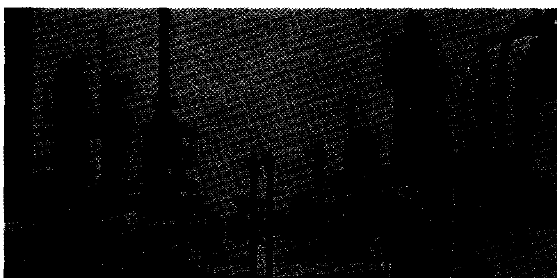
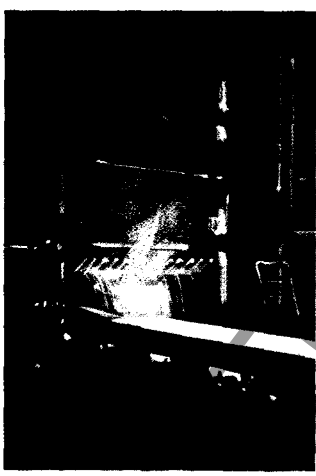
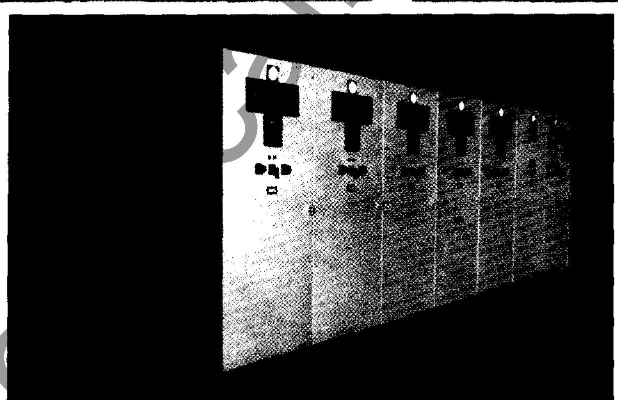
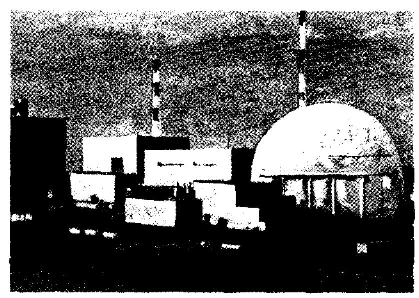
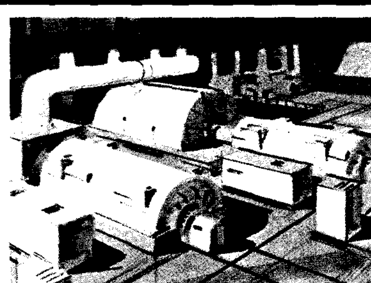
GEA-5664M

Vertical Lift Metal-Clad Switchgear with magne-blast power circuit breakers





GENERAL ELECTRIC

Since 1928, when General Electric introduced its vertical lift metal-clad switchgear design, a steady stream of technological improvements has provided a consistently high quality product with superior performance. The benefits of metal-clad switchgear are many. For example:

Simpler station planning is achieved with one complete engineering specification and purchase, standardized factory-assembled units adaptable to any switching scheme, and a design uniformity that simplifies future expansion.

Safest possible switching arrangements are built in. Each unit is metal-enclosed, function compartmentalized, grounded, insulated. Live parts are not exposed. The primary PT fuses can only be handled in a deenergized position. The chances of operator or maintenance personnel touching live parts are minimized.

Maintenance costs are reduced because magne-blast breakers require infrequent maintenance. Use of arc-resistant material on the arc runners and an extended arc chute throat piece help to extend the maintenance period. Other design features allow for easy removal, inspection and, when necessary, replacement of meters and relays.

System economics are enhanced by fast opening speed and clearing time that reduce line burn-down and equipment damage. Pre-shipment assembly means speed of installation and ease of relocation. And because GE's metal-clad switchgear is compact, you save on valuable floor space.

TABLE OF CONTENTS

GE's indoor metal-clad switchgear . . .
the leader in performance dependability

General Electric metal-clad performance dependability is the result of years of experience and leadership in the switchgear field. These units are the answer to a wide variety of switching applications, from protection of feeders to arc furnace operation. Versatility is but one part of the General Electric metal-clad story. It takes much more to make switchgear than you can take for granted.

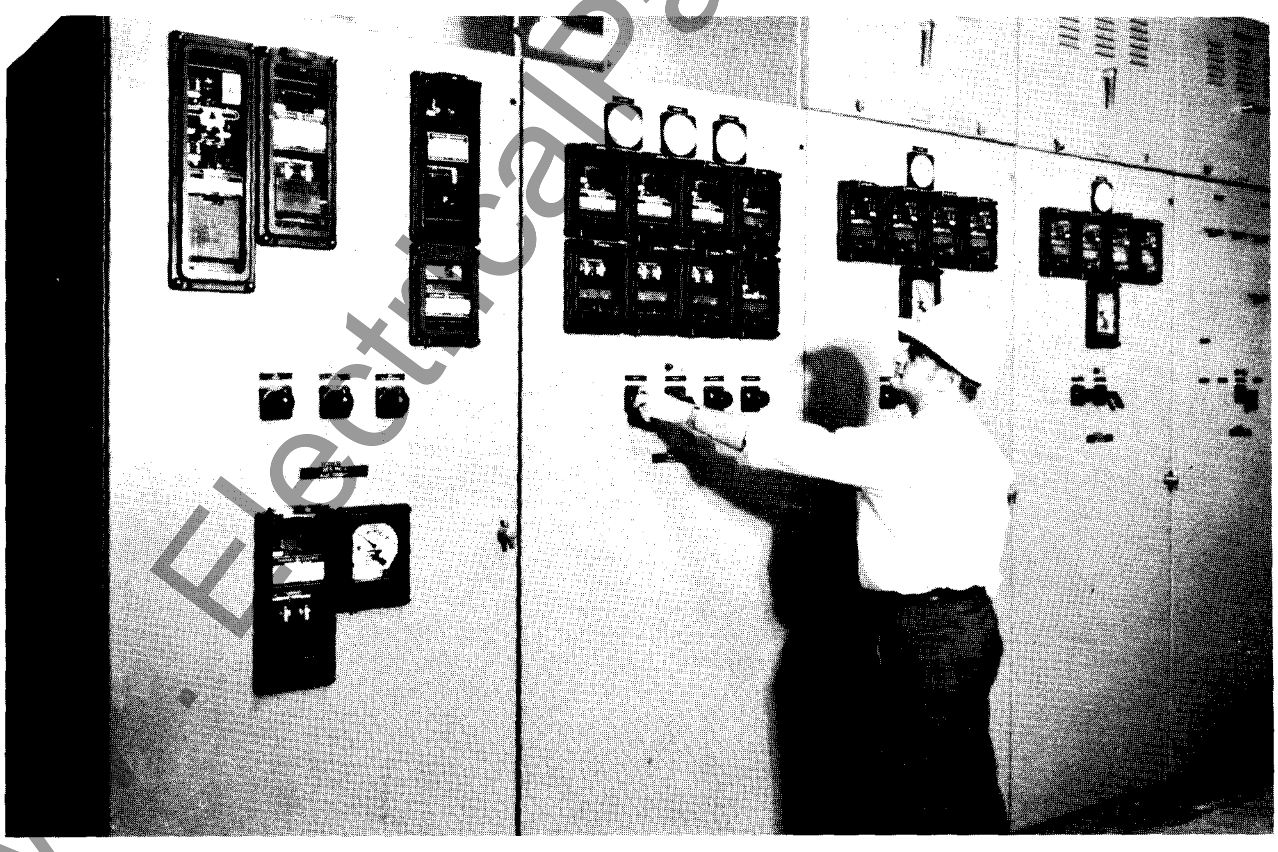
First and foremost, switchgear must provide effective system protection. To accomplish this, the magne-blast circuit breaker is designed to clear normal faults and extinguish the arc in five cycles or less.

Next, switchgear must be easy as well as safe to maintain. GE's vertical-lift breaker meets both these requirements. Raising and lowering of the breaker is accomplished effortlessly by a universal type motor with complete electrical and mechanical safety interlocks. The operator is assured of maximum safety because he can see the primary disconnects separate. As the breaker is lowered, safety shutters automatically cover the energized primary disconnects. Maintenance can be performed rapidly. When a spare breaker is used, replacement time, from start to finish, can take as little as one minute.

The entire unit must be constructed of the finest materials available, incorporating design features that contribute to ease of operation and long life. Here, too, General Electric metal-clad is the answer. The rugged all-welded steel frame and steel compartmentation give the units structural support.

Where power paths must be protected, the GE developed family of coordinated insulation materials do the job — from bus supports with track resistant polyester glass to roll-out potential transformers with butyl rubber.

In varied applications, in superior design, in high quality insulation — General Electric performance in metal-clad switchgear can be taken for granted.



A TYPICAL INDUSTRIAL INSTALLATION of General Electric indoor metal-clad switchgear.

Outdoor metal-clad is compact and convenient

General Electric outdoor metal-clad switchgear provides better service, safer switching, reduced maintenance costs, and simpler station planning.

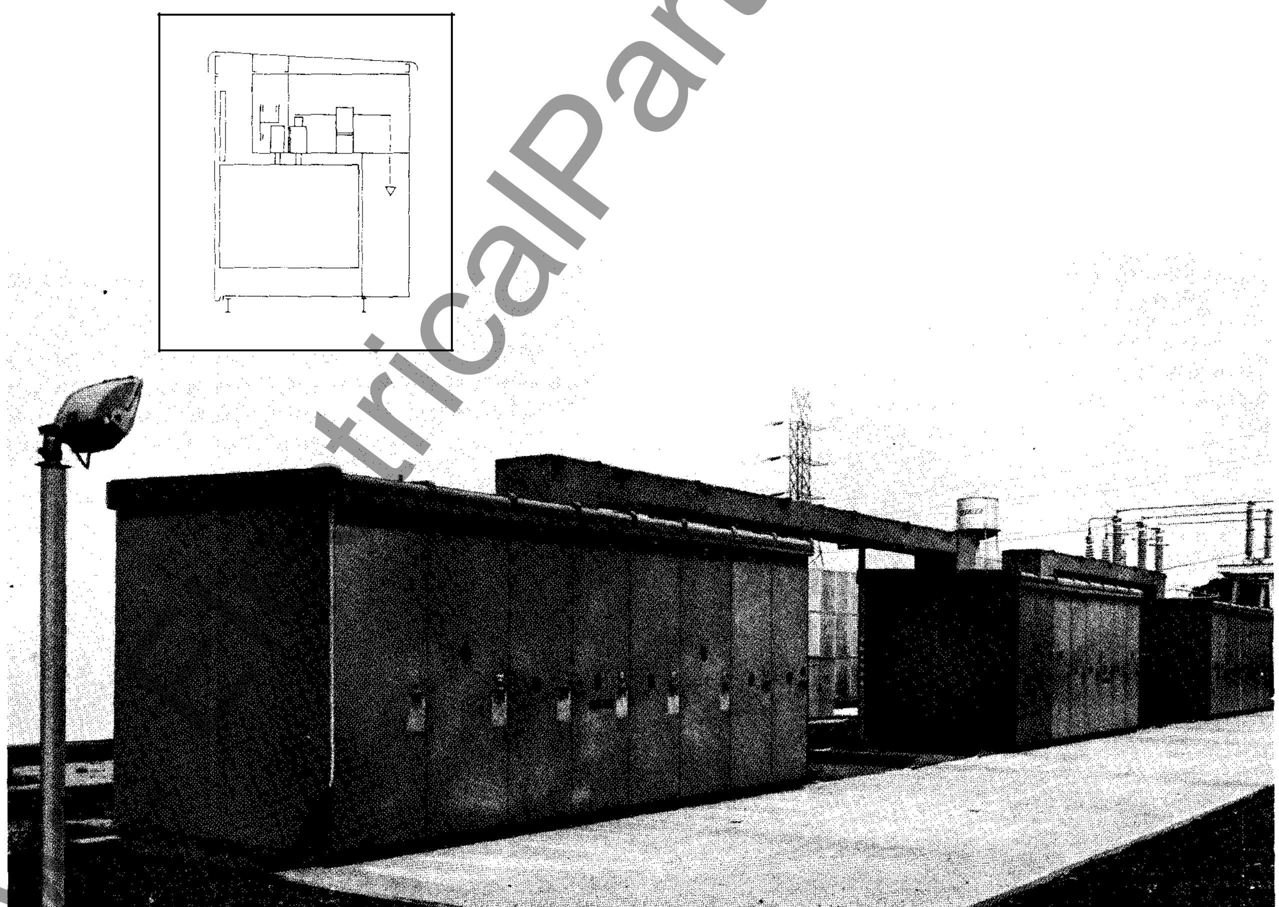
In GE's weather-tight steel enclosure units, the complete control panel — with instruments, relays, switches, etc. — is at the front of the unit for easy access. The panel is directly above the breaker, providing the same amount of space, in the same position, as indoor equipment. The control device panel is hinged to swing aside easily and allow access to the rear of the panel.

This design puts the device panel up front and reduces the space required for an outdoor installation. Foundations can be smaller, reducing installation cost. Now, it is possible to position the switchgear so that it overhangs the foundation at the rear. This permits you to install power conduit and cable after the switchgear is in place, eliminating many subsequent installation problems.

Inspection and maintenance are faster, too, since a workman need only open the front door to gain access to the breaker and control panel. One man can easily handle the job.

Convenience features include: lamp receptacle for interior lighting, utility power outlets for operating small tools and heaters to retard condensation.

And, since electric substation acceptance by aesthetic-minded residential neighborhoods is important to substation planners, you will want your switchgear to help, rather than hinder you in solving this problem. You will find that General Electric metal-clad will integrate with whatever station landscaping plans you might have.



SUBSTATION furnished with General Electric's outdoor metal-clad switchgear.

Protected aisle switchgear permits all-weather maintenance

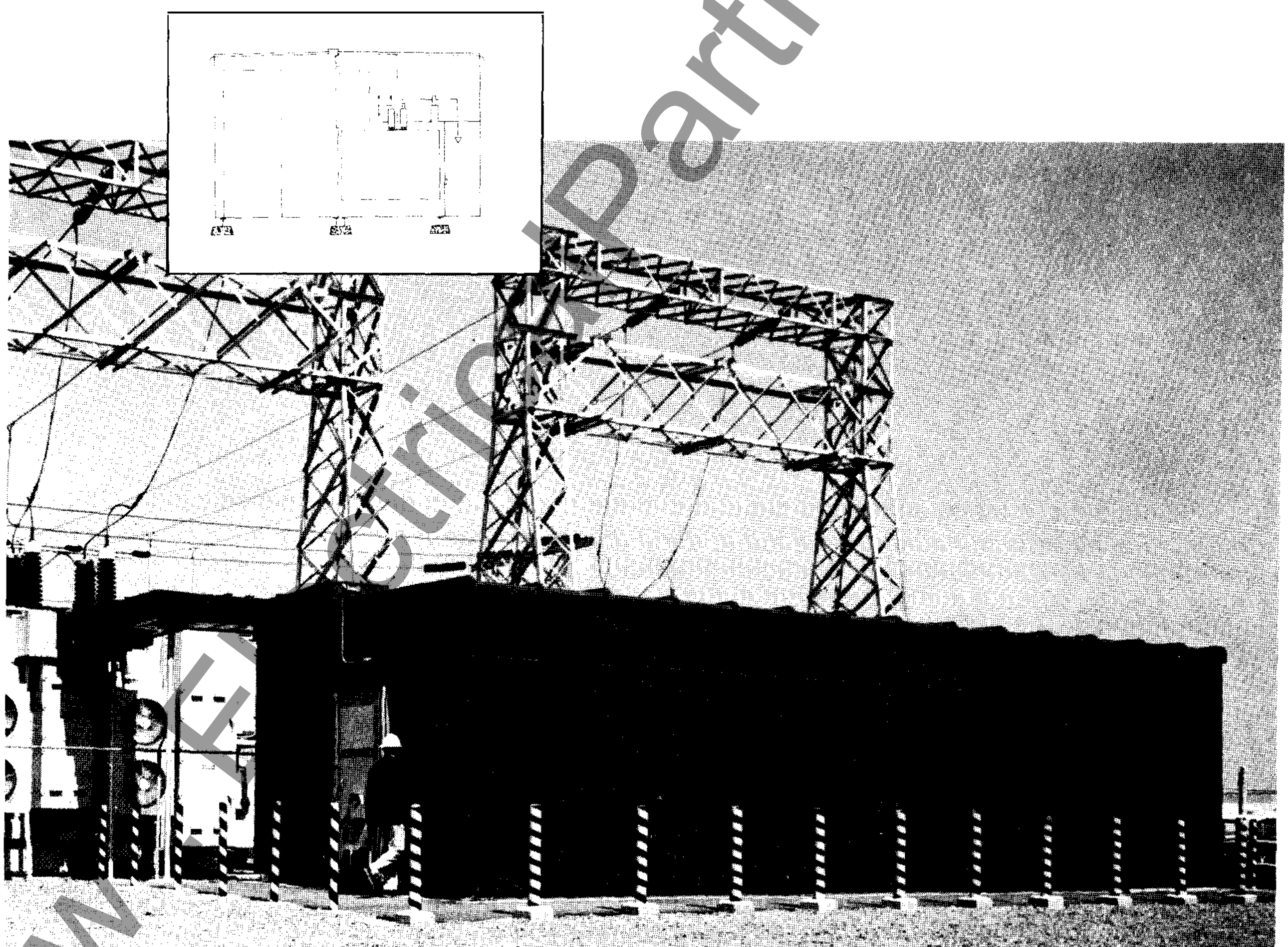
Your maintenance crew works indoors while servicing General Electric metal-clad switchgear with outdoor protected aisle housings. You can plan your year-round maintenance schedule with confidence.

The protected aisle is a walk-in enclosure designed to match associated metal-clad switchgear. It is available with a single lineup of metal-clad units, or as a common operating aisle between facing lineups.

There is adequate space for two breakers to pass side by side. The reinforced steel floor is at the same level as the floor of the metal-clad enclosures to permit breaker removal and servicing without the use of a transfer truck.

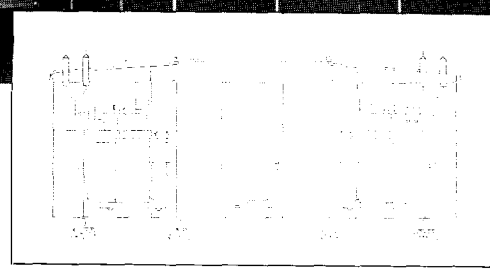
The protected aisle and metal-clad switchgear are assembled together as a complete unit at the factory. The unit is then split for shipment, assuring a perfect fit at installation.

Before leaving the factory, the complete structure is painted and weatherproofed. The sides and roof are sprayed with a second coat of primer, and then with a finish coat of acrylic paint. The underside of the steel flooring is coated with a corrosion-resistant compound.

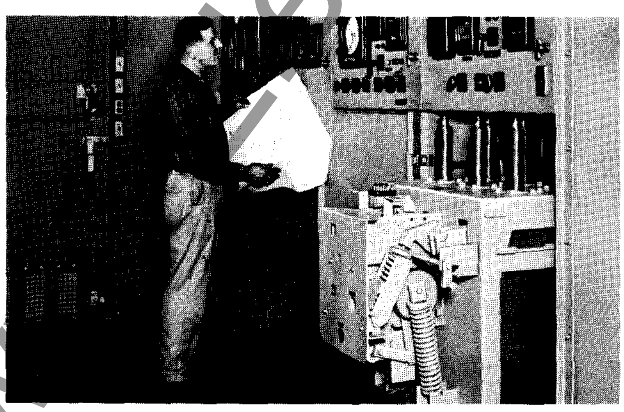


IN ANY WEATHER, protected aisle allows on-schedule inspection and maintenance.

Common aisle design offers arrangement flexibility



COMMON AISLE serves facing lineups of General Electric metal-clad switchgear with working space protected from the weather.



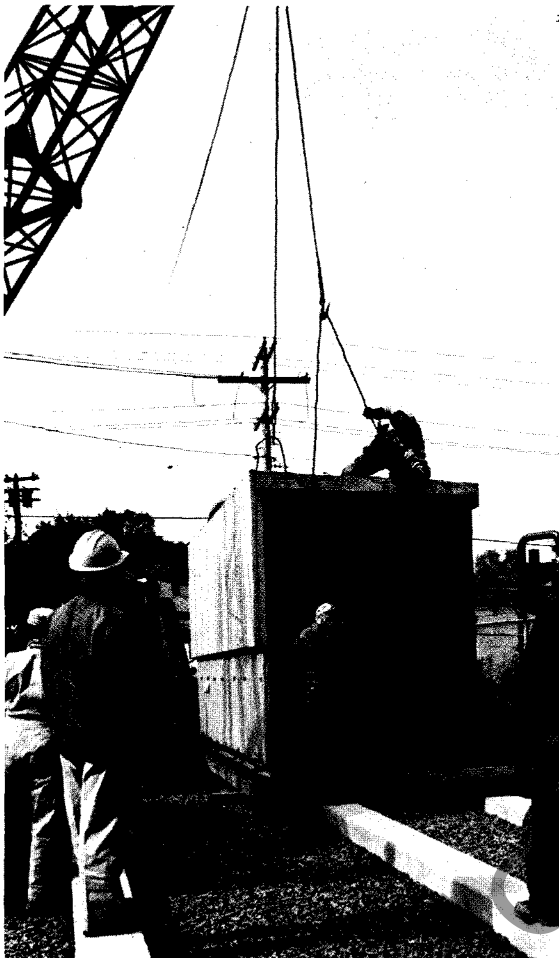
AISLE SPACE is large enough for two breakers to pass side by side.

For common aisle switchgear, as for protected aisle, the basic switchgear units and compartments are similar to those used for conventional outdoor equipment, except the individual weatherproof doors are omitted and hinged access doors are provided in the front of each breaker compartment.

Full height doors are standard and can open to 135°, allowing breakers to be removed when extended instrument space is required.

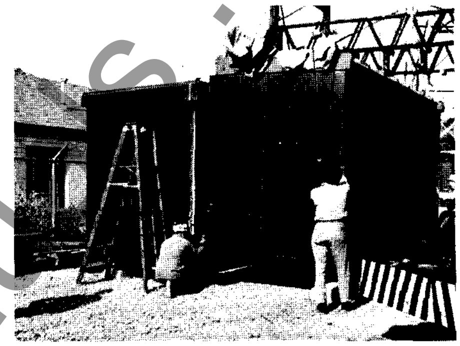
Lighting and electrical outlets for small tools and portable lamps are provided as an aid to inspection and maintenance. Safety-type lockable doors at each end of the protected aisle keep unauthorized persons out. However, the inside opening latch is designed to permit door opening at all times when actuated from inside the protected aisle housing, even if the door is padlocked on the outside.

Factory assembled equipment means faster installation



1. GE METAL-CLAD switchgear (being placed on piers) and protected aisle arrive as separate units for easier handling.

2. DISPOSABLE PLATES protect relays, instruments, and control handles during shipment. When shipment is via closed car, heavy duty polyethylene protectors are used.



3. PROTECTED AISLE is positioned on piers next to the metal-clad lineup. Pre-assembly at factory assures proper fit.

4. VENT CAPS are bolted on roof to form completed weatherproof assembly. Breakers are moved into place.

5. INTO SERVICE in eight hours, unit has already been tested and energized.

Superior design features are standard with GE metal-clad switchgear

In switchgear equipment, safety and value go hand in hand. From General Electric's vertical-lift design to the complete compartmentation of major functions, every consideration is given to making safety a primary consideration and outage time as low as possible.

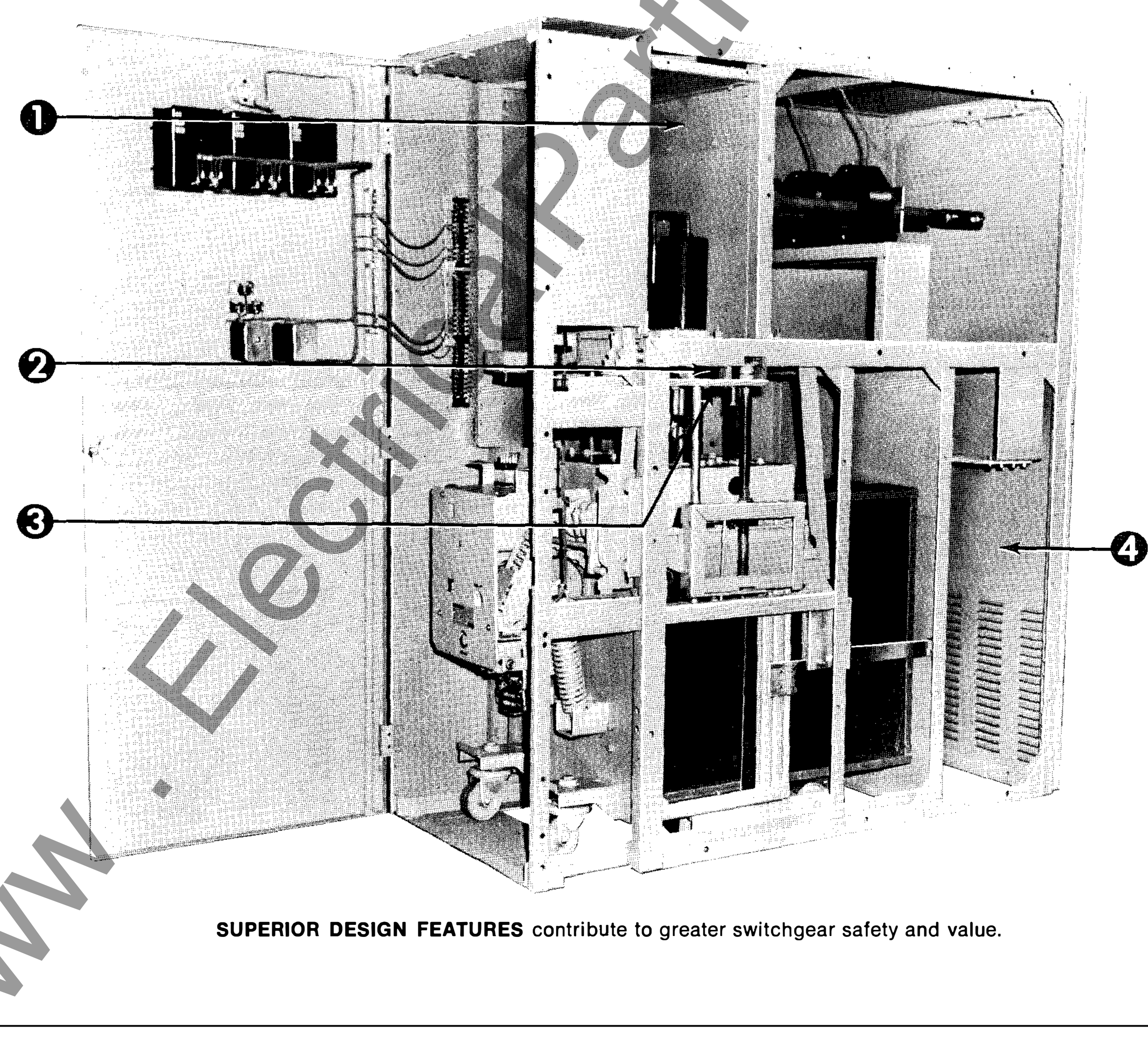
The breaker, bus, potential transformers, current transformers and cables all have their own compartments. And, each function is isolated by rugged steel partitions.

General Electric metal-clad provides the value of a superior insulation system at vital points, and greater structural strength from a rugged all-welded steel frame. A welded steel gusset reinforces each right-angle joint of the frame. Since there are no protruding rivets or bolts, the units have smooth side plates.

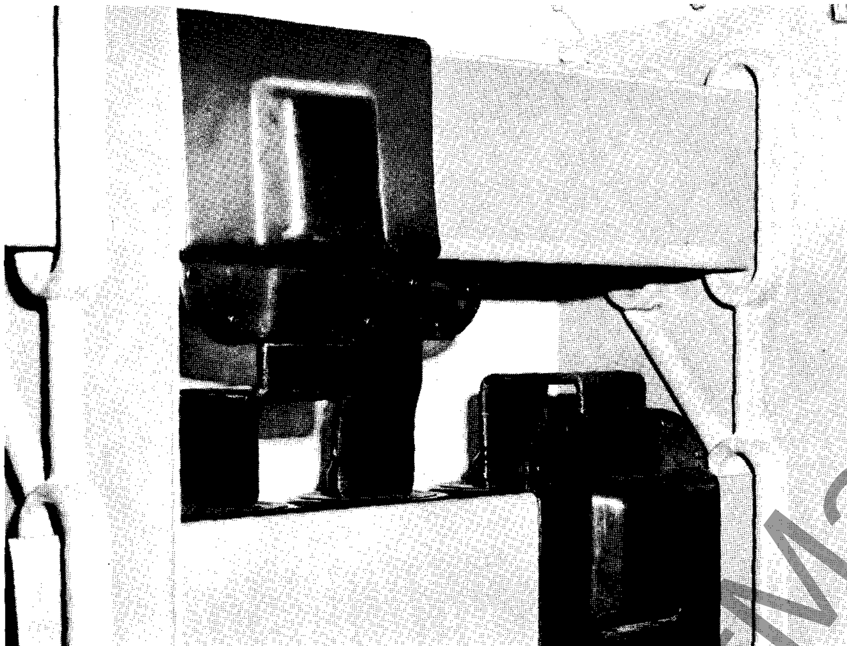
General Electric designed relays and instrumentation are mounted on the upper half of the unit door so that the low vertical-lift breaker can be removed or inserted without damaging a relay.

Guide rails are provided so that the breaker will roll into proper position in the cubicle. The lifting mechanism assures perfect alignment when the breaker is raised into its operating position.

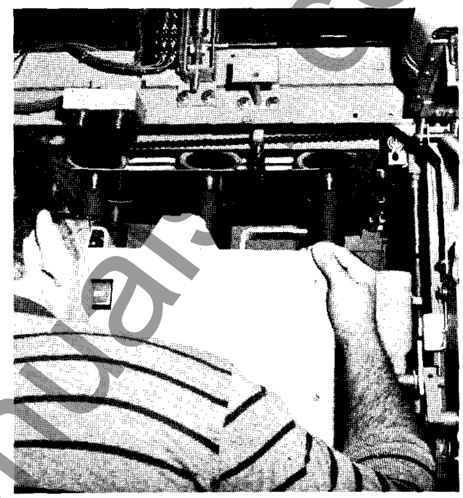
Units are constructed in standard sizes so that you can plan your layout without match-and-lineup problems — either now or in the future.



SUPERIOR DESIGN FEATURES contribute to greater switchgear safety and value.

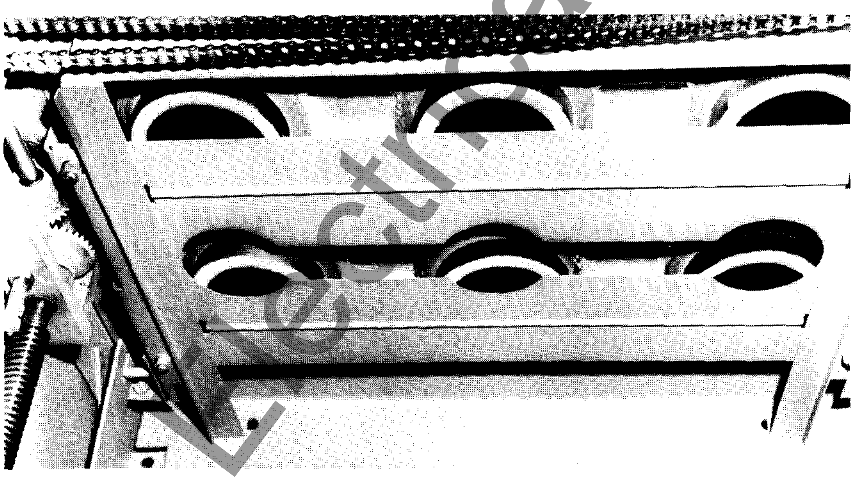


❶ MAIN BUS COMPARTMENT is completely isolated by metal and rugged track resistant polyester glass insulation barriers. These molded barriers also serve as high strength, shock resistant bus supports. All bus bar joints have silver-to-silver connections for low resistance and positive contact, and are insulated by a vinyl boot. The main bus is insulated with high-strength, high dielectric NORYL® thermoplastic sleeves.

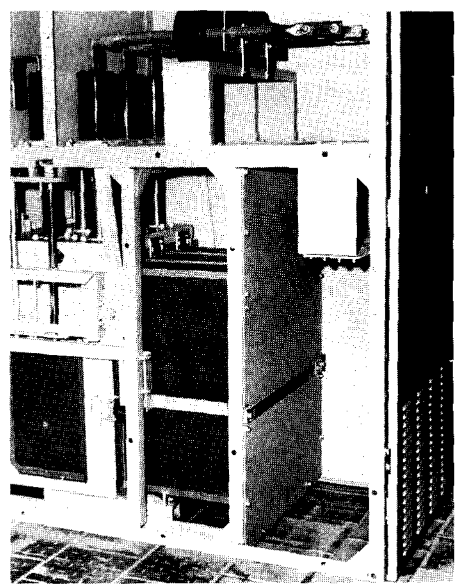


❷ SAFETY YOU CAN SEE —The operator can always see the parted disconnects. The result is minimum danger that operating or maintenance personnel will contact live parts while working with General Electric metal-clad.

An operator cannot raise or lower the breaker until the contacts are safely opened, and safety shutters move into place as the breaker descends, thus shielding energized parts that would otherwise be exposed.



❸ AUTOMATIC SAFETY SHUTTER moves to cover the female primary disconnects as soon as the breaker begins to lower. The closed shutter prevents a workman from accidentally touching an energized part.



❹ TERMINATION COMPARTMENT has room for two cables per phase.

Carefully selected insulating materials

General Electric's metal-clad switchgear insulation system is a family of carefully selected and applied materials that have resulted from over 45 years of insulation research. Detailed laboratory and field proof testing, as well as extensive in-service experience, have confirmed the critical engineering considerations necessary to insure a rugged, reliable insulation system. Testing includes such factors as:

a. dielectric strength and moisture absorption under 100% humidity and cycling conditions.

b. insulation power factor under varying conditions.

c. flame retardance where required.

d. mechanical and thermal strength-shock characteristics under normal operating conditions, abnormal fault conditions and the modern day problems of shipment.

e. ability to meet accurate dimensional tolerances, when required.

NORYL® MAIN BUS INSULATION

Noryl thermo-plastic sleeves are used for main bus insulation. This material has high dielectric and thermal strength and superior impact resistance.

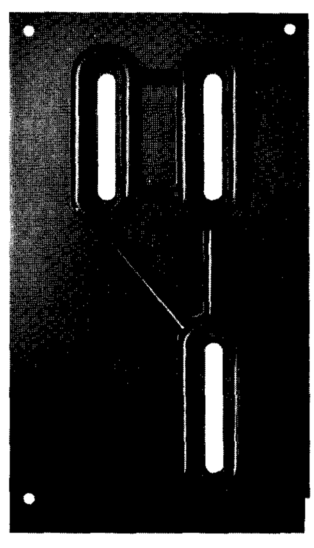
VINYL INSULATING BOOTS

Vinyl "boots" are used for bus splice coverings on all equipment, except certain bus configuration connections where boots can not be conveniently utilized. This same vinyl insulation is also used on certain breaker arc-chute members.

TRACK-RESISTANT POLYESTER GLASS

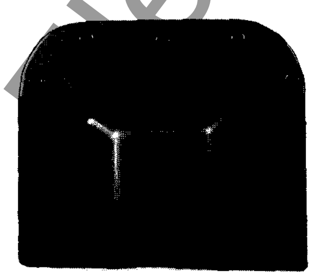
Track-resistant polyester glass is one of the major insulation components in both the breaker and equipment housings. Track resistance is an essential characteristic of insulation applied where it can provide a creepage path from phase to phase or phase to ground.

NORYL® THERMO-PLASTIC MAIN BUS INSULATION



TRACK-RESISTANT POLYESTER GLASS

IRRATHENE TAPE



VINYL INSULATING BOOT FOR BUS JOINT

provide trouble-free operation

This characteristic is regularly laboratory checked to insure uniform high quality.

Further, the mechanical and thermal shock characteristics of track-resistant polyester glass are superior to porcelain slabs, or unconventional configurations. In the dual role of bus support and isolating barrier between cubical housings, track-resistant polyester glass meets the needed rugged qualities of mechanical and thermal shock capabilities to limit a fault condition to its isolated compartment.

IRRATHENE TAPE

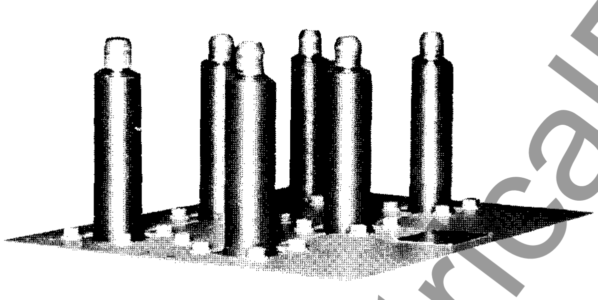
Another member of the General Electric insulation family is Irrathene Tape. It is used for wrapping certain bus bars and bus splices. This irradiated polyethylene insulating tape has excellent dielectric properties, high tensile strength, and can be readily applied in a smooth coating. It is particularly useful for joints and splices, making neat, compact and effective covering for irregularly shaped areas.

BREAKER BUSHINGS

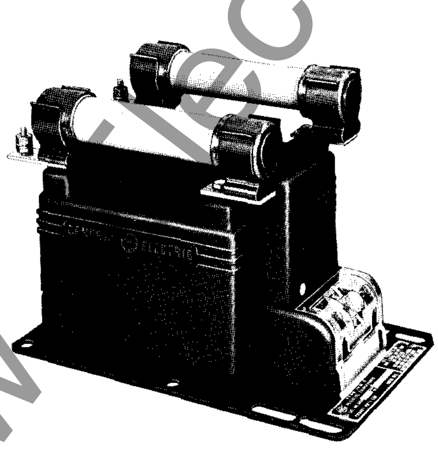
Breaker bushings are made of electrical grade kraft paper form wound with epoxy resin compound impregnation and sealed with a special final finish. Rescon equalizers and ground shields are built in to assure proper voltage distribution and dielectric strength. The same quality construction is used on both 4.16 kV and 13.8 kV ratings in 1200, 2000 and 3000 ampere sizes. All bushings receive a power factor test.

HY-BUTE/60 TRANSFORMERS

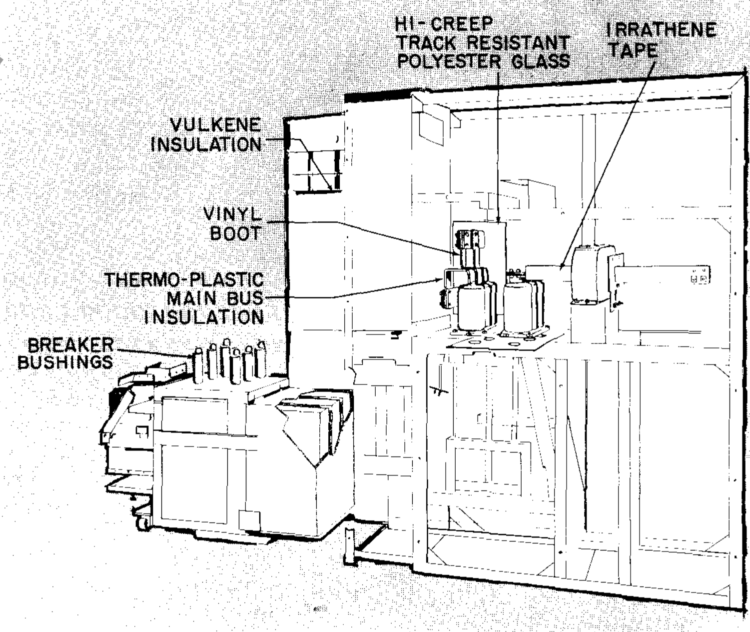
Current and potential transformers are standard General Electric Hy-Bute/60 units which use butyl rubber molded to form the insulating body and bushings of these transformers. Hy-Bute/60 provides a homogeneous insulation that is tough, resilient and resists oxidation, creepage-tracking and moisture. It will not crack from coil expansion nor from changes over a wide range of ambient temperatures. Its strength resists damage from mechanical forces.



BREAKER BUSHINGS



HY-BUTE/60 POTENTIAL TRANSFORMER



IN VITAL AREAS where current flows in General Electric metal-clad switchgear, proven quality insulation materials are used to provide greater value.

Added features and optional accessories increase efficiency of operation

GROUND AND TEST DEVICES

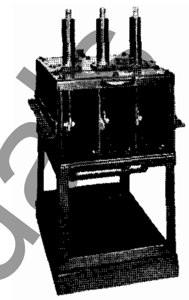
Ground-and-test devices provide facilities for readily grounding either the bus side, or the outgoing cable side, of the metal-clad unit, or for the "phasing-out" of the operating circuits. The open-type may also be used to supply emergency power to a bus or line from a power source such as a mobile unit substation.

The open-type GV device includes three through-studs which are shaped similar to the bushings of the removable power circuit breakers furnished in the metal-clad switchgear breaker units. They can readily be fitted into the stationary disconnecting devices of such units.

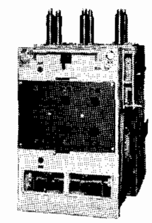
The lower ends of the studs are formed as terminals to permit the ready attachment of the grounding or testing equipment and cables, which are supplied by the purchaser.

The application of the simpler open-type device is recommended only when operated under the supervision of experienced operating engineers.

The deluxe power-operated type GM device has six through bushings, a self-contained bus or line selector disconnecting switch, a separately-controlled, power-operated, 3-phase switch with internal ground-connections, mechanical and electrical interlocks, and dead-front features, with provision for remote control, and plug-type cable testing and phasing. All required functions can be performed with maximum safety to personnel. The primary conductors that are required for the grounding functions are self-contained, with no external cable connections required.



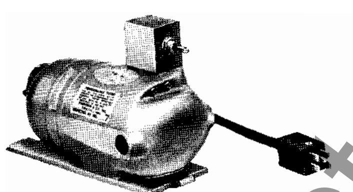
Type GV Ground and Test Device



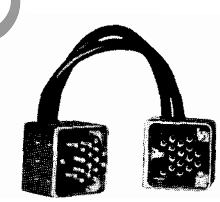
Type GM Ground and Test Device

MAINTENANCE AND TESTING ACCESSORIES

To speed and simplify your inspection, maintenance and testing operations, General Electric offers a full selection of devices and accessories for your metal-clad switchgear.

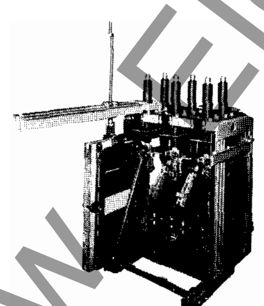


PORTABLE GEAR MOTOR provides fast and easy breaker elevating and lowering.

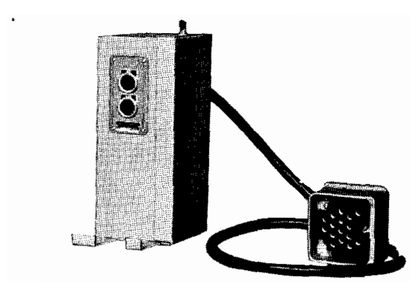


SECONDARY TEST COUPLER permits testing of breaker without removal from housing.

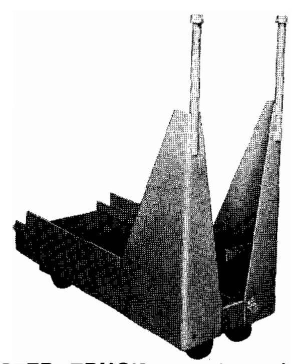
HAND CRANK operates breaker elevating mechanism in emergencies.



ARC CHUTE LIFTER simplifies contact replacement on General Electric circuit breakers rated 7.2 and 13.8 kV.



TEST CABINET provides for electrical closing and tripping of magne-blast breakers at indoor maintenance locations.

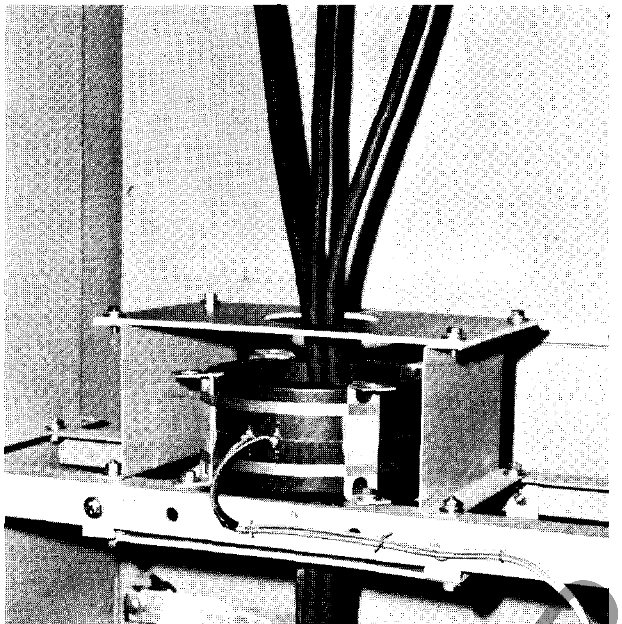


TRANSFER TRUCK speeds maintenance by facilitating movement of breaker units during non-aisle outdoor maintenance operations.

"GROUND SENSOR" EQUIPMENT IMPROVES MOTOR PROTECTION

A carefully matched current transformer and high-speed relay comprise a "ground sensor" equipment. It has the sensitivity required to rapidly open the breaker and greatly reduce damage caused to motors by low current faults.

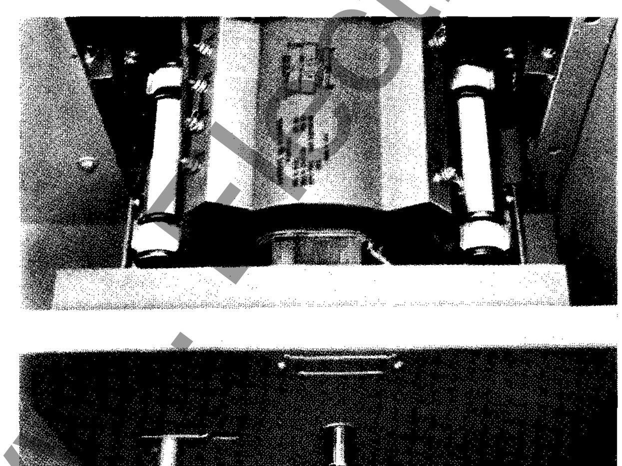
An optional feature, the ground sensor equipment can mean substantial savings.



GROUND SENSOR, comprised of current transformer and high-speed relay, senses low current ground faults.

EASY ACCESS TRANSFORMERS

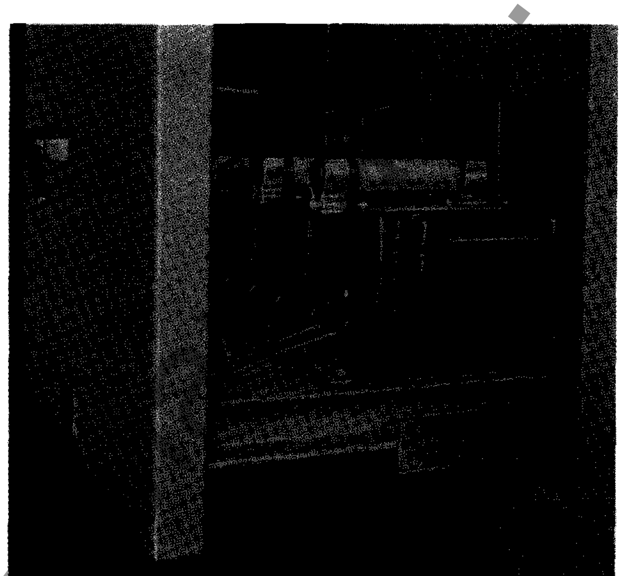
Molded epoxy resin insulation assures full basic insulation level for GE dry type control power transformers. Current limiting type EJ fuses are provided for control power circuit protection. Transformer is draw-out mounted for accessibility in ratings through 15 kVA single phase.



ROLL-OUT CONTROL POWER TRANSFORMER provides for ease of inspection and maintenance.

HY-BUTE / 60 POTENTIAL TRANSFORMER

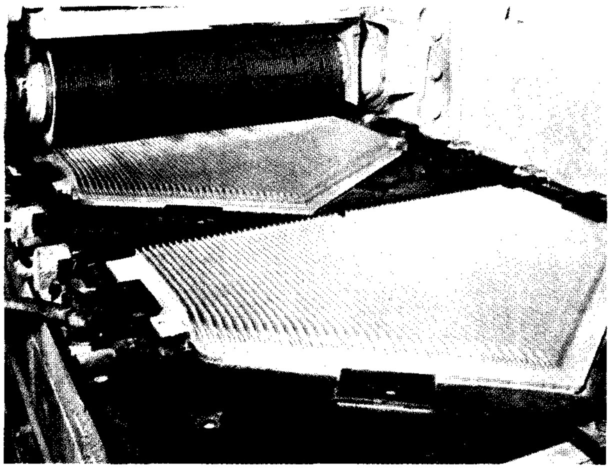
Hy-Bute/60 GE potential transformers are as much as 40% smaller than compound-filled potential transformers of the same rating. This smaller size can reduce the space required for accessory equipment in metal-clad by as much as a full compartment. Characteristics meet all applicable industry standards.



POTENTIAL TRANSFORMERS are GE Hy-Bute/60 units. They take less space and are readily accessible.

Metal-clad switchgear excellence is assured by quality control

A reputation for quality that can be taken for granted takes years to build. It is arrived at by constant attention to detail, by thorough testing, by the use of superior materials, by design research and by applying yesterday's experience to today's needs.



The arc chutes of General Electric magne-blast breakers are fabricated using patented material specially developed for this purpose. They are made of a refractory material with a phospho-asbestos binder. The interleaving teeth of the chutes are precision grooved, using high speed diamond-headed cutters. And, as a further step, once the chutes are slotted, their reliability of performance is increased by flame treatment to vitrify the surface.

All insulation used in metal-clad switchgear meets the precise and exacting specifications of the General Electric Metallurgy and Fabrication Laboratory. This Laboratory continually monitors with careful testing the acceptability of all materials used.

Typical of important insulation components, track resistant polyester glass materials receive numerous continuous production and laboratory tests. Laboratory tests include insulation tracking (a precise accelerated life test), power factor, impact strength, Rockwell hardness, elasticity and tensile strength; to mention a few.

Built-in quality is only one part of the story — because that quality must be tested and checked in the completed unit to assure quality of operation. Every unit is tested at the factory for conformity to rigid quality control, and electrical and mechanical specifications.

Quality Control Tests

The following are some of the checks made on General Electric metal-clad:

Magne-blast air circuit breakers:

. . . mating and matching points checked and adjusted by precise master fixture alignment to assure unit interchangeability.

. . . auxiliary wiring continuity and correctness.

. . . operation of mechanism at maximum, minimum and rated voltages to assure smooth, functional operation.

. . . resistance measurements of operating coils.

. . . resistance measurement of each pole by low ohmic bridge.

. . . high potential test.

. . . final inspection.

Breaker housings:

. . . cubicle frame multiple point alignment by master fixture.

. . . final master breaker fixture alignment of all mating and matching points including elevating mechanism, bushing matching, auxiliary contact mating, grounding shoe contact to assure correct operation to accommodate interchangeability of breaker units.

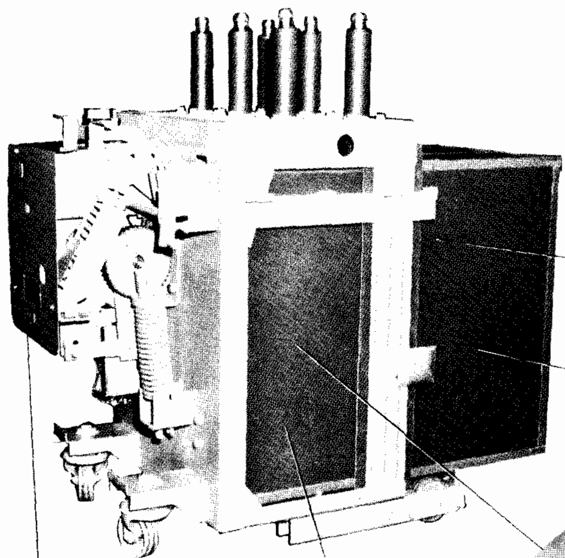
. . . auxiliary wiring check to assure correctness and continuity.

. . . all relays and devices given complete secondary power check by test consoles.

. . . high potential tests of primary and secondary circuitry in accordance with ANSI standards.

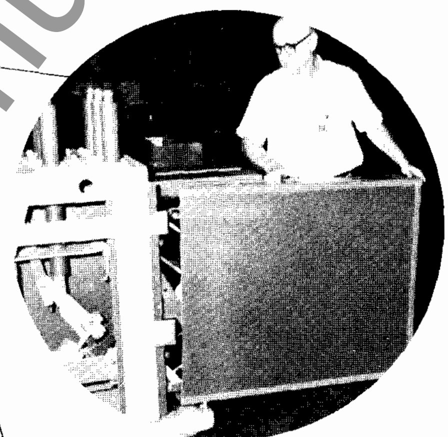
. . . final inspection.

Breaker maintenance . . .
It's fast, easy and safe

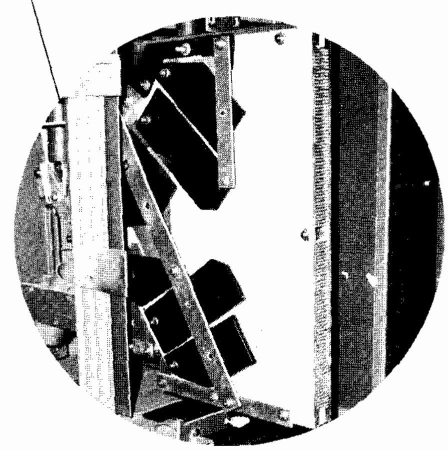


Routine inspection and maintenance are fast, simple and safe with GE vertical-lift magne-blast breakers. Emphasis has been placed on simplicity of design to facilitate maintenance. The main and arcing contacts are accessible without tilting or removal of arc chutes. For easy inspection and adjustment, the mechanism is located up front.

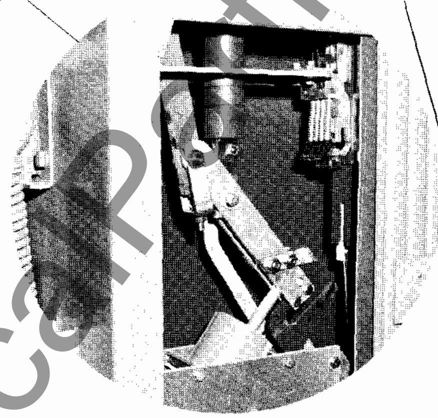
Under normal conditions the entire inspection and maintenance job can be done by one man in only 20 minutes.



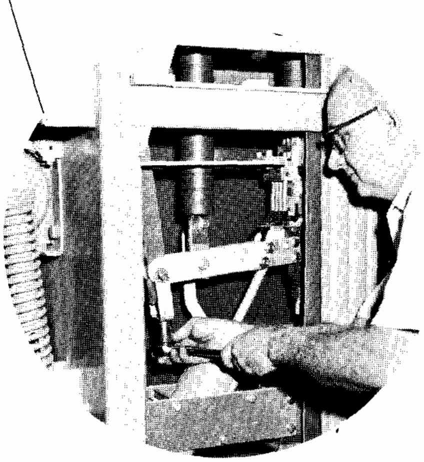
❶ The interphase barriers can be easily removed in less than a minute . . .



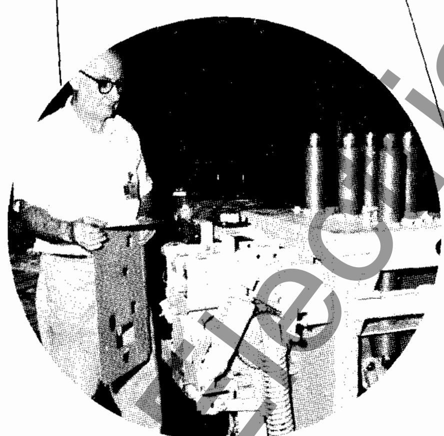
❷ . . . exposing the arc chutes for easy inspection. Arc chutes need not be moved for routine servicing.



❸ With the interphase barriers removed, the main and arcing contacts are visible for inspection . . .



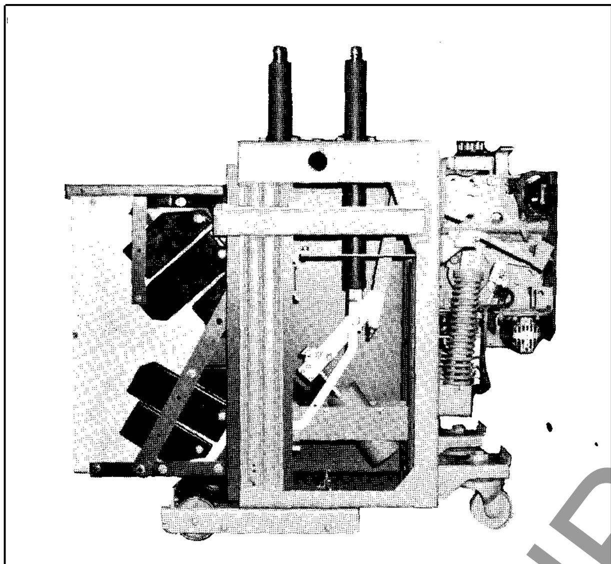
❹ . . . and cleaning or adjustment as required.



❺ Removal of the cover provides easy access to the operating mechanism.

GE breakers assure system reliability

Effective system protection depends on fast and positive fault interruption. GE magne-blast breakers operate to clear faults on command from relays or control devices and will clear a normal fault in five cycles or less. Here is how interruption occurs:

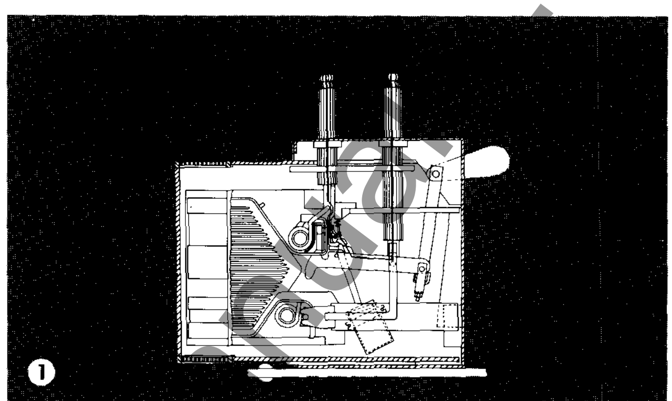


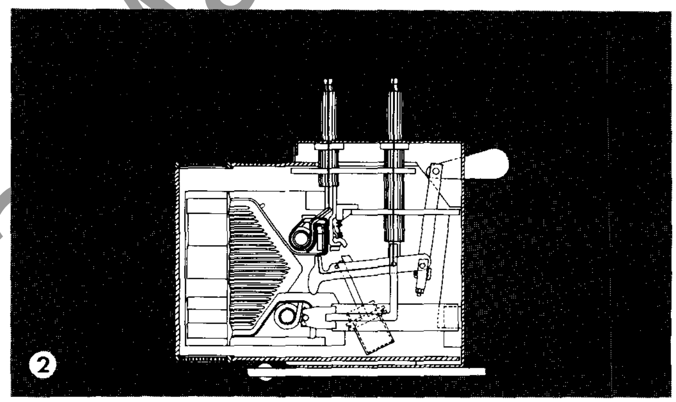
1. WHEN THE BREAKER IS STANDING GUARD on your system during normal operation, current flows into the breaker through the bushing as shown. It flows down through the main contacts, then horizontally through the current-carrying contacts, then up through the primary disconnects.

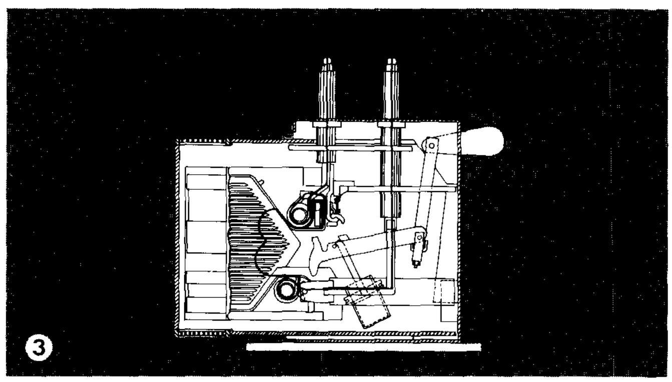
2. WHEN A FAULT IS SENSED, the breaker is given its command to interrupt. As shown here, the main contacts part and the current is diverted on to the arcing contacts, away from the main contacts. From the arcing contact, the arc rapidly transfers to the arc runners. This causes current to flow in the upper blowout coil, creating a magnetic field.

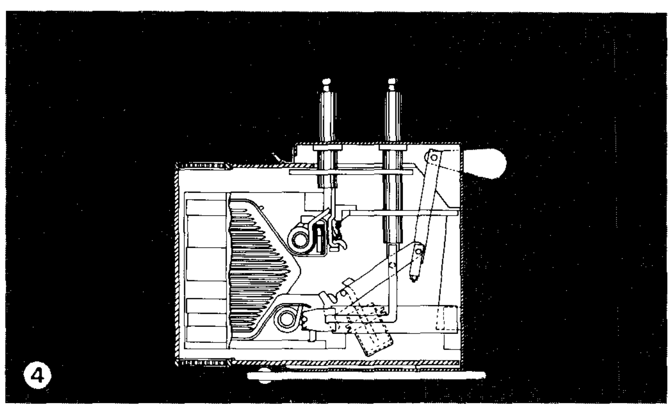
3. THE OTHER END OF THE ARC runs down the arcing horn, transfers to the lower runner, introducing current to the lower blowout coil. As the arc is drawn across the opening arcing contacts, it is forced magnetically out into the arc chute labryinth, elongated, cooled, and reduced in cross section. This increases resistance to a point where, at an early current zero, the arc cannot re-establish itself and goes out.

4. HERE THE INTERRUPTION IS COMPLETE and the breaker contacts are fully open. The entire interruption sequence described above normally occurs in five cycles or less.









Metal-clad switchgear application guide

GENERAL

The application of metal-clad switchgear is a relatively simple procedure in most cases. For the more complex installations, the services of GE application engineers should be utilized.

The following steps are normally pursued in applying this equipment.

1. Switching scheme selection and one line diagram.
2. Determination of available fault and continuous currents for breaker selection.
3. Main bus rating selection.
4. Current transformer selection.
5. Potential transformer selection.
6. Relay and control function selection.
7. Closing, tripping and power requirements.
8. Special applications.

SWITCHING SCHEME

Essentially all recognized basic switching schemes are available in metal-clad switchgear to insure the desired system reliability. A choice should be made based on the system requirements.

BREAKER SELECTION

The available fault current information for industrial and commercial installations is obtained from the serving electric utility. Additional system contributions (such as from synchronous motors) must also be included in this total determination. Continuous current ratings are selected on the basis of feeder and main breaker loading. If metal-clad switchgear is served by a closely coupled transformer, the total available current is normally used for selection of main breaker and bus current ratings.

A complete line of magne-blast air circuit breakers is available. Standard ratings are shown in table I (page 18). The applicable standards of ANSI and NEMA are noted in table IV (page 21).

In some applications, breakers are used for reclosing duty to maintain service continuity. Breakers in this application must be derated in accordance with Fig. 1 & 2 (page 19). In some cases, this derating might dictate selection of the next higher interrupting rating breaker.

The repetitive duty limitations and normal maintenance requirements of magne-blast air circuit breakers are listed in table II (page 20). The further special repetitive duty limitations for these breakers when applied for arc-furnace switching are listed in table III (page 20).

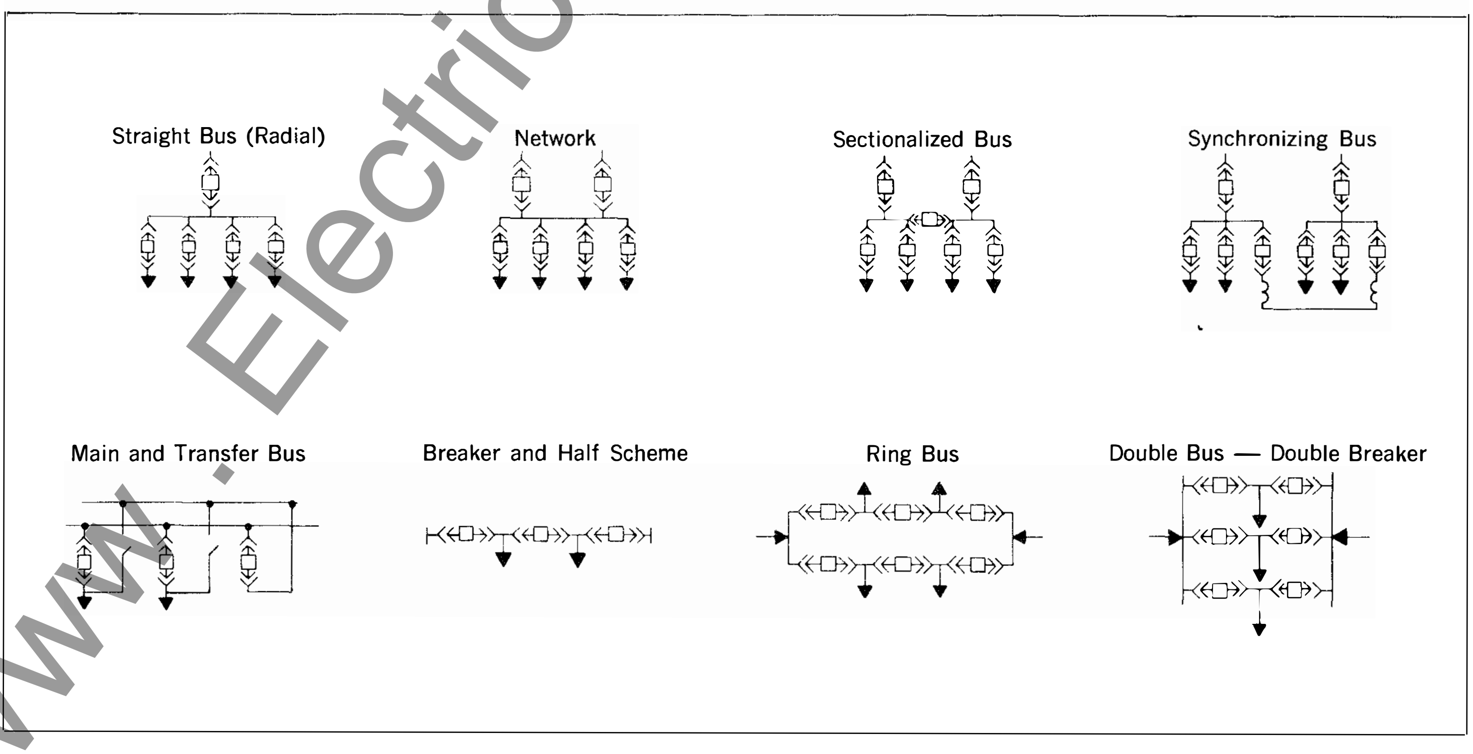


TABLE I—POWER CIRCUIT BREAKER CHARACTERISTICS (Symmetrical Rating Basis ANSI C37.06)

Identification			Rated Values								Related Required Capabilities			
			Voltage		Insulation Level (Rated Withstand Test Voltage)		Current					Current Values		
ANSI Line Number	Nominal Voltage Class kV, rms	Nominal 3-phase mVA Class	Rated Maximum Voltage (1)* kV, rms	Rated Voltage Range Factor, K (2)	Low Frequency kV, rms	Impulse kV Crest	Rated Continuous Current at 60 Hz amp, rms	Rated Short-circuit Current (at Rated Max kV) (3) (4) kA, rms	Rated Interrupting Time Cycles	Rated Permissible Tripping Delay, Y Sec	Rated Maximum Voltage Divided by K kV, rms	Maximum Symmetrical Interrupting Capability (5) K Times Rated Short-circuit Current kA, rms	3 Sec Short-time Current Carrying Capability kA, rms	Closing and Latching Capability 1.6 K Times Rated Short-circuit Current kA, rms
3	4.16	250	4.76	1.24	19	60	1200	29	5	2	3.85	36	36	58
4	4.16	250	4.76	1.24	19	60	2000	29	5	2	3.85	36	36	58
5	4.16	350	4.76	1.19	19	60	1200	41	5	2	4.0	49	49	78
6	4.16	350	4.76	1.19	19	60	3000	41	5	2	4.0	49	49	78
8	7.2	500	8.25	1.25	36	95	1200	33	5	2	6.6	41	41	66
9	7.2	500	8.25	1.25	36	95	2000	33	5	2	6.6	41	41	66
11	13.8	500	15	1.30	36	95	1200	18	5	2	11.5	23	23	37
12	13.8	500	15	1.30	36	95	2000	18	5	2	11.5	23	23	37
13	13.8	750	15	1.30	36	95	1200	28	5	2	11.5	36	36	58
14	13.8	750	15	1.30	36	95	2000	28	5	2	11.5	36	36	58
15	13.8	1000	15	1.30	36	95	1200	37	5	2	11.5	48	48	77
16	13.8	1000	15	1.30	36	95	3000	37	5	2	11.5	48	48	77

NON-STANDARD BREAKERS—HIGH CLOSE AND LATCH CAPABILITY

	4.16	250	4.76	1.24	19	60	1200 2000	29	5	2	3.85	36	36	78
	13.8	500	15	1.30	36	95	1200 2000	18	5	2	11.5	23	23	58
	13.8	750	15	1.30	36	95	1200 2000	28	5	2	11.5	36	36	77

*Numbers in parentheses refer to the Notes, below.

(1) Maximum voltage for which the breaker is designed and the upper limit for operation.

(2) K is the ratio of rated maximum voltage to the lower limit of the range of operating voltage in which the required symmetrical and asymmetrical interrupting capabilities vary in inverse proportion to the operating voltage.

(3) To obtain the required symmetrical interrupting capability of a circuit breaker at an operating voltage between 1/K times rated maximum voltage and rated maximum voltage, the following formula shall be used:

$$\text{Required Symmetrical Interrupting Capability} = \text{Rated Short-circuit Current} \times \frac{(\text{Rated Max. Voltage})}{(\text{Operating Voltage})}$$

For operating voltages below 1/K times rated maximum voltage, the required symmetrical interrupting capability of the circuit breaker shall be equal to K times rated short-circuit current.

(4) With the limitation stated in 04-4.5 of ANSI C37.04, all values apply for polyphase and line-to-line faults. For single phase-to-ground faults, the specific conditions stated in 04-4.5.2.3 of ANSI C37.04 apply.

(5) Current values in this column are not to be exceeded even for operating voltages below 1/K times rated maximum voltage. For voltages between rated maximum voltage and 1/K times rated maximum voltage, follow (3) above.

ANSI-C37.06 symmetrical rating basis is supplementary to ANSI-C37.6 (total current rating basis) and does not replace it. When a changeover from the total current basis of rating to the symmetrical basis of rating is effected the older standards will be withdrawn.

In accordance with ANSI-C37.06, users should confer with the manufacturer on the status of the various circuit breaker ratings.

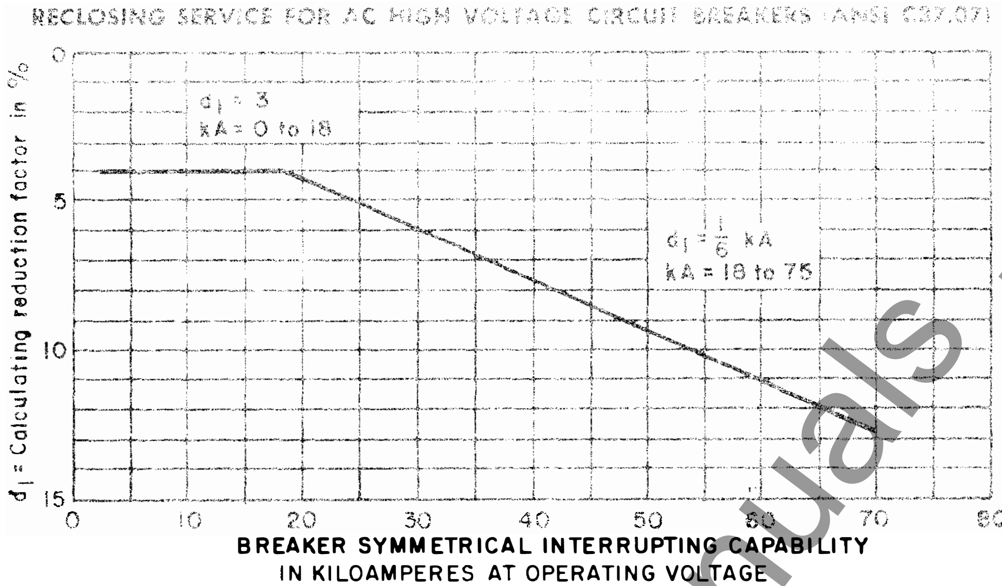


Fig. 1

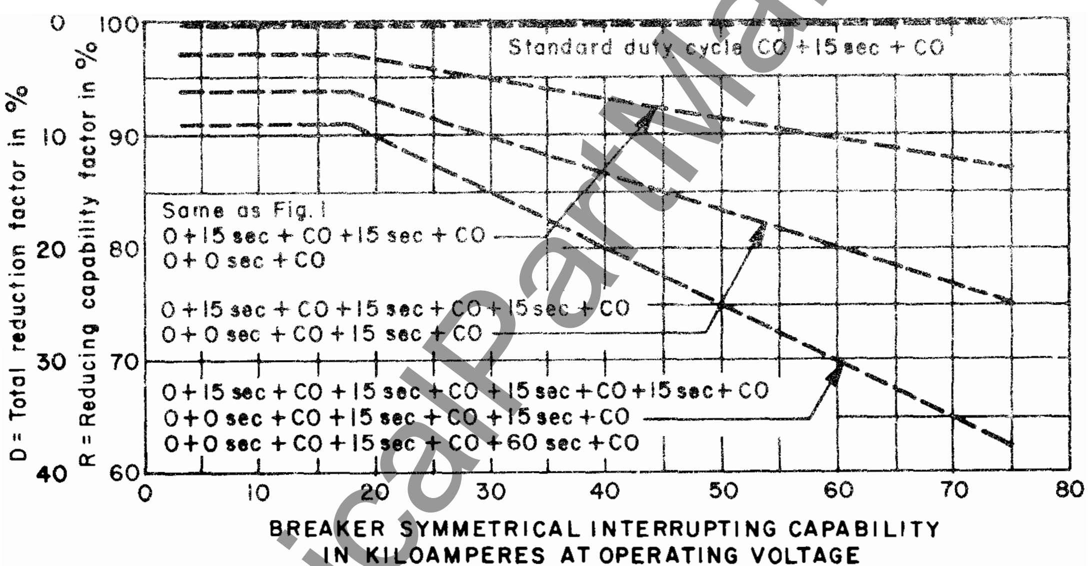


Fig. 2

The above standard capability factors apply to all ac high-voltage circuit breakers as shown in ANSI Preferred Ratings and Related Required Capabilities for AC High-Voltage Circuit Breakers, C37.06, which are rated below 72.5 kV and having continuous current ratings of 1,200 amperes and below. Breakers with continuous current ratings above 1,200 amperes are not intended for reclosing service applications. When such applications arise, refer to the nearest General Electric district office.

A duty cycle shall not contain more than 5 opening operations.

All operations within a 15-minute period are considered part of the same duty cycle.

GENERAL

The circuit breaker may be applied at the determined operating voltage and duty cycle to a circuit whose calculated short circuit does not exceed the symmetrical interrupting capability as determined.

If the X/R ratio for the circuit exceeds 15, refer to the standards for complete information.

Step #1 Determine the symmetrical interrupting capability at the operating voltage from ANSI C37.06.

Step #2 Determine the factor d_1 from the reclosing capability curve in Fig. 1 for the current value determined in step #1.

Step #3 Multiply this d_1 factor by the number of opening operations in excess of 2. Add to this an additional d_1 factor for each period less than 15 seconds modified by interpolation. This sum is the total reduction factor D which, when subtracted from 100 percent, gives the reclosing capability factor R.

Step #4 The symmetrical interrupting capability of the breaker for the operating voltage and duty cycle desired is now determined by multiplying the Step #1 symmetrically interrupting capability by the reclosing capability factor as determined in Step #3.

TABLE II. REPETITIVE DUTY AND NORMAL MAINTENANCE FOR OTHER THAN ARC FURNACE SWITCHING

Power-operated circuit breakers, for other than arc furnace switching, when operating under usual service conditions, are capable of operating the required number of times given in this table. The operating conditions and the permissible effect upon the breakers are specified in the notes. For each column, all notes listed must be given consideration. (Reference NEMA Standard SG4.) As a guide for single bank capacitor switching, use values listed in column 5 only. For back-to-back switching applications refer to the nearest General Electric district office.

Breaker Type	Breaker Continuous Amperes	Maximum No. of Operations Between Servicing Note A	Number of Operations: No-load Mechanical Notes B, E, F, G, H, I	Full-load Non-fault Notes C, E, F, G, H, J	Full-load Fault Notes D, E, F, G, H, I, K	Inrush Non-fault Notes D, E, F, G, H, J	Inrush Fault Notes D, E, F, G, H, I, K
Column 1		Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
AM-4.16.250/250B	1200 2000	2000	10000	5000 3000	1000	3000 2000	750
AM-4.16-350	1200 3000	1000	5000	2500	500	1500	400
AM-7.2-500	1000 2000	2000	10000	5000 3000	1000	3000 2000	750
AM-13.8-500/500B	1200 2000	2000	10000	5000 3000	1000	3000 2000	750
AM-13.8-750	1200 2000	2000	10000	5000 3000	1000	3000 2000	750
AM-13.8-750B	1200 2000	1000	5000	2500	500	1500	400
AM-13.8-1000	1200 3000	1000	5000	2500	500	1500	400

Servicing

A. Servicing shall consist of adjusting, cleaning, lubricating, tightening, etc., as recommended by the Company. The operations listed are on the basis of servicing at intervals of six months or less.

Circuit Conditions

B. When closing and opening no load.

C. When closing and opening currents up to the continuous current rating of the breaker at voltages up to the maximum design voltage and at 80 per cent power factor or higher.

D. When closing currents up to 600 per cent and opening currents up to 100 per cent (80 per cent power factor or higher) of the continuous current rating of the breaker at voltages up to the maximum design voltage.

Operating Conditions

E. With up to rated control voltage applied.

F. Frequency of operation not to exceed 20 in 10 minutes or 30 in 1 hour. Rectifiers or other auxiliary devices may further limit the frequency of operations.

G. Servicing at not greater intervals than shown in Column 2.

Conditions of the Breaker After the Operations Shown in the Table

H. No parts shall have been replaced.

I. The breaker shall meet all of its current, voltage, and interrupting ratings.

J. The breaker shall meet all of its current and voltage ratings but not necessarily its interrupting ratings.

Operation Under Fault Conditions

K. If a fault operation occurs before the completion of the permissible operations, it is not to be inferred that the breaker can meet its interrupting rating or complete its number of operations without servicing and making replacements if necessary.

TABLE III. REPETITIVE DUTY FOR ARC-FURNACE SWITCHING

Air circuit breakers designed for arc-furnace switching, when operating under usual service conditions, shall be capable of operating the required number of times given in this table. The operating conditions and the permissible effect upon the breakers are given in the notes following the table. For each column, all paragraphs listed must be given consideration. (Reference NEMA Standard SG4.)

Breaker Type	Continuous Current Rating Amperes	Arc-Furnace Rating Full Load, Amperes	Maximum Number of Operations Between Servicing Note A	Number of Operations: No Load Mechanical Notes B, C,D,E,F, and G	Switching and Interrupting Notes C,D, E,F,H, and I
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
AM-4.16-250	1200	Below 100	2000	20000	See Schedule 1
AM-13.8-500 AM-13.8-500B		100 to 1200	2000	20000	See Schedule 2
AM-7.2-500 AM-13.8-750	1200	Up to 1200	2000	10000	See Schedule 2
AM-7.2-500 AM-13.8-500 AM-13.8-500B AM-13.8-750	2000	1201 to 2000	2000	10000	See Schedule 3
AM-4.16-350 AM-13.8-750B AM-13.8-1000	1200	Up to 1200			See Schedule 2
AM-4.16-350 AM-13.8-750B AM-13.8-1000	2000	1201 to 2000	2000	5000	See Schedule 3
AM-4.16-350 AM-13.8-1000	3000	1201 to 3000			

Servicing

A. Servicing shall consist of adjusting, cleaning, lubricating, tightening, etc., as recommended by the Company. The operations listed are on the basis of servicing at intervals of six months or less.

Circuit Conditions

B. When closing and opening no load.

Operating Conditions

C. With rated control voltage maintained at 90 to 100 per cent of rated value.

D. Frequency of operation not to exceed 20 in 10 minutes or 30 in 1 hour. Rectifiers or other auxiliary devices may further limit the frequency of operations.

E. Servicing at not greater intervals than shown in Column 4.

Condition of the Breaker After the Operations Shown in the Table

F. No parts shall have been replaced.

G. The breaker shall meet all of its current, voltage, and interrupting ratings.

H. The breaker shall meet all of its current and voltage ratings but not necessarily its interrupting rating.

Operation Under Fault Conditions

I. If a fault operation occurs before the completion of the permissible operations, it is not to be inferred that the breaker can meet its interrupting rating or complete its number of operations without servicing and making replacements if necessary.

SCHEDULE 1

10,000 operations interrupting no load or load currents less than 100 amperes, plus 5000 operations interrupting fault currents up to 350 amperes, plus one opening operation (O) at rated interrupting current.

SCHEDULE 2

2500 operations interrupting no load or load currents less than 1200 amperes, plus 200 operations interrupting fault currents up to 3600 amperes, plus one opening operation (O) at rated interrupting current.

SCHEDULE 3

2000 operations interrupting no load or load currents less than 2000 amperes, continuous current rating in column 2, plus 200 operations interrupting fault currents up to 6000 amperes, plus one opening operation (O) at rated interrupting current.

TABLE IV. INDUSTRY STANDARDS

NATIONAL ELECTRICAL MANUFACTURERS ASS'N (NEMA)
155 East 44th Street
New York, New York 10017

Standard No.	Description
SG-2	High-voltage Fuses
SG-4	Power Circuit Breakers
SG-5	Power Switchgear Assemblies
SG-6	Power Switching Equipment

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
70 East 45th Street
New York, New York 10017

Standard No.	Description
C37.03 C37.04a	AC Power Circuit Breakers Definitions and Rating Structure.
C37.06 C37.06a	Preferred Ratings of Power Circuit Breakers
C37.07	Interrupting Factors — Reclosing Service
C37.09 C37.09a	Test Code for Power Circuit Breakers
C37.010 C37.11	Application Guide Power Circuit Breaker Control Guide Specifications
C37.1	Relays Associated with Electric Power Apparatus
C37.2	Automatic Station Control, Supervisory and Associated Telemetering Equipment (Includes Device Function Description)
C37.20	Switchgear Assemblies and Metal-Enclosed Bus

THREE MAIN BUS CONTINUOUS-CURRENT RATINGS

Bus continuous-current ratings are available in standard metal-clad switchgear equipment, which match the continuous-current rating of the associated magne-blast circuit breaker. Standard ratings are 1200, 2000, and 3000 amperes.

By the proper arrangement of the "source" and "load" breakers or bus taps it is possible to obtain the lowest bus current requirements. Therefore, it may be possible to have a 2000-ampere source breaker and only require a 1200-ampere bus. Regardless of varying bus densities at different points of the bus, the bus will be designed and rated for the maximum current density at any one point and it will not be tapered for reducing current densities.

Future expansion should be considered when selecting the bus current rating. Should future expansion require the next larger size bus rating, the present initial investment is extremely small when compared to the future down time and expense of modifying or replacing the complete bus.

METAL-ENCLOSED NONSEGREGATED PHASE BUS

Three-phase metal-enclosed nonsegregated phase bus is normally used for joining a metal-clad structure to the incoming or outgoing lines entering or leaving a station building, or for joining independently located metal-clad structures, or for any other similar connection purposes.

It can be used as "metal-enclosed conductors" instead of power cables where current requirements are high, or where the additional benefits of reliability and dependability are important, or for reasons of installation and maintenance. It can be used as a "bus," as in a synchronizing bus arrangement with current-limiting reactors.

RATINGS

The 3-phase, 3-wire metal-enclosed nonsegregated phase bus is rated: 4.16 or 13.8 kV; 1200, 2000, or 3000 amperes continuous current; 50 or 60 cycles; momentary current, insulation and temperature rise ratings are equal to those ratings of the associated metal-clad switchgear. When used as a "synchronizing bus," higher momentary ratings may be required.

DESCRIPTION

The metal-enclosed nonsegregated phase bus is designed, tested, and assembled in accordance with the applicable standards of ANSI, IEEE and NEMA.

The 3-phase conductors are totally enclosed by metal plates in a common enclosure with removable covers. The enclosure is suitable for indoor installation or it can be weatherproofed for outdoor installations. The conductors are insulated with NORYL® thermoplastic sleeves. The insulation, connection joints, bracing, etc. are similar to the main bus in metal-clad switchgear equipment. Provisions are included for external hangers or supports, which are furnished and installed by the Purchaser.

Complete assemblies are available in various lengths covering horizontal and vertical runs and "L" connection sections.

The sizes and arrangements allow for a simple and flexible installation, which satisfies most requirements.

CURRENT TRANSFORMERS

In general, provision for current transformers in metal-clad switchgear equipment is guided by the following rules and as illustrated in the following one-line schematic. Unless otherwise indicated, all current transformers will be furnished with metal-clad equipment.

Generators: Three current transformers at (A) for metering and relaying. 1 current transformer at (B) for voltage regulator. 3 current transformers at each location of (C) for generator differential relaying. All current transformers will be furnished with metal-clad equipment.

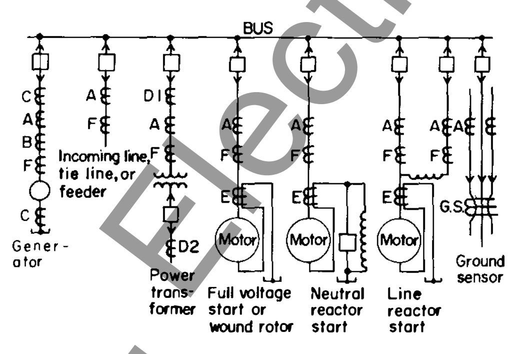
Incoming line, tie line or feeder: Three current transformers at (A) for metering and relaying. All current transformers will be furnished with metal-clad equipment.

Power transformer: Three current transformers at (A) for metering and relaying. Three current transformers at (D1) and three current transformers at (D2) for transformer differential relaying.

Current transformers at (A) and (D1) will be furnished with metal-clad equipment. Current transformers at (D2) to be furnished by others.

Motors: (Neutral Reactor Start): Three current transformers at A for metering and relaying. When specified, add one ground sensor current transformer adjacent to motor on line side. (NOTE: Total of three phase overcurrent relays always required.) Three current transformers at location E for motor differential relaying. Line-reactor Start with motor differential protection: Same as preceding paragraph. Line-reactor Start without motor differential protection: three current transformers at A. (NOTE: Total of three overcurrent relays required) and when specified ADD one ground sensor current transformer adjacent to motor on line side. (NOTE: One additional overcurrent relay required.)

For further data on GROUND SENSOR EQUIPMENT refer to Handbook Section 6733.



Requirements for current transformers in metal-clad switchgear equipment.

Bus: Three current transformers at each location of (F) for bus differential relaying. All current transformers will be furnished with metal-clad equipment.

GROUND-SENSOR EQUIPMENT

Ground-sensor equipment does not replace the phase-to-phase, or three-phase fault protection which is obtained from the protective relays that operate from conventional phase-current transformers and which are usually furnished in switchgear equipment. This equipment does replace the residual relay operating from the secondary circuit of three individual phase-current transformers, and allows the omission of one of these transformers if it is not required for some other purpose in the particular switchgear unit involved.

With the use of ground-sensor equipment, the sensitivity of the ground-fault protection is not dependent upon the ampere rating of the phase-current transformers.

The outstanding advantage of the ground-sensor equipment is that sensitive ground-fault protection can be obtained which is both instantaneous in action and sensitive in setting. It will not operate falsely on faults between phases or normal-load-inrush currents. This combination of features is not obtainable from ground-fault protective relays operating in the residual circuit of three-phase current transformers. Hence, the use of the protective scheme results in the fast clearing of the circuit on ground faults with resultant minimum damage to the protected apparatus. The scheme generally makes use of an instantaneous relay, No. 50GS, which can be set to operate on primary ground-fault current as low as 15 amperes.

This sensitive ground-fault protective relay scheme can also be provided with time-overcurrent relay, No. 51GS, on incoming line or similar circuits where it is necessary to obtain selective tripping with instantaneous ground-sensor relays. Selective relay settings can also provide back-up protection for other time ground-sensor relays. The time overcurrent relay can also be set to operate on primary ground-fault currents as low as 15 amperes.

The application of ground-sensor equipment to circuits where circulating currents may exist should be avoided; *e.g.*, generator and/or transformer neutrals simultaneously grounded to a common grounding resistor.

POTENTIAL TRANSFORMERS

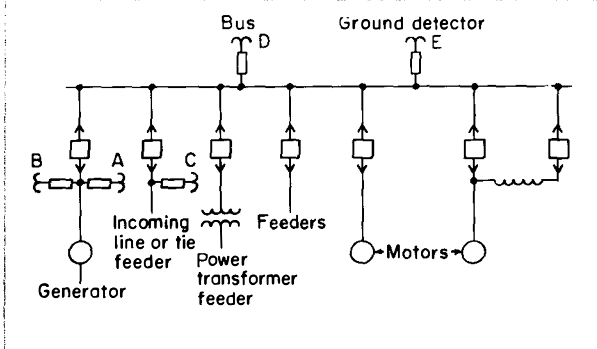
In general, provision for potential transformers in metal-clad switchgear equipment is guided by the following rules, and as illustrated in the following one-line schematic.

Generator: Potential transformers are required at (A) for generator metering and relaying and at (A) and (D) for synchronizing. Voltage regulator requires one, in some cases two, potential transformers at (B).

Incoming line or tie feeder: One potential transformer is required at (C) and (D) for synchronizing equipment. Potential transformers are required at (C) for line-voltage readings. Watthour meter, wattmeter, varmeter or directional relaying require potential transformers at (D) or (C).

Feeder: Watthour meter, wattmeter, varmeter, voltmeter require potential transformers at (D).

Power transformer feeders: Watthour meter, wattmeter, varmeter, voltmeter require potential transformers at (D).



Requirements for potential transformers in metal-clad switchgear equipment.

Motors: Undervoltage protection and watthour meter, wattmeter or varmeter require potential transformers at (D).

Bus potential transformers: To reduce to a minimum the number of potential transformers used in a complete installation, it is practical to install on each station bus one set of potential transformers at (D) from which all the potential coils of meters, synchronizing equipment, and some relays are energized through a potential bus. Such an arrangement usually eliminates the need for individual meter potential transformers for each circuit.

Ground detection potential transformers: System ground detection indication or relaying potential transformers are usually connected to the bus (E) and a separate set of 3-potential transformers are recommended for this purpose only.

Number required: 3-wire systems require 2-potential transformers. 4-wire solidly grounded systems usually require 3-potential transformers.

RELAY AND CONTROL FUNCTIONS

The determination of relay and control functions has been simplified by their listing in the basic functional specifications and further in GE Handbook section 6731, which also include normal options for the principal applications encountered. The further selection of specific relays is by the customer or consulting engineer. GE application engineers are available for individual recommendations when requested. Further guidance literature is also available.

CLOSING, TRIPPING AND POWER REQUIREMENTS

BREAKER OPERATION AND CONTROL POWER

Successful operation of metal-clad switchgear is dependent upon a reliable source of control power which at all times will maintain voltage at the terminals of electrically-operated devices within the rated operating-voltage range. In general, the operating-voltage range of switchgear equipment is determined by the rated operating voltage range of the circuit breaker. These ranges, as established by NEMA standards are given in table V.

TABLE V. STANDARD CONTROL VOLTAGES AND OPERATING RANGE

Normal Control Voltage		OPERATING RANGE—VOLTS	
	Volts	Stored-energy Mechanism — Spring Motor and Closing Spring-Release Coil	Trip Coil of Both Mechanisms
DC	24	....	14–30
	48	36–52	28–60
	125	90–130	70–140
	250	180–260	140–280
AC	115	95–125	95–125
	230	190–250	190–250

There are two primary uses of control power in metal-clad switchgear which merit separate consideration when selecting the source of control power to operate it: namely, closing power and tripping power. The applicable current requirements are listed in table VI (page 24).

CLOSING POWER

It is generally preferable that the availability of closing power be independent of voltage conditions on the power system associated with the switchgear. The 48 V, 125 V or 250 V dc battery is normally considered the most reliable auxiliary power source. However, in many instances, particularly where the switchgear consists of only a few circuit breaker units, the storage battery or other independent power source necessary to achieve this goal may represent an investment out of proportion to the advantage gained.

The choice between dc closing power derived from a storage battery and ac closing power derived from transformers connected to the switchgear's power system is economic, dictated by the desired system reliability.

Other factors influencing the choice are:

1. Closing of breakers with the power system deenergized.

2. Availability of housing facilities for a battery and its charging equipment.

3. Effect of low ambient temperature on battery.

4. Availability of adequate maintenance for a battery and its charging equipment.

5. Future additions to the equipment sufficient to shift the economic preference from an ac to a dc system.

TABLE VI. OPERATING CURRENTS OF STORED-ENERGY-OPERATED CIRCUIT BREAKERS‡

Type of Breaker	Closing Current in Amperes										Tripping Current in Amperes*					
	At 48 Volts DC		At 125 Volts DC		At 250 Volts DC		At 115 Volts AC		At 230 Volts AC		Direct current volts				AC Volts	
	Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor	24	48	125	250	115	230
AM-4.16-250 AM-4.16-350 AM-7.2-500 AM-13.8-500 AM-13.8-750 AM-13.8-1000	6.5	32	6	14	3	7	8	14	4	10	13	6.5	6	3	23	10

‡ Values listed for operating currents are subject to change and should be used for estimating purposes only.

* Fuses for the tripping circuit should have an ampere rating of at least 2 times the tripping current and not less than 35 amperes.

TABLE VII. OPERATING CURRENTS OF SOLENOID-OPERATED CIRCUIT BREAKERS‡

BASIC METHODS OF CLOSING

The stored-energy operated mechanism can use the arrangements shown in Fig. A and B. A closing rectifier is not required for ac closing of the breaker.

When the stored-energy operated mechanism is operated from alternating current, the current required is such that it can be taken from a general-purpose or lighting source, as shown by Fig. C. The energy for the next operation is stored in the springs as soon as the breaker is closed. In order to permit control switch or automatic initiation of closing, the ac source must also be present at the time of breaker closing to energize the spring-release solenoid. However, at attended locations, somewhat less reliable ac control source may be permissible since an operator could manually release the closing springs if necessary. The mechanism also offers the possibility of complete manual operation, Fig. D, both for charging the springs and for releasing them to close the breaker.

METHODS OF TRIPPING

DC BATTERY TRIP

When properly and adequately maintained, the battery offers the most reliable tripping source. It requires no auxiliary tripping devices, and uses single-contact relays that directly energize a single trip coil in the breaker. A battery trip supply is not affected by the power circuit voltage and current conditions during time of faults, and therefore is considered the best source for all types of protective relay tripping. Additional advantages are that only one battery is required for each location, and it may be used for other equipment; *e.g.*, high-voltage breaker trip circuits and ground switches.

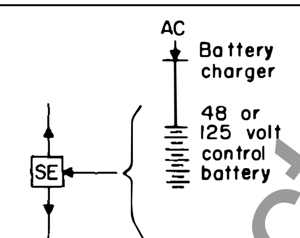


Fig. A. DC stored-energy close

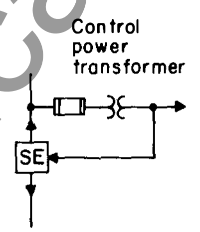


Fig. B. AC stored-energy close

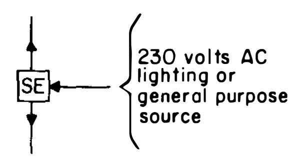


Fig. C. AC stored-energy close

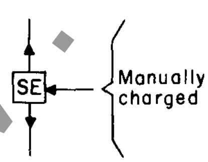


Fig. D. Manually stored-energy close

When a 125 or 250 volt dc battery is available for closing power, it is also used for the breaker tripping circuits. A 48 volt tripping battery is recommended for all tripping battery applications where a 125 volt or 250 volt battery is not available or cannot be justified. The 48 volt battery equipment can be mounted in outdoor switchgear equipment. However, it is recommended for separate mounting, external to indoor metal-clad switchgear equipment. In outdoor equipment the preferred closing power (with 48V dc battery tripping) is by 48V dc or by 115 or 230 volt ac source.

CAPACITOR TRIP

An ac potential source is required for charging the capacitors used in the capacitor trip unit. This source may be either a control power transformer connected where voltage is normally present or a reliable 230 volt ac single-phase source. A control power transformer is usually used because it is required for ac closing of the circuit breakers. Capacitor trip uses the same standard single-closing contact relay as dc battery trip. *A separate capacitor trip unit is required for each breaker.*

The capacitor trip unit may be the General Electric "Auto Charge Trip Device" which will retain sufficient tripping power for a minimum of three days upon loss of control power or the standard capacitor trip which will retain its charge for a minimum of 30 seconds.

POWER FOR OTHER USES

Power for control purposes such as indicating-lamp circuits, sequential control and interlocking circuits of automatic equipment, etc., is derived from the closing power source except where the circuits involved enter into the protective scheme and embody no continuously energized devices, in which case tripping power is used. DC control power is recommended for most automatic equipment operations.

Power is also required for the motor-operated vertical-lift elevating mechanism. The mechanism is available for 125 volt dc, 250 volt dc, 230 volt ac single-phase. The current requirements of the mechanism are low and of intermittent duty. When a 125 or 250 volt battery or a reliable 230 volt ac source is used for breaker closing or for the spring motor of the stored-energy mechanism, the same source is used for the elevating mechanism.

Unit heaters are furnished as standard in outdoor metal-clad switchgear equipment but are an optional feature addition for indoor metal-clad switchgear equipment.

When unit heaters are included, it is recommended that the heaters be continuously energized. It is usually not practical to connect the heaters to a dc source. Therefore a separate ac source is recommended when dc closing is used. When ac closing is used, this source can also be used for the heaters, provided this source is of sufficient capacity for the continuous current requirements of the heaters and for the impulse loading of breaker closing. Heater requirements for each metal-clad unit are listed in the following table. The table applies to either a breaker unit or a structure high auxiliary compartment.

Metal-clad Switchgear Rated kV	Heater Requirements	
	Watts per Metal-clad Unit	AC Single-phase Circuit Voltage
4.16	250	115/230 or 115
7.2 or 13.8	500	

Battery chargers require an ac source, and the rating of the source depends on the type and ratings of the charger used for the application. The usual rating is 230 volt or 115 volt, and obtained from the ac source used for closing the breaker.

SPECIAL APPLICATIONS

REACTOR SWITCHING

GE magne-blast breakers have been successfully applied to their full rating capability for switching reactors in many applications to date. On EHV installations, where 13.8 kV reactors have been installed on the tertiaries of large auto or power transformers, magne-blast breakers have been used to neutral switch these reactors.

CAPACITOR SWITCHING

The listed magne-blast circuit breakers are applicable to shunt-capacitor-bank switching. The following table provides an application guide for the 1200 and 2000 ampere breakers applied to "Single-shunt-Capacitor Banks," *i.e.*, one breaker feeding one 3-phase capacitor bank. If this circuit is closely paralleled by another switched capacitor bank, this table will not apply because the application requires additional special considerations, such as local high-frequency equalizing currents between the separately switched capacitor banks, and therefore should be referred to the nearest General Electric district office.

For more complex capacitor switching applications including back-to-back switching, refer to the nearest General Electric district office for recommendations. NEMA Pub. #SG-4 Part 2 also applies.

MAXIMUM 3-PHASE, SINGLE-CAPACITOR-BANK NAMEPLATE KVAR

Capacitor Voltage	Capacitor-bank KVAR	
	Breaker Continuous Rating	
	1200 Amp	2000 Amp
2400	3700	6200
4160	6400	10,700
4800	7400	12,300
7200	11,100	18,500
12,470	19,200	32,000
13,800	21,500	35,400

FOOTNOTES: The capacitor-bank rating is subject to the following conditions:

1. The transient voltage from line to ground shall not exceed 2½ times maximum design line-to-ground crest voltage measured at the breaker terminal.
2. The number of restrikes or reignitions shall not be limited as long as the transient voltage to ground does not exceed the value given in Note 1.
3. The capacitor rating applies only to "Single Bank Switching" as noted herein.
4. Interrupting time is in accordance with the rated interrupting time of the circuit breaker.

FAST BUS TRANSFER

Fast bus transfer is normally used for transferring a generating station auxiliary bus to an emergency power source upon failure of the normal source of power. During this transfer it is essential that bus "dead time"* be as short as possible to prevent loss of critical auxiliary functions. GE magne-blast circuit breakers with stored-energy closing meet the critical requirements for fast transfer. "Fast" transfer means there is no intentional time delay in the transfer of a bus or load from one source of power to another.

Two sequences of breaker operation can be used to achieve fast transfer. In the first sequence, the trip signal to the opening breaker and the close signal to the closing breaker are given simultaneously. In this case, the possibility of overlap exists and should be prevented since overlap could mean that the second source could be closing into a fault or the equipment could be tied to the high voltage system through the auxiliary system while the two sources are paralleled. To insure against overlap, several cycles of time delay should be provided by means of a timing relay.

In the second sequence, a trip signal is first given to the tripping breaker, then a "b" contact on the tripping breaker initiates the closing of the second breaker. The length of dead time is dependent on whether a standard auxiliary switch "b" contact or a special early "b" is used. The early "b" contact is faster and is operated when the main breaker contacts separate.

*WITH ARCING — Time between arc extinction of opening breaker to contact making of closing breaker.

NO ARCING — Time between contact parting of opening breaker to contact making of closing breaker.

The following tabulation shows typical dead-times for various types of high speed transfer conditions.

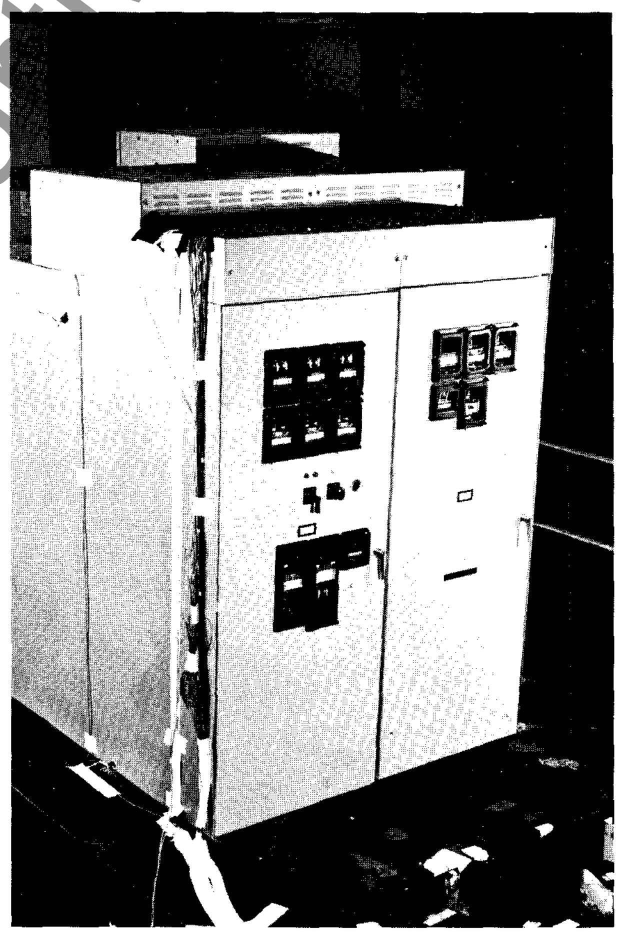
BREAKER Type	Cont. Current Rating, A	TOLERANCE (Plus & Minus) (Cycles) (2)	Simultaneous Close & Trip: No Arcing (6)	Simultaneous Close & Trip: With Arcing (7)	Trip Then Close Using Early "b" Contact (3): No Arcing (6)	Trip Then Close Using Early "b" Contact (3): With Arcing (7)	Trip Then Close Using Std. "b" Contact (4): No Arcing (6)	Trip Then Close Using Std. "b" Contact (4): With Arcing (7)
			NOMINAL DEAD TIME FOR FAST TRANSFER (CYCLES) (1)					
AM-4.16-250	1200 / 2000	1.0	2.1	0.8	4.5	3.2	5.9	4.6
AM-4.16-350	1200	1.5	1.4	Note (5)	3.7	1.8	5.1	3.2
	3000	1.3	1.5	Note (5)	3.8	2.2	5.2	3.6
AM-7.2-500	1200	1.0	2.1	0.8	4.4	3.1	5.8	4.5
	2000		2.3	1.0	4.7	3.3	6.1	4.7
AM-13.8-500	1200	1.0	2.4	1.0	4.8	3.4	6.2	4.8
	2000		2.6	1.2	4.9	3.5	6.3	4.9
AM-13.8-750	1200 / 2000	1.2	2.2	0.6	4.5	2.9	5.9	4.3
AM-13.8-1000	1200	1.7	1.8	Note (5)	4.1	2.1	5.5	3.5
	3000	1.4	2.4	0.7	4.7	3.0	6.1	4.4

(1) Control Voltage at rated Value for 125 Vdc, 250 Vdc or 230 Vac (60 Hz).
(2) Variance covers entire current range from lowest values to maximum rating interrupting current.
(3) Early "b" contact operates at time arcing contacts separate.
(4) Standard "b" contact located on Breaker Auxiliary Switch. Time from arcing contact parting to "b" contact making is approximately 1.4 cycles.
(5) Nominal times produce overlap.
(6) Contact separation to contact making.
(7) End of arcing to contact making.

SEISMIC REQUIREMENTS

In the last few years requests have been increasing rapidly for seismic qualification of metal-clad switchgear installed in nuclear generating stations. General Electric is responding to this customer need through equipment testing, active participation in the development of industry standards for seismic qualification, and analysis and interpretation of the successful performance of GE switchgear involved in earthquake disturbances.

Conservative, full scale, biaxial, random multi-frequency seismic testings have been conducted on M26,



4.16kV–350 MVA 3000 ampere breaker and auxiliary metal-clad unit set up for biaxial testing at Wyle Laboratories, Huntsville, Alabama.

M26H, and M36 metal-clad switchgear. The M26H units shown on this page are representative of the heaviest and widest unit generally used in nuclear station auxiliary operations. GE seismic testing has been conducted with feeder, generator, and voltage throw-over control circuits energized — including simulated CT and PT currents and voltages — to insure that power circuit breakers respond to command close and trip signals, without malfunctioning, before, during and after the seismic tests. Tests have been conducted in accordance with IEEE 344 — 1975, "IEEE Recommended Practices for Seismic Qualification of Class I Electrical Equipment for Nuclear Power Generating Stations." Certified tests results are on file.

With respect to field experience, some installations of GE switchgear have been involved in severe earthquake disturbances with no structural damage or electrical malfunction even though other equipment in the area sustained extensive damage. Analysis of GE switchgear performance before, during and after these disturbances has provided useful guidance in predicting seismic adequacy of other switchgear assemblies and has supported our confidence that GE's standard metal-clad switchgear is suitable for application in areas subject to certain defined seismic conditions. Notwithstanding the successful performance of General Electric switchgear through seismic testing as well as actual earthquakes, the importance and value of industry standards (which explicitly define a seismic test procedure for switchgear assemblies) is recognized. Accordingly, GE continues as an active participant in all industry standards work related to seismic qualification.

Of course, the real benefit of GE's leadership role in seismic work is to you, the customer. Testing, analysis, and experience under severe earthquake conditions makes us confident that GE switchgear will function normally over a wide range of seismic conditions. Moreover, it is probable that test data is available for seismically qualifying your Class I nuclear application by the GE pioneered method of Combined Testing and Analysis approach rather than in the full scale testing approach with representative metal-clad units. (Due to the size, complexity and custom-built nature of switchgear assemblies, seismic tests are considered "special," thus, are not part of regular production testing.)

So, bring your seismic needs to General Electric! Our experience, information and expertise are available to evaluate your seismic requirements and to assist you in finding practical ways to assure seismic adequacy of GE metal-clad switchgear for Class I applications in nuclear plants.

COMPUTERIZED DOCUMENTATION

General Electric utilizes sophisticated computer capabilities and techniques to assist in the engineering and manufacturing of each switchgear equipment order.

Computers are given parameters for each job and with this information, diagrams are generated for customer documentation. This computerized information has the following significant advantages:

1. All terminal points and wires are shown on the electrical elementary diagram as they exist in the equipment.
2. Drawing discrepancies caused by human error are virtually eliminated.
3. The graphic quality of the drawings is outstanding, permitting them to be "B" size for easy handling and storage.
4. When complete technical information is available at the time of order placement, these capabilities and techniques can be used most efficiently with drawing schedules dramatically reduced. However, when customer approval is required, computer generated drawings are supplied reflecting an accurate, fully engineered product in complete compliance with all customer specifications.

In the event customers require certified drawings, which will allow them to pour concrete for new facilities, a construction detail drawing is available in advance of the complete documentation package. The construction detail drawing will show overall lineup dimensions, and locations provided for incoming line conduit stub-ups.

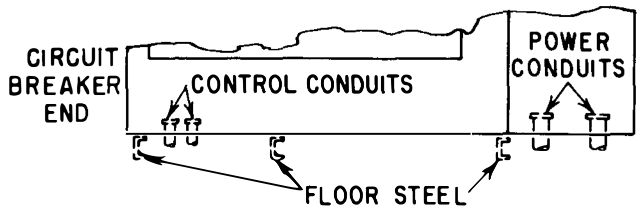
PRE-ENGINEERED EQUIPMENT ARRANGEMENTS

General Electric has developed a line of pre-engineered equipment arrangements which will meet most of today's switchgear functional requirements. Functions included in the pre-engineered equipment line are: General Purpose Feeder, Transformer, Incoming Line, AC Generator, Full Voltage Start-induction Motor, Roll-out Switch and Fuse, Dummy Breaker, Bus Entrance, Bus Tie, Main and Transfer Bus and Auxiliary Compartment.

These structured designs have been developed to provide customers with equipment flexibility while at the same time streamlining engineering and drafting procedures. They are stored in computer memory banks for immediate retrieval and use.

Installation information

INDOOR METAL-CLAD SWITCHGEAR



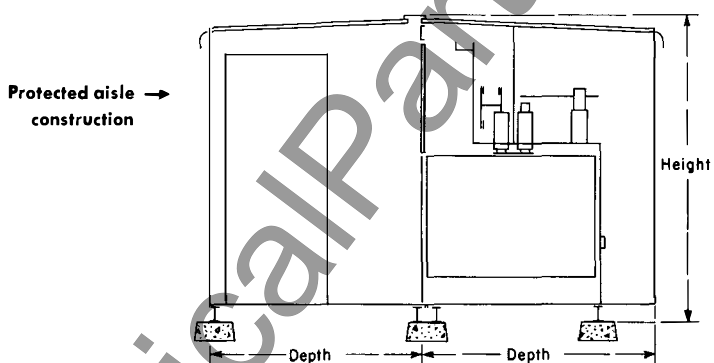
4.16 and 13.8 kV.

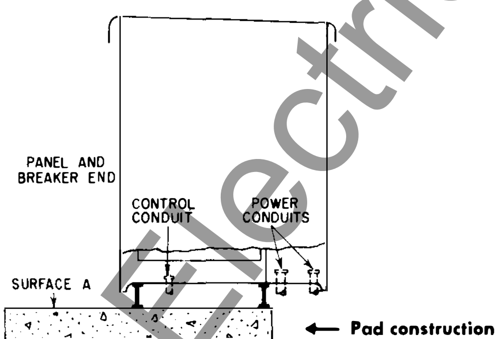
NOTE:

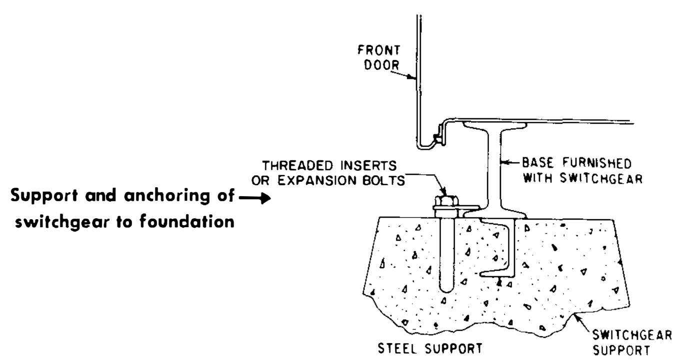
All floor steel to be furnished by Purchaser. Floor steel should be set level with each other, should be level over its full length and should be even with the level, finished floor. The metal-clad switchgear can be anchored to the floor steel by plug welds or ½-inch bolts, furnished by Purchaser.

Floor thickness, reinforcing, etc., depends on impact loading of the switchgear and other normal factors and should be designed in accordance with recommended practices.

OUTDOOR METAL-CLAD SWITCHGEAR







NOTES:

Surface A should be level with switchgear support and reasonably level and smooth for easy handling of power circuit breaker removable elements. For construction, see "Switchgear support."

Switchgear support should be concrete or reinforced concrete with depth, fill, drainage, etc., according to recommended foundation design for the loading, type of construction and local conditions involved. The base furnished with the switchgear should be supported level between "ends" and level over the full length.

Steel support to be furnished by purchaser if desired for anchoring switchgear by tack-welding or required for leveling and supporting switchgear.

Anchor bolts and clips should be used for anchoring the switchgear if tack-welding is not used. The anchor clips are furnished with the switchgear. The purchaser is to furnish the ⅝-inch threaded inserts or ⅝-inch expansion bolts.

Indoor 4.16 kV typical section views

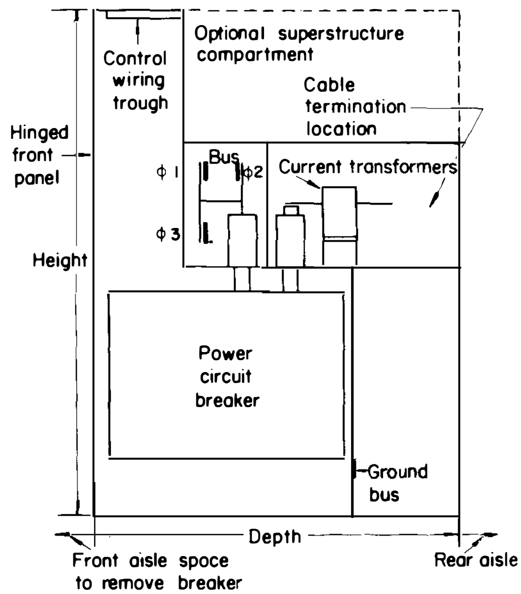


FIG. 1. Indoor Metal-clad Type M-26, 250 MVA

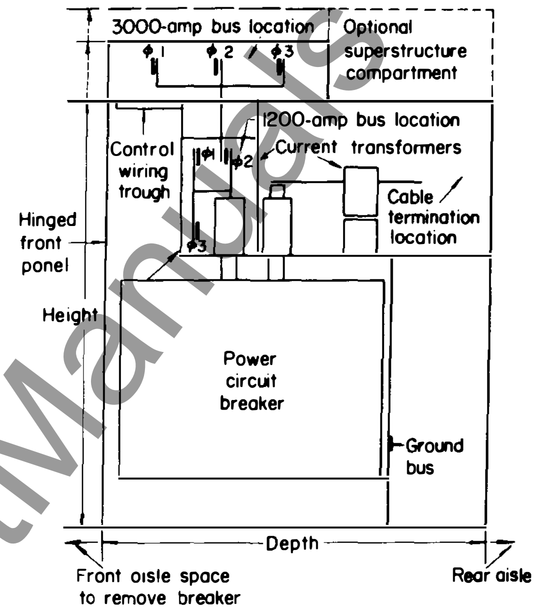


FIG. 2. Indoor Metal-clad Type M-26H, 350 MVA

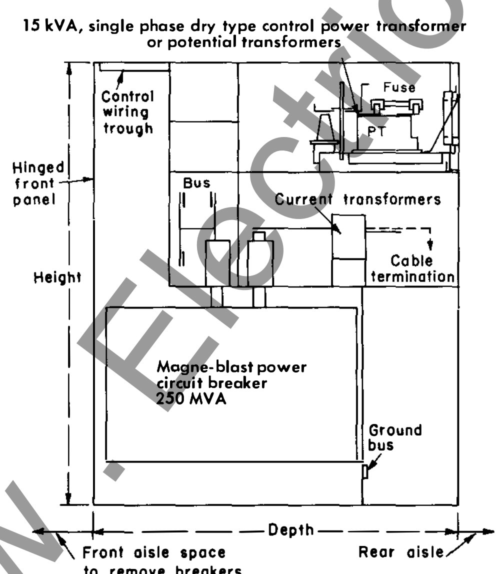


FIG. 3. Indoor Metal-clad Type M-26, 250 MVA

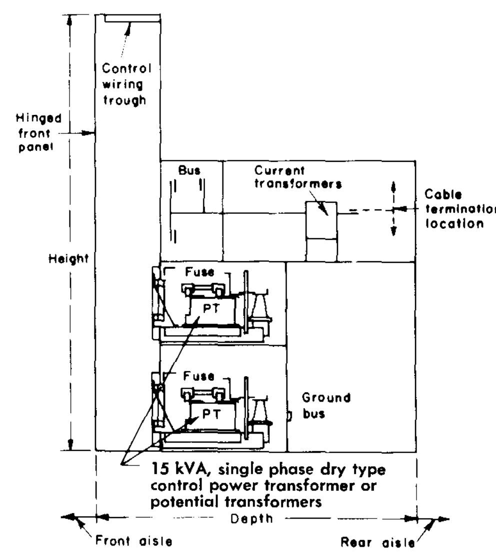


FIG. 4. Indoor Metal-clad Type M-26, 250 MVA

Max. Number of PT's per Rollout Tray		
	L–N connected (1 fuse per PT)	L–L connected (2 fuses per PT)
4.16 kV	3	2

For dimensions see page 32.

Indoor 13.8 kV typical section views

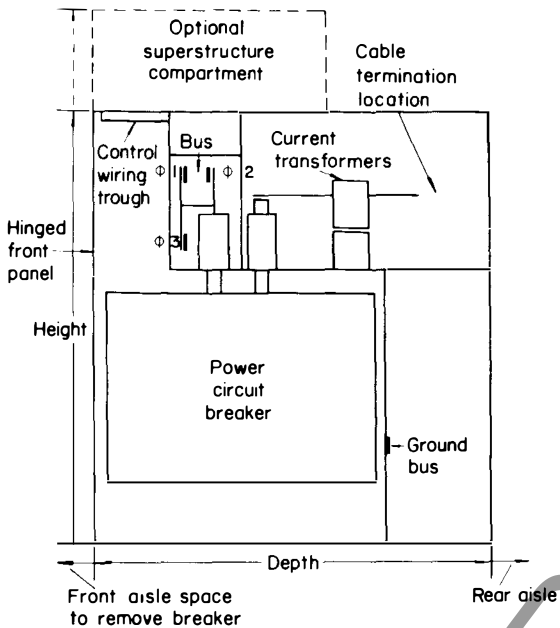


FIG. 5. Indoor Metal-clad Types M-36, 500 MVA or M-36HN, 750 MVA

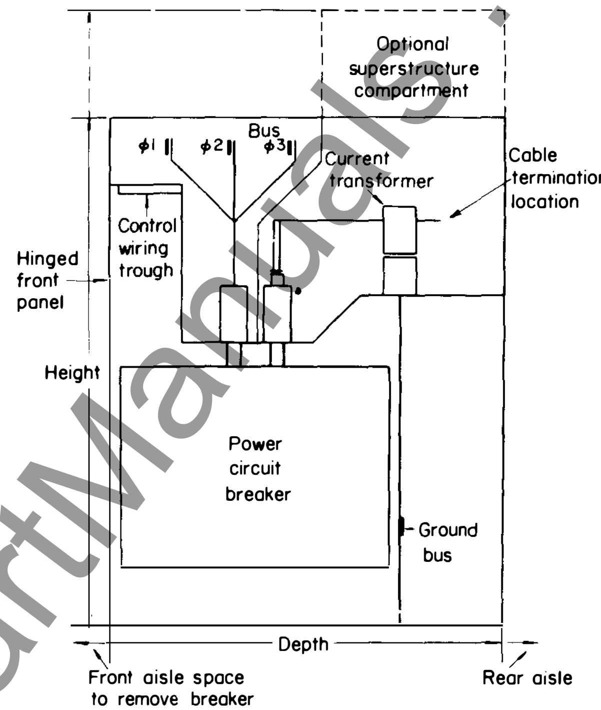


FIG. 6. Indoor Metal-clad Type M-36HH, 1000 MVA

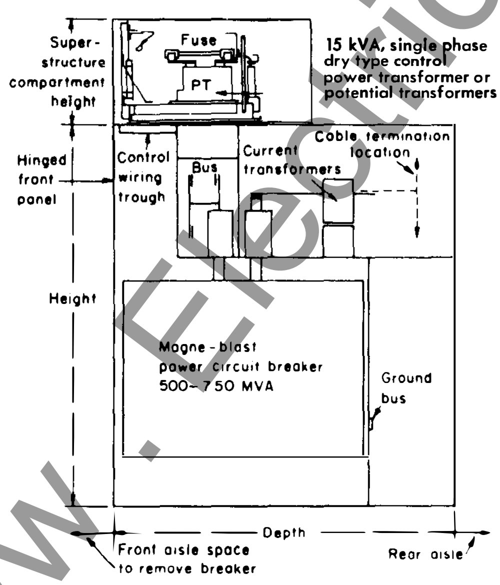


FIG. 7. Indoor Metal-clad Types M-36, 500 MVA or M-36HN, 750 MVA

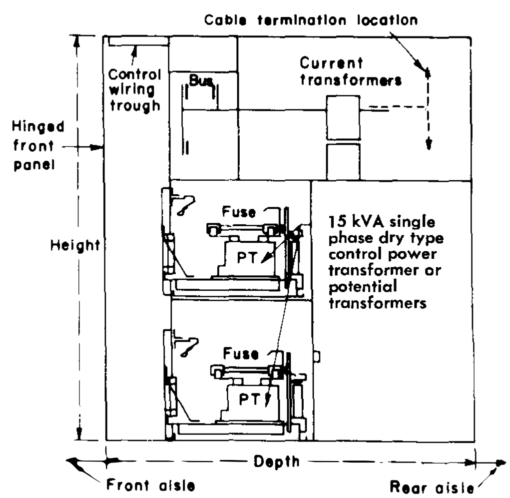


FIG. 8. Indoor Metal-clad and Types M-36, 500 MVA or M-36HN, 750 MVA

Max. Number of PT's per Rollout Tray

	L–N connected (1 fuse per PT)	L–L connected (2 fuses per PT)
13.8 kV	3	2

For dimensions see page 32.

Typical section views outdoor metal-clad switchgear

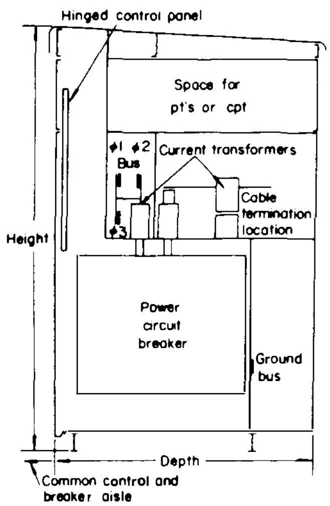


FIG. 9. Outdoor Metal-clad Type M-26, 250 MVA

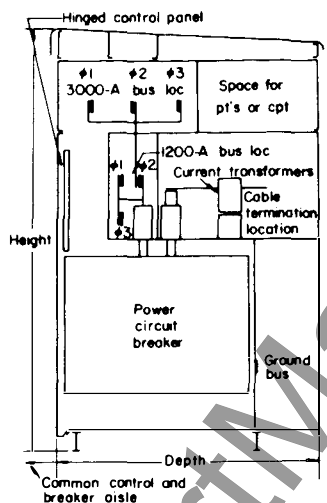


FIG. 10. Outdoor Metal-clad Type M-26H, 350 MVA

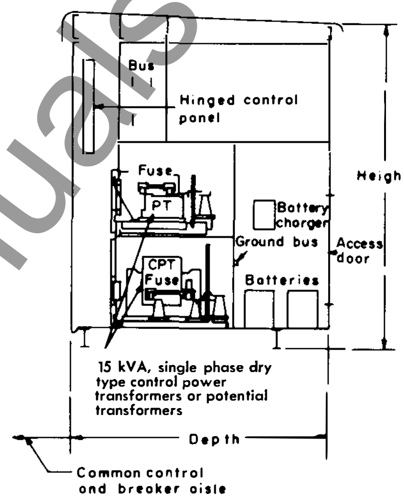


FIG. 11. Outdoor Metal-clad Auxiliary Compartments (Various Options Available)

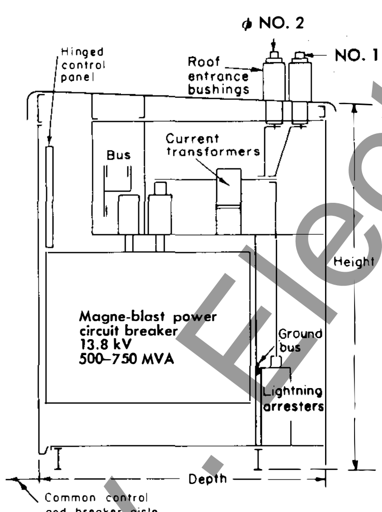


FIG. 12. Outdoor Metal-clad Type M-36, 500 MVA or M-36HN, 750 MVA

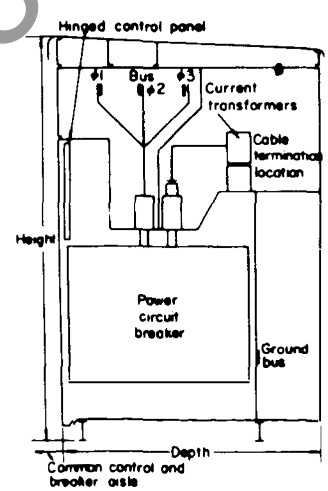


FIG. 13. Outdoor Metal-clad Type M-36HH, 1000 MVA

For dimensions see page 32.

Dimensions, weights and ratings

OUTDOOR METAL-CLAD PROTECTED AISLE AND COMMON AISLE [1]

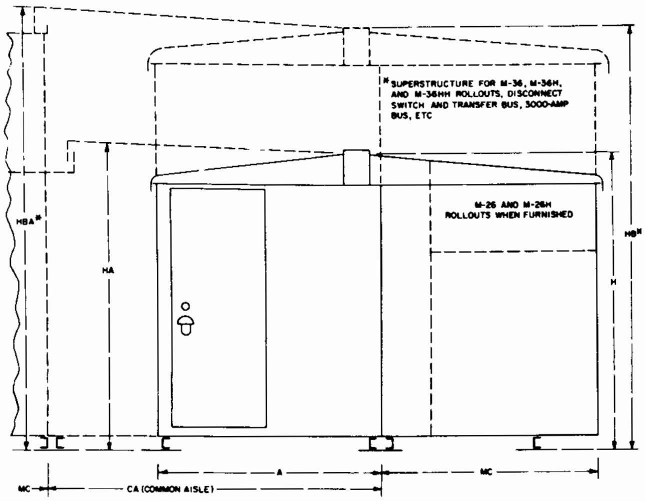


FIG. 14. End view of outdoor metal-clad with protected aisle

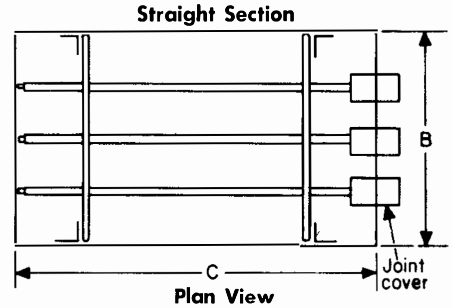
Type	MAX MVA	Dimensions in Inches							Approx. weight increase/cubicle (3)	
		MC	A	CA	H	HA	HB (2)	HBA (2)	Protected Aisle	Common Aisle
M-26	250	77	76	96	108½	110¾			700	500
M-26 H	350	87½	76	96	125⅜	127⅝			700	500
M-36	500	87½	76	96	108½	110¾	143¼	145½	700	500
M-36 HN	750	87½	76	96	108½	110¾	143¼	145½	700	500
M-36 HH	1000	105	102	108	133⅜	135⅝	146⅜ R/O Only	148⅝	1300	1000
		Add 2⅝ for Roof Overhang			Add 1¾ for Roof Caps					

(1) Standard paint color is Outdoor Dark Grey (ANSI #24). Optional colors are Berkshire Green (ANSI #45) and Sky Grey (ANSI #70) which may be used to color coordinate with other equipment.
(2) Refer to page 33 for breaker unit and auxiliary compartment basic weights.
(3) Add to outdoor unit weight.

METAL-ENCLOSED NONSEGREGATED PHASE BUS

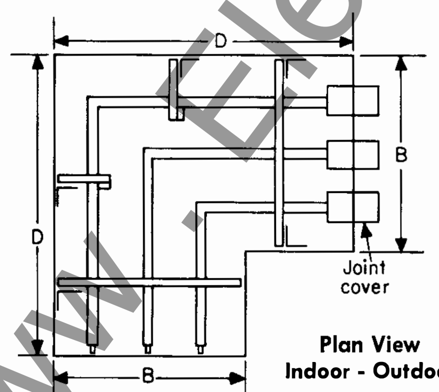
Installation	Rated kV	Rated Continuous Current Amperes	Dimensions—Inches					Net Weight Pounds per Foot *	
			A	B	C	D	E	AL	CU
Indoor	4.16 or 13.8	1200	16	26	Max of 96	34	26	50	55
		2000	16	26		34	26	55	70
		3000	16	36		44	26	70	105
Outdoor	4.16 or 13.8	1200	16¾	26		34	26	60	65
		2000	16¾	26		34	26	65	75
		3000	16¾	36		44	26	75	110

Straight Section

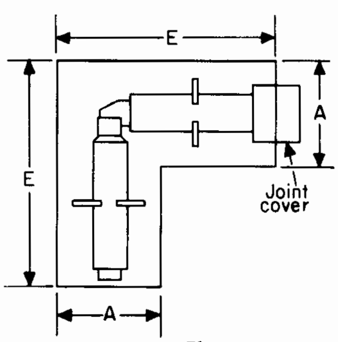


Plan View
Indoor - Outdoor

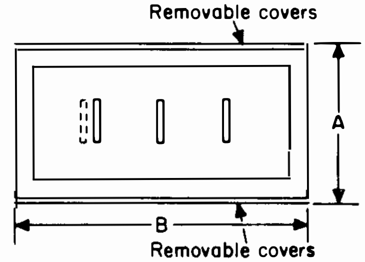
NOTE: All dimensions and weights are approximate. Do not use for construction.
*Measured on center line.



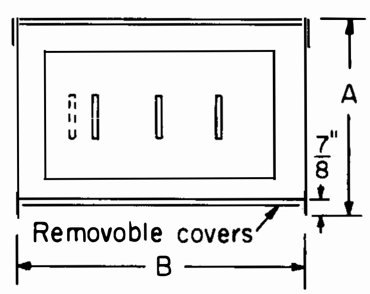
Plan View
Indoor - Outdoor



Elevation View
Indoor - Outdoor



End View - Indoor
3000A (2) Bars/ Ø



End view - outdoor

INDOOR METAL-CLAD SWITCHGEAR [1][3]

Nomenclature: Metal-clad Type	Nomenclature: Breaker Type	Cont. Current Rating: Amperes	Height	Depth	Front Aisle Space to Remove Breaker Min.	Rear Aisele Min.	Breaker Unit (Includes Breaker): Fig.	Breaker Unit: Width	Breaker Unit: Weight	Breaker Weights	Optional Superstr. Compt with PT's or CPT—1-phase 15 kVA Max: Width	Optional Superstr.: Weight	Optional Superstr.: Total Height of Unit	Auxiliary Compt: Width	Auxiliary Compt: Weight
M-26	AM-4.16-250	1200	90	73½ or 81½ (2)	61	26	1, 3, 4	26	2800	1000	26 or 36	350	90	26	2000
		2000							3000	1150				36	2400
M-26H	AM-4.16-350	1200	90 or 107	79½ or 87½ (2)	66	26	2	26	3100	1300	26	350	112	26	2000
		3000						36	4600	2000	36	500		36	2800
M-36	AM-7.2-500	1200	90	87½	66	26	5, 7, 8	36	4100	1500	36	500	115	36	3000
		2000							4300	1650					
M-36	AM-13.8-500	1200	90	87½	66	26	5, 7, 8	36	4100	1450	36	500	115	36	3000
		2000							4300	1550					
M-36HN	AM-13.8-750	1200	90	87½	66	26	5, 7, 8	36	4200	1550	36	500	115	36	3200
		2000							4300	1700					
M-36HH	AM-13.8-1000	1200	115	105	102	26	6	36	5700	2600	36 or 40	500	140	36	3500
		3000						40	6600	3100					

(1) For synchronous motor full voltage start and line reactor start the separately mounted Indoor field compartment is 68″ high, 36″ deep, and 26″ wide with net weight 550 pounds.
(2) Alternate depth. Provides additional instrumentation and wiring space.
(3) Standard paint color is Indoor Light Grey (ANSI #61).

OUTDOOR METAL-CLAD SWITCHGEAR [1][2]

Nomenclature: Metal-clad Type	Nomenclature: Breaker Type	Cont. Current Rating: Amperes	Height	Depth	Aisle Space to Remove Breaker Min.	Breaker Unit (Includes Breaker): Fig.	Breaker Unit: Width	Breaker Unit: Weight	Breaker Weights	Auxiliary Compt: Width	Auxiliary Compt: Weight	Add for Protected Aisle to Each Unit or Compt: Depth	Add for Protected Aisle: Weight
M-26	AM-4.16-250	1200	106	77	73	9	26	3000	1000	26	2300	76	700
		2000						3200	1150	35	2900		
M-26H	AM-4.16-350	1200	106 or 123	87½	78	10	26	3300	1300	26	2300	76	700
		3000					36	4900	2000	36	3500		
M-36	AM-7.2-500	1200	106	87½	78	12	36	4400	1500	36	3500	76	700
		2000						4600	1650				
M-36	AM-13.8-500	1200	106	87½	78	12	36	4400	1450	36	3500	76	700
		2000						4500	1550				
M-36HN	AM-13.8-750	1200	106	87½	78	12	36	4500	1550	36	3500	76	700
		2000						4600	1700				
M36HH	AM-13.8-1000	1200	131	105	96	13	36	6200	2600	36	4300	102	1300
		3000					40	7200	3100				

(1) For protected aisle and common aisle dimensions, see opposite page.
(2) Standard paint color is Outdoor Dark Grey (ANSI #24). Optional colors are Berkshire Green (ANSI #45) and Sky Grey (ANSI #70) which may be used to color coordinate with other equipment.

All dimensions and weights are approximate — do not use for construction. Dimensions are in inches; all weights are average, net weights in pounds; breaker unit weight includes the static weight of the breaker. For master unit substations dimensions refer to Apparatus Sales Office.

Guide specifications
medium voltage metal-clad switchgear

GENERAL*

The (indoor -- outdoor -- protected aisle -- common aisle) metal-clad switchgear described in this specification is intended for use on a (2400 -- 4160 -- 4800 -- 6900 -- 13800) volt 3-phase (3-4) wire (grounded -- ungrounded) 60 Hertz system. The switchgear shall be rated (4160 -- 7200 -- 13800) volt and have removable element air-magnetic circuit breakers. The enclosure and circuit breaker either individually or as a unit shall have a basic impulse rating of (60 — 95) kV. The switchgear, including air circuit breakers, meters, relays, etc., shall be factory tested.

APPLICABLE STANDARDS

The switchgear equipment covered by these specifications shall be designed, tested and assembled in accordance with the latest applicable standards of ANSI, IEEE and NEMA.

STATIONARY STRUCTURE

The switchgear shall consist of ( ) breaker units and ( ) auxiliary units assembled to form a rigid self-supporting completely metal-enclosed structure. Outdoor metal-clad switchgear shall be enclosed in a weatherproof enclosure and shall include: suitable weatherproof access doors or doors with provision for padlocking; protected openings for ventilation, as required; interior lighting and utility outlets with protective devices; and heaters with protective devices. In each unit the major parts of the primary circuit, such as the circuit breaker, buses, potential transformers and control power transformers shall be completely enclosed by grounded metal barriers. This shall include an inner barrier in front of or a part of the circuit breaker.

ARRANGEMENT

The switchgear shall be arranged and include the units as shown on the attached one-line diagram.

CIRCUIT BREAKER COMPARTMENT

Each circuit breaker compartment shall be designed to house (4160 -- 7200 -- 13800) volt removable element air-magnetic circuit breaker. The stationary primary disconnecting contacts shall be constructed of silver-plated copper. Safety shutters shall be provided which isolate all primary connections in the circuit breaker compartment when the breaker is withdrawn from the connected position.

CABLE COMPARTMENT

Cable termination facilities shall be provided as detailed in the descriptions. Where more than two cables per phase are terminated, a rear extension of the switchgear housing is acceptable. A ¼" x 2" ground bus shall be furnished and be secured to each unit. It shall extend the entire length of the switchgear and be equipped with a terminal for connection to a ground system.

BUS COMPARTMENT

The main bus shall be rated (1200 -- 2000 — 3000) amperes. Bus bars shall have the specified continuous current rating, limited by ANSI standards of temperature rise and documented by design tests. All joints will be silver plated with at least two bolts per joint. Bus bars will be braced to withstand the magnetic stresses developed by currents equal to the main power circuit breaker close, carry and interrupt ratings. The bus shall be provided with front access through removable panels.

FINISH

All steel surfaces shall be chemically cleaned and treated to provide a bond between the primer paint and metal surfaces. The switchgear exterior will be finished with air-dried nitrocellulose lacquer paint of grey color (ANSI #61) for indoor equipment and air-dried acrylic lacquer paint of dark grey (ANSI #24) for outdoor equipment. (Optional outdoor colors are Berkshire Green (ANSI #45) and Sky Grey (ANSI #70) which may be used to color coordinate with other equipment.)

CIRCUIT BREAKERS

The circuit breakers shall be rated (4160 — 7200 — 13800) volts, 60 Hertz, with a continuous current rating of (1200 -- 2000 — 3000) amperes and a nominal interrupting rating of (250 -- 350 — 500 — 750 — 1000) MVA. All circuit breakers of equal rating shall be completely interchangeable.

The circuit breaker shall be operated by an electrically charged, mechanically and electrically trip-free, stored-energy operating mechanism. Provision shall be included for manual charging of the mechanism and for slow closing of the contacts for inspection or adjustment.

The circuit breaker shall be equipped with secondary disconnecting contacts which shall automatically engage in the operating positions.

The breaker compartment shall be furnished with a mechanism which will move the breaker between the operating and disconnect positions. The mechanism shall be designed so that the breaker will be self-aligning and will be rigidly held in the operating position without the necessity of locking bars or bolts. In the disconnect position the breaker shall be easily removable from the compartment by rolling.

Interlocks shall prevent moving the breaker to or from the operating position unless its contacts are in the open position. As a further safety precaution, the operating springs shall be automatically discharged when the breaker is rolled fully into the compartment or is moved into the disconnect position. Means shall be provided for padlocking the breaker in either the connected (operating) position or disconnected position. When locked in the disconnected position, the breaker shall be movable to the test position and completely removable from the compartment. Padlocking shall not interfere with operation of the breaker or its mechanism.

The circuit breaker control voltage shall be: (48 -- 125 — 250 dc; 115 -- 230 ac, 60 Hertz) volts.

*NOTE: Blue color denotes information to be supplied by purchaser regarding either:

1. Choice of alternates
2. Addition of optional features
3. Specific information

INSTRUMENT TRANSFORMERS

CURRENT TRANSFORMERS

Current transformers shall have ratios and relay and metering accuracy as indicated in the details of each switchgear unit. The transformers shall have mechanical rating equal to the momentary rating of the circuit breakers, and shall be insulated for full voltage rating of the switchgear.

POTENTIAL TRANSFORMERS

Potential transformers shall be drawout type, equipped with current limiting fuses, shall have an accuracy as required by the details of each switchgear unit. The ratio shall be as indicated in each switchgear unit specification.

CONTROL WIRING

Switchgear wire shall be #14 AWG minimum, type SIS tinned copper wire, unless otherwise specified.

DRAWINGS

Upon award of the contract, the manufacturer shall furnish drawings for (approval — record). Drawings for approval shall include a front view, plan view, elementary diagram and device summary. Drawings for record shall include the above information plus connection diagrams.

GENERATOR AND EXCITER PANELS

The metal-clad switchgear for control of one generator and one exciter shall consist of two housings. The breaker unit shall contain:

1 — (4160 — 7200 — 13800) volt air circuit breaker, amp, 3 pole, electrically operated stored energy.
1 — Set of insulated bus, amp.
3 — Current transformers, -5 ratio for overcurrent relays and instruments.
1 — Current transformer, -5 ratio for voltage regulator (required for parallel operation).
3 — Relays, time overcurrent with voltage restraint and instantaneous element.

For generators rated above 500 kVA for voltages 5000 volts and below and for generators of all ratings at service voltages above 5000 volts the following is recommended:

3 — Generator differential relays (high speed relays recommended for 2000 kVA and above).
3 — Current transformers -5 ratio for differential relay.
3 — Current transformers -5 ratio to be connected in generator neutral for differential protection.

The auxiliary unit shall contain:

1 — AC ammeter, 0- scale.
1 — Polyphase indicating wattmeter.
1 — Polyphase watthour meter, ... element.
1 — Polyphase varmeter.
1 — DC field ammeter, 0- scale, and shunt.
1 — DC voltmeter, 0-............... scale.
1 — Temperature indicator, 0- .... degrees scale.
1 — Auxiliary tripping relay for differential protection.
1 — Anti-motoring relay (required for parallel operation).
1 — Overcurrent ground relay.
1 — Voltmeter switch.
1 — Ammeter switch.
1 — Synchronizing switch.
1 — Governor motor control switch.
1 — Field breaker control switch with red and green indicating lights.
1 — Generator breaker control switch with red and green indicating lights.
1 — Regulator transfer switch.
1 — Temperature indicator switch.
1 — Rheostat control consisting of one of the following:
- (a) Handwheel (when necessary) and provision for mounting of exciter field rheostat having not more than two plates of 12-inch maximum diameter (rheostat furnished by customer).
- (b) Control switch for electrically operated remote mounted rheostat.

1 — Space and mounting for voltage regulator.
1 — Provision for mounting field discharge resistor.
2, 3 Drawout type potential transformers, -120 volt with current limiting fuses.
1 — Drawout type potential transformer, -120 volt with current limiting fuses for use with voltage regulator.
2, 3 Drawout type potential transformers, ... -120 volt (for bus potential).

1 — Set of insulated bus, amp.
1 — Drawout field breaker, electrically operated.

SWINGING INSTRUMENT BRACKET

A swinging steel instrument bracket shall be mounted on the (right — left) hand end of the switchgear for the following instruments:
2 — Voltmeters, 0- volt scale.
1 — Synchroscope.
2 — Indicating light for synchronizing.

INCOMING LINE UNIT

The metal-clad switchgear for the control of an incoming line shall contain:
1 — volt air circuit breaker, amp, 3-pole, electrically operated stored energy.
1 — Set of insulated bus, amp.
3 — Current transformers, -5 ratio.
3 — Overcurrent relays, instantaneous and time overcurrent.
1 — Breaker control switch with red and green indicating light.
1 — Ammeter, 0- scale.
1 — Ammeter transfer switch.

Necessary cable terminations.

FEEDER UNIT

The metal-clad switchgear for the control of a feeder circuit shall contain:
1 — volt air circuit breaker, amp, 3-pole, electrically operated stored energy.
1 — Set of insulated bus, amp.
3 — Current transformers, -5 ratio.
3 — Overcurrent relays, instantaneous and time overcurrent.
1 — Breaker control switch with red and green indicating lights.
1 — Ammeter.
1 — Ammeter transfer switch.
Necessary cable terminations.

BUS SECTIONALIZING UNIT

The metal-clad switchgear for bus sectionalizing shall contain:
1 — volt air circuit breaker, amp, 3-pole, electrically operated stored energy.
1 — Set of insulated bus, amp.
1 — Breaker control switch with red and green indicating lights.

SYNCHRONOUS MOTOR CONTROL UNIT — FULL VOLTAGE

The metal-clad switchgear for the control of a synchronous motor and its excitation shall consist of two housings. The breaker unit shall contain:
1 — volt air circuit breaker, amp, 3-pole, electrically operated stored energy.
1 — Set of insulated bus, amp.
3 — Current transformers, -5 ratio, phase.
1 — Three-phase thermal overload relay with instantaneous trip type THC.
1 — Overcurrent relay, instantaneous time overcurrent, for ground fault protection.
1 — Toroidal current transformer, -5 ratio for use with overcurrent relay for ground fault protection (Zero sequence type).
1 — Phase sequence and undervoltage relay.
1 — AC ammeter, 0- scale.
1 — Ammeter switch.
1 — Breaker control switch with red and green indicating lights.

The auxiliary compartment for the field equipment shall contain:
1 — Field ammeter, 0- amp, and shunt.
1 — Wattmeter or varmeter.
1 — Field failure relay.
1 — Automatic field application relay.
1 — Field thermal relay field forcing equipment thermal type incomplete sequence and/or out of step relays.
1 — Field contactor.
1 — Field discharge resistor.
1 — Rheostat control consisting of one of the following:
(a) Handwheel (when necessary) and provision for mounting of exciter field rheostat having not more than two plates of 12-inch maximum diameter (rheostat furnished by customer).
(b) Control switch for electrically operated remote mounted rheostat.
1 — Set of insulated bus, amp.

Field forcing relays when required.

Necessary cable terminations.

1 — 3-Phase current balance relay.
1 — Current transformer, -5 ratio, phase for current balance relay.
1 — Lockout relay.
3 — Motor differential relays — high speed.
3 — Current transformers, -5 ratio (for differential relays).
3 — Current transformers, -5 ratio, for mounting at motor (for differential relays).

SYNCHRONOUS MOTOR CONTROL UNIT — REACTOR START

The reactor shorting breaker unit shall contain:
volt air circuit breaker, amp, 3-pole, electrically operated stored energy.
1 — Timing relay and necessary auxiliary relays.
1 — Set of insulated bus, amp.
1 — Set of necessary primary connections to reactor.

The reactor unit shall contain:
1 — 3-phase starting reactor, duty.
1 — Set of necessary primary connections to shorting breaker.

INDUCTION MOTOR CONTROL UNIT — FULL VOLTAGE

The metal-clad switchgear for the control of an induction motor shall contain:
1 — volt air circuit breaker. amp, 3-pole, electrically operated stored energy.
1 — Set of insulated bus, amp.
3 — Current transformers, -5 ratio, phase.
1 — Three-phase thermal overload relay with instantaneous trip type THC.
1 — Overcurrent relay, instantaneous time overcurrent, for ground-fault protection.
1 — Toroidal current transformer, -5 ratio for use with overcurrent relay for ground fault potection (Zero sequence type).
1 — Phase sequence and undervoltage relay.
1 — AC ammeter, 0- scale.
1 — Ammeter switch.
1 — Breaker control switch with red and green indicating lights.

Necessary cable terminations.

1 — 3-phase current balance relay.
1 — Current transformer, -5 ratio, phase for current balance relay.
1 — Lockout relay.
3 — Motor differential relays — high speed.
3 — Current transformers, -5 ratio (for differential relays).
3 — Current transformers, -5 ratio, for mounting at motor (for differential relays).

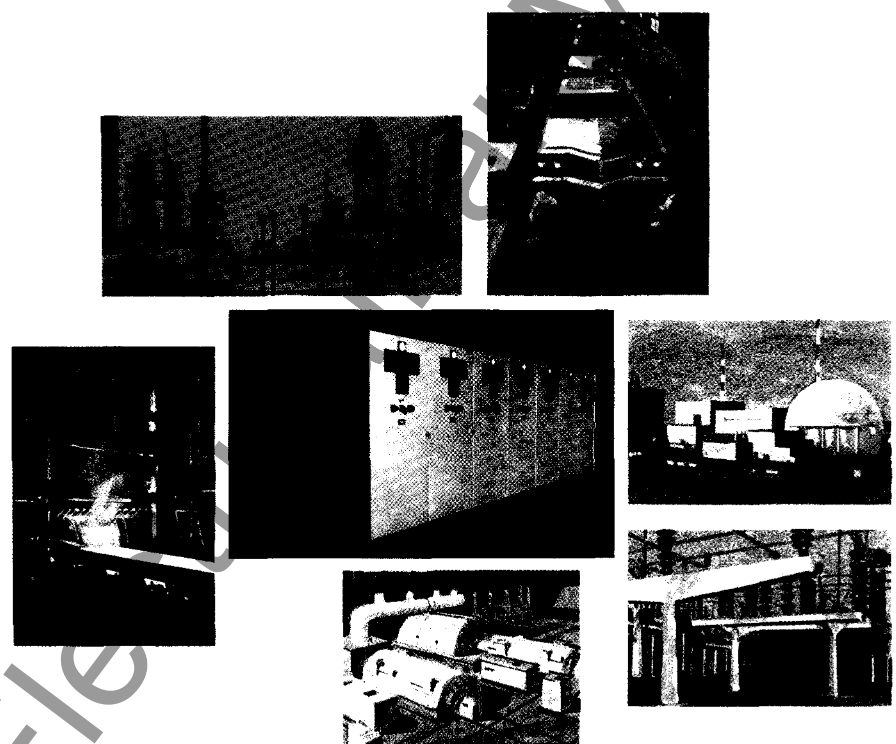
INDUCTION MOTOR CONTROL UNIT — REACTOR START

The reactor shorting breaker unit shall contain:
1 — volt air circuit breaker, amp, 3-pole, electrically operated stored energy.
1 — Timing relay and necessary auxiliary relays.
1 — Set of insulated bus, amp.
1 — Set of necessary primary connections to reactor.

The reactor unit shall contain:
1 — 3-phase starting reactor, duty.
1 — Set of necessary primary connections to shorting breaker.

AUXILIARY COMPARTMENT

Auxiliary units shall be furnished to house the following equipment:



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