GEH-5305

Instructions

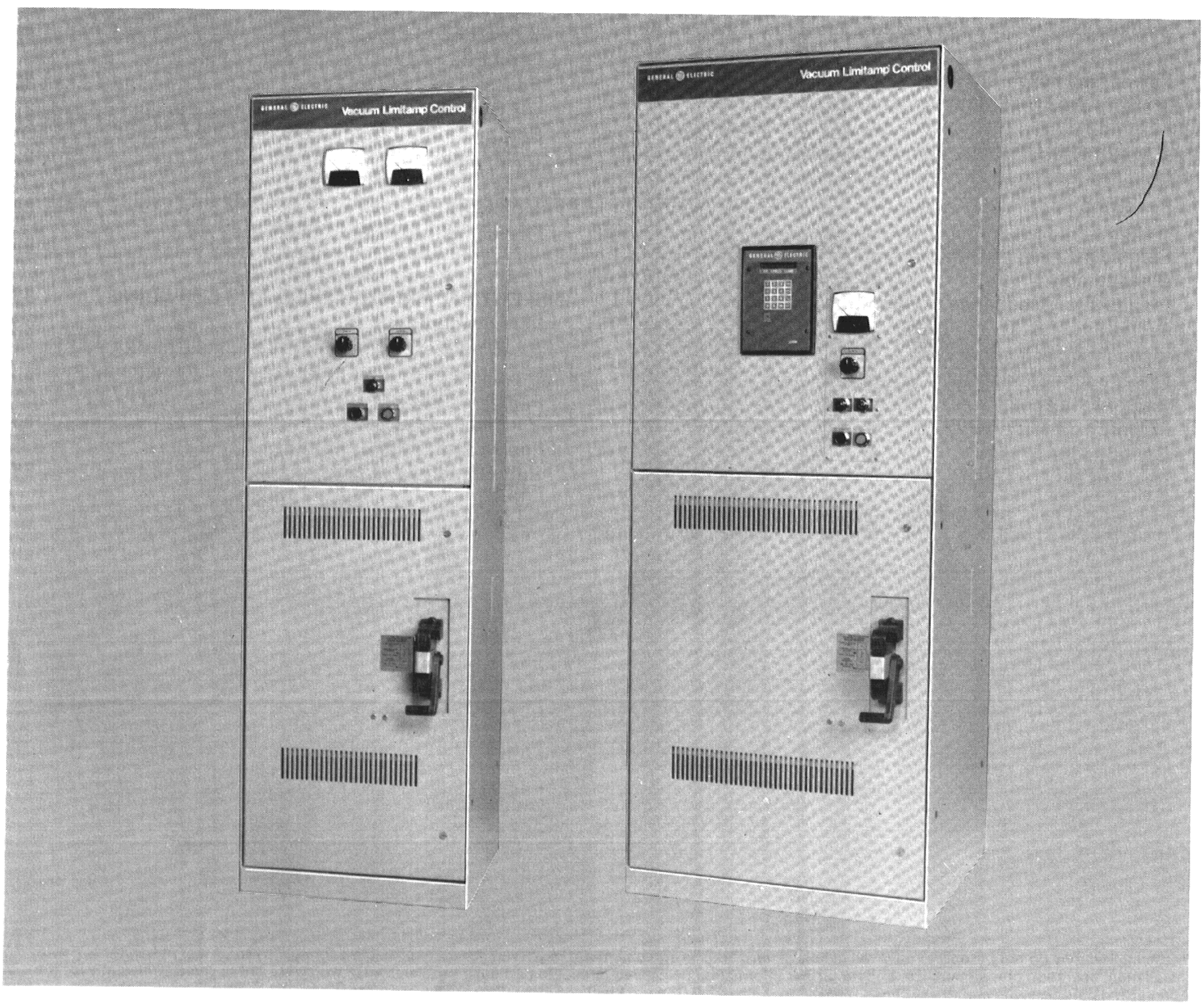
CR194 Vacuum Limitamp™ Control

Controllers with Contactor Control Module

Utilization Voltage —
2.4 through 7.2 KVAC
One-high Starters rated —
200 and 400 ampere
Full-voltage, Non-reversing
(FVNR)

WARNING: *DO NOT ATTEMPT TO PERFORM ANY MAINTENANCE ON THIS EQUIPMENT UNTIL ALL POWER IS REMOVED FROM THE MAIN BUS AND ANY ATTACHED ROTATING EQUIPMENT HAS COASTED TO A COMPLETE STOP.*

CAUTION: *PRODUCT IS NOT INTENDED FOR NUCLEAR USE.*



GENERAL ELECTRIC

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WARNING: *BEFORE ANY ADJUSTMENTS, SERVICING, PARTS REPLACEMENT OR ANY OTHER ACT IS PERFORMED REQUIRING PHYSICAL CONTACT WITH THE ELECTRICAL WORKING COMPONENTS OR WIRING OF THIS EQUIPMENT, THE POWER SUPPLY MUST BE DISCONNECTED.*

USER PERSONNEL MUST BE COMPLETELY FAMILIAR WITH THE FOLLOWING OPERATING AND MAINTENANCE INSTRUCTIONS BEFORE ATTEMPTING TO SERVICE THIS EQUIPMENT.

WARNING: *THE VACUUM INTERRUPTER INTEGRITY TEST SHOULD BE PERFORMED BEFORE THE HIGH VOLTAGE VACUUM CONTACTOR IS ENERGIZED FOR THE FIRST TIME AND EACH TIME IT IS RETURNED TO SERVICE AFTER MAINTENANCE, ADJUSTMENT OR REPAIR.*

FAILURE TO PERFORM THESE TESTS MAY RESULT IN SERIOUS INJURY OR DEATH.

Introduction

Vacuum Limitamp controllers are designed to meet NEMA ICS2-324 "AC General Purpose High-voltage Class E Controllers" and UL 347 requirements, and may be described as metal-enclosed high-interrupting capacity, vacuum-contactor-type starter equipments with manual isolation. Individual starters and controllers are designed for specific applications; the components and functions being dictated by the Purchaser specifications and needs. Controllers may be fused or unfused.

The essential control functions for all types of a-c motors consist of starting, stopping, and overload protection. Vacuum Limitamp controllers also include short-circuit protection, but other functions are provided in each controller as they are applicable to the type of motor being controlled (such as synchronous and wound-rotor motors). Also, special functions are provided in great variety as may be required for particular applications.

These instructions were prepared as a guide to handling, installation, operation and maintenance of all one-high types of Vacuum Limitamp controllers. This includes the 26-inch wide one-high and the 34-inch wide one-high controller. Figure 1 shows the 26-inch wide controller and Fig. 2 shows the 34-inch wide synchronous controller.

The intent of these instructions is to give the Purchaser the necessary general information to identify his controller as to type and function, to describe suggested methods of installation, and to demonstrate some techniques of operation and maintenance. The Purchaser should interpret these instructions for applicability to his particular controller by referring to the nameplate data on the controller and to the electrical diagrams supplied with the controller.

If the controller is for a synchronous motor, these instructions should be used with GEH-5201A.

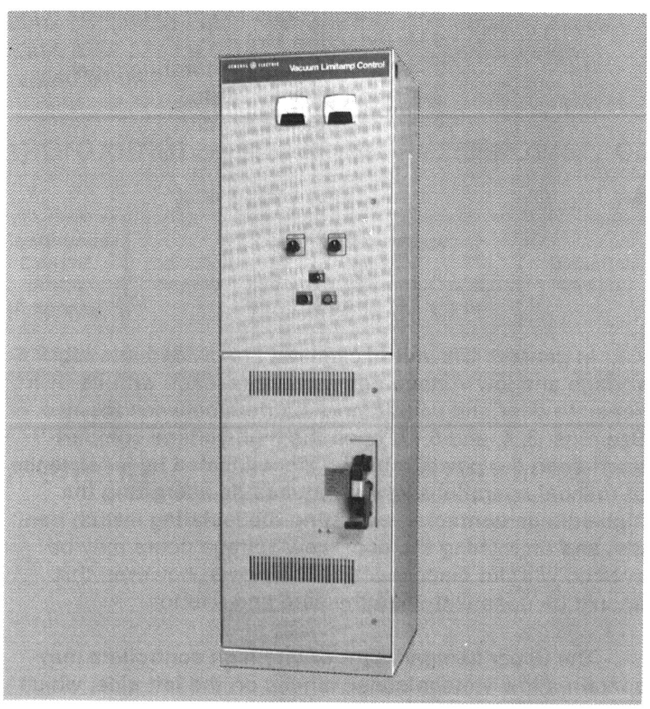


Figure 1. 26-inch wide one-high controller.

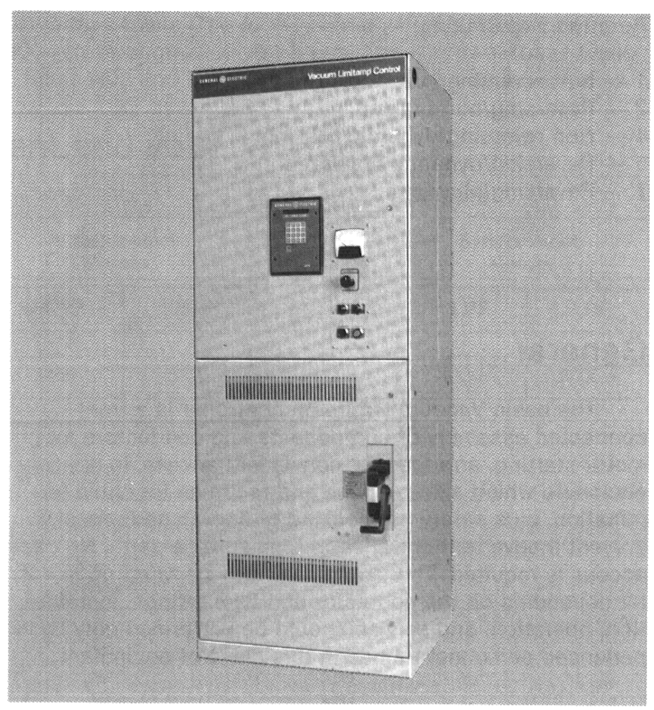


Figure 2. 34-inch wide synchronous controller.

Description

Equipment identification — CR number designation

Basic type designation for all Vacuum Limitamp Control equipment is CR194 with significant alpha-numeric suffixes used to define rating, function, contactor type and enclosure type.

CR194 _ _ _ _ _ _

Starting and Speed Functions

A — Single-speed, full voltage
B — Single speed, reduced voltage reactor type
C — Single speed, reduced voltage autotransformer type
D — Single speed, part winding start
E — Single speed, reduced voltage primary resistor
G — 2 speed, 1 winding full voltage
H — 2 speed, 1 winding reactor reduced voltage
J — 2 speed, 1 winding autotransformer reduced voltage
N — 2 speed, 2 winding full voltage
P — 2 speed, 2 winding reactor reduced voltage
Q — 2 speed, 2 winding autotransformer reduced voltage

Rotation and Braking

1 — Non reversing/non braking
2 — Reversing/non braking
4 — Non reversing/dynamic braking
5 — Reversing/dynamic braking
7 — Reversing/plugging

Controlled Apparatus

0 — Synchronous Motor (brushless type)
1 — Induction Motor
2 — Synchronous Motor (ring type)
3 — Wound Rotor Motor
4 — Transformer Feeder
5 — Capacitor Feeder

System Voltage

7 — 2400 Volts
8 — 4200 Volts
2 — 7200 Volts

Enclosure

A — 26" 1-HI
B — 34" 1-HI

NEMA TYPE

1 = NEMA E1 (Unfused)
2 = NEMA E2 (Fused)

General

The basic Vacuum Limitamp controller is a front-connected assembly of components and conductors for motor starting, arranged for convenient access, in an enclosure which allows space and facilities for cable termination, plus safety interlocking of doors and isolator to prevent inadvertent entrance to high-voltage parts. No back access is required. This equipment may be rated up to 7.2 kV depending on the contactor and fuse ratings. Installation, operation, and service should be performed only by experienced personnel trained in this class of equipment.

In general, the unit enclosures are divided into high-voltage and low-voltage compartments, each with its own

In general, the unit enclosures are divided into high-voltage and low-voltage compartments, each with its own separate door and with interior barriers between the two. See Figs. 3, 4, and 5. **To open the high-voltage compartment door, the power must be disconnected by a sequence of manual operations which requires de-energizing the high-voltage contactor, operating the isolating switch handle, and unlatching the door.** Low-voltage doors may be entered without disconnecting the power; however, this should be done with extreme care and caution.

The upper compartment of one-high controllers may contain a low-voltage panel, hinged on the left side, which acts as a barrier to the high-voltage control power transformer mounted on the upper rear cover.

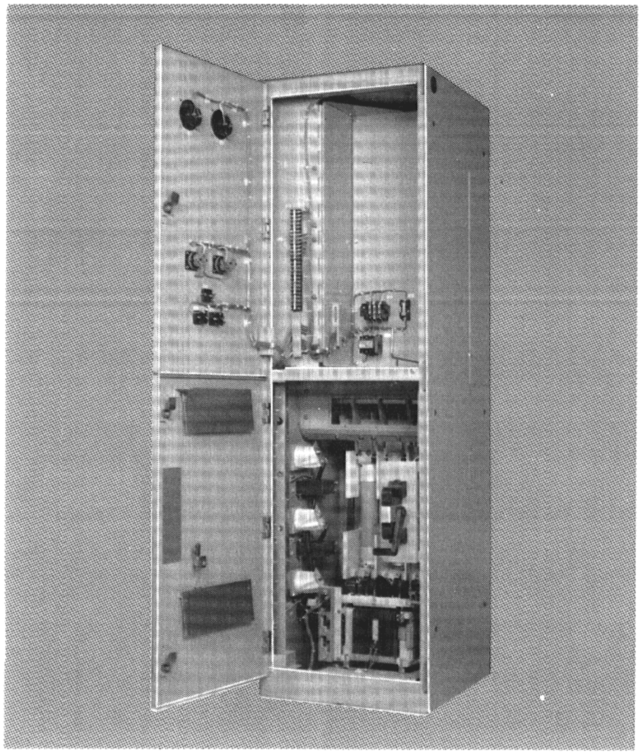


Figure 3. 26-inch wide 200-ampere FVNR starter.

Ratings

Refer to the panel data nameplate (see Fig. 6) on front of the enclosure for detailed ratings applicable to a particular controller. Equipment basic ratings equal or exceed NEMA ICS2-324 for Class E2 Controllers, and are summarized below:

Basic impulse level (BIL)

The standard BIL rating of Vacuum Limitamp controllers is 60 kV crest (design rating). This rating excludes dry-type control transformers and starting reactors or autotransformers. The 200-ampere contactor is rated 45KV BIL.

Dielectric test voltage

2-1/4 x nameplate voltage plus 2000 volts.

High-voltage vacuum contactors

The vacuum contactors used in Vacuum Limitamp controllers are available in three different ratings: 200, 400 and 800 amperes. This publication covers only the 200 and 400 ampere ratings. The contactors are similar in operation but are very different in size and ratings. For this reason they are not directly interchangeable mechanically. See Fig. 7.

The contactors are easily removable from the controller assembly by removing a few bolts that hold the contactor in position and by disconnecting the line and load power connections. The auxiliary contacts and the coil terminals are connected by means of a removable connector that is retained by two wing nuts. By removing these wing nuts, the wiring harness is easily disconnected from the contactor. Refer to the information beginning on Page 13 of this publication that details the correct method for contactor removal.

Vacuum Limitamp Control is supplied standard with bolt-in type fuses. The fuse holders will accommodate 2400-volt through 7200-volt fuses. The length of these types of fuses vary and the lower fuse mount can be adjusted to

Approximate maximum horsepower, current and voltage ratings

2200 — 2400 Volts				4000 — 4800 Volts			7200 Volts		
Continuous Current (RMS) (Amperes)	Induction Motors	Synchronous Motors		Induction Motors	Synchronous Motors		Induction Motors	Synchronous Motors	
		0.8 PF	1.0 PF		0.8 PF	1.0 PF		0.8 PF	1.0 PF
200 Max	800	800	1000	—	—	—	—	—	—
400 Max	1600	1600	2000	3450	3450	3725	4800	4800	6000

NOTE: *Above ratings apply to controllers in NEMA 1, vented enclosure, at 40 degrees C ambient.*

Interrupting ratings at utilization voltage shown

Maximum Volts	Maximum Continuous Amperes (RMS)	Three Phase Symmetrical System MVA	
		Class E1 Unfused	Class E2 Fused
2500	200	25	200
3600	200	37	300
2500	400	29	200
5000	400	50	400
7200	400	50	600

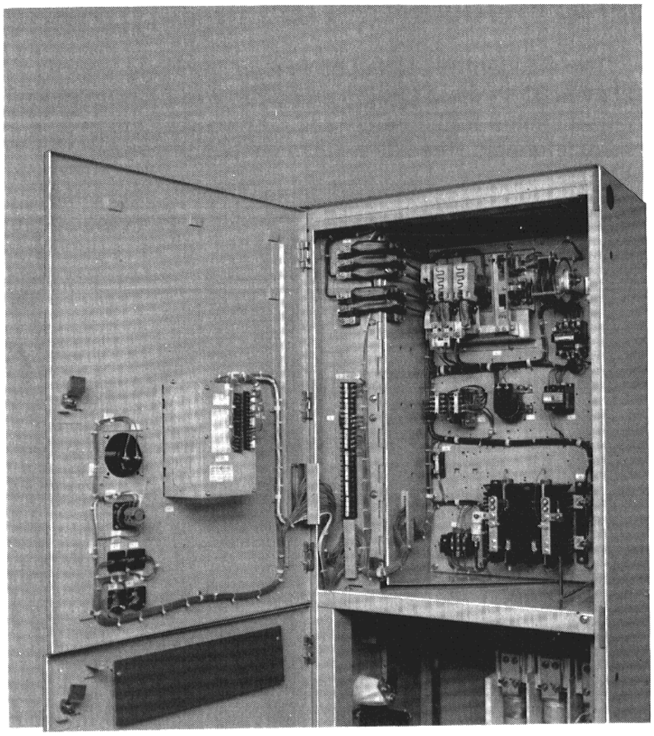


Figure 4. 34-inch wide 400-ampere FVNR synchronous starter low-voltage control section.

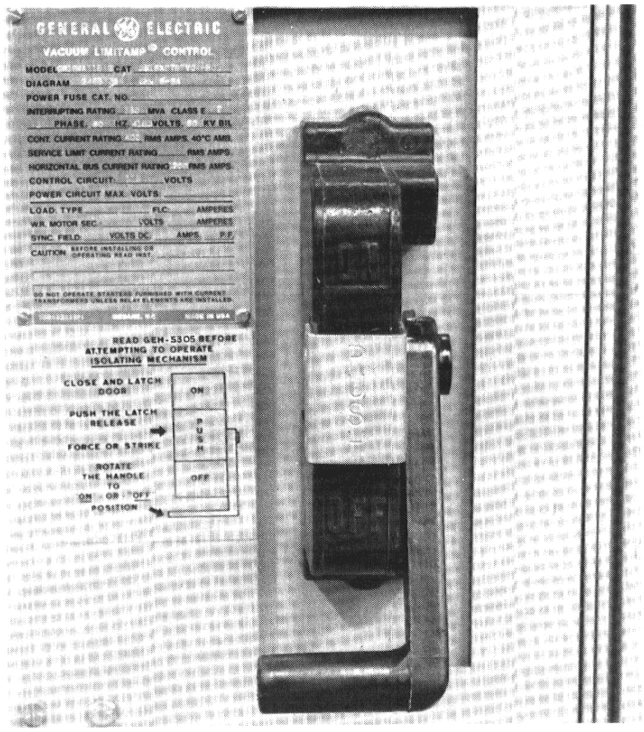


Figure 6. Panel data nameplate.

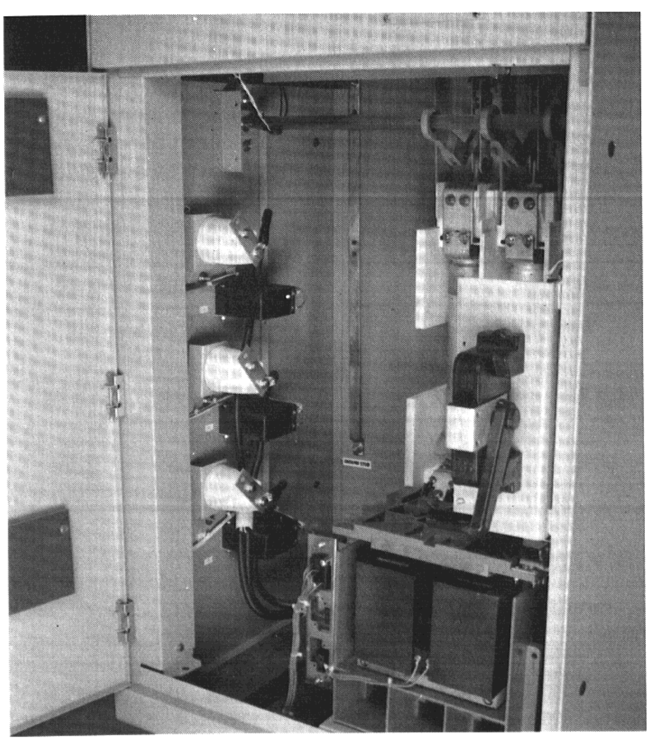


Figure 5. 34-inch wide 400-ampere FVNR synchronous starter high-voltage section showing the 400-ampere contactor.

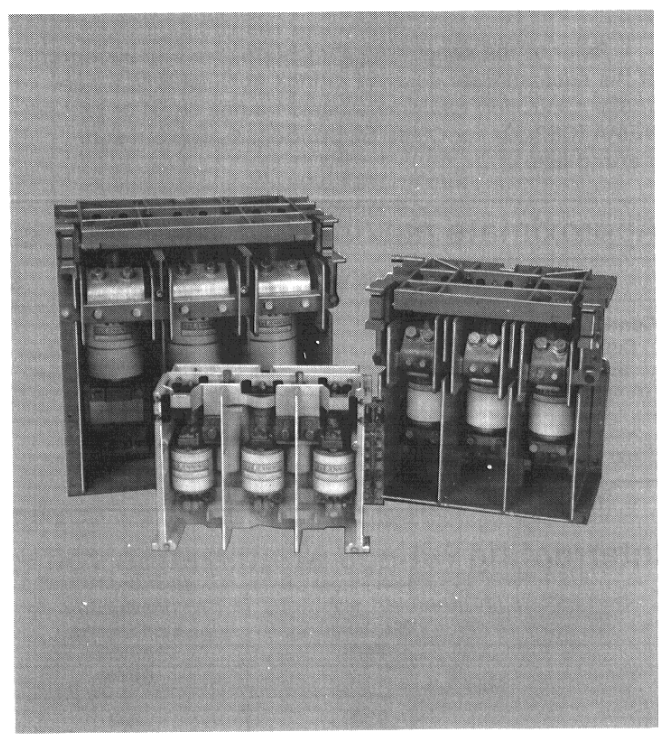


Figure 7. The Vacuum Limitamp control family of contactors.

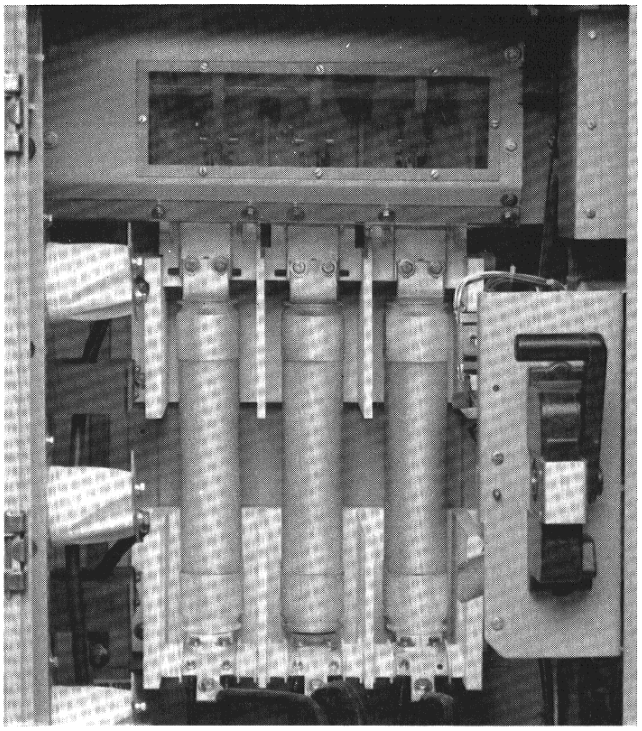


Figure 8. High-voltage compartment showing fuse assembly.

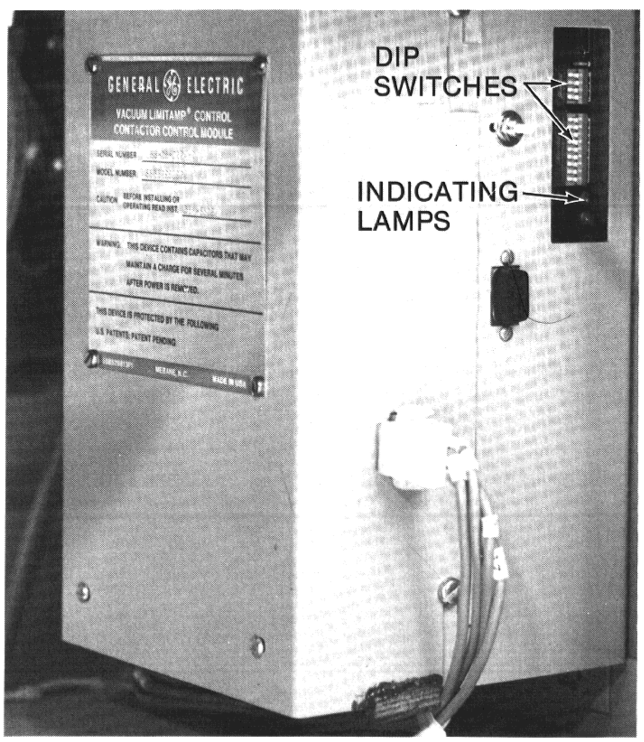


Figure 9. Contactor control module (CCM) — showing indicating lamps and DIP switches.

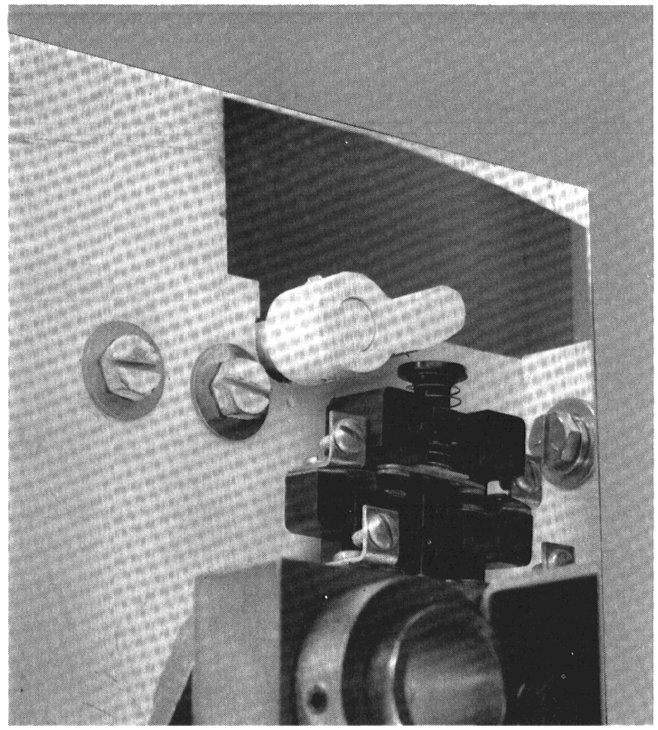


Figure 10. Anti single-phase contact block — wiring removed for clarity.

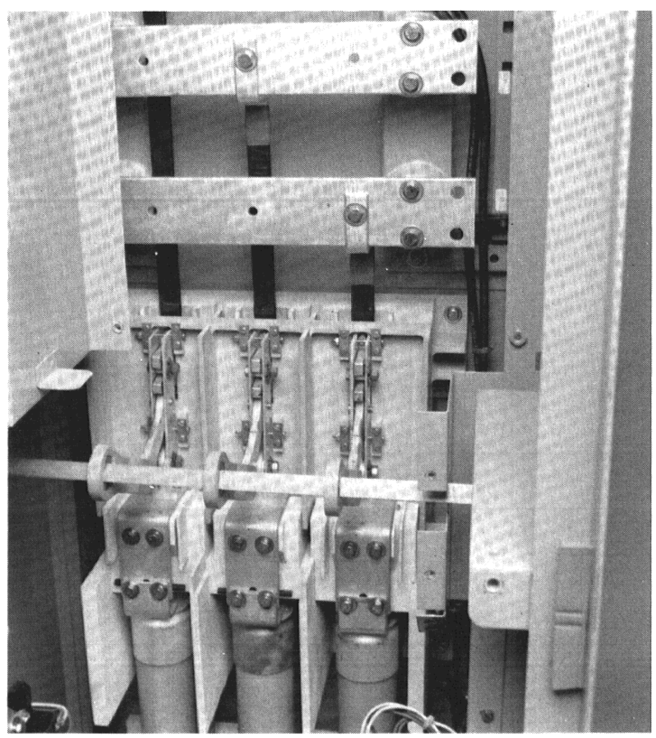


Figure 11. View of disconnect switch in the CLOSED position. Barriers are removed for clarity.

the proper length by unbolting the mount from the back rail and remounting it in the proper location. For 7200-volt applications, the fuses require a slightly different lower mounting strap and the top fuse mounting strap must be changed. This requires that the disconnect switch be disassembled. See Fig. 8.

The vacuum contactors supplied with Vacuum Limitamp Control are magnetically operated by a dc coil rated 120 volts. Power is supplied to the coil by a contactor control module (CCM). The CCM supplies regulated dc power to the coil, eliminates the need for coil economizing resistors, and provides precise control of the contact tip opening point (point-on-wave) in relation to the load current waveform. Point-on-wave control is designed to control the opening of the tips so that the possibility of multiple reignitions and virtual current chopping is greatly reduced. The regulated coil power also provides a means to prevent dropout of the contactor during momentary voltage dips on the power system. The contactor control module is shown in Fig. 9.

Blown fuse indicator

Blown fuse indication is activated by a trip bar located at the rear of the top fuse holder. The blown fuse indicator requires bolt-in type fuses. When one or more of the fuses blow, a small indicator moves upward from the top center of the fuse to indicate which fuse has blown. The right end of the trip bar has a cam that operates an anti-single phase contact which is wired to trip the controller off-line to prevent single phasing of the connected load. See Fig. 10.

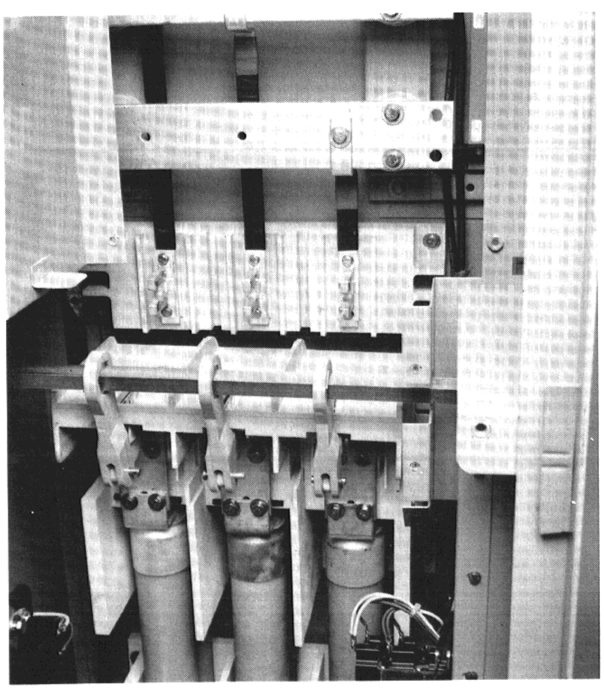


Figure 12. View of the disconnect switch in the OPEN position. Barriers are removed for clarity.

Manual disconnect or isolating mechanism

Vacuum Limitamp controllers, following the NEMA definition, contain a means for manually isolating the power circuit by operation of a disconnecting device. The disconnecting mechanism consists of a quick-make quick-break non-load break disconnect switch (Figs. 11 through 13) which is controlled by the operating handle (See Fig. 6). A fixed barrier (Fig. 13), with a viewing window, is supplied to provide isolation from the energized bus parts. There are no moving shutters that require maintenance. The quick-make quick-break operator is shown in Fig. 15.

Load current is not interrupted by the disconnect switch. A mechanical interlock is provided to ensure that the contactor is in the open position before the operating handle can be actuated. Also, the contactor cannot be operated while the operating handle assembly is being moved from one position to another.

The mechanical isolator will accept up to four padlocks to prevent operation. See Fig. 16.

Mechanical interlocking

Vacuum Limitamp equipment is designed so the high-voltage contactor performs all normal load current interrupting. The current-limiting fuses generally interrupt the fault currents.

NOTE: *The quick-make quick-break manual isolator will not interrupt any load or fault current.*

A mechanical interference system is included with all Vacuum Limitamp controllers (mechanical interlock), which prevents opening of the manually operated isolating contacts unless the high-voltage contactor itself is demonstrated by magnet position to be already open. This is to ensure that the contactor has opened the power circuit and interrupted the current before the disconnect switch may be operated. See Fig. 17.

WARNING: *THE MANUAL ISOLATOR SHOULD NEVER BE FORCIBLY OPERATED. ITS MECHANICAL INTERFERENCE INTERLOCK SHOULD BE DEFEATED ONLY BY KNOWLEDGEABLE AND QUALIFIED ELECTRICAL MAINTENANCE PERSONNEL WHO HAVE DE-ENERGIZED ALL POWER FEEDING THE CONTROLLER.*

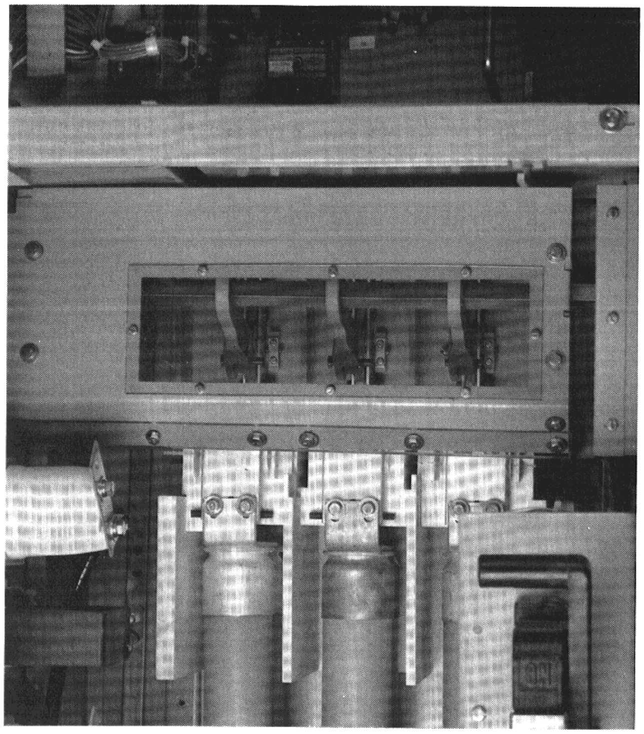


Figure 13. Disconnect switch shown with barrier in place. Switch shown in CLOSED position.

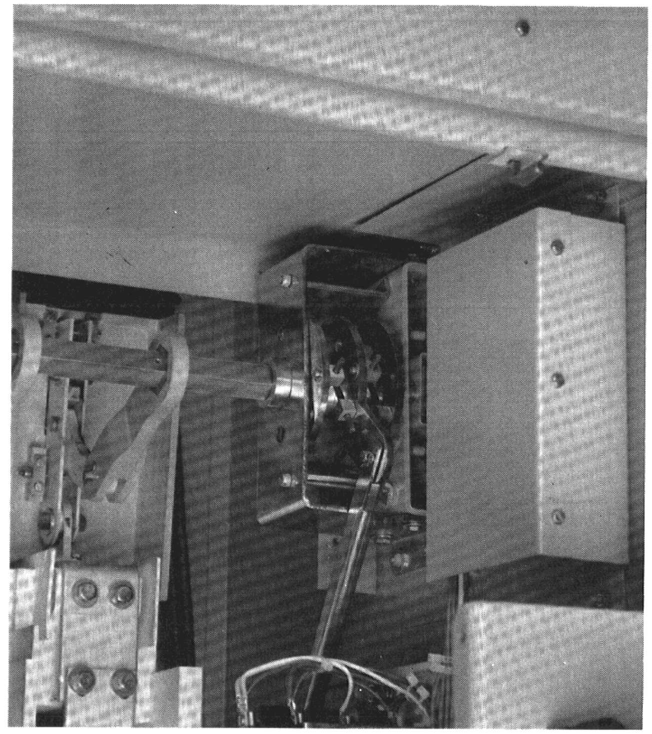


Figure 15. View of quick-make quick-break operator.

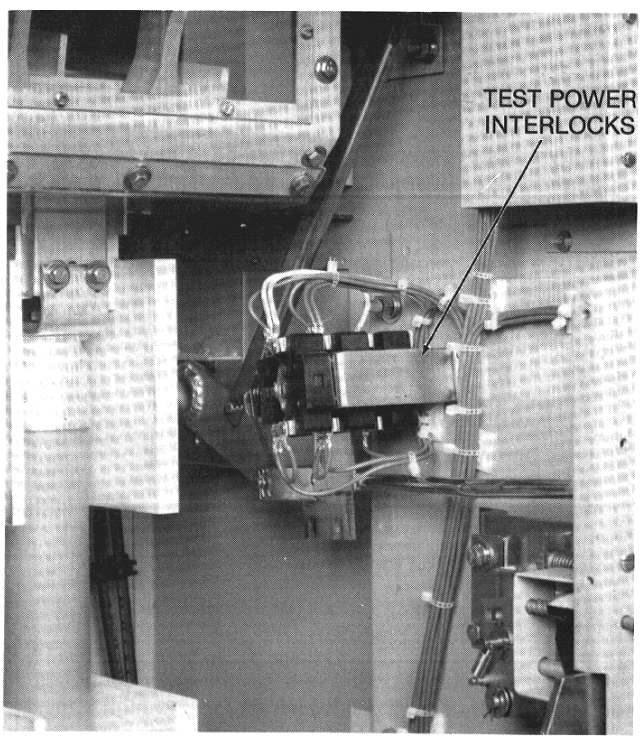


Figure 14. View of handle assembly area showing test power interlocks. (handle cover removed for clarity)

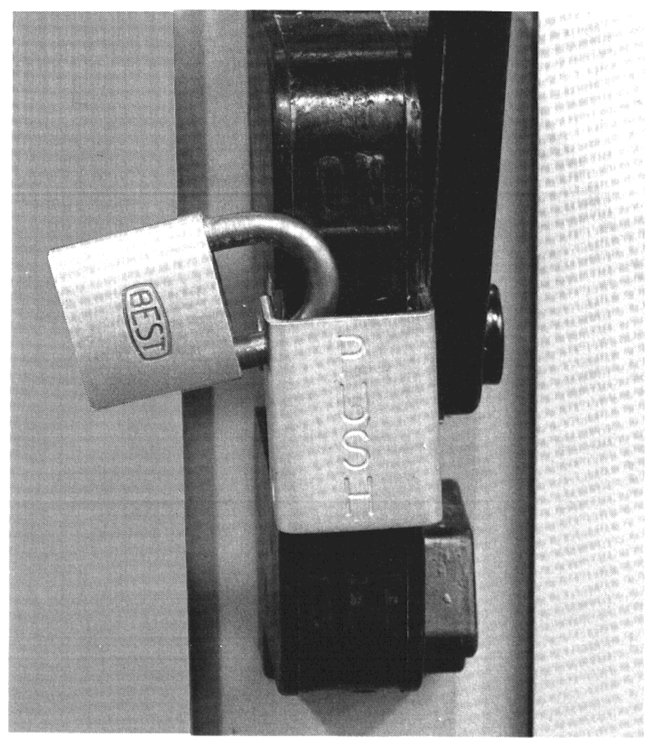


Figure 16. The operating handle for the disconnect may be padlocked to prevent operation.

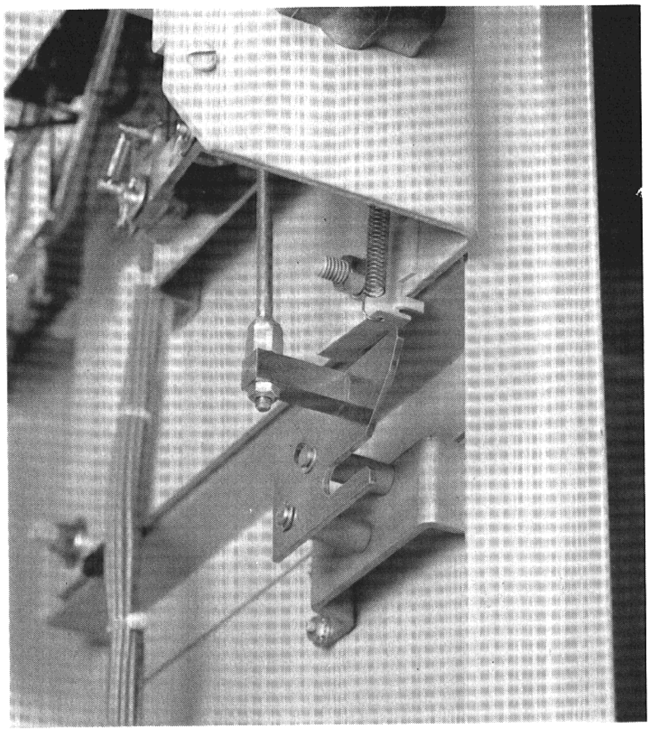


Figure 17. Contactor engagement pawl for mechanical interlock.

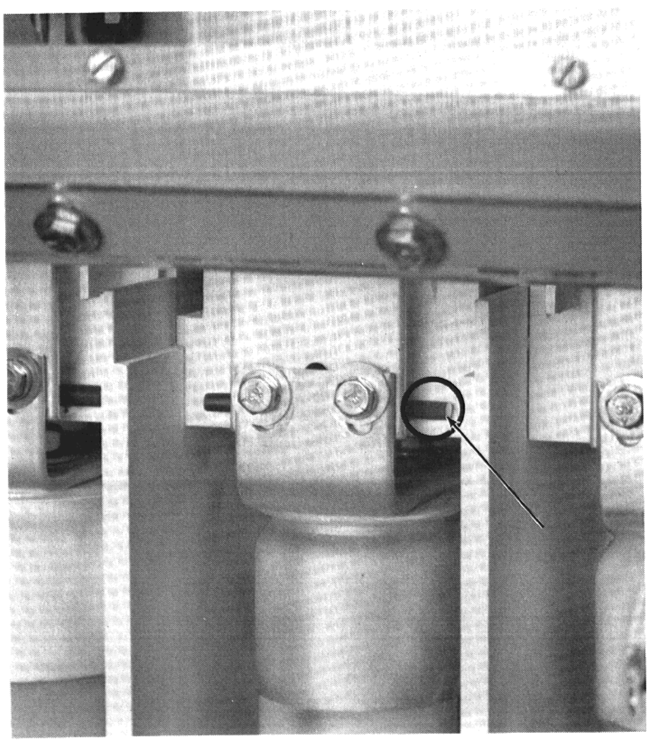


Figure 18. Blown fuse indicator shown in the NORMAL position.

WARNING: *THERE IS NO EMERGENCY CONDITION THAT CAN JUSTIFY FORCIBLE OPERATION OF THE MANUAL ISOLATOR WITH THE MAIN CONTACTOR CLOSED. THE ISOLATOR MUST BE OPERATED ONLY WITH THE CONTACTOR OPEN.*

All high-voltage doors are interlocked by mechanical interference mechanisms that lock high-voltage doors closed until the disconnect switch is in the OPEN position. This is done to prevent exposure to high voltage. In one-high controllers the bottom door covers the high-voltage compartment. Other high-voltage doors may be full height to cover high-voltage parts located in auxiliary sections. These devices may include reactors, autotransformers or control power transformers, etc.

Key interlocking is frequently used in lieu of mechanical interference mechanisms to lock high-voltage doors closed until power inside has been removed. Non-loadbreak switches are also key interlocked to prevent operation under load. In all cases of key interlocking, it is important to follow the operating sequence as described on the drawings furnished with the equipment.

On some one-high enclosure designs, a low-voltage control panel mounted by hinges to the left side of the enclosure serves as a barrier to isolate the high-voltage control power transformer and fuses. An interference latch, shown in Fig. 54, prevents swinging this panel out until the high-voltage door is opened, thus ensuring that high-voltage power to the Control Power Transformer is disconnected.

Auxiliary enclosures

Many sizes of enclosures are furnished in Vacuum Limitamp control lineups for various purposes. Some are tabulated below:

Wound rotor, secondary contactor and resistor compartments
Bus transitions to switchgear
Bus transitions to transformers
Cable entrance compartments
Rectifier exciter compartments
Starting reactor or autotransformer compartments
Relay and metering compartments
Instrument transformer compartments
Manual switch compartments

Refer to Figure 62 for details.

Dimensions

Vacuum Limitamp controllers are normally 30-inches deep and 90-inches high. Width varies for one-high controllers, induction motors, synchronous motors, other special applications, or cable space requirements. Refer to Figures 60 and 61 of these Instructions for typical outline dimensions.

Power fuses

Current-limiting power fuses are supplied as standard with Vacuum Limitamp controllers. These fuses are bolt-in type because the blown fuse indicator and the trip bar, that operates the anti-single phase contact block, require precise alignment of the striker pin at the top of the fuse with the operators. Clip-in fuses are not available. Coordination information for these fuses is available in GES-5000. Interrupting ratings are shown on page 5 of these instructions. Figure 18 shows the top of the power fuse assembly with the blown fuse indicators in the normal position.

Power fuse conversion instructions

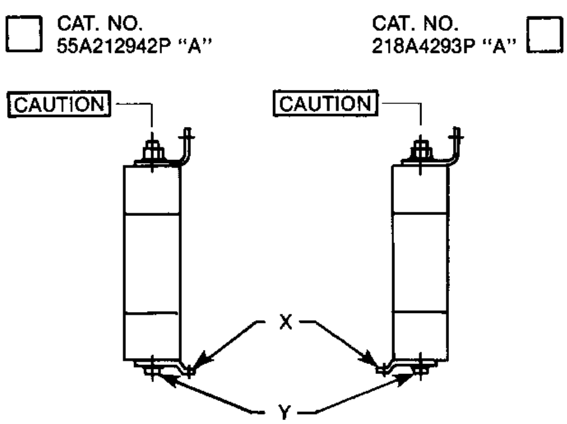
Bolt-in fuses used on Vacuum Limitamp and Air-break Limitamp may be field converted from one to the other by carefully following the instructions below.

Some Vacuum Limitamp controllers used as transformer feeders may be supplied with Type EJ-1 current-limiting fuses, as described in GES-5002.

Starting autotransformers and reactors

Reduced voltage controllers include a reactor or autotransformer designed for starting duty in accordance with NEMA ICS2-214. The duty cycle generally furnished is for medium-duty applications which consist of three 30-second starts spaced 30-seconds apart followed by a one-hour rest. To prevent overheating and possible damage when applied on more severe duty (heavy duty) applications, special reactors or autotransformers must be specified. Thermostats are mounted on the reactor and transformer cores to offer protection against overheating. These thermostats must be manually reset if tripped by high temperature.

SINGLE BARREL

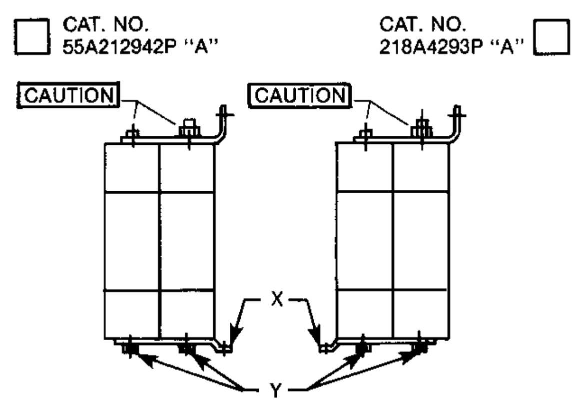


BY CAREFULLY FOLLOWING THESE INSTRUCTIONS, THE ABOVE FUSE VERSIONS MAY BE FIELD CONVERTED FROM ONE TO THE OTHER.

1. LOOSEN BOTTOM BOLT (Y) WHILE INSURING FUSE BARREL DOES NOT ROTATE (SEE CAUTION).
2. ROTATE BOTTOM STRAP (X) 180 DEGREES.
3. RETIGHTEN BOTTOM BOLT (B) TO 23-31 FT/LBS WHILE ENSURING THAT FUSE BARREL DOES NOT TURN.

CAUTION: *DO NOT LOOSEN TOP BOLT OF FUSE. THIS WILL DAMAGE INTERNAL ELEMENTS OF FUSE.*

DOUBLE BARREL



BY CAREFULLY FOLLOWING THESE INSTRUCTIONS, THE ABOVE FUSE VERSIONS MAY BE FIELD CONVERTED FROM ONE TO THE OTHER.

1. LOOSEN AND REMOVE BOTH BOTTOM BOLTS (Y) WHILE INSURING FUSE BARREL DOES NOT ROTATE (SEE CAUTION).
2. ROTATE BOTTOM STRAP (X) 180 DEGREES.
3. REINSTALL BOTTOM BOLTS (Y) AND SPECIAL SPRING WASHER (BELLEVILLE). RED PAINTED STRIPE ON WASHER TO FACE TOWARD BOLT HEAD.
4. TIGHTEN BOTTOM BOLTS (B) TO 23-31 FT/LBS WHILE INSURING THAT FUSE BARREL DOES NOT TURN.

CAUTION: *DO NOT LOOSEN TOP BOLT OF FUSE. THIS WILL DAMAGE INTERNAL ELEMENTS OF FUSE.*

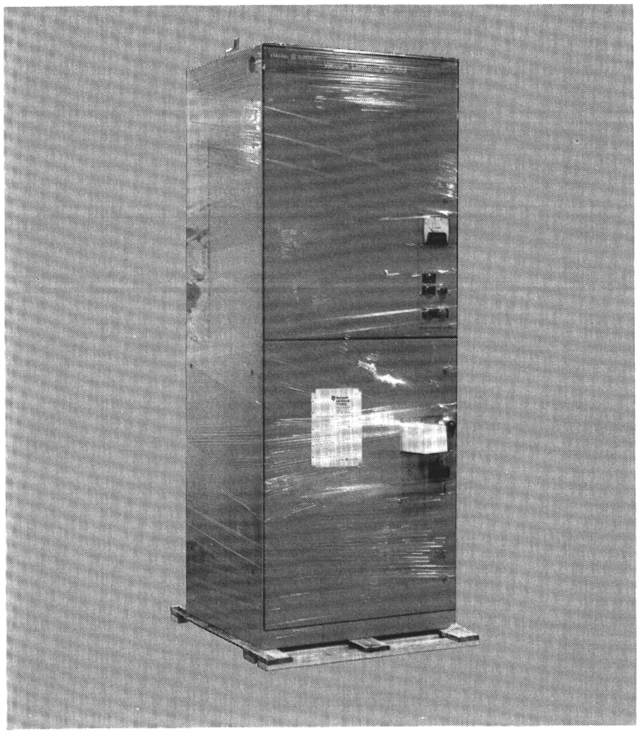


Figure 19. Vacuum Limitamp controller wrapped in plastic film wrap ready for shipment.

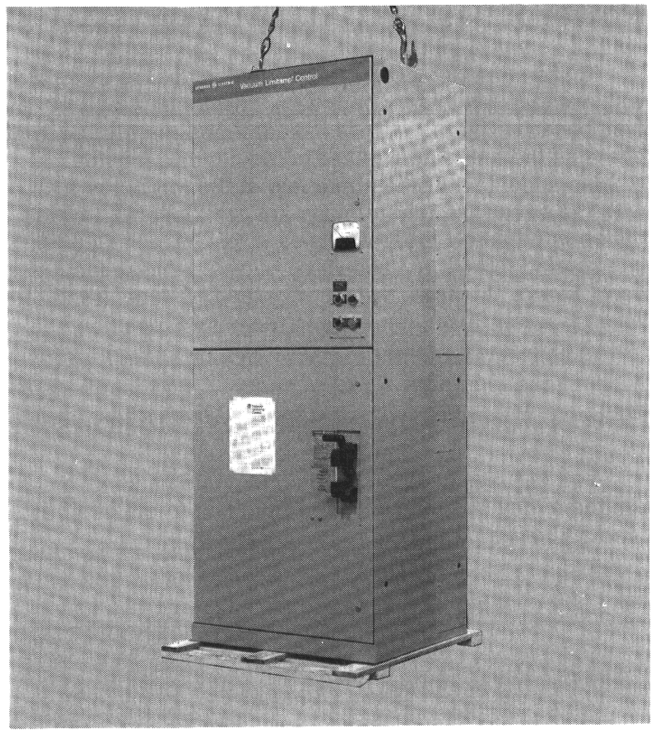


Figure 21. Recommended method of lifting single panel.

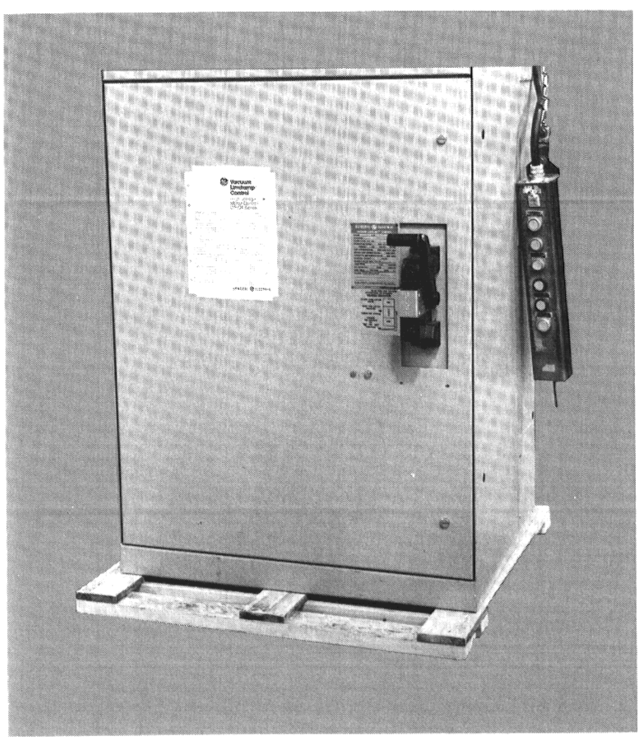


Figure 20. Vacuum Limitamp controller with outside packaging material removed and ready for handling.

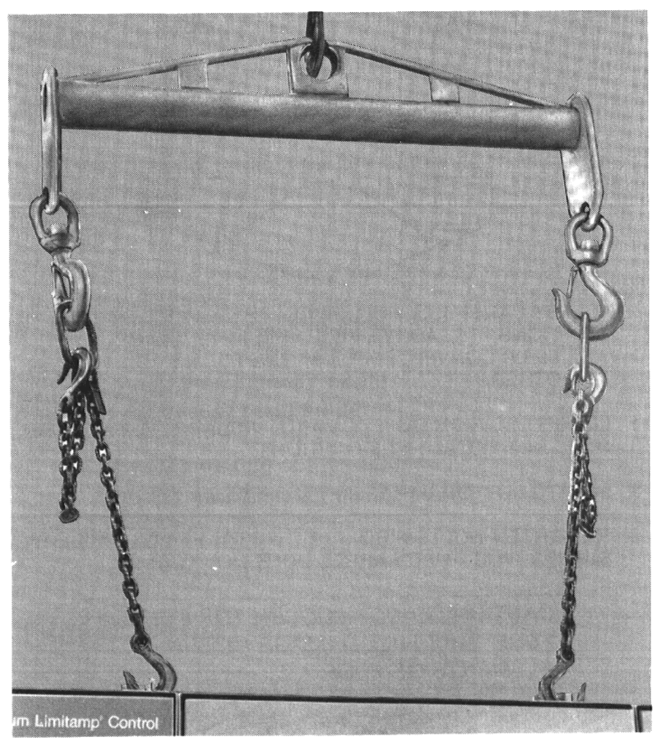


Figure 22. Recommended method of lifting a Vacuum Limitamp lineup. Note that the lineup is suspended from an equalizing bar.

Installation

General

This section contains information on receiving and handling, disassembly, power-cable termination, grounding, and reassembly to make the equipment ready for operation.

Receiving

Vacuum Limitamp controllers are fabricated as rigid, floor-mounted, self-supporting steel sections requiring no floor sills. They are crated and shipped in an upright position and, when received, should be kept upright.

Some components may be shipped separately, such as top-mounted resistors or potential transformers. These components are identified by catalog number coinciding with that of the section on which they are to be mounted.

Plastic film wrap or corrugated cardboard is normally used for domestic crating with the steel enclosure sections bolted to a wooden skid. See Fig. 19. After receiving, the packing may be removed and the equipment handled on the wooden skid. See Fig. 20.

Handling

It is always preferable to handle Limitamp controllers by the lifting means provided. Figure 21 shows the recommended method of lifting a single section, while Fig. 22 shows the recommended method of lifting a lineup.

Note that the lineup in Fig. 22 is suspended from an equalizing bar. A lineup should be supported at as many points as possible. If there is not enough headroom to lift the panel by its lifting beam, then a track jack, can be used. The controller can be raised by placing a track jack under the shipping skid. Rollers can then be placed under the skid for rolling the equipment to its final location. The panel should then be raised by its lifting beam, the shipping skid removed, and the panel set into place.

The use of fork-lift trucks is *not* recommended, since the forks may damage the enclosure or interior parts of the equipment. If no other method of handling is available, the forks must go under the skid bottom to avoid damaging the equipment.

Placement of enclosure

It is essential that the controller be securely fastened in an upright position on a level surface to allow proper functioning of the internal devices. While there are no roll-out components, access will be improved if the controller is located at floor level with plenty of room allowed for doors to swing fully open as shown on the drawings supplied with the equipment.

After the controller has been placed in position, the floor mounting bolts may be installed and tightened. The location of these bolts is shown on the outline drawing furnished with each controller. These bolts are 1/2-inch bolts and are usually located in each corner of the controller base.

Disassembly

After the equipment has been set in place where it is to be permanently connected, some internal disassembly is required to make the necessary external power-cable and control-wire connections. Disassembly should be done in a definite sequence by following Figs. 23 through Fig. 34, and as described below:

Disassembly Sequence of Operation

WARNING: *REMOVE ALL POWER FROM THE EQUIPMENT BEFORE PROCEEDING WITH DISASSEMBLY*

1. Move the manual isolater handle to the OFF position. Refer to the nameplate attached to the high-voltage door near the handle. Figure 23-2 shows the method of first depressing the pusher with one hand and moving the handle with the other. Refer to page 29 for normal and emergency door opening procedures.

2. Open both the top (low-voltage) and bottom (high-voltage) doors.

Contactor removal

Normally it is not necessary to remove the contactor (200-ampere or 400-ampere) from its mount in order to make external power-cable and control-wire connections. If the contactor is not removed proceed to Step 5. Otherwise, follow the steps outlined below to remove the contactor from the controller.

3. 200-Ampere Contactor

To remove the contactor from its mount, the following steps should be taken;

a. Remove the wing nuts holding the contactor umbilical cord and connectors in place and save the hardware. This hardware will be re-used to remount the connector when the contactor is reinstalled. Unplug the connector and place the bracket in the lower front channel to the left of the contactor for safe storage. See Figs. 24 and 26.

b. Loosen the line side cable bolts at the bottom of the fuse assembly and save the hardware. Be sure the cables are free of their mounts and that they can be freely removed. See Fig. 28.

c. Remove the hardware attaching the load cables to the standoff insulators behind the contactor. Again save the hardware.

d. The contactor is mounted on four insulators above the metal base. Remove the mounting bolts that attach the contactor to the insulators and save the hardware.

e. Once all of the bolts have been removed, the contactor may be lifted out of the enclosure by sliding it forward slightly and lifting out.

4. 400-Ampere Contactor

a. Remove the wing nuts holding the contactor umbilical cord and connectors in place and save the hardware. This hardware will be reused to remount the connector when the contactor is reinstalled. Unplug the connector and place the bracket in the lower front channel to the left of the contactor for safe keeping. See Fig. 25.

b. Loosen the line side cable bolts at the bottom of the fuse assembly and save the hardware. Be sure the cables are free of their mounts and that they can be freely removed. See Fig. 27.

c. Remove the three load side connection bolts in the bottom of the contactor. These bolts are accessed through the openings at the bottom of the contactor from the front. A socket wrench with an extension may be used to remove these bolts. Save this hardware for reuse. See Fig. 29.

NOTE: *Do not loosen R.T.V. covered bolts.*

d. There are two retaining nuts at both sides on the lower front of the contactor. These nuts must be removed. See arrows in Fig. 29.

e. Slide the contactor out of the mounting base and lift it and the line side cables out of the enclosure.

f. Replace the three bolts removed from the load side connections in their holes and thread them in a few turns. These bolts will prevent reinstalling the contactor until removed again. This serves as a reminder that the bolts are there and need to be reinstalled when the contactor is being replaced.

5. Prepare to remove the horizontal compartment barrier by removing the two bolts shown in Fig. 30.

6. Remove the horizontal barrier, Fig. 30. (If a hinged low-voltage panel is used, swing it to the left and out of the enclosure.)

7. Remove the horizontal bus barrier bolts as shown in Fig. 31, and then lift the barrier out of the enclosure. The horizontal bus is then exposed as shown in Fig. 32.

8. Detach the switch barrier with the viewing window by removing the ten bolts, Fig. 33. Pull the barrier out of the enclosure.

9. Remove the front cover of the lower incoming line barrier, Fig. 34, (if incoming cables are to be routed from the floor) or remove the top incoming line barrier (if cables are to be routed into the enclosure from the top).

After the preceding steps have been completed, all power termination points and bus connections are accessible. See Fig. 35.

Grounding

All controller enclosures must be grounded. A stud is welded to the lower back of the enclosure in the incoming-line compartment area for connection to the grounding system. This connection must be made before making any power connection.

If ground bus is ordered, the ground stud is connected to the ground bus at the factory and the system ground can be connected to the ground bus instead.

The control and instrumentation circuits are grounded to the enclosure at the terminal board. This is the only grounding point. It can be temporarily removed for test purposes; but it must be regrounded before the control is returned to operation.

Incoming power connections

Incoming power connections to the bus may be made in any one of the enclosures in a lineup. Space for one 500-MCM cable with stress cones per phase is available in the standard 26-inch wide enclosure. A 34-inch wide enclosure is also optionally available when larger cable capacities are required. The 34-inch enclosure is standard with synchronous controllers and 7200 volt controllers. If shielded cable is used, refer to the information on Page 23 of this manual.

In the one-high enclosure with horizontal power bus, incoming power connections are made on the left end of the bus bars. When the barriers are removed from the enclosure, both ends of the power bus and the ground bus are accessible from the inside of the enclosure. To add additional units to a line-up of enclosures, the new enclosure can be located in position and, with the bus splices furnished with the equipment, the bus connections can be made to either side of the existing equipment. Figure 35 shows the accessibility of both ends of the bus bars with the barriers removed and the low-voltage panel swung out. The splices must be bolted in place with the 1/2-inch hardware supplied with the splice kit. Torque splice bolts to 30-34 lb.-ft.

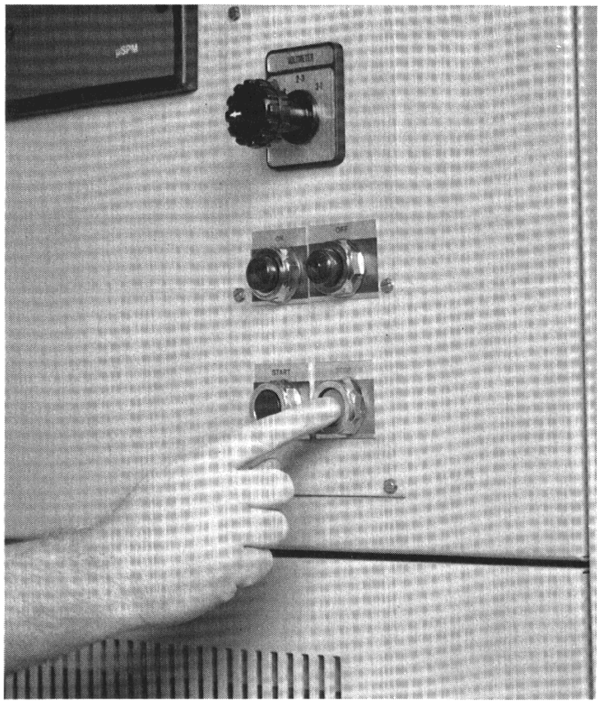


Figure 23-1. Depress STOP push button.

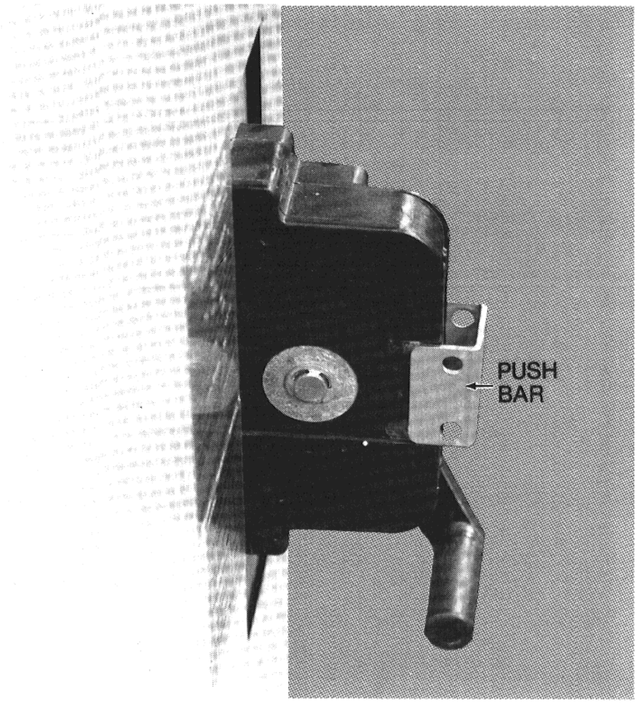


Figure 23-3. Handle OFF — Pusher bar OUT.

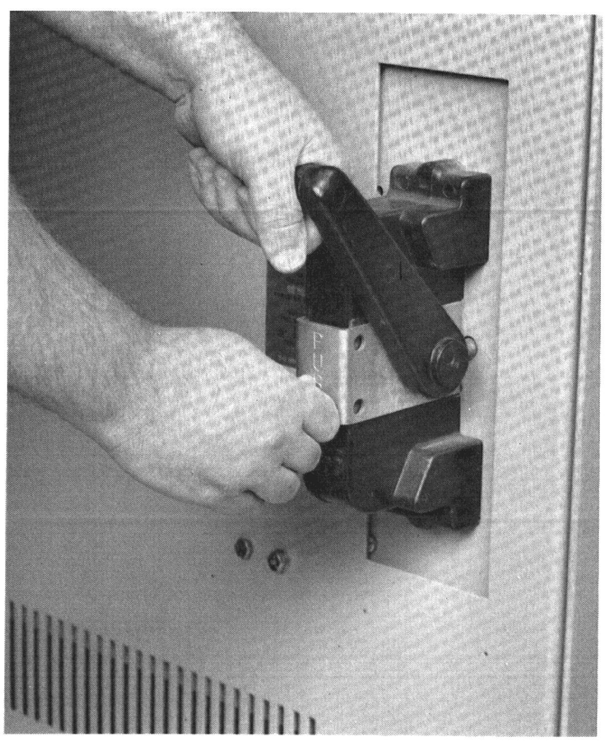


Figure 23-2. Place isolator handle in the OFF position by depressing pusher bar and pulling handle down.

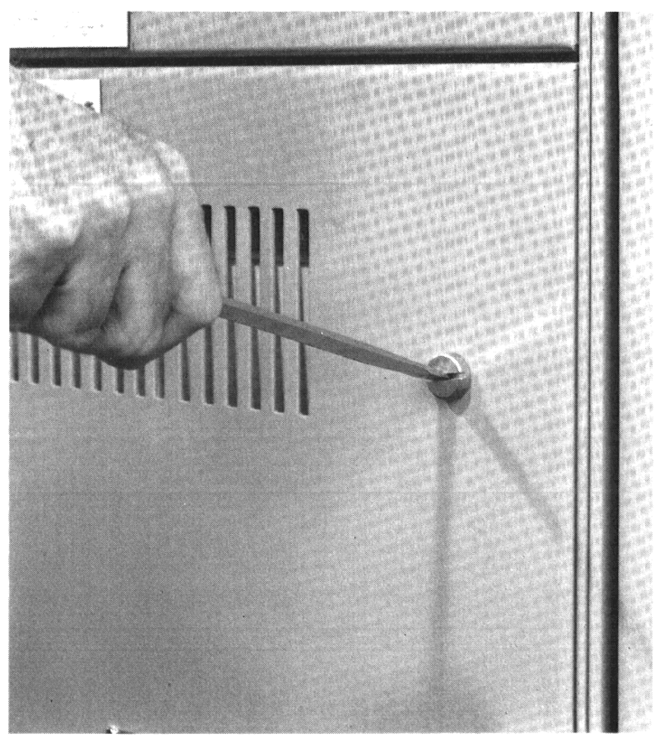


Figure 23-4. Turn door latches and open door.

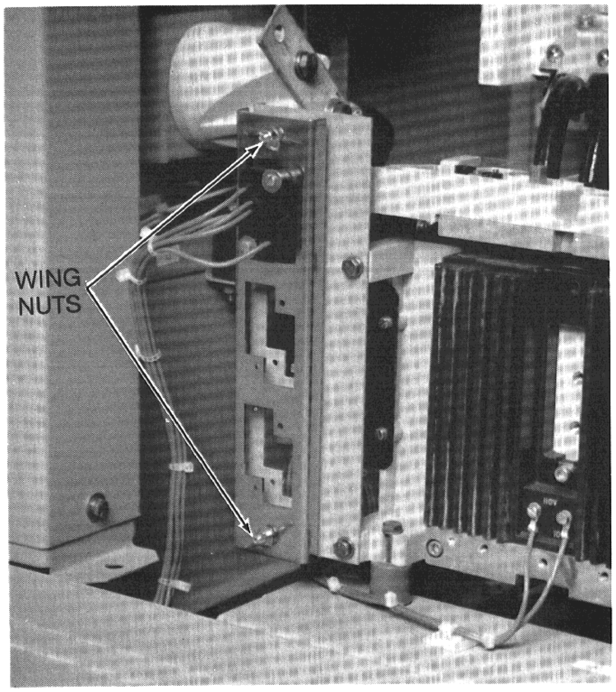


Figure 24. Remove wing nuts shown.

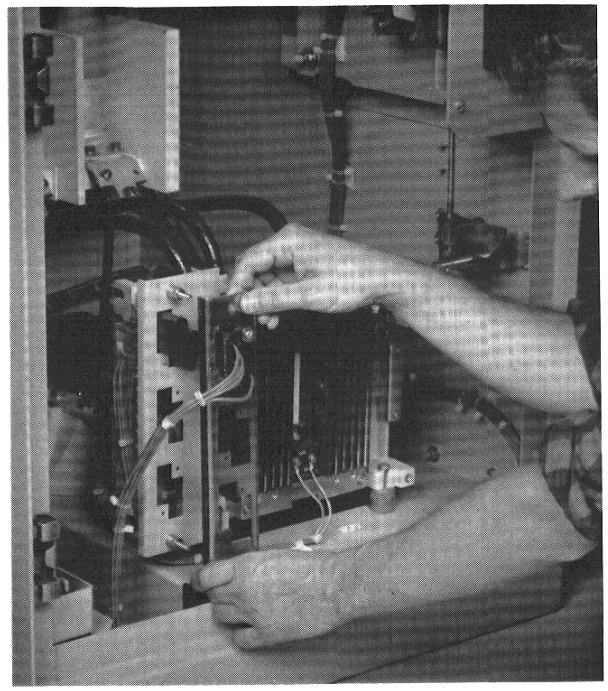


Figure 26. Unplug the umbilical cord assembly.

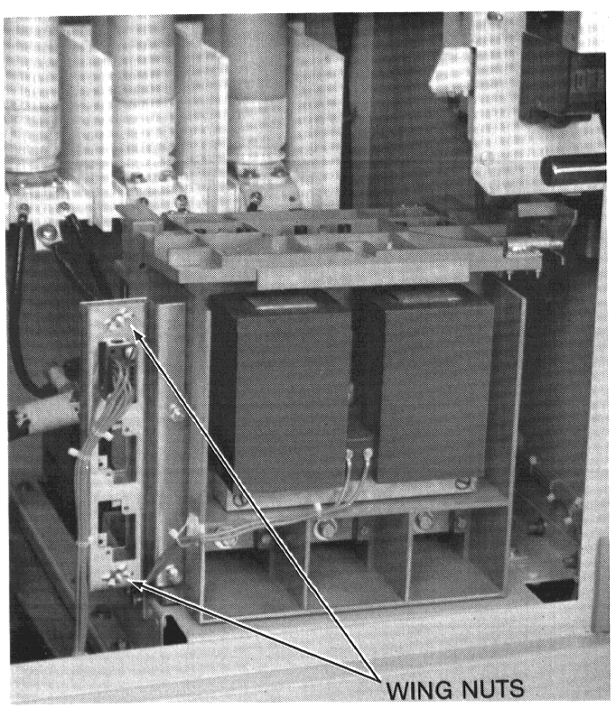


Figure 25. Remove the wing nuts securing the umbilical cord on the left side of the contactor.

Figure 27. Unbolt the cables from the bottom of the fuse assembly.

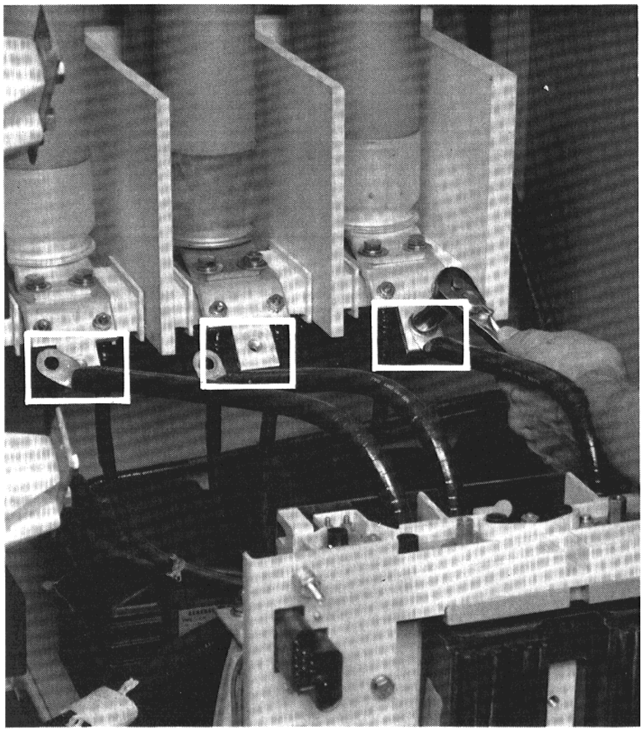


Figure 28. Unbolt the cables from the bottom of the fuse assembly.

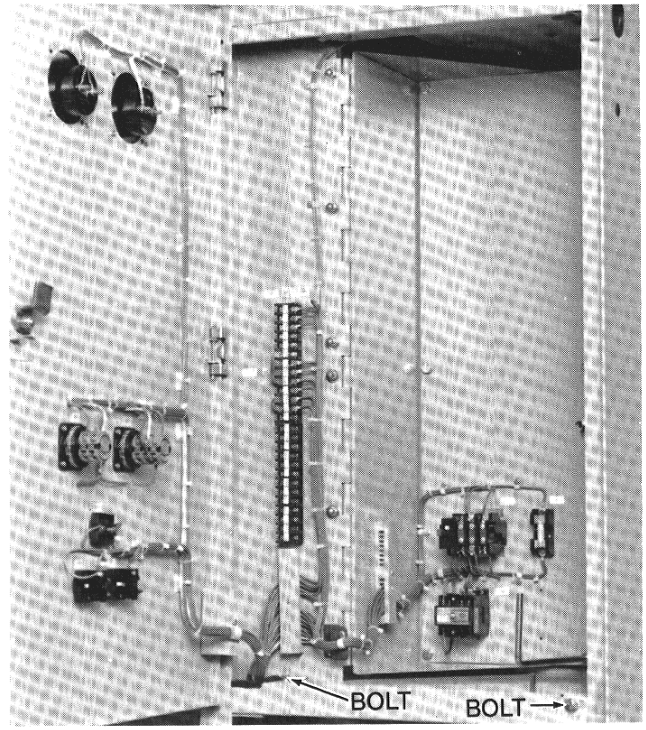


Figure 30. Remove the bolts shown and slide the horizontal barrier out of the enclosure.

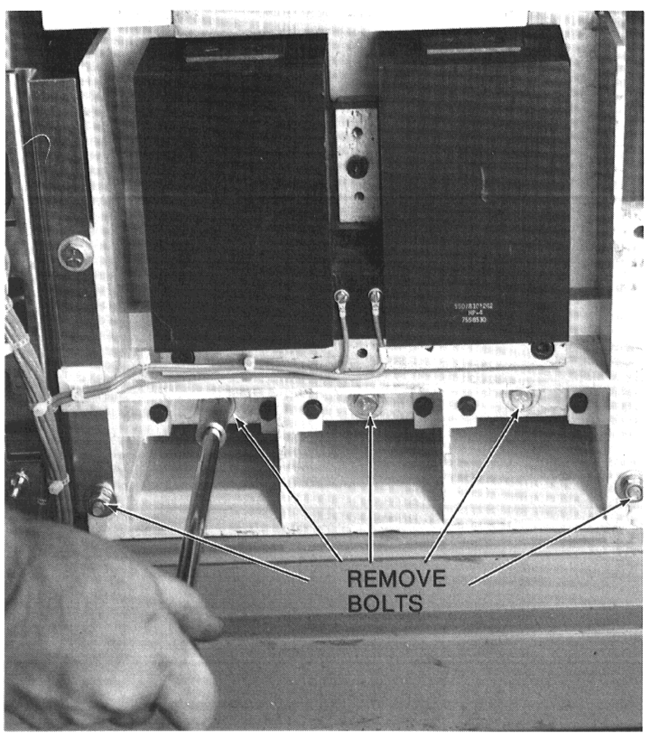


Figure 29. Remove the three load-side connecting bolts. (do not adjust the R.T.V. covered bolts)

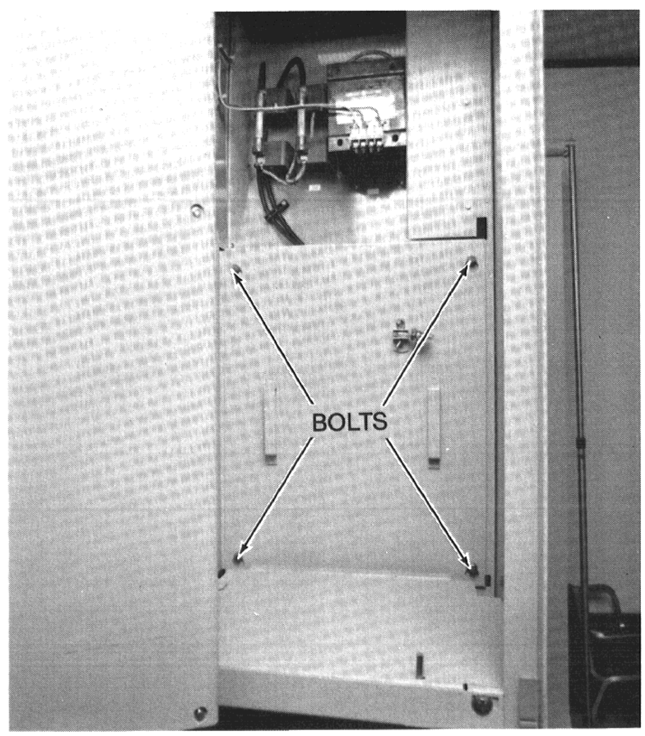


Figure 31. Remove the horizontal main bus barrier bolts shown and remove the barrier.

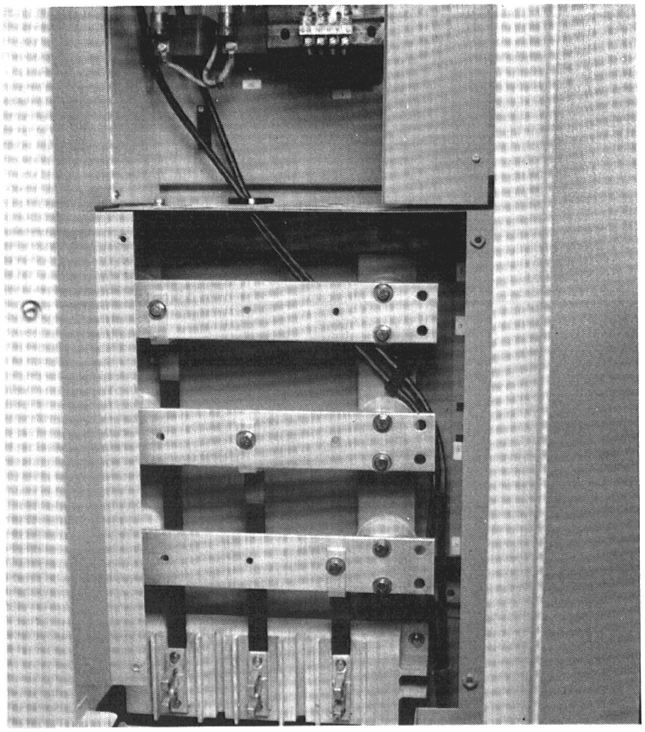


Figure 32. Exposed main bus after removal of main bus barrier.

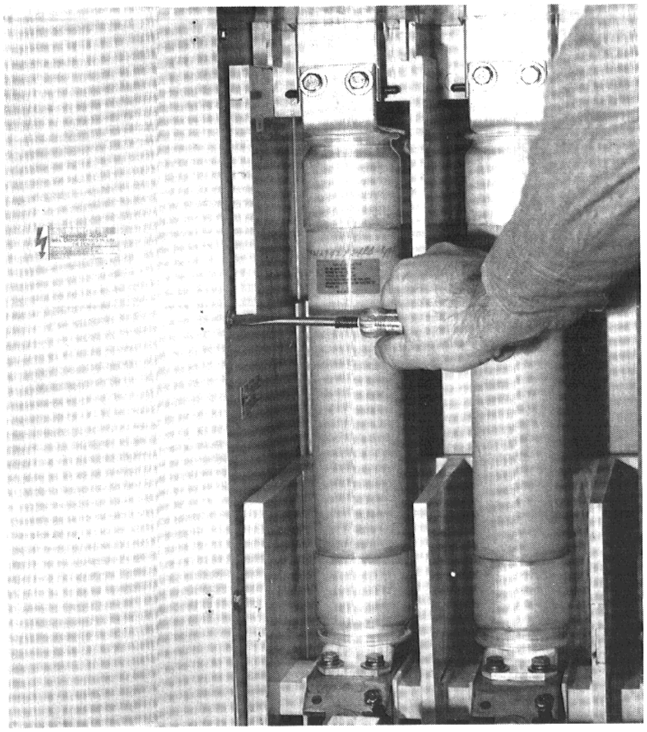


Figure 34. Lower incoming line barrier.

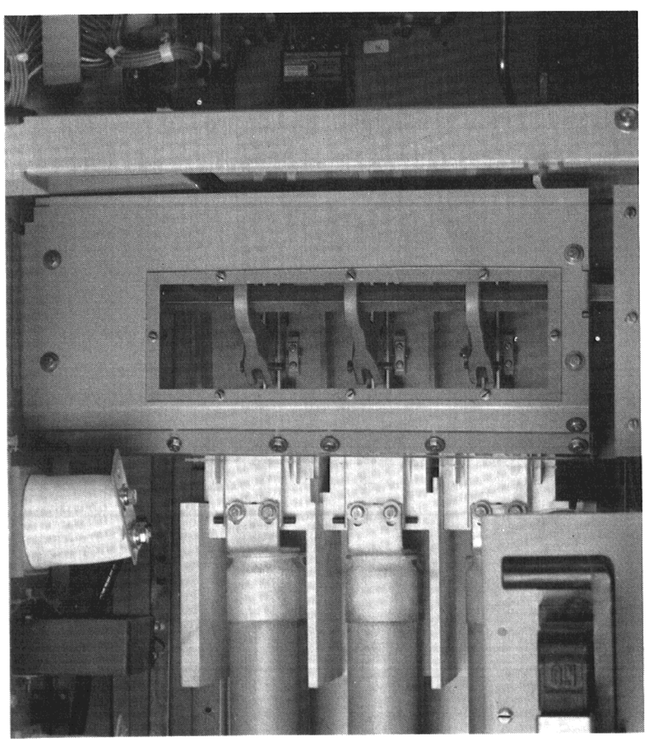


Figure 33. Isolator switch barrier showing bolts to be removed.

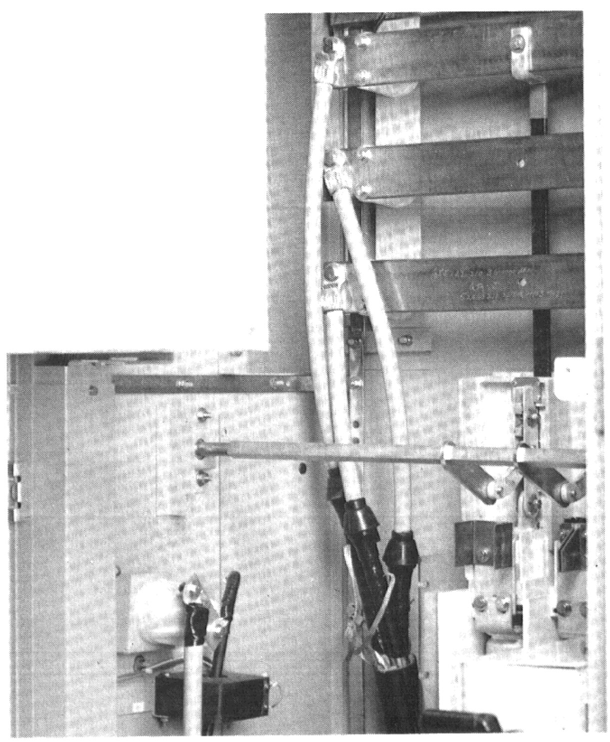


Figure 35. Main bus compartment with all barriers removed and incoming line cables terminated.

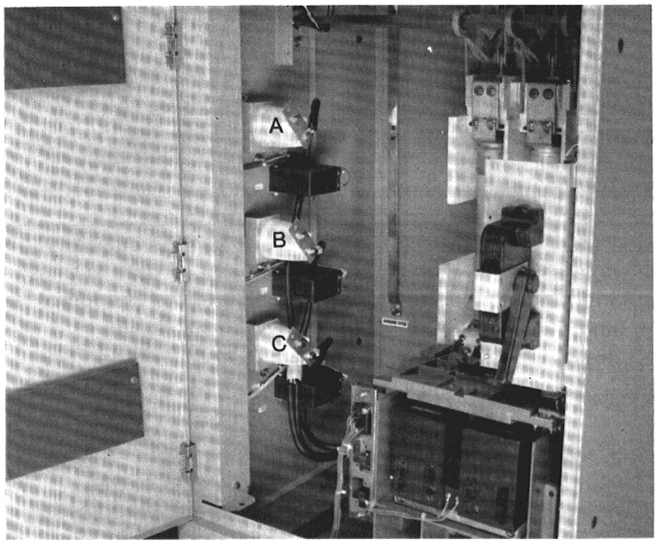


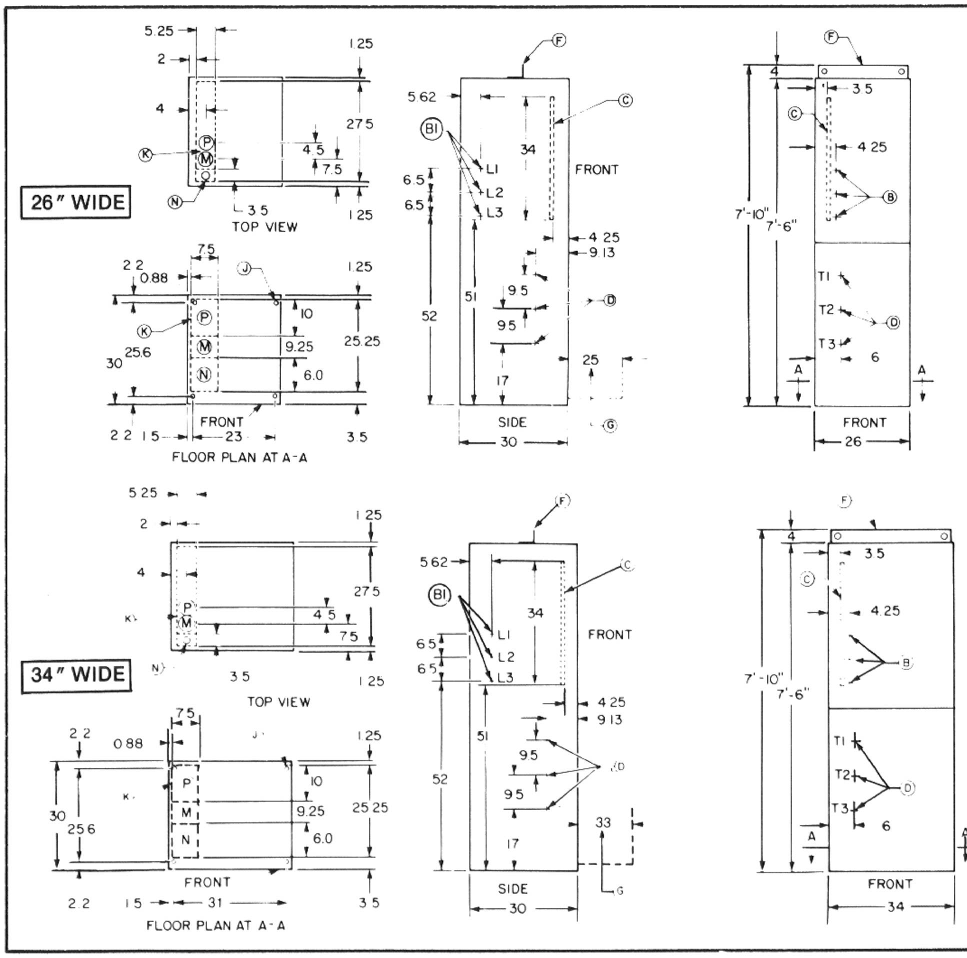
Figure 36. Load terminals located on the left wall of the high-voltage compartment. The lower incoming line barrier and isolator switch barrier have been removed. Phase A is at the top.

Motor connections

Motor cables may enter from the top or bottom of the enclosure. In the one-high enclosure, the motor terminals are located on the inside lower left wall as shown in Fig. 36. The incoming leads should be trained for maximum space between phases and ground. The connections may be made before or after energizing the main bus and without shutting down adjacent equipment.

> **WARNING:** *IF THE MAIN BUS IS ENERGIZED WHILE LOAD CABLES ARE BEING INSTALLED, ALL BARRIERS MUST BE IN PLACE AND THE DISCONNECT SWITCH MUST BE IN THE OFF POSITION AND THE BLADES MUST BE VISUALLY CHECKED TO ENSURE THAT THEY ARE COMPLETELY DISCONNECTED FROM THE VERTICAL BUS.*

The motor terminals can accommodate up to one 500-MCM per phase with stress cones in the standard 26-inch wide enclosure. If larger cable entries are required, an optional 34-inch wide cabinet is available.



LEGEND

B1 — Ac power bus
C — Control lead terminal board
D — Motor lead terminal connection
G — Space required to open doors 90 degrees
J — Mounting holes for 1/2 inch diameter anchor bolts
K — Space available for incoming conduit
M — Recommended position for incoming motor conduit
N — Recommended position for incoming control conduit
P — Recommended position for incoming power conduit

NOTE: All dimensions under 6 feet are in inches.

Figure 37. Cable space available in 26-inch and 34-inch wide enclosure.

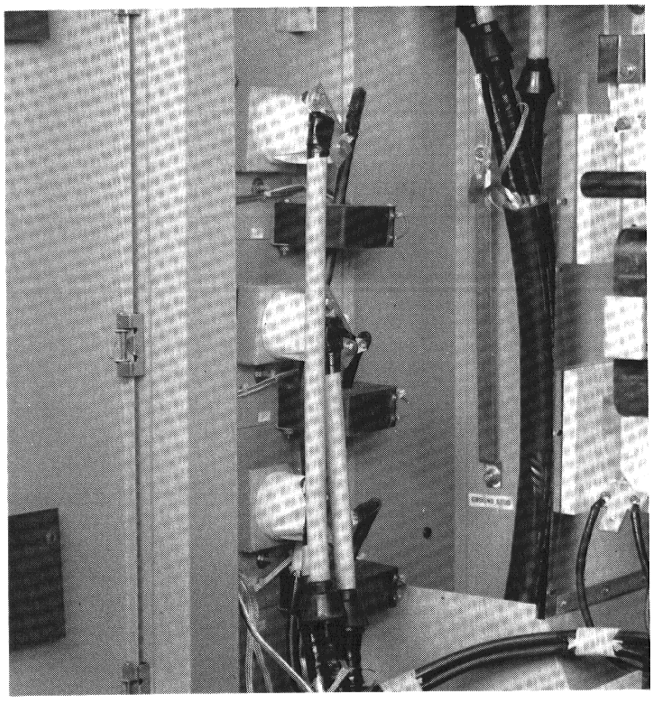


Figure 38. Motor cable terminations in 26-inch or 34-inch wide enclosures.

Extra-width enclosure

A special 34-inch-wide enclosure is available for terminating shielded cable with stress cones, or for terminating more than one large cable per phase. The enclosure design permits space for termination of two 750-MCM cables per phase with stress cones* for motor and power leads. Figures 35 and 38 show the space available in this extra-width enclosure. Design is basically the same as the 26-inch-wide one-high, and all data and information in these Instructions applicable to the 26-inch one-high design apply to the 34-inch-wide enclosure.

Power cable termination

In any installation, the cable should be prepared for termination in accordance with the instructions of the cable manufacturer. However, the following general recommendations are given for proper cable termination in Vacuum Limitamp equipment.

1. Pull in the cables in accordance with the panel outline diagram and position them for maximum clearance between phase, ground and other cable or wire runs. Refer to Figures 60 and 61 of these instructions for recommended location of incoming cables in a standard Limitamp controller.

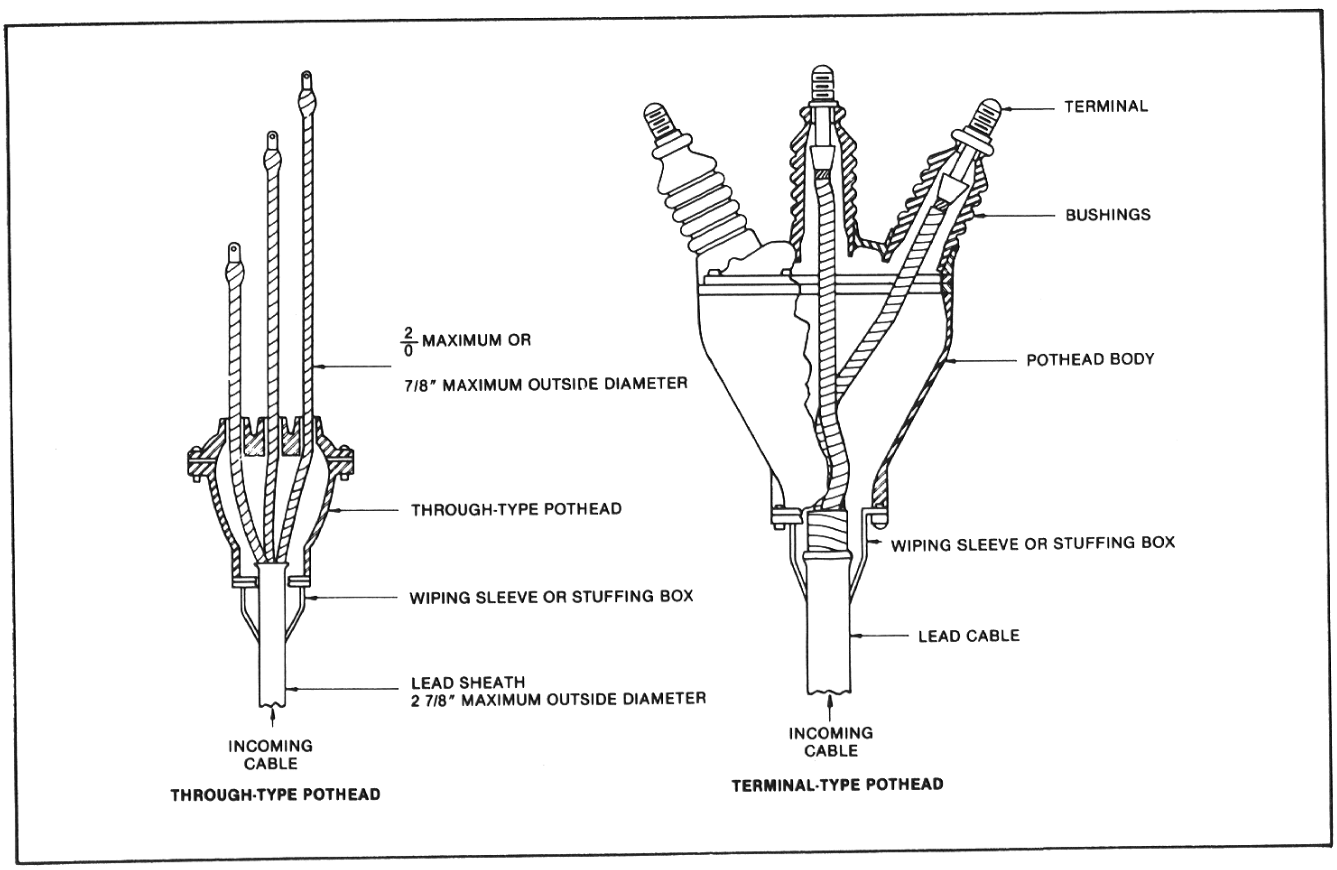


Figure 39. Termination of cable in pot heads.

*General Electric Termi-Kit® stress cones.

2. Prepare the cable for termination in accordance with the manufacturer's instructions. For suggested terminating methods, see pages 20 through 23 and Fig. 39 through 45.

3. Bolt the cable terminals to the bus or other point of termination.

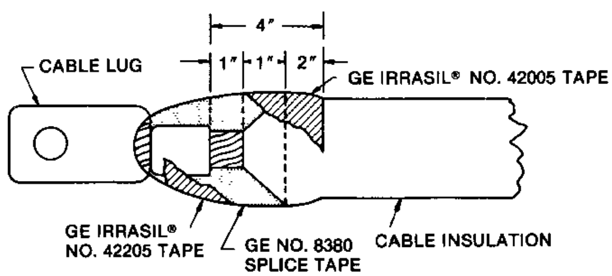


Figure 40. Termination of rubber-insulated, non-shielded, non-lead-covered, 5000-volt cable.

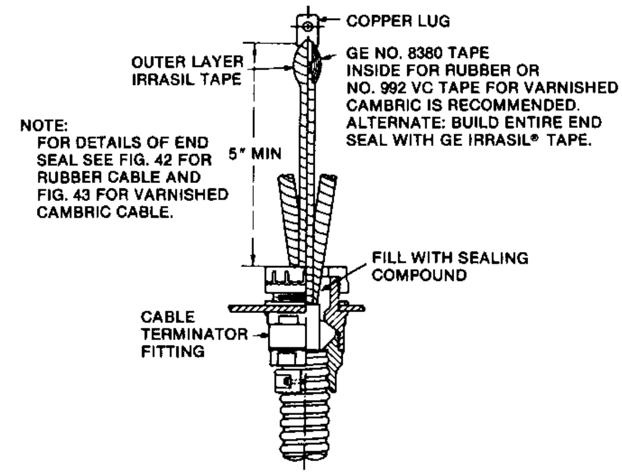
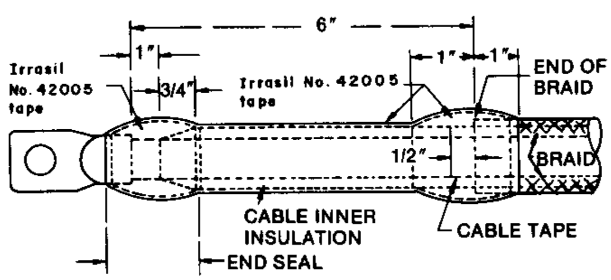


Figure 42. Termination of interlocked-armor, non-shielded, 5000-volt cable.



1. Cut cable to proper length leaving conductor sufficiently long to extend into the terminal lug.

2. Remove braid, tape, and inner insulation and expose the conductor end for a distance of one inch plus the length of conductor to go into the terminal lug.

3. Attach terminal to conductor.

4. Taper the insulation as shown.

5. Remove the braid and tape, if any, six inches from the lug, exposing the insulation. Leave one-half inch of original cable tape extending beyond the cutback braid.

6. Apply the end seal using GE Irrasil® electrical tape. Obtain a smooth wrapping but do not stretch tape more than necessary.

7. Bind down end of braid and tape, if any, with Irrasil tape as shown on drawing.

8. Apply two layers half-lap of GE Irrasil® tape over-all from lug to exposed braid.

Figure 41. Termination of varnished-cambric-insulated, non- shielded, non-lead-covered, 5000-volt cable.

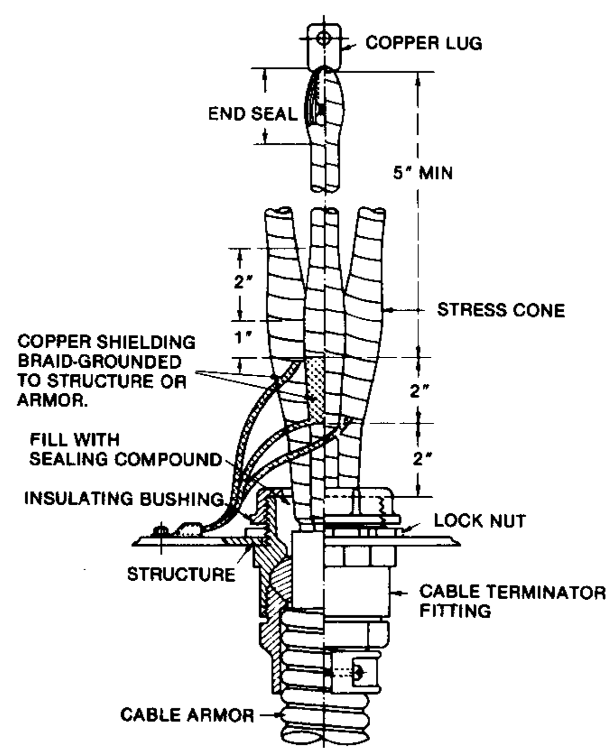


Figure 43. Termination of interlocked-armor, shielded, 5000-volt cable.

4. If contact between the cable and an adjacent bus cannot be avoided, as may be the case with the two 500-MCM cables per phase, tape the bus in the immediate vicinity of the cable contact point so that the surface creepage distance from the cable to the bare bus bar is at least three inches. Thus, the surface creepage from the bare bus where the cable terminates, to the bare part of the bus where the cable touches, will be at least seven inches. The thickness of tape on the bus should be approximately 5/32 inch. General Electric No. 8380 tape is recommended for most of the buildup and General Electric No. 42005 Irrasil® tape is recommended over-all.

5. Where more than two 500-MCM cables per phase are required, they should be brought into different sections, or an incoming line compartment must be provided. If the two 500-MCM cables must be terminated with stress cones, a cable entrance compartment must be ordered.

6. Run all the low-voltage wires so as to avoid any possible contact with high-voltage lines.

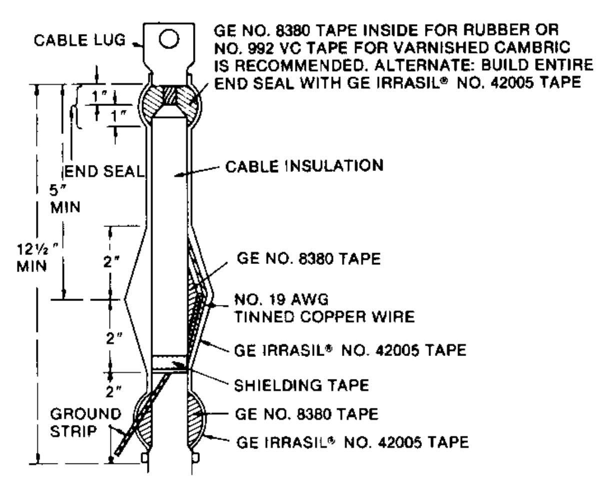


Figure 44. Termination of shielded, 5000-volt cable showing stress-cone construction.

1. Maintains tight fit under load cycling and all cable operating conditions.
2. Track-proof insulating EPDM rubber.
3. Heavily-insulated shield edge protects high stress area of stress cone.
4. High conductivity semi-conducting rubber relieves electrical stress.
5. Internal step positions stress cone properly on cable shield.
6. Ground clamp provides positive ground.

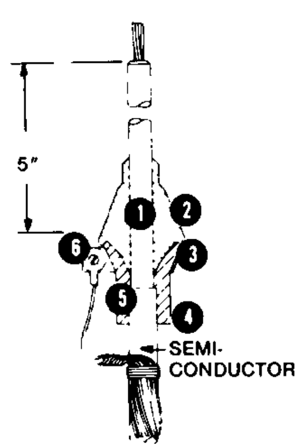


Figure 45. TERMI-MATIC preformed stress cones (5 kV).

Termination of lead-covered cable

Termination of lead-covered cable requires the use of potheads (see Fig. 39). The pothead manufacturer's instructions should be followed in terminating the cable at the pothead. Standard Limitamp starters have space for locating one pothead of the pull-through type which accommodates up to and including 2/0, three-conductor, 5000-volt cable. In this type of pothead, the three conductors of the cable are fanned out within the pothead and pass completely through it, with the pothead sealing and terminating the lead covering. For larger cables, potheads with terminating bushings are required. In this case, or when more than one pull-through type is required, special cable entrance compartments are available.

Through-type potheads are satisfactory for varnished-cambric cable indoors. Paper-insulated cables are more hygroscopic and, since the only thing protecting the individual conductors from moisture is tape on the surface, high humidity might cause difficulty. Terminal-type potheads are required for paper-insulated cable.

Termination of pothead cable

The instructions for terminating lead-covered cable by using potheads apply as well to those terminations of other types of cable where potheads may be desired.

Termination of non-shielded, non-lead-covered cable

This cable is generally run through rigid conduit or cable raceways and brought into the enclosure by the use of conventional cable clamps and conduit fittings. Refer to Figs. 40 and 41 for terminating details.

Termination of interlocked-armor cable

Interlocked-armor cable is terminated by means of specially designed cable fittings. These terminators consist generally of mounting bracket, armor clamp, and supporting base and bushing, with various modifications available for special types of sealing.

Interlocked-armor, non-shielded cable

RUBBER-COVERED — Refer to Fig. 42 for general information concerning termination. For details, refer to Fig.

40. Note that rubber-covered cable requires only taping near the terminal and not back to the terminator fitting. However, if there is a possibility of oil coming in contact with the rubber insulation, it would be well to use a layer of Irrasil® No. 42005 tape all the way back to the terminator fitting.

VARNISHED-CAMBRIC — Refer to Fig. 42 for general information concerning termination. Note that varnished-cambric cable requires taping back to the terminator fitting, since the individual conductors or "singles" have no braid.

Interlocked-armor, shielded cable

Interlocked-armor, rubber-covered, and varnished-cambric insulated cables are sometimes shielded at ratings of 5 kV and below. If they should be, proceed to terminate as detailed for other types of shielded cables. Refer to Fig. 43.

Termination of shielded cable

It is recommended that when shielded cable is used, "stress-relief cones" be built up at the cable terminations, or else General Electric Termi-Matic® stress cones be used as shown in Fig. 44 and Fig. 45. This will relieve the electrical stress which occurs in the area around the termination of the ground shield. Whenever possible, the conduit should be brought in through the bottom. A maximum of one 500-MCM cable per phase may be terminated in one full-voltage starter section. When making shielded-cable terminations to Limitamp, the following procedure is recommended:

Use GE Termi-Matic system per Fig. 45, or else build stress cones with tape as follows:

1. Mark the cable at least 10 inches from the terminal point.

2. Remove all shielding from the terminal end to this point, leaving sufficient ground strip to reach the nearest ground connection.

3. Proceed to build stress cones as prescribed by the cable manufacturer. Refer to Fig. 43 and 44 for details.

4. Tie all of the ground strips together and fasten them to ground bus (if ordered) or to a large stud on the enclosing case. (See note on grounding under item on "Wire and Cable Entrance".)

If the foregoing recommendations, along with the cable manufacturer's recommendations, are followed, the cable terminations should be satisfactory and reliable. These instructions apply to both rubber-covered and varnished-cambric insulated shielded cables.

Control connections

Conduit for control wires should be brought in the areas as shown in the outlines. There is room in both the bottom and top for the control conduits to be brought into the enclosure. In all Vacuum Limitamp controllers, the control connections are made through a terminal board on the left side of the low-voltage control compartment. Refer to Figs. 46 and 47 for details.

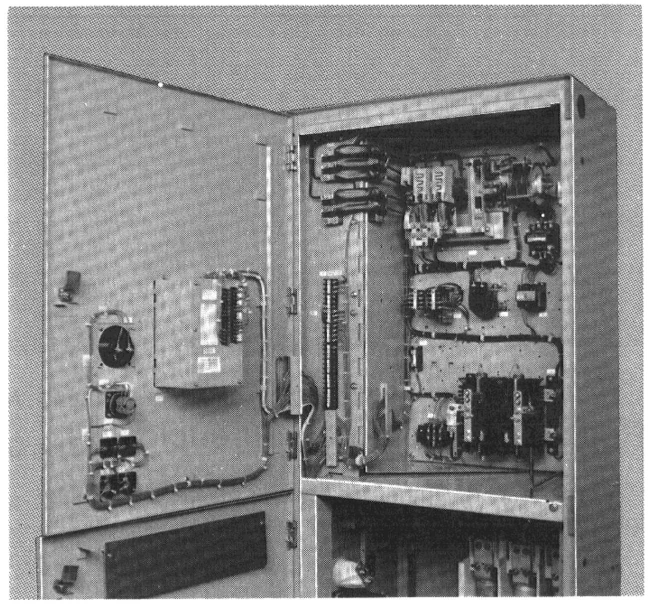


Figure 46. Low-voltage compartment showing low-voltage terminal strip on left side of panel.

Figure 47. High-voltage compartment showing low-voltage wiring trough cover in position. Low-voltage cables entering from the floor should be routed through this channel.

Control wires coming up through the floor should be run just behind the door hinges inside the channel (see Fig. 47) provided for this purpose and the wires should be terminated on the terminal board in the low-voltage compartment. When the connections are completed, the trough cover must be reinstalled to protect and isolate the control wires from the high-voltage compartment. Control wires entering from the top of the enclosure should also be run in the channel provided just behind the low-voltage door hinges and terminate on the terminal block. No cover is required for the trough in the low-voltage section of the controller.

Reassembly

After all power and control-wire connections are made, the Vacuum Limitamp controller must be reassembled by following the sequence on pages 13 and 14 in reverse order. If the controller is enclosed in a NEMA 3 type enclosure, refer to Figure 51 for assembly instructions.

> **NOTE:** *Do not attempt to operate without all barriers reassembled.*

Replacing contactors in enclosure

When replacing the contactor in the enclosure, the following procedures should be followed;

200-Ampere contactor

1. Before mounting the contactor, be sure that all of the cable connections to the line side and load side of the contactor are **properly tightened** and that the clear cover over the vacuum interrupters is properly in place.

2. Mount the contactor into position and be sure that the armature interlock rod is properly engaged in the interlock pawl located on the lower-right side wall. (See Fig. 17.)

> **NOTE:** *The armature interlock rod and the interlock pawl transmits the contactor armature motion to the mechanical interlock and it is vital that this device function properly.*

3. Attach the line cables to the bottom of the fuse assembly and the load cables to the standoff insulators behind the contactor and properly torque all connections.

4. Manually operate the contactor armature and observe that the mechanical interlock functions properly. If so, the contactor is properly mounted.

5. Reconnect the control umbilical cord to the contactor and be sure the retaining nuts are tight. Installation of the contactor is now complete.

400-Ampere contactor

1. Before installing the contactor, ensure that the cables attached to the line side of the contactor are **properly tightened** to 12-16 lb.-ft.

2. Remove the three bus bar bolts that were placed in position during contactor removal and slide the contactor onto its mounting base and ensure that the retaining studs protrude through the front of the contactor side bars. Also ensure that the armature interlock is properly engaged in the interlock pawl on the lower-right side wall. (See Fig. 17.)

> **NOTE:** *This mechanism transmits the contactor armature motion to the mechanical interlock and it is vital that this mechanism function properly.*

3. Install and tighten the three load-side connection bolts. See Fig. 48.

> **CAUTION:** *BE ABSOLUTELY CERTAIN THAT THESE BOLTS ARE PROPERLY INSTALLED AND TIGHTENED. THESE ARE CURRENT CARRYING CONNECTIONS AND THEY MUST BE TIGHT OR DAMAGE WILL RESULT. THESE CONNECTIONS MUST BE TIGHTENED TO 12-16 LB.-FT. SEE FIG. 29.*

4. Install the mounting nuts on the retaining studs on each side of the contactor and tighten.

5. Attach the line cables to the bottom of the fuse assembly. Be absolutely certain that these connections are properly tightened. See Fig. 48.

6. Manually operate the contactor armature and observe that the mechanical interlock functions properly. If so, the contactor is properly installed.

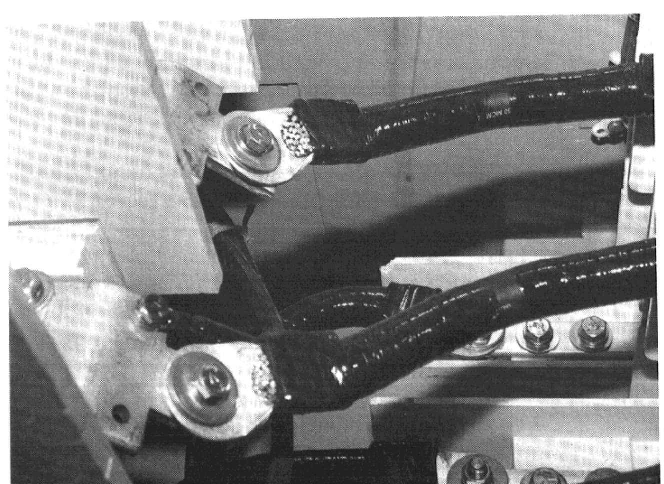


Figure 48. Line connection bolts for 400-ampere contactor.

7. Reconnect the control umbilical cord to the contactor and be sure the retaining nuts are tight. Installation of the contactor is now complete.

> **WARNING:** *MAKE CERTAIN THAT ALL BARRIERS ARE REPLACED AND BOLTED TIGHTLY INTO POSITION. MAKE SURE THE LINE AND LOAD SIDE TERMINATIONS OF THE CONTACTOR ARE TIGHTENED PROPERLY. FAILURE TO PERFORM THESE OPERATIONS COULD RESULT IN FAILURE OF THE UNIT TO OPERATE SAFELY AND RELIABLY.*

Mechanical operation check

All power off

With the main incoming power removed, operation of the isolating switch should be checked. This may be accomplished as follows:

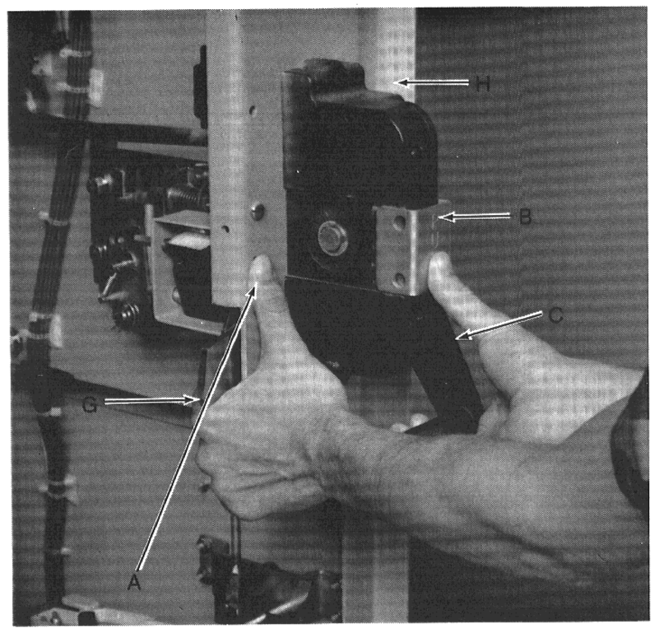
1. With the high-voltage door open (and power disconnected) push in the door-operated release (A), Fig. 49, with your left hand. This is not a normal function and should only be used for initial equipment check out.

2. Push in the handle latch release (B), Fig. 49, with the thumb of your right hand and begin to lift the handle (C) from the OFF to the ON position. The door operated release (A) can now be released. Near the top of the handle movement a sharp snap should be heard and the isolator switch contacts should be in the closed position. The contacts may be viewed by looking through the window supplied in the main fixed barrier. The contacts should be fully seated on all three phases.

3. Push in the latch release (B) and move the handle (C) mechanism from the ON to the OFF position.

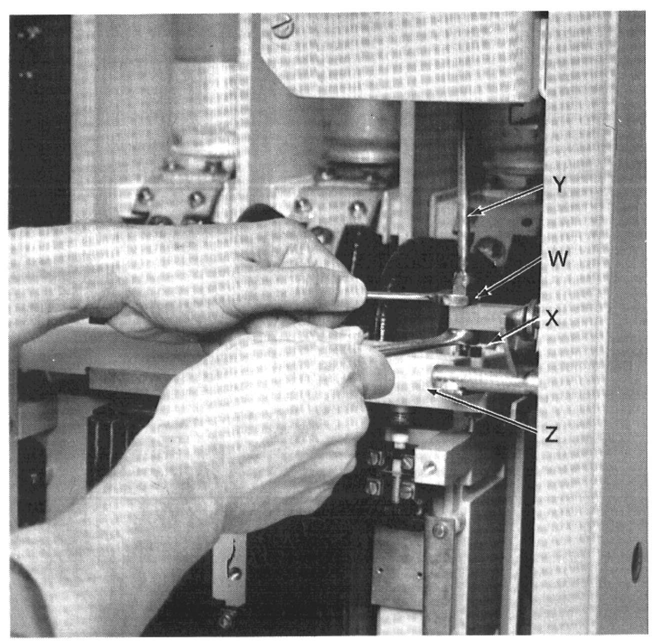
Near the bottom of the handle travel, a sharp snap should again be heard and the disconnect contacts should be fully open. Inspection may be made by viewing through the window provided in the fixed barrier. The handle latch release (B), Fig. 49, should pop fully out at the bottom of the handle travel.

4. Repeat steps 1 and 2 until the disconnect switch is again in the closed position. Simulate the contactor being energized by depressing the contactor armature downward until the contactor is in the fully closed position. While holding the contactor in the closed position, attempt to push in the latch release (B). The release should move forward only slightly and the handle should not rotate. Now, release the contactor armature and depress the latch release. Attempt to close the contactor armature. The armature should move slightly and stop preventing the contactor from moving to the closed position.



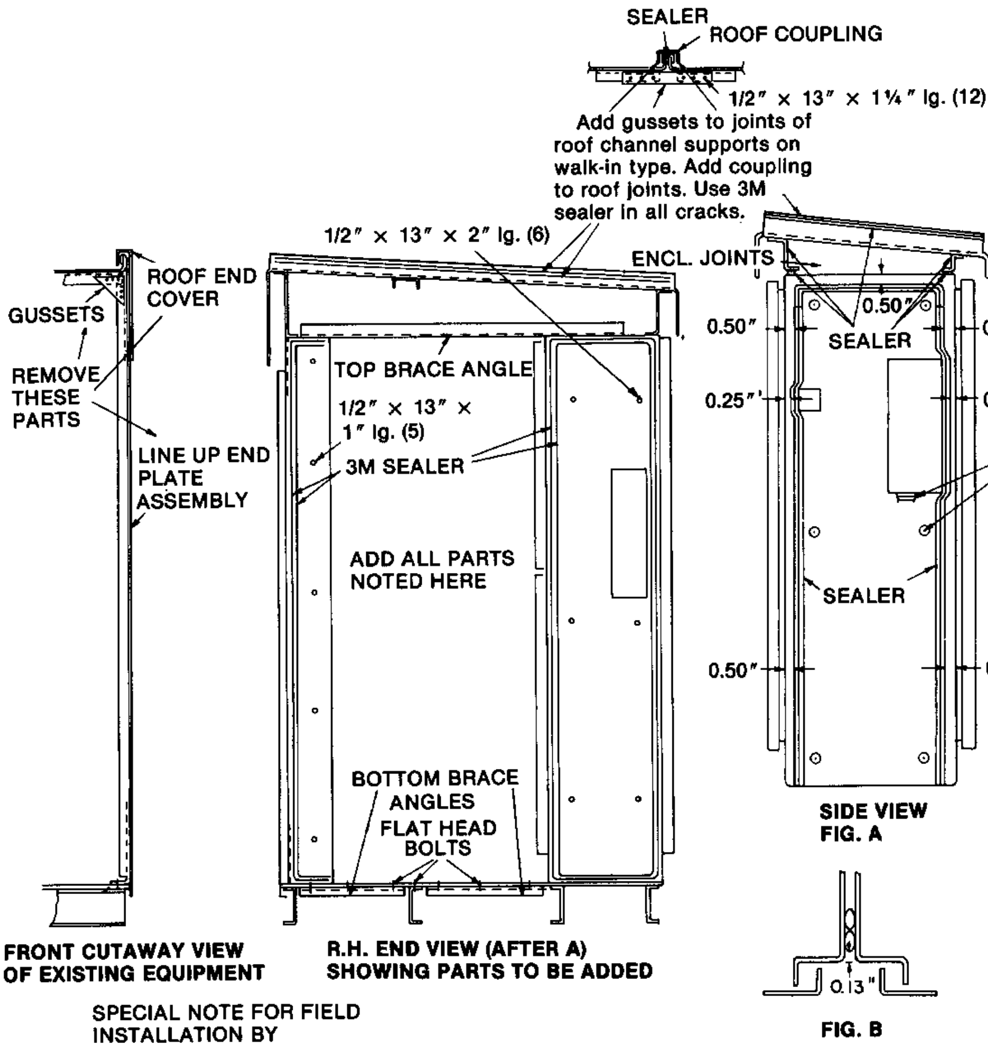
A Door-operated release (Not Visible)
B Handle latch release
C Handle
G Door latch
H Handle assembly

Figure 49. Operating handle parts.



W Top adjusting nut
X Bottom adjusting nut
Y Armature interlock rod
Z Contactor armature

Figure 50. Adjusting the interlock mechanism.



SPECIAL NOTE FOR FIELD INSTALLATION BY CUSTOMER:

In addition to other instructions shown, hardware should be removed and used to bolt new enclosures to existing enclosures. The end-plate assembly and gaskets should be removed and discarded. After enclosures are in place, install roof coupling furnished with new enclosures.

On sides of single cases and sides of cases on ends of lineups, use sealer around cutouts under all cover plates. Also use sealer in all bolt holes.

Purpose of sealer is to have weathertight seal between exposed joints of enclosures.

Where to apply:

Apply to one side of one case at each junction of lineup of cases.

Method of Application:

Place the extruded sealer strip with slight pressure 1/2-inch in from front and rear edge of side of case except 1/4-inch in at cutouts. Use two (2) strips side by side the full height of case. Also apply across the top of the side of the case 1/2-inch down. See Fig. "A".

Material:

Extruded 3M sealer formula EC1126, 1/4-inch diameter extruded bead × 30-inch long strips. Product of Minnesota Mining and Manufacturing Co., 700 Grand Avenue, Ridgefield, New Jersey.

The approximate total length of sealer required at each junction will be 42 feet, for non walk-in and 70 feet for walk-in.

Figure 51. Assembly of outdoor enclosure.

5. Repeat steps 1 and 2 above. When the handle (C) is rotated to the ON position, the door latch (G) should drop to within 1 3/4 to 2 inches from the bottom of the handle assembly (H).

6. If the mechanism fails to meet any of the above checks, an adjustment must be made to the interlock assembly as shown in Fig. 50. This adjustment is made to ensure that the interlock slider is moving properly. If the contactor can be made to turn ON manually when the disconnect switch operating handle is in an intermediate position, the interlock needs to be adjusted.

> **CAUTION:** *BEFORE MAKING ANY ADJUSTMENTS, BE SURE THAT THE CONTACTOR IS IN THE FULLY OFF POSITION AND THE DISCONNECT SWITCH HANDLE IS IN AN INTERMEDIATE POSITION WITH THE HANDLE LATCH RELEASE (B), FIG. 49, FULLY DEPRESSED.*

a. Loosen the bottom locking nut (X), Fig. 50, while holding the top adjusting nut (W) firmly in position. Also loosen the two retaining nuts at the top of the rod.

b. Turn the adjusting nut until the interlock slider is just slightly below the handle latch release rod (0.06 inches).

c. When the proper position has been reached hold the top adjusting nut (W) and tighten the lower locking nut (X) to hold the adjustment. Finally tighten the two locking nuts at the top of the rod.

d. Test the interlock mechanism again by following Steps 1 through 6 above.

If the controller fails to meet any of the above checks DO NOT ENERGIZE THE CONTROLLER. Contact your nearest General Electric sales office.

7. Return the disconnect handle to the OFF position.

Operation

General

A test-power interlock circuit is provided to check out the control circuit of the complete unit without applying power to the motor. After all control-circuit connections are made, the controller should be put through its complete operating sequence, in the test position, as a final check.

A wiring diagram which shows the circuit and connections that apply to the controller is included with the controller when it is shipped from the factory. All external wiring from the controller must be made in accordance with the connection diagram supplied with the controller.

Test power circuit

A complete operational check of the controller can be made without applying voltage to the motor or to the bus as follows:

1. The isolating-device handle must be in the open position. In the open position, contacts of the mechanically operated test-power interlock will open the secondary circuit of the control-power transformer, thereby isolating it. Other contacts of the test-power interlock will close the circuit to the test-power terminals on the control terminal board. See Fig. 14.

2. Refer to the elementary and connection diagrams for the required control voltage, frequency, and test-power terminal designations. Connect the required test-power to terminals provided on the terminal board in the low-voltage control compartment. Power may then be applied to the low-voltage control circuit and tested for proper operation.

Preparation of controller for operation

Once the panel is in place and the cable terminated, clean the inside with a brush, soft cloth, or dry compressed air. Make certain that any dirt, dust or bits of packing material, which may interfere with successful operation of the panel devices, are removed from the panel.

> **CAUTION:** *CARE SHOULD BE TAKEN DURING THE CLEANING OPERATION TO PREVENT ANY DIRT FROM BEING BLOWN INTO THE INACCESSIBLE SPACES OF THE DEVICES.*

Before the controller can be operated, even for a tryout without power, all devices must be placed in full operating condition. Also, check to ascertain that no tools or loose wires have been left within the panel during installation.

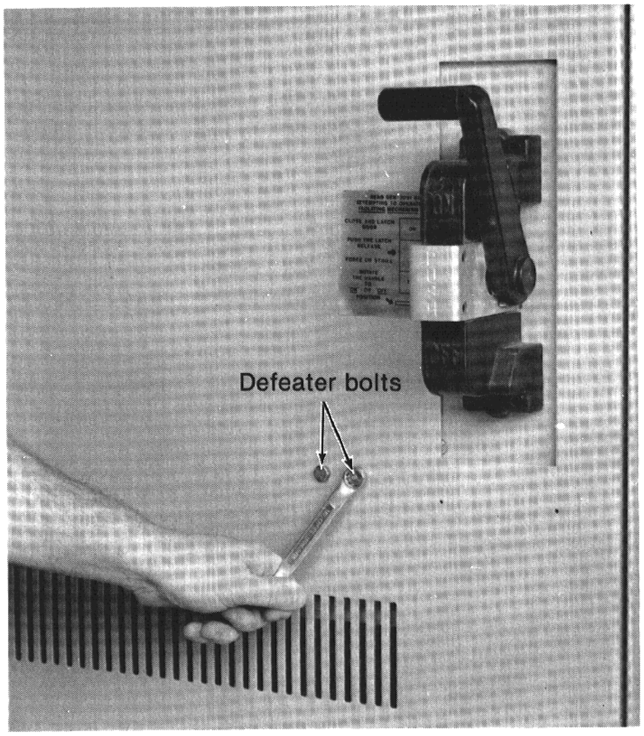


Figure 52. Door interlock defeater bolts.

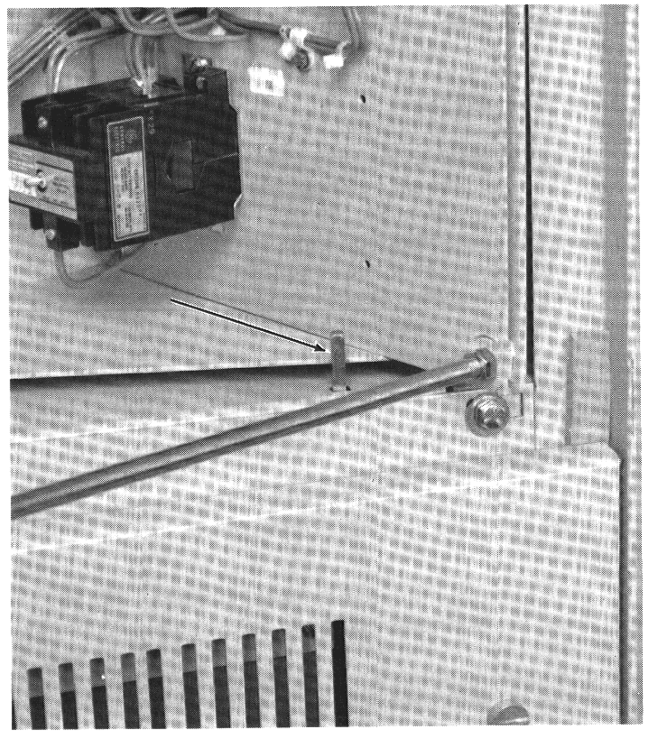


Figure 54. Interference latch may be operated by opening the high-voltage door and pulling latch down.

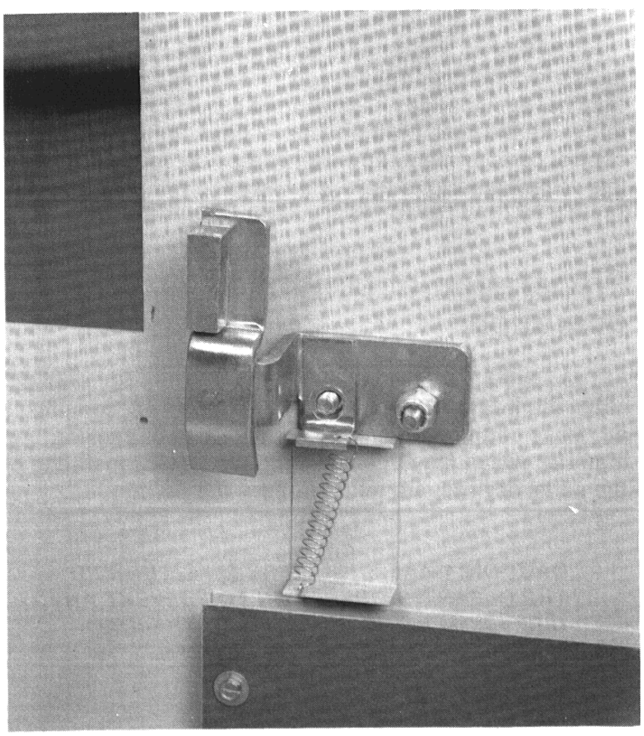


Figure 53. Interlock defeater bolt — rear view from inside of door.

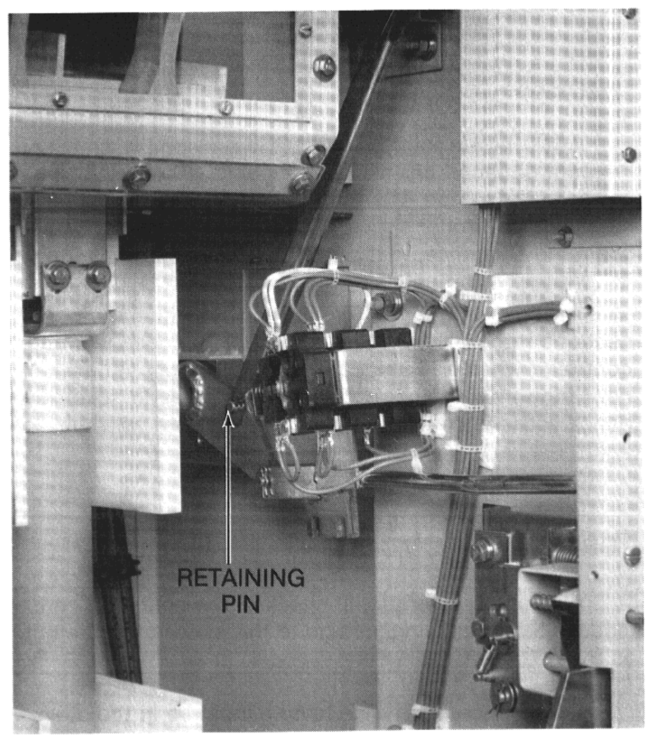


Figure 55. Isolating mechanism and electrical interlocks mounted in enclosure.

The seating surfaces of unplated and laminated a-c relay magnets, as well as the ends of shafts, are coated with a heavy-grease rust preventative. Before operating the panel, the rust preventative should be wiped off and the magnet seating surfaces coated with a thin film of light machine oil.

Operate each device by hand to see that the moving parts operate freely and without binding. Make sure that all electrical contact tips are clean, free of grease and dirt, and make a good contact when closed. The relay and contactors are carefully adjusted at the factory; however, should an adjustment of these devices be necessary, these adjustments are explained in the individual instructions for each device.

After all connections have been properly made, all parts properly assembled, and all components thoroughly inspected and adjusted, the controller is ready for operation.

Normal operation

1. After all power and control connections are made, AND WITH THE ISOLATING DEVICE OPEN, megger between phases at the motor terminals, and between each phase and ground stud or bus, to ascertain that no short circuits are present.

2. Close the compartment doors and apply power to the controller.

If the operating handle of the isolating mechanism cannot be moved to the closed position, it may be that the mechanical interlock device is preventing this movement. To move the handle to the closed position, the high-voltage door must be fully closed and the contactor must be open.

3. Close the isolating-device handle by moving the handle with a positive motion to the extreme upper position until it latches into position. Unless the latch (pusher) snaps out when the handle is moved to the extreme positions, either in the open or closed position, the contact marked CPI (control-power interlock) will not close.

4. Operate the controller in the normal manner with the pilot devices (usually, push buttons) provided.

5. After the preliminary operation check is made, check the motor for proper rotation.

Door opening procedure

General

To open the high-voltage doors to gain access to the contactor or motor terminals, the contactor must be in the de-energized position. If the contactor is energized, the latch on the disconnect handle cannot be pushed in, the handle cannot be operated, nor can the door be opened.

Depressing the stop button de-energizes the contactor. The latch release on the disconnect handle can then be depressed, which opens an electrical interlock in the secondary of the control-power transformer. When the latch release has been depressed, the isolating switch handle may be moved to the lower or open position. With the disconnect handle in the lower position, the high-voltage door may be opened by turning the 1/4 turn latches.

Door-defeater latch

WARNING: *THE FOLLOWING STEPS SHOULD ONLY BE TAKEN AS A LAST RESORT TO ENTER A MALFUNCTIONING CONTROLLER. IT IS IMPERATIVE THAT ALL POWER TO THE MAIN BUS BE REMOVED BEFORE PROCEEDING.*

IN CASE OF EMERGENCY, remove all power to the controller; then, the high-voltage door may be opened with the contactor in the closed position and with the isolating switch closed, by using the hex-head bolts, located to the lower left of the isolating-switch handle, as follows:

WARNING: *DO NOT PROCEED UNLESS ALL POWER TO THE CONTROLLER IS REMOVED. DOORS MUST NOT BE OPENED WITH THE POWER CONNECTED TO THE BUS.*

1. Turn the door latches 1/4 turn counterclockwise.

2. Remove the right-hand hex-head bolt, as shown in Fig. 52.

3. Turn the left-hand bolt 1/4 turn counterclockwise. Figure 53 shows the bolts from the inside. The door may then be opened.

WARNING: *DEFEATING THE DOOR INTERLOCK LEAVES THE CONTROLLER CONNECTED TO THE BUS. THE BUS POWER MUST BE REMOVED.*

On some one-high enclosures, the low-voltage control panel serves as a barrier to isolate the high-voltage control-power transformer and fuses. An interference pin, shown in Fig. 54, prevents swinging this low-voltage panel out until the high-voltage door is opened.

Contactor control module (CCM)

General

Power Source: 115 VAC nominal 50 or 60 Hertz.
Operating Temperature: 0°C to 55°C (-40°C to 70°C Storage)

The Contactor Control Module (CCM) is a microprocessor based control device for the vacuum contactor coil. The device provides regulated coil power for the contactor and performs several functions which are described below.

The CCM is supplied with 115 Volts ac nominal on Pins 12 and 13 from the control power transformer in the Vacuum Limitamp controller. The CCM contains an internal rectifier to convert the coil power to direct current. A switching transistor (MOSFET) is placed in the circuit to regulate the coil current to a fixed value. The gate of the MOSFET is controlled by the microprocessor which in turn determines how the coil should be operated based on a number of conditions.

On-off commands are sent to the CCM by means of a switched 115-Volt ac line to Pins 10 and 11. When power is supplied to these pins, the CCM turns the contactor on and holds it on as long as power is applied. When power is removed from Pins 10 and 11 the CCM releases the contactor after a slight timing delay (one cycle maximum) to provide **controlled point on wave tip opening** of the contactor tips.

During operation, the indicator lamps on the front of the CCM (see Fig. 9) perform several functions. These functions are described below. A detailed technical description of the CCM and how it works is available from the General Electric Company.

Green LED

This is the power "ON" indicator. This LED should be illuminated at all times when power is applied to the CCM. If this light is out power may not be available to the CCM or the internal power supply fuse is blown.

Yellow LED

This LED is the warning LED. This LED is normally off except under four conditions.

1. The LED will blink briefly when the microprocessor updates the internal non-volatile memory. This occurs during the fifth switch-off operation after power is applied to the CCM and every ten operations thereafter. The quick blink indicates that the microprocessor has successfully updated the non-volatile memory and has read back the data and determined that what was read is equal to what was stored.

2. The LED will be illuminated continuously if the CCM Power Supply is experiencing an under-voltage condition. The CCM will continue to operate until the power supply voltage falls to about 45 percent of normal. The LED will begin to illuminate at about 65 percent of normal supply voltage. At this point, the contactor coil current is boosted in an attempt to hold it in. This permits the CCM to operate the coil during severe voltage dips.

3. The LED will blink very fast (several times a second) if an error in the non-volatile memory is discovered. The CCM will become non-operational if this fault occurs. If the LED is blinking fast this means the EEPROM memory integrated circuit must be replaced. The EEPROM has an expected life of 15 million contactor operations.

4. The yellow LED will blink slowly (once a second) if the microprocessor has detected a fault in the ON-OFF input lines. These input lines are opto-isolated from the power source and are redundant in nature. This prevents the CCM from holding the contactor in if one of the input devices should fail. By blinking the LED slowly the CCM is announcing that one of the opto-isolators has failed and needs to be replaced. The circuit arrangement makes the CCM start-stop command line fail-safe. In other words, if a problem should occur in the start-stop command input, the CCM will trip off line instead of holding the contactor in.

If the yellow LED is "ON" during operation of the CCM and the system supply voltage is normal, contact the factory for a replacement CCM module.

Red LED

The red LED is the CPU FAULT light. The LED is normally off. The LED will illuminate if the microprocessor has stopped. When the LED is on, power is removed from the MOSFET gate and the contactor cannot pick up.

The CCM is equipped with the capability of detecting a fault in the coil power circuit. If a problem is detected the RED LED will blink to indicate a fault. If the RED LED is blinking, turn off the controller disconnect for 30 seconds and then reapply power. If the RED LED continues to blink, replace the CCM.

WARNING: *THE CCM CONTAINS CAPACITORS THAT MAY MAINTAIN A LEVEL OF ELECTRICAL CHARGE FOR SEVERAL MINUTES AFTER POWER IS REMOVED FROM THE CCM. DO NOT TOUCH THE INTERNAL PARTS OF THE CCM FOR ABOUT FOUR MINUTES AFTER POWER IS REMOVED.*

Fuses

The CCM is equipped with three fuses. The fuse sizes have been carefully selected to protect the CCM and the contactor coil from damage.

If any of these three (3) fuses in the CCM blow, do NOT attempt to replace the fuses. The user should replace the CCM and return the failed unit to the General Electric Company for repair.

WARNING: *DO NOT REPLACE ANY FUSES INSIDE THE CCM. THIS MAY CAUSE IMPROPER OPERATION OF THE CCM AND/OR CONTACTOR RESULTING IN EQUIPMENT DAMAGE, INJURY OR DEATH.*

DIP switches

The CCM is equipped with two DIP switches. The first switch is a four position device.

Switches 1 through 4 on the smaller switch provide a means of "slugging" or intentionally delaying the opening of the contactor. This means that when an OFF command is received, the CCM will not shut off the contactor until a selectable time delay has passed. This provides the same function that a copper jacket around the coil armature provides except the time delay is adjustable. The tip opening continues to be controlled when the delay is enabled. The switch settings and the corresponding delay times are shown in the table. The time delay is selected in steps of 50 milliseconds and the switches act like a binary counter with switch number 1 as the least significant bit. The delay can be varied from 0 to 750 milliseconds. If no intentional delay is desired place switches 1 through 4 in the down position. In the table the switch is considered to be "OFF" when it is down or in its closest position to the circuit board. With the CCM mounted vertically in the enclosure, the down position in relation to the circuit board is to the right.

The second switch (1-9) is the CCM calibration switch. These switches are set using the CCM calibration device available from the factory. The CCM calibration should be checked once every year to make sure the CCM is functioning properly. For optimum performance the CCM should be recalibrated when the contactor is replaced, after replacing bottles, after tip wear adjustment, after replacing a contactor coil and if the CCM is replaced. Consult the next section in these instructions for calibration information.

WARNING: *THE CONTROLLER DISCONNECT MUST BE PLACED IN THE OFF POSITION BEFORE PERFORMING THE CCM CALIBRATION PROCEDURE. BEFORE CONTINUING WITH THE CALIBRATION BE SURE THAT THE LOAD HAS COASTED TO A COMPLETE STOP. A SOURCE OF EXTERNAL TEST CONTROL POWER IS REQUIRED TO PERFORM THE CALIBRATION.*

SWITCH NUMBER				TIME DELAY — MILLISECOND *
1	2	3	4	
OFF	OFF	OFF	OFF	0
ON	OFF	OFF	OFF	50
OFF	ON	OFF	OFF	100
ON	ON	OFF	OFF	150
OFF	OFF	ON	OFF	200
ON	OFF	ON	OFF	250
OFF	ON	ON	OFF	300
ON	ON	ON	OFF	350
OFF	OFF	OFF	ON	400
ON	OFF	OFF	ON	450
OFF	ON	OFF	ON	500
ON	ON	OFF	ON	550
OFF	OFF	ON	ON	600
ON	OFF	ON	ON	650
OFF	ON	ON	ON	700
ON	ON	ON	ON	750

* The time delay shown as "0" means that there is no intentional delay before the contactor coil is released. The times shown do not include actual contactor drop out time which may vary from 20 to 80 milliseconds after the coil power is removed. Actual total drop out time is the sum of the switch setting and the drop out time of the contactor plus or minus one electrical cycle (16.6 millisecond at 60 Hertz).

Setting the calibration switches

The following procedure should be followed to set the calibration switches;

1. Operate the disconnect and ensure that the isolation switch is in the open position. If an attached load has been operating, wait until the motor has completely stopped spinning before continuing with the calibration procedure. A spinning motor could generate voltage which will be back-fed to the load side of the contactor.

2. When the load has stopped rotating, remove PT and CPT primary fuses and connect the two leads from the calibrator that are equipped with alligator clips to the top and bottom ends of the phase A vacuum interrupter on the vacuum contactor. This is the interrupter located on the leftmost side of the contactor. This can be done by attaching the leads to the bottom of the leftmost fuse mount and to the topmost load terminal. Plug the 9 pin power connector from the calibrator into the socket provided on the CCM module.

3. Refer to the equipment elementary diagram and locate the control terminal board points where test power may be applied. These terminals will be located in the low voltage compartment. Apply control voltage to these points. The green LED on the CCM should illuminate.

4. Turn the small toggle switch on the calibrator module ON and observe that eight of the nine (9) LEDs begin to blink.

5. Press the start button on the Vacuum Limitamp controller and allow the contactor to pick up. Wait until the LED's have gone out on the calibrator module and then press the stop button on the controller front panel. The LED's should now illuminate in a repetitive pattern. The test should be repeated at least ten (10) times until a definite pattern showing on the LED's occurs. If the same pattern does not appear every time use the switch setting that appears most often. Some count variations are normal and do not indicate a problem with the CCM or vacuum contactor. Small variations do not affect the ability of the CCM to maintain the contactor tip openings on target. Use a test chart (Fig. 63) to determine the most repetitive pattern of LED's. Record this pattern for future reference. The setting will not change if the same contactor is used with another CCM.

6. Each LED is numbered and corresponds to one of the DIP switches on the CCM (1-9). If the LED for a particular switch is ON then that switch should be moved to the ON or up position. That is, the switch should be moved to the position that is farthest from the circuit board. Some switches supplied on the CCM circuit board may have markings indicating an ON or OFF position. Ignore those markings and follow the instructions above. The switches whose LEDs are OFF should be moved to the OFF position or the position closest to the circuit board. This completes the calibration procedure.

7. Remove the external control power from the panel. Remove the calibration module from the enclosure by disconnecting the small plug first and then disconnecting the clip leads from the vacuum interrupter circuit. Do not allow the tester leads to become grounded while control power is applied. Failure of the CCM is likely if this occurs. Close the doors and operate the controller normally. Replace PT and CPT primary fuses.

CCM calibrator

The CCM Calibrator can be ordered from the General Electric Company. The Catalog Number is 55C679605G1.

CCM service

The CCM has no user serviceable parts. Repair should not be attempted. Do NOT probe the CCM printed circuit boards with an oscilloscope or other instrument that has a grounded frame. Damage will result to the CCM coil power rectifier. This will require a replacement module from the factory and a charge for replacement since damage of this type will void the equipment warranty.

Modifying the CCM

The CCM works with all three of General Electric's vacuum contactors. However, internal jumpers must be changed and an internal EPROM containing the system program must be changed. Do not attempt to use a CCM that has been set up for a particular contactor without making the required changes. Contact the factory for modification information and parts.

Replacing the CCM

WARNING: *BEFORE REPLACING THE CCM REMOVE POWER TO THE STARTER HIGH VOLTAGE COMPARTMENT BY TURNING THE DISCONNECT SWITCH TO THE OFF POSITION.*

WARNING: *THE CCM USES POWER RESISTORS THAT MAY BECOME HOT DURING OPERATION. ALLOW THE CCM TO COOL BEFORE REMOVING IT.*

The CCM is located on the right side of the high voltage compartment just below the horizontal shelf. Before removing the CCM the main disconnect must be in the OFF position in order to enter the high voltage compartment. To remove and replace the CCM proceed in the following manner;

1. A 12-pole plug connects to the left side of the CCM. A 6-pole plug connects to the right side of the CCM. Release the retainer latches on each plug. Then, disconnect the two control cable runs by unplugging them one at a time.

2. Remove the four CCM mounting nuts. Two nuts are located at the top and bottom ends of the CCM. Remove the CCM from its mounting.

3. Mount the new CCM into position on the mounting studs.

4. Plug the two cable harnesses into their proper connector. Make sure the DIP switches on the new unit are in the same position as the old unit.

CAUTION: *DO NOT FORCE CONNECTION DURING ENGAGEMENT. CONNECTION PINS WILL BE DAMAGED IF EXCESSIVE FORCE IS APPLIED RESULTING IN POOR CONNECTION AND IMPROPER OPERATION OF THE CCM AND/OR CONTACTOR.*

5. Close the high voltage door. The controller may now be energized.

Inspection, maintenance, and servicing

Vacuum contactor

Complete maintenance and adjustment instructions for the high-voltage contactors are presented in GEH-5306. Refer to that Instruction for all problems of servicing and adjusting; and to the proper renewal parts bulletin for renewal parts.

Contactor tip life depends on the severity of the service, but in any case, it is recommended that the contactor tip wear be checked at least once a year or in very high duty cycle operations, after every 250,000 operations.

Isolating mechanism and mechanical interlock

WARNING: *UNDER NO CIRCUMSTANCES SHOULD THE ISOLATION SWITCH BE INSPECTED OR ADJUSTED WITH POWER APPLIED TO THE MAIN BUS.*

The quick-make quick-break isolation switch assembly is adjusted and tested at the factory. Under normal circumstances the switch does not need adjustment, however, if conditions require it the switch may be adjusted in the field. To adjust the disconnect switch the following steps should be followed;

WARNING: *ALL POWER MUST BE REMOVED FROM THE MAIN BUS BEFORE ATTEMPTING TO ADJUST THE ISOLATING SWITCH MECHANISM.*

1. After removing all power to the controller, remove the fixed barrier (Fig. 33) by removing the retaining screws that hold it in place. Remove the barrier and place it aside. Retain the hardware for reassembly. Remove the pin (Fig. 55) holding the connecting rod from the handle to the swing plate at the back of the enclosure and disengage the connecting rod. This will allow the switch blade assembly to pivot freely during the adjustment operation.

Some of the barrier mounting hardware is nylon type hardware. Note the location of these parts so they may be reassembled properly.

2. Near the end of each switch blade assembly adjusting screws and nuts are located along with a Belleville washer type spring. To adjust the blade pressure the screw must be adjusted. Loosen the small set screw located on each of the retaining nuts to enable adjustment.

3. Using a 0.495 inch diameter pin gage adjust the nut at the top of the blade until the gage slides snugly between the blades. The fit must not be tight. Just enough pressure for a snug fit is sufficient.

4. After the proper adjustment point has been found, tighten the set screw on the nut to lock the adjustment in position. Use caution to prevent turning the nut on the main screw while tightening the set screw.

5. When the adjustment is complete for all three phases apply a thin coating of General Electric D50H47 zinc chromate grease to the contact surfaces of the male stab portion of the disconnect.

To properly adjust the lower pivot point Belleville washer type spring follow the following steps;

1. On each phase loosen the set screw on the adjusting nut.

2. Loosen the adjusting nut and then retighten using your fingers until the nut is just snug and no side play of the parts is evident.

3. Using wrenches tighten the adjusting nut an additional one-half (1/2) turn and tighten the set screw to hold the adjustment in place.

4. Reinstall the retaining pin that connects the driver rod from the handle to the swing plate. Be sure to replace the cotter pin that was removed during disassembly. Finally, reinstall the isolator switch barrier. If necessary the viewing window may be cleaned before reinstallation of the barrier. Use a soft cloth and a mild soap and water solution or a commercial cleaner such as Windex or other similar cleaner.

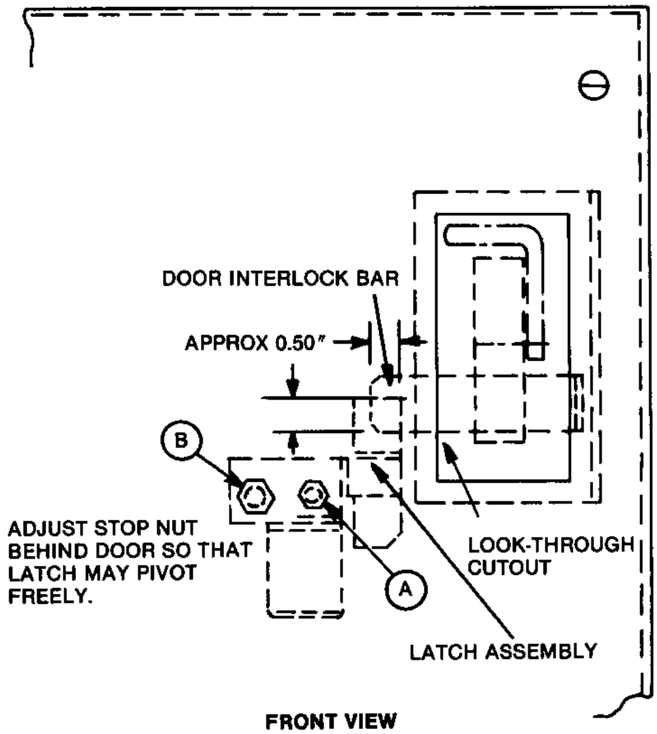
WARNING: *SEVERE INJURY OR DEATH MAY RESULT IF THE EQUIPMENT IS ENERGIZED WITH THE MECHANICAL INTERLOCKS DEFEATED. REMOVE ALL POWER FROM THE EQUIPMENT BEFORE DEFEATING ANY OF THE MECHANICAL INTERLOCKING MECHANISMS.*

Checking procedures — Mechanical Interlock and Manual Isolator (See Figs. 56-58)

1. Check door mechanical interlock for proper interference. See Figure 56.

2. Check for proper operation of pusher rod and control power interlock operation. See Figure 57.

3. Check test power interlock adjustment. See Figure 58.



NOTE

To check if sufficient (or safe) interlocking between door and door interlock bar exists, the following should be done:

A. Open high-voltage door.

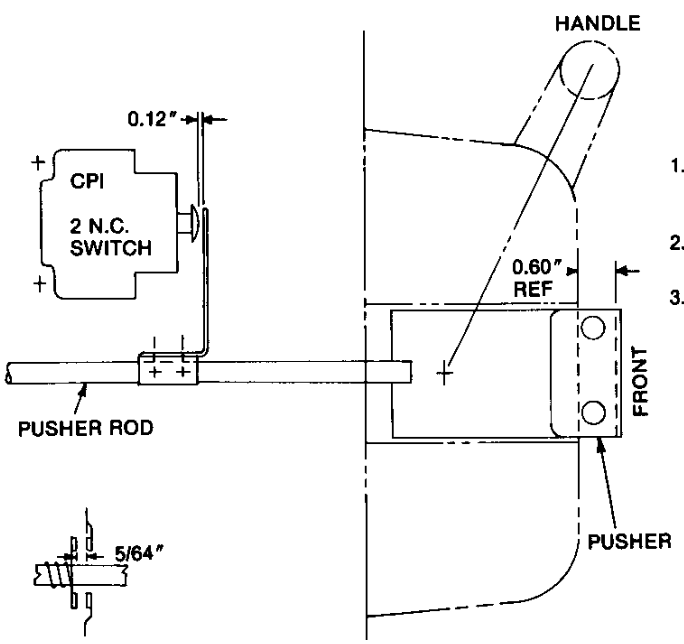
B. With the door open, close the isolator switch by manually depressing the door interlock defeater. See Fig. 53.

C. Close door against interlock bar.

D. Look through door cutout below handle and visually determine if there is a minimum of 0.50-inch overlap (see sketch).

E. For a final check, close the door, close the disconnect switch, and try to pull the door open. The door should not open.

Figure 56. Checking procedures for mechanical door interlock.



NOTE

1. Set 0.12-inch gap (as shown) with push rod extended (Out position). See 0.60-inch reference.
2. Then, check the interlock operation with the switch rod depressed.
3. Both contacts must be open and have a contact gap of at least 5/64 inch.

Figure 57. Checking for proper operation of pusher rod and control power interlock operation.

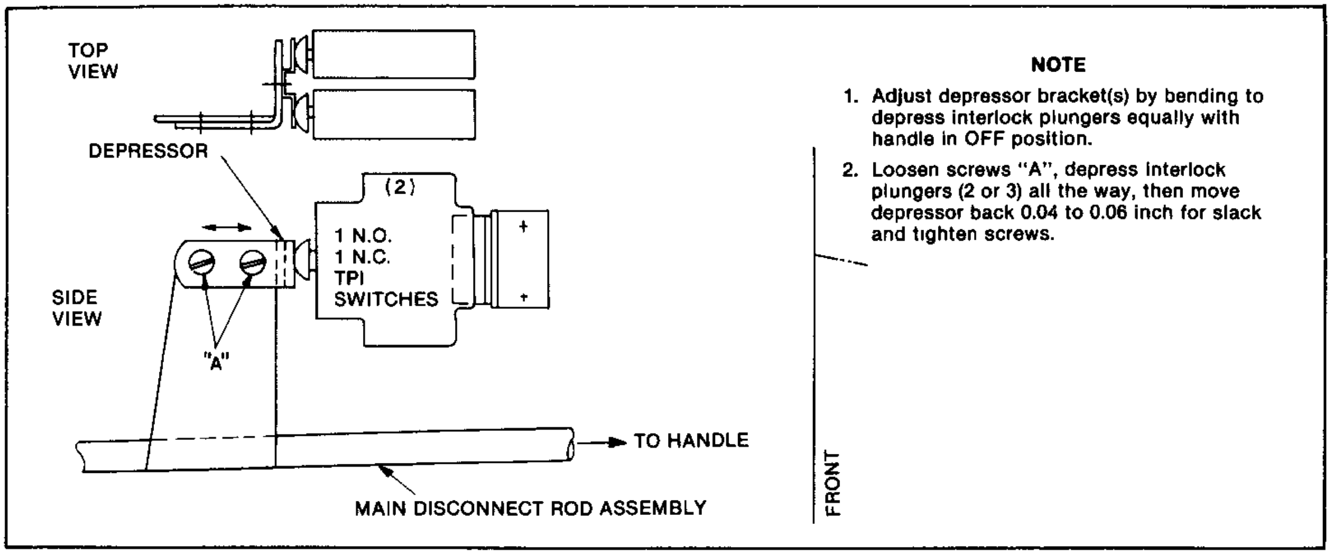


Figure 58. Checking test power interlock adjustments.

Vacuum interrupter integrity test

WARNING: *THE CONTROLLER ISOLATION SWITCH (QMQB) MUST BE PLACED IN THE OFF POSITION AND THE MOTOR LOAD MUST HAVE COME TO A COMPLETE STOP BEFORE ATTEMPTING TO PERFORM THE VACUUM INTERRUPTER INTEGRITY TEST.*

CAUTION: *X-RAY EMISSION MAY BE PRODUCED IF AN ABNORMALLY HIGH VOLTAGE IS APPLIED ACROSS THE OPEN CONTACTS OF A VACUUM INTERRUPTER. DO NOT APPLY A VOLTAGE THAT IS HIGHER THAN THE VALUE RECOMMENDED IN THE FOLLOWING TABLE:*

CONTACTOR MODEL	CURRENT RATING	RECOMMENDED TEST VOLTAGE
CR193A	200 Amps	13.5 kV RMS
CR193B	400 Amps	20.0 kV RMS

General

This test determines the internal dielectric condition and vacuum integrity of the vacuum interrupters. Prior to performing this test the outside surfaces of the vacuum interrupters should be wiped clean of any contaminants with a non-linting cloth or industrial type wiper. During this test each interrupter should be checked separately.

WARNING: *THE VACUUM INTERRUPTER INTEGRITY TEST SHOULD BE PERFORMED BEFORE THE HIGH VOLTAGE CONTACTOR IS ENERGIZED FOR THE FIRST TIME AND EACH TIME IT IS RETURNED TO SERVICE AFTER MAINTENANCE, ADJUSTMENT OR REPAIR. (SEE GEH-5306.) OTHERWISE THE VACUUM INTERRUPTER INTEGRITY TEST SHOULD BE PERFORMED ANNUALLY.*

CAUTION SHOULD BE EXERCISED DURING THIS TEST SINCE HIGH VOLTAGE TESTING IS POTENTIALLY HAZARDOUS. FIRST OPEN THE CONTROLLER ISOLATING SWITCH THEN COMPLETELY ISOLATE THE CONTACTOR BY DISCONNECTING THE BOLTED CONNECTIONS AT THE CONTACTOR LOAD TERMINALS PRIOR TO PERFORMING THE HIGH POTENTIAL TEST. ALSO REMOVE CPT PRIMARY FUSES.

FAILURE TO PERFORM THESE TESTS MAY CAUSE SERIOUS INJURY OR DEATH.

High potential test instruments can be purchased to perform the vacuum interrupter integrity test. The following is a recommended test instrument:

Hipotronics Model 7BT 60A

Test procedure

1. Disconnect load side power leads from contactor and CPT primary fuses.

2. With the contactor in the open position connect the test leads to the contactor power terminals as shown in Figure 59. Apply the recommended test voltage (per table above) and hold for a minimum of five (5) seconds.

3. Reverse the leads and repeat the test.

4. If no breakdown occurs the interrupter is in acceptable condition. If a breakdown occurs the interrupter should be replaced. Refer to the "Interrupter Replacement" section in GEH-5306.

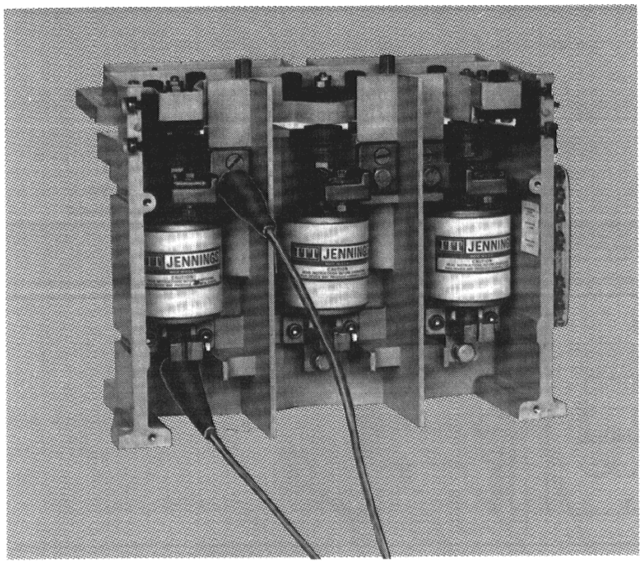


Figure 59. Method of connecting test leads to interrupter for vacuum integrity test.

5. After the high potential voltage is removed from the interrupters, the metal end caps of the interrupters should be discharged with a grounding stick to remove any residual electrical charge.

6. Make sure that all connections are tightened properly to 12-16 lb.-ft. Reconnect load cables and replace CPT fuses.

Preventive maintenance guide

WARNING: *BEFORE PERFORMING ANY PREVENTIVE MAINTENANCE ON THE VACUUM LIMITAMP CONTROLLER ALL POWER MUST BE REMOVED FROM THE EQUIPMENT AND ALL ROTATING EQUIPMENT MUST HAVE COASTED TO A COMPLETE STOP.*

Maximum trouble-free service from Vacuum Limitamp controllers requires periodic inspection, preventive maintenance, and periodic cleaning. A definite schedule should be maintained for inspection, the frequency depending upon operating conditions. Preventive maintenance activity should then be established as the result of periodic inspection.

In these routine inspections, four basic categories of deteriorating influences should be kept in mind:

1a. The effect of foreign material: Dirt and dust from the environment such as wood fibers, coal dust, cement, lamp black, lint.

1b. The effect of chemicals in the atmosphere: such as sulfur dioxide, chlorine, some hydrocarbons and salt water.

2. Mechanical wear and fatigue on all moving parts.

3. Heat.

4. Loose joints and connections.

5. Perform vacuum interrupter integrity test as described in these instructions.

Follow directions in these Instructions for obtaining access to all sections of the controller including high-voltage door interlocking. Also, refer to GEH-5306 for directions relative to inspection of the high-voltage contactor.

The following are some specific recommendations:

1. Check for cleanliness generally, but particularly for accumulation of any foreign material on insulators. Voltage failures can result from tracking across insulation surfaces when they are dirty. The primary circuit insulation on the controller may be checked phase to phase and phase to ground using a 2500 volt megger.

2. Check for abrasive material accumulated in the isolating mechanism and mechanical interlock bearing and cam surfaces.

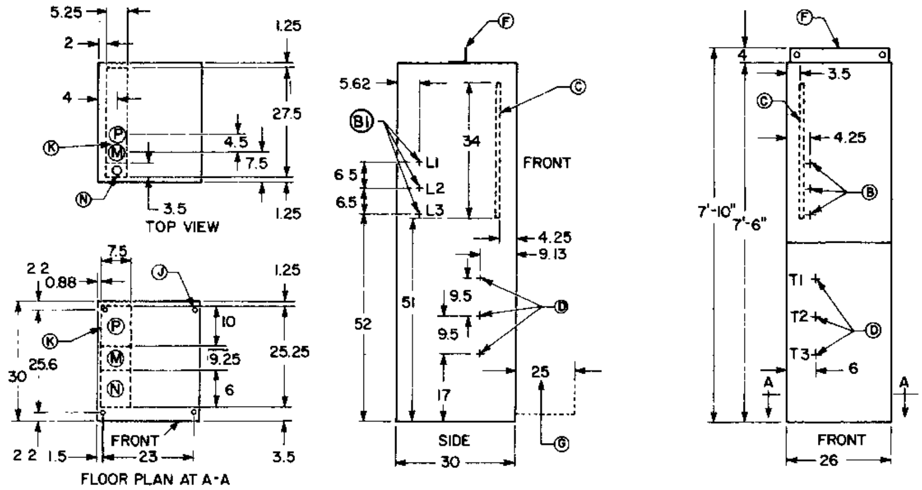
3. Check for buildup of dust or dirt which would reduce any air or surface voltage clearances.

4. Excessive heat can cause wire and cable insulation breakdown. Therefore, check for any evidence of melting, discoloring, deterioration of wire and cable.

5. The isolating mechanism has a life expectancy of approximately 6000 operations. If the application is such that the mechanism is operated more than twice each day, then the mechanism should be checked at the end of each 1000 operations, otherwise a yearly inspection is recommended.

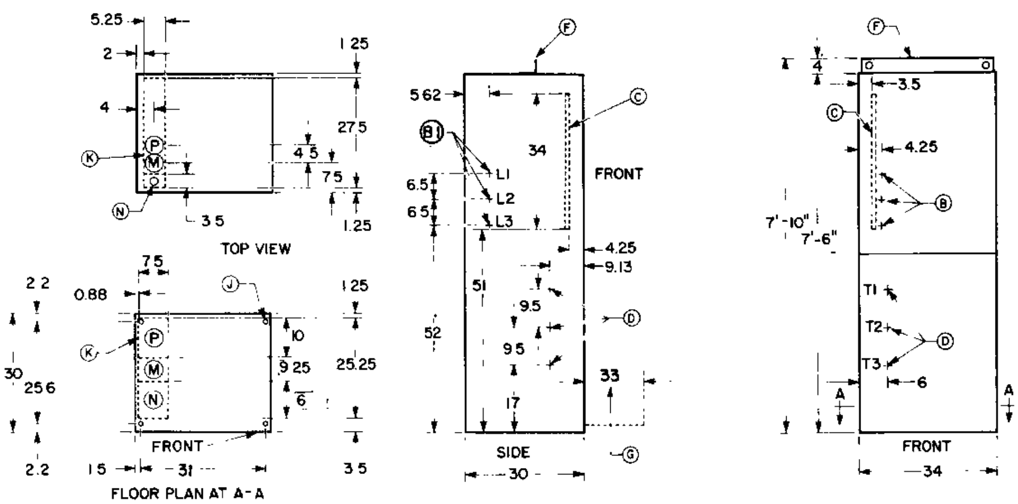
6. Periodic checks of dimensions of the isolating mechanism and mechanical interlocks is strongly recommended. Follow the section in these Instructions entitled "ISOLATING MECHANISM AND MECHANICAL INTERLOCK".

7. When any part of the isolating mechanism and mechanical interlock is replaced, all dimensions and checking procedures referred to under No. 6 above should be followed to be sure the system is in normal working order.



NOTE: All dimensions under 6 feet are in inches

Figure 60. Dimensions, one-high enclosure (400 amperes and below).

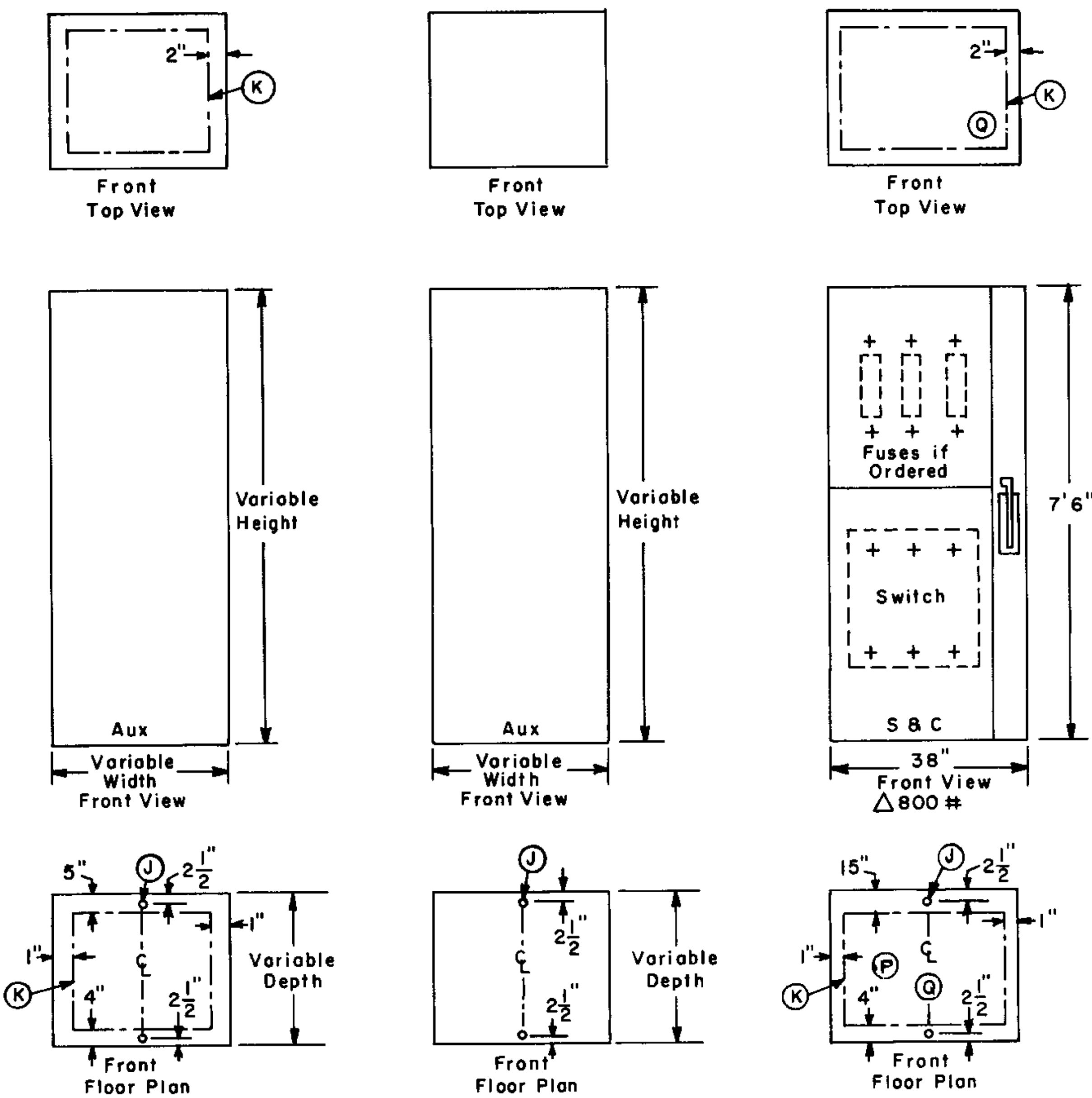


NOTE: All dimensions under 6 feet are in inches

Figure 61. Typical dimensions, one-high design, extra-width/synchronous enclosure

LEGEND

B1 — Ac power bus
C — Control lead terminal board
D — Motor lead terminal connection
G — Space required to open doors 90 degrees
J — Mounting holes for 1/2 inch diameter anchor bolts
K — Space available for incoming conduit
M — Recommended position for incoming motor conduit
N — Recommended position for incoming control conduit
P — Recommended position for incoming power conduit



NOTES:

J - Mounting holes for 1/2-inch diameter anchor bolts

K - Space available for incoming conduit

P - Recommended position for incoming conduit

Q - Recommended position for incoming conduit

Δ - Approximate uncrated weight
- Add 5 percent for domestic shipping weight
- Add 20 percent for export shipping weight

Figure 62. Auxiliary enclosures.

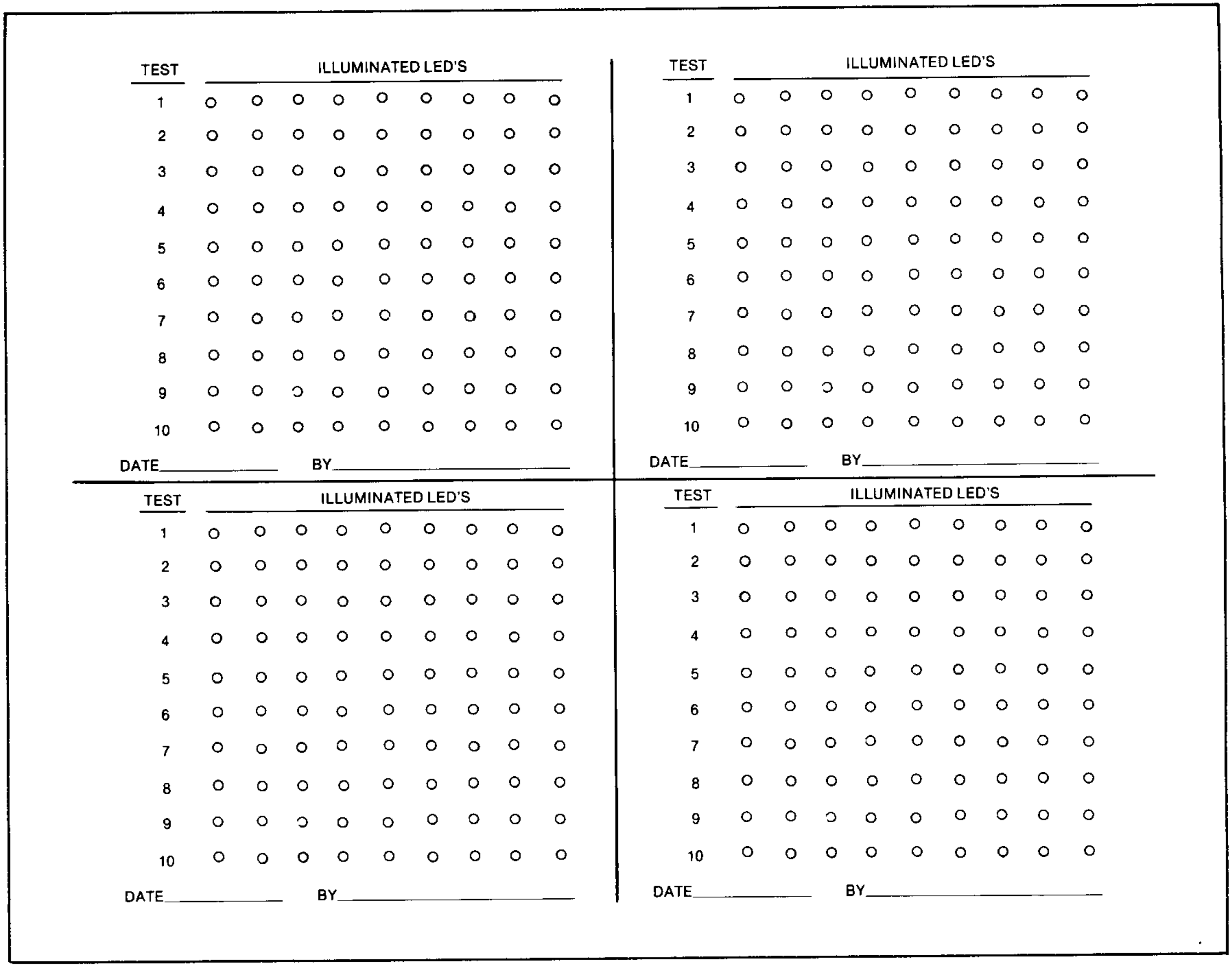


Figure 63. CCM Calibration charts.

For further information call or write your local General Electric Sales Office or

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