sealed mechanisms and do not require internal inspection or maintenance.

Consult the individual circuit breaker instruction and maintenance manual for cleaning, adjustments and lubrication.

Preparation For Return To Service

It should not be necessary to Hi Pot the assembly after a normal inspection and maintenance, but a resistance measurement comparison is advisable. Consult the "Installation and Maintenance Log Book" for previous readings.

Place all circuit breakers, except the main circuit breaker, in the connected position; but do not close. Make phase to phase and phase to ground resistance measurements on the main bus side primary high voltage stabs in the main circuit breaker compartment.

Resistance measurements should be made with the same or similar type megger that was used on previous testing if at all possible. The resistance readings should be no lower than when originally installed and will probably be higher because of the way the testing is being done. Lower resistance readings are an indication of possible insulation deterioration that was missed during the inspection and maintenance. Localize the problem, correct and retest before putting the assembly into service.

If proper previous resistance measurement records are not kept refer to Table 4, page 23, for MINIMUM ACCEPTABLE READINGS.

Rack all of the circuit breakers to the TEST/DISCONNECT position with their secondary control power plugs engaged and close the compartment doors. Insert the control power transformer and voltage transformer drawers in the operate position.

Close the main source/sources of power and operate each circuit breaker electrically in the TEST/DISCONNECT position. CAUTION: THE MAIN BUS AND ALL HIGH VOLTAGE PARTS MUST BE CONSIDERED HOT AND IN OPERATION AT THIS TIME.

ACCESSORIES

Circuit Breaker Lift Truck (Figure 20)

One circuit breaker lift truck is required for each two-high assembly. It is intended to be used for the circuit breakers in the top compartments of the two-high cells, but it may also be used for the lower compartments.

The cradle is raised and lowered by self-braking worm and pinion drive system with a winch and wire cable. No ratchet release or locking is required due to the automatic load retaining clutch feature. A clockwise rotation of the handle raises the cradle and counterclockwise lowers it.

Push the lift truck toward the circuit breaker compartment so that the cradle is square with the front of the circuit breaker compartment. Raise the cradle until the two holes in the cradle clear the two pins in the front of the circuit breaker compartment floor. Lower the cradle until the pins lock in the holes and the cradle bottom rests on the compartment floor locking the lift truck to compartment. Release the disconnect position latch and roll the circuit breaker directly from the compartment onto the cradle and pull forward until the circuit breaker/lift truck latch is engaged.

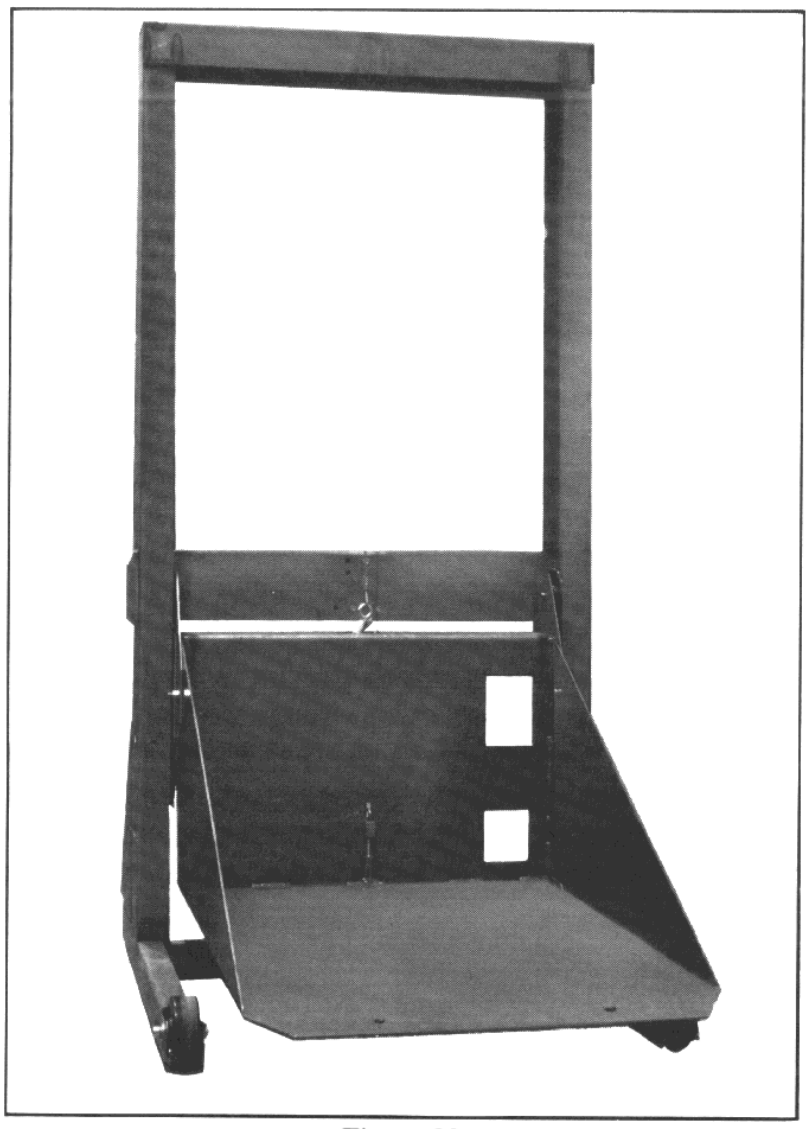


Figure 20
Breaker Lift Truck.

DO NOT RAISE THE CRADLE AND MOVE THE LIFT TRUCK UNLESS THE CIRCUIT BREAKER/LIFT TRUCK LATCH IS ENGAGED AND IS HOLDING THE CIRCUIT BREAKER SECURELY AGAINST THE FRONT OF THE LIFT TRUCK AND THE BACK-UP SAFETY CABLE IS HOOKED TO THE BREAKER FRONT HANDLE.

The circuit breaker/lift truck latch may be released when the circuit breaker is lowered to the floor level. An access hole is provided in the cradle front panel to easily reach the circuit breaker/lift truck latch.

Two fixed wheels on the compartment side and two swivel wheels on the operator side of the circuit breaker lift truck provide for maneuverability in limited aisle space.

CAUTION

LUBRICATION OF ANY KIND MUST NOT COME IN CONTACT WITH THE LOAD RETAINING CLUTCH.

Test Cabinet (Option) (Figure 21)

An optional wall mounted test cabinet may be furnished if specified in the users specification.

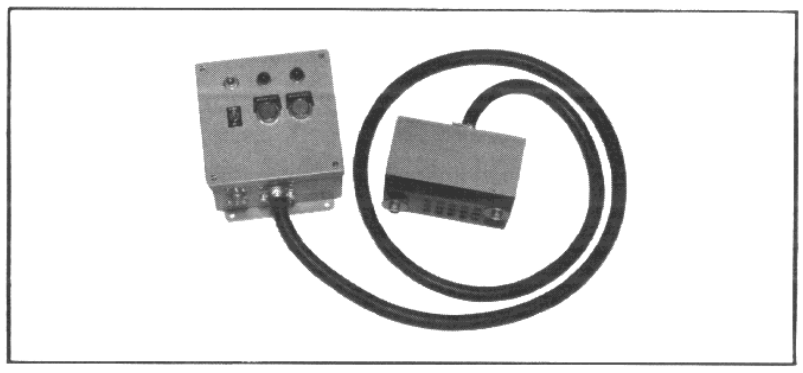


Figure 21
Breaker Test Cabinet.

The test cabinet consists of a small enclosure with a Power ON-OFF toggle switch, White Power-On indicating light, Red Circuit Breaker Closed indicating, Green Circuit Breaker Open indicating light, Close and Open pushbuttons and an 8 foot cable with a Secondary Control Power Receptacle.

Mount the test cabinet on a wall approximately 4 feet above the floor. The location must allow for sufficient working space to move a circuit breaker in and out, to be able to easily get around the circuit breaker, and to be able to manually insert the cable mounted secondary control power receptacle on to the circuit breaker mounted secondary control power plug. Consult the customer drawings for the external power connections and requirements necessary for the cabinet. A convenient terminal block is provided inside the test cabinet for these connections.

Ground And Test Device (Option)

Two types of ground and test devices are available:

(1) Manual
(2) Automatic

Manual ground and test devices are designed to mechanically and electrically withstand their rated short circuit current for two seconds.

Automatic ground and test devices are designed to close into and mechanically and electrically withstand their rated short circuit current for two seconds.

Ground and test devices are safety devices, typically used for:

a) Grounding of circuits during maintenance periods.

b) Connection points for applying voltage for hi-pot testing and cable testing.

c) Access to both line and load side circuits for phase sequence testing.

d) Connection points for emergency connection of an alternate power source during a prolonged unscheduled or scheduled main power source outage.

Complete description, operating instructions and maintenance information is included in separate Ground and Test Devices Instruction Manual.

INSTALLATION AND MAINTENANCE LOG BOOK

An installation and maintenance log book should be started and kept current for reference. The log book may be only a loose leaf note book, but if good entries are made it becomes a reliable source of information when maintenance is performed as well as a guide to when immediate or normally scheduled maintenance is required.

Typical installation and start up entries are:

Date of installation and contractor or workman names.

List of problems (if any) during installation, and any parts damaged and replaced or modification made.

Date of pre-start up check, checks made, resistance or Hi Pot results and contractor or workman's names.

Date of start up and acceptance and names of personnel involved.

Circuit breaker serial numbers with operation counter reading for each, and circuit identification.

Typical operational entries are:

Dates of unscheduled outages due to main source of power failure.

Dates of severe thunder and lightning storms in area.

Dates of individual circuit breaker operation due to protective relay opening, with relay operated and circuit identification.

Dates and description of abnormal sounds, vibrations, etc. within the assembly, and action taken.

Dates of variations in meter readings and possible reasons.

Typical maintenance entries are:

Date of maintenance and workman's names.

Circuit breaker serial numbers with operation reading for each, operations since start up/ last maintenance and circuit identification.

Specific list of all maintenance work done.

Specific list of any parts to be replaced or work to be done immediately or at next maintenance period.

List parts ordered, when received, where stored, etc.

The log book, complete instruction manual and a complete set of as-installed customer drawings should be kept together in one safe place (preferably in the metal-clad switchgear assembly area) and available for use and reference by authorized personnel.

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