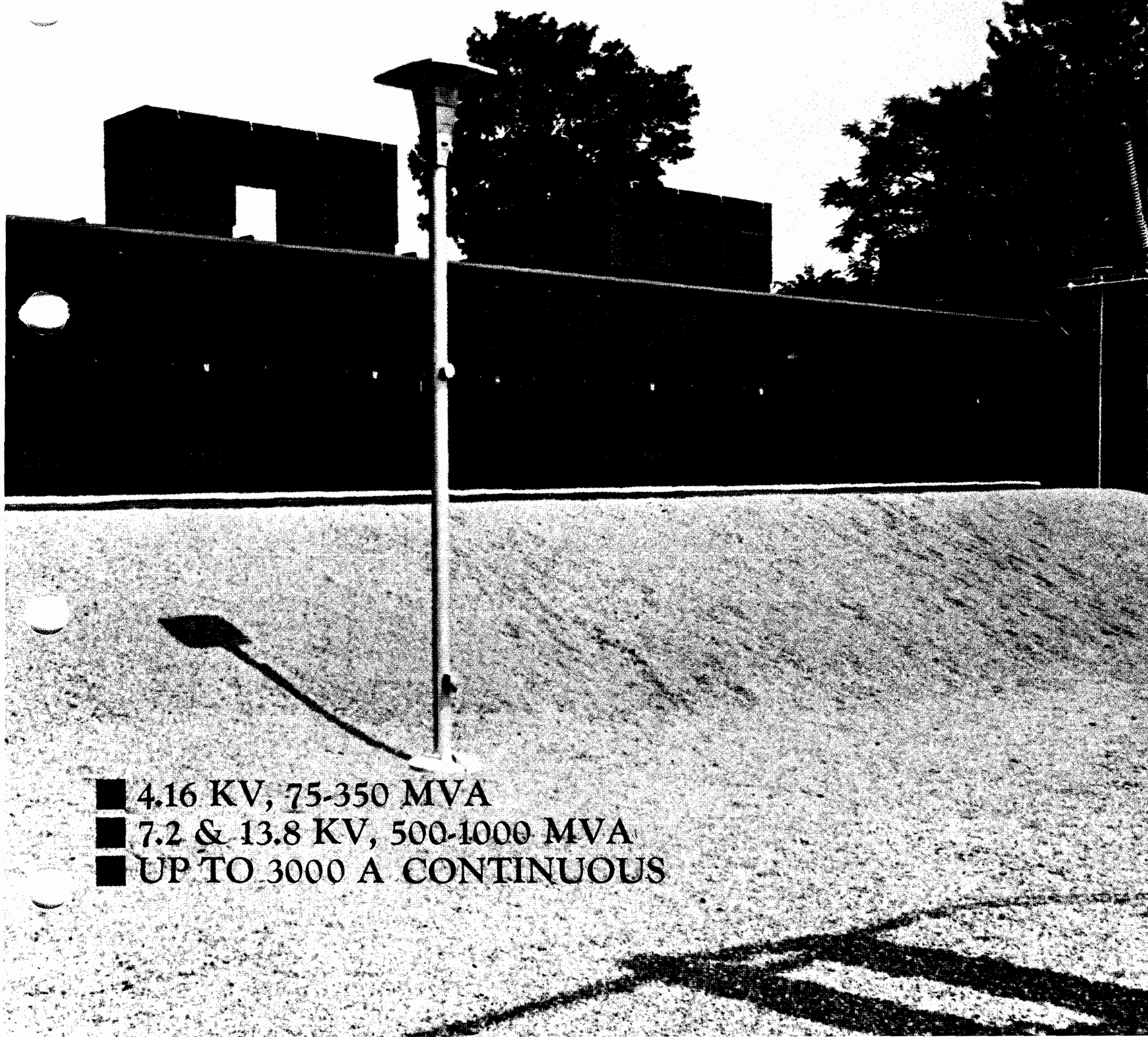
TYPE HK STORED-ENERGY METAL-CLAD SWITCHGEAR

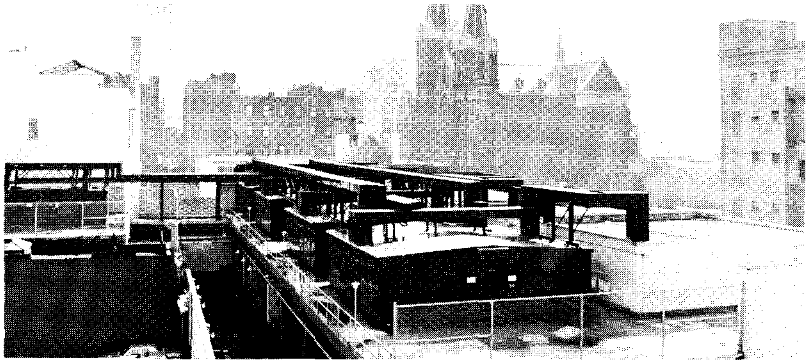
Bulletin 8.2-1C

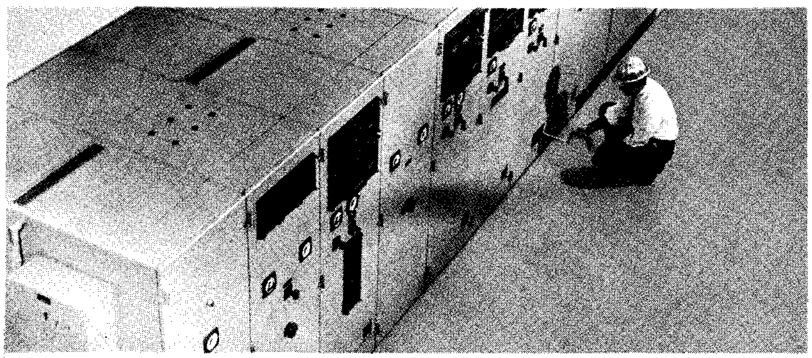
1

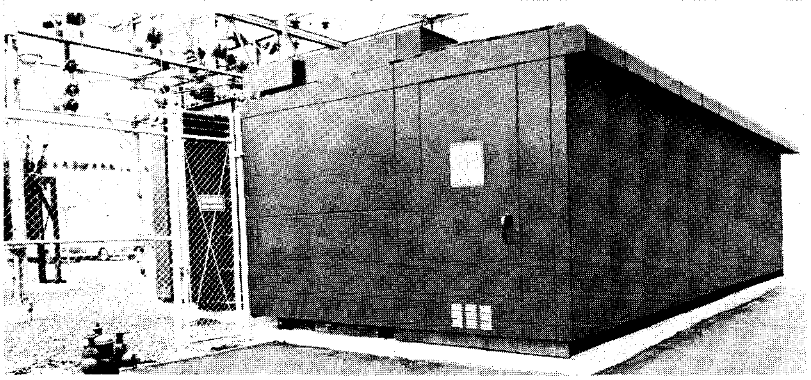


- 4.16 KV, 75-350 MVA
- 7.2 & 13.8 KV, 500-1000 MVA
- UP TO 3000 A CONTINUOUS

AIR-MAGNETIC METAL-CLAD SWITCHGEAR DESIGNED FOR SAFETY AND RELIABILITY







Stored-energy closing.
Closed-door horizontal drawout.
Superior accessibility of all parts.
Economical, one-man maintenance.
Most compact gear in its class.
Precision construction—
no unnecessary field adjustments.
Safe, positive interlocking.
Modern insulation system.

FULL SYMMETRICAL INTERRUPTING RATINGS THROUGHOUT THE ENTIRE LINE

With I-T-E Metal-clad switchgear you get full name-plate symmetrical MVA interrupting capability on every circuit breaker.

I-T-E's program of design, qualification and quality control testing is the most complete in the industry. See pages 41 and 42 for complete rating information.

WHAT METAL-CLAD SWITCHGEAR IS

Metal-clad switchgear is a type of switchgear assembly consisting of metal-enclosed units and auxiliary compartments characterized by the following:

1. All live parts are completely enclosed within grounded metal enclosures.
2. Secondary control devices and their wiring are isolated by grounded metal barriers from all high-voltage primary devices, except for short lengths of certain secondary wiring.
3. Major parts of the primary circuit such as circuit breakers, transformers and buses are isolated by grounded metal barriers.
4. The circuit breaker is of the removable type, equipped with self-coupling primary and secondary disconnecting contacts and is arranged with a disconnecting mechanism for moving it physically between connected and disconnected positions.
5. Interlocks are provided to insure proper sequence and safe operation.
6. Buses, connections and joints are insulated throughout.

INDEX—5, 7.5 & 15 HK Switchgear

Cover photograph—Bala Substation; Courtesy of Philadelphia Electric Company.

TWO BASIC VOLTAGE CLASSES OF HK SWITCHGEAR

4.16 KV AND 13.8 KV, AVAILABLE IN BOTH INDOOR AND OUTDOOR CONSTRUCTION

SPACE-SAVING COMPACTNESS

SMALLER SPACE AND LIGHTER WEIGHT DRASTICALLY REDUCES INSTALLED COST

Space-saving compactness is the first thing you notice in this I-T-E metal-clad switchgear.

One standard cubicle size in each class saves space and simplifies layout. It also permits complete allocation of space for future frame additions. You may even substitute some higher-rated breakers in existing cubicles.

I-T-E makes it possible for you to save space in every installation. Standard frames are designed to house auxiliary equipment—potential transformers—lightning arresters—and bus tie transitions. Information on pages 27 and 31 show preferred location of auxiliary equipment.

You can install this equipment in many locations where other switchgear won't fit.

ADDITIONAL FEATURES OF METAL-CLAD SWITCHGEAR

Economy and Convenience:

- Completely engineered product.
- Standardized construction.
- Ease of match and line-up.
- Arc extinction in air.
- Standardized ratings.

Safety and Ease of Maintenance:

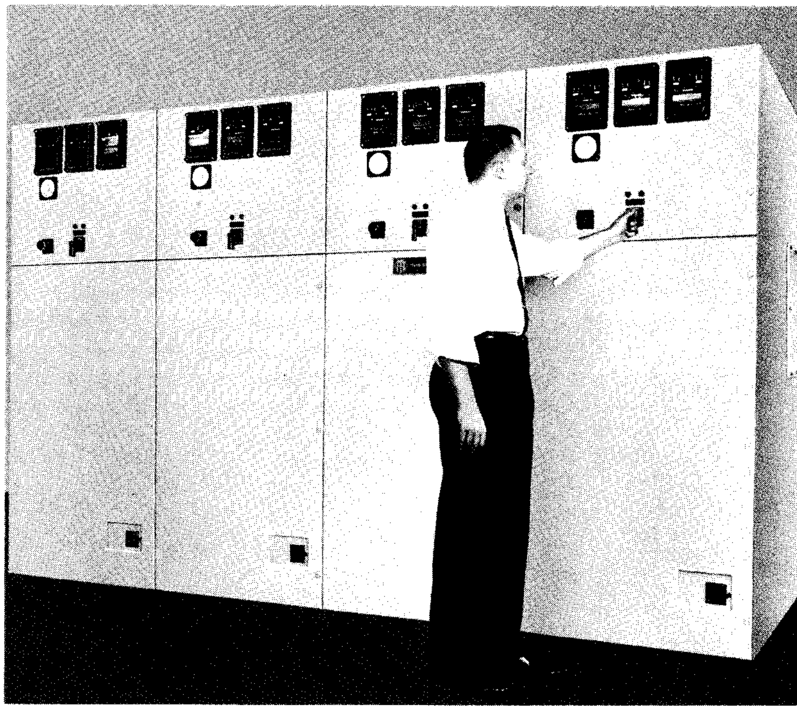
- Segregated compartmentation.
- Drawout potential transformers or stationary control power transformers with drawout primary fuses.
- Bus sectionalizing through a tie breaker.
- Safe manual closing of stored energy breakers.

Service Continuity:

- Re-usable interrupting device.
- Self-contained operating mechanism.
- Multiple-shot reclosing.
- Automatic transfers for multiple-source systems.
- Limiting of damage to a single compartment.
- Bus differential protection minimizes bus fault downtime.
- Stored-energy breakers permit fast transfer of banks of feeders.
- Three-phase interruption—no single phasing.
- Speed and positive action for bringing a synchronized generator on to a system.

4.16 KV SWITCHGEAR

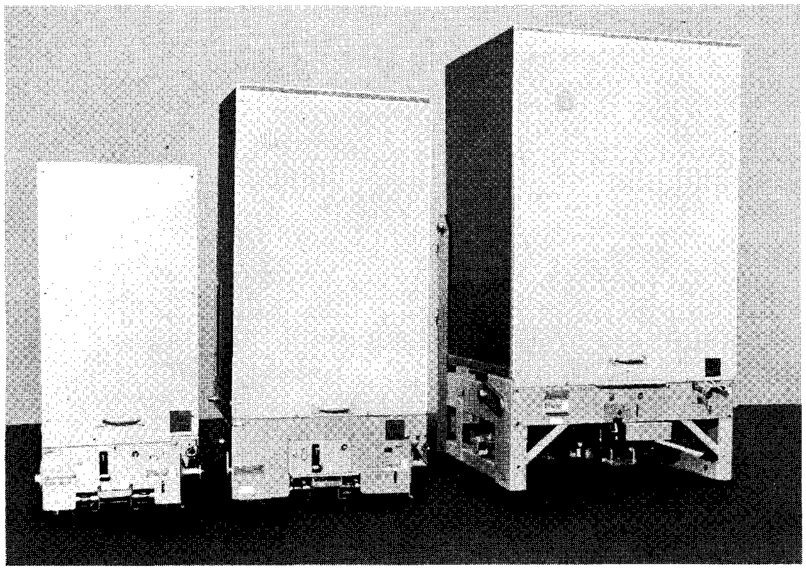
13.8 KV SWITCHGEAR



COMPLETE LINE OF HIGH-VOLTAGE AIR-MAGNETIC POWER CIRCUIT BREAKERS

TABLE 1

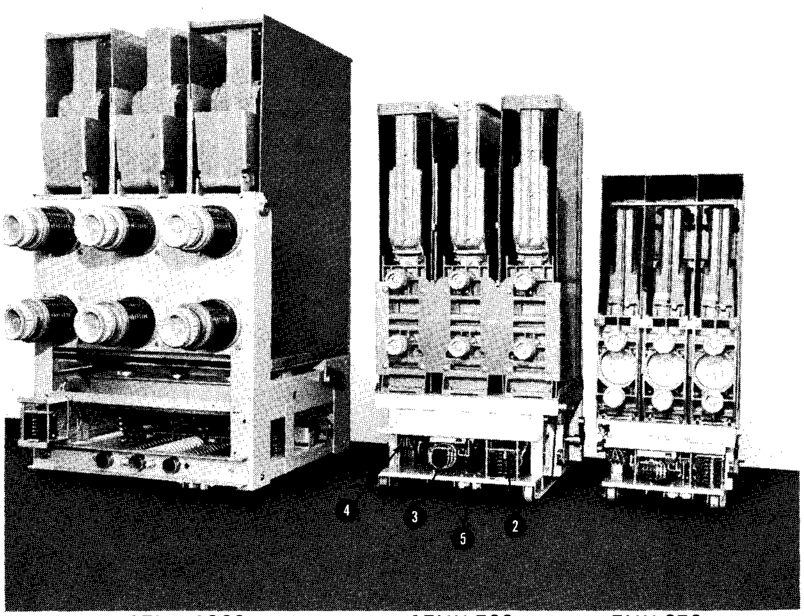
TYPE	CONTINUOUS CURRENT, A	INTERRUPTING CAPACITY
5 HK 75	1200	75 MVA
5 HK 250	1200 2000	250 MVA
5 HK 350	1200 2000 3000	350 MVA
7.5 HK 500	1200 2000	500 MVA
15 HK 500	1200 2000	500 MVA
15 HK 750	1200 2000	750 MVA
15 HK 1000	1200 2000 3000	1000 MVA



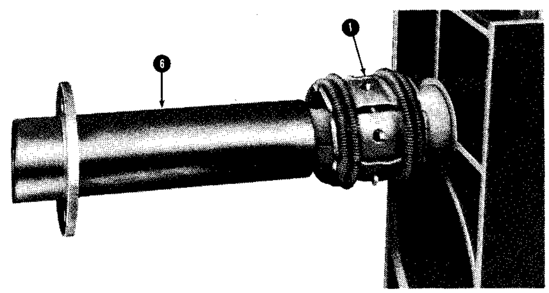
5HK 250 15HK 500 15HK 1000

COMPACT BREAKER DESIGN

I-T-E designed the HK air-magnetic power circuit breaker to make optimum use of every inch of space. Because of the use of modern materials throughout, you get a breaker with superior interrupting and dielectric performance in a more compact size.

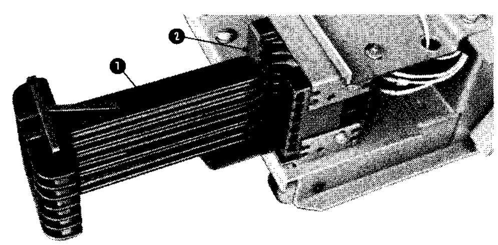


15HK 1000 15HK 500 5HK 250



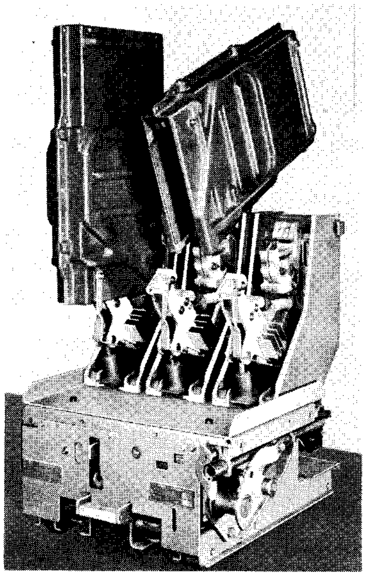
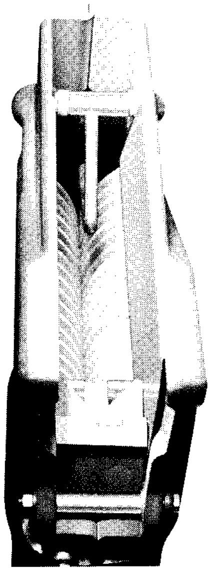
PRIMARY CONTACTS

The self-aligning primary disconnects (1) are located on the circuit breaker for complete accessibility. Conservatively designed lock-wound, stainless steel multiple springs insure good high-pressure contact with the stationary primary disconnects (6) located in the switchboard.



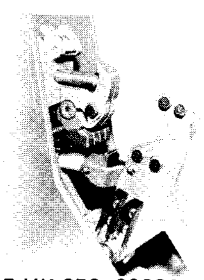
SECONDARY CONTACTS

The self-aligning, secondary contacts (2) automatically mate with contacts (7) in the circuit-breaker compartment while in test and connected positions. The control relay (3) and four-stage auxiliary switch (4) are mounted on the readily-accessible rear panel for easy maintenance. The high pressure ground contact (5) is located under the circuit breaker.

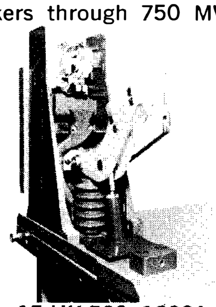



TILTING ARC CHUTES

Contact and arc chute inspection on most HK breakers are simplified with light weight, easily tilted and removable arc chutes. The three separate arc chute shells and primary lead supports are made of high-impulse strength, flame-retardant, polyester-glass moldings. Also, note the polyester-glass "chair" moldings for individual pole pieces which are supplied on HK breakers through 750 MVA.



5 HK 250, 2000A



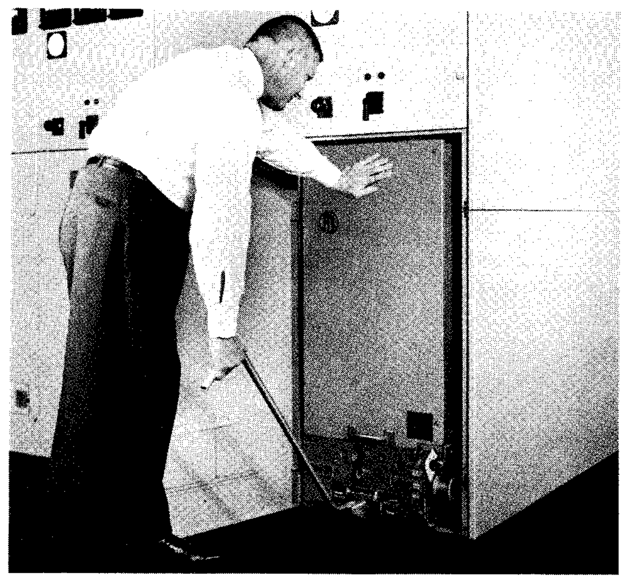
15 HK 500, 1200A

Breaker Contact Structure

SUPERIOR ARC INTERRUPTION

Full interrupting time of any HK breaker is uniformly less than 5 cycles. The jump gap immediately transfers the current into face-wound blowout coils that provide a high-density magnetic field. This magnetic field forces the arc up into arc plates of special ceramic material with high-mechanical and heat-shock characteristics. The action is quick and uniform, speeding arc extinction, while extending arc chute life. Low-current arcs are driven up into the chute by long life, high-capacity puffers, that also cushion contact opening and prevent contact bounce.

Special high-refractory, low-resistance silver-alloy contact surfaces coupled with 5-cycle interrupting time and high speed, stored-energy closing guarantees minimum deterioration from arcing. Abundant wiping action keeps all contact surfaces clean. Simple contact and wipe adjustment is made by a screw in the pushrod.



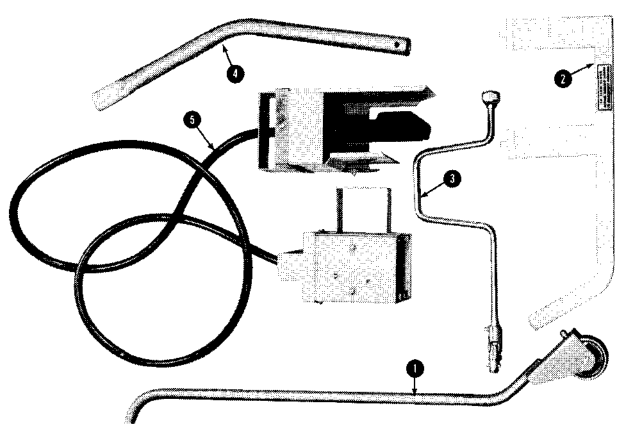
EASY HANDLING

The low center of gravity HK circuit breaker rolls quickly and easily. The handy fifth wheel steering bar permits maneuvering even in tight quarters. Entrance of the breaker into the compartment, even from an angle, is facilitated by full length guide rails. For extra operator safety, there is a grounded barrier on the front of the breaker for protection even when the compartment door is open.

STANDARD BREAKER ACCESSORIES

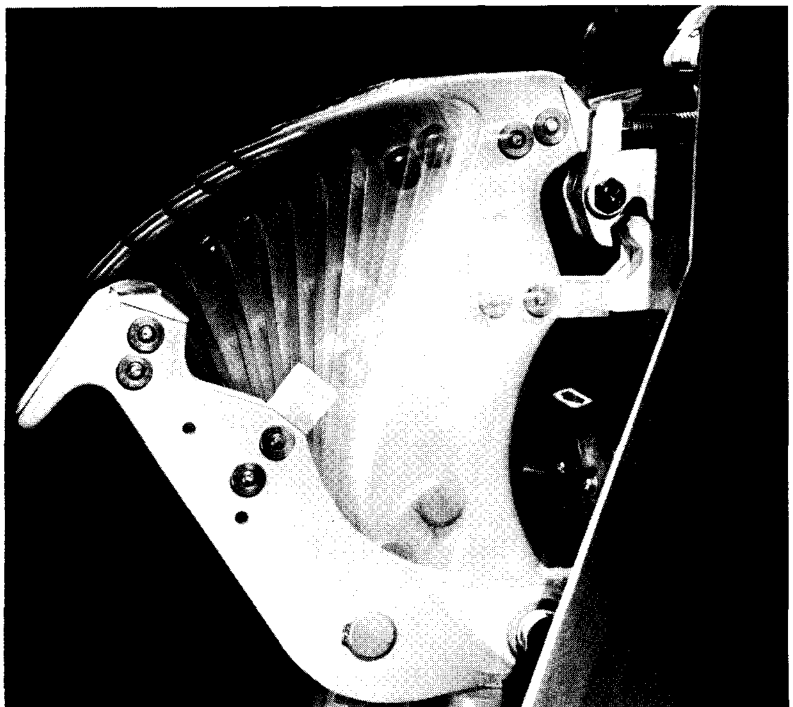
The following accessories are supplied as standard for all breakers except as noted:

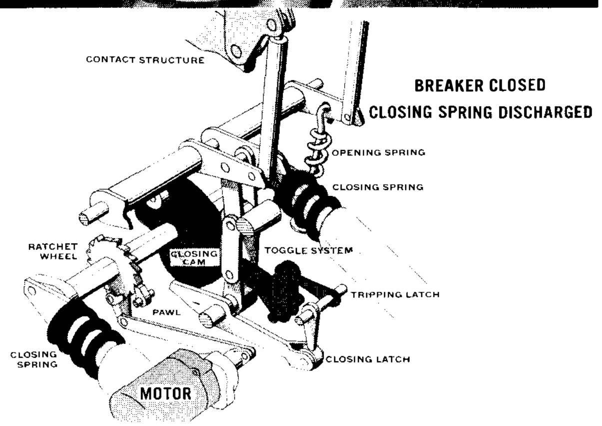
Fifth wheel (1)
Slow-close bar (2)
Racking crank assembly (3)
Manual charging handle (4)
Test jack and plug (5)
Breaker lifting yoke
Arc chute tilting support (7.5 and 15HK breakers)
Arc chute lifting plates (5HK 350, 7.5 and 15HK breakers)
Ramps for outdoor, non walk-in switchgear

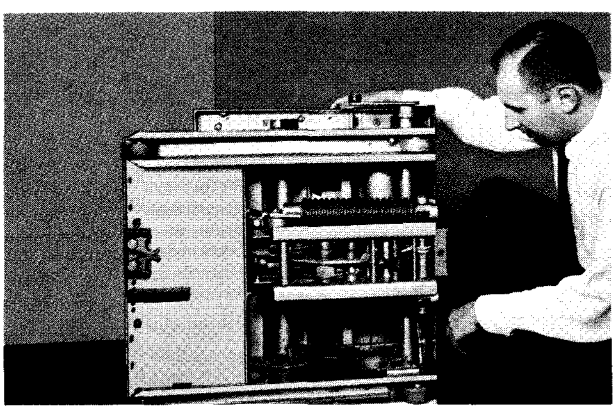


STORED-ENERGY CLOSING

I-T-E WAS THE FIRST TO OFFER SPRING-POWERED STORED-ENERGY CLOSING DESIGNED INTEGRALLY WITH AIR-MAGNETIC CIRCUIT BREAKERS AND METAL-CLAD SWITCHGEAR







Stored-energy closing insures operator safety and greatly increases contact life. Regardless of the external power source, it provides faster, uniform closing every time even against full momentary rating. Powerful compression springs store the closing energy until needed.

You can even store energy in the springs manually to close the breaker when control power is not present. This means extra dependability of control over your circuits.

There's an economy advantage in I-T-E stored-energy closing too. The spring charging motor draws only about one-tenth the current of solenoids. So you can get along with a proportionately smaller battery, control power transformer or use an ordinary lighting circuit.

MAIN AND ARCING CONTACTS

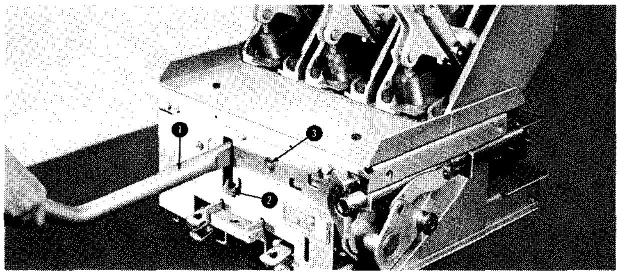
Made to be as nearly maintenance free as possible. Arcing contact surfaces are made from a high refractory silver alloy having minimum deterioration during arcing. The main contacts are a silver alloy having excellent electrical conductivity. All contacts have abundant wiping action to insure good contact. Adjustment for contact and wipe is provided by a screw on the pushrod. The arcing contacts are offset for better absorption of mechanical energy when the circuit breaker is closed.

STORED-ENERGY CLOSING—means long contact life, little maintenance and fast, uniform closing every time regardless of control voltage. The simplified drawing shows primary mechanism elements: motor, closing cam and closing springs, and ratchet & pawl with skip tooth that eliminates need for clutch or brake. Need for unnecessary adjustments is eliminated by the absence of high pressure wear points.

The underside breaker view shows the stored-energy mechanism. Its fractional horsepower universal motor charges the springs through a unique ratchet and pawl system. A missing tooth on the ratchet wheel allows the motor to coast to a stop at the end of charging. There is no need for a brake or clutch which would require periodic maintenance. Closing springs are charged in compression and conservatively designed for long life.

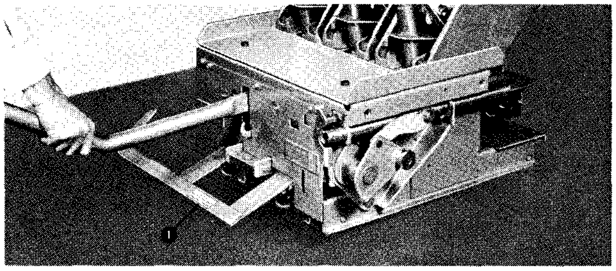
All bearings, cams and latches have been engineered without high-pressure wear points to insure long life and minimum adjustment. They are assembled in precision fixtures and lubricated for life to assure faultless operation.

Note the dual heavy duty closing springs—these afford an extra measure of circuit breaker reliability. Only one closing spring is required for emergency closing of the breaker.



MANUAL OPERATION

The convenient manual charging handle (1) fits easily over the charging lever on the front of the breaker escutcheon. A few strokes of the handle manually charges the closing springs. This arrangement provides for emergency charging without control power, with the circuit breaker in or out of the compartment. Breaker may be closed manually by simply pulling the manual closing lever (2); tripped with manual button (3).

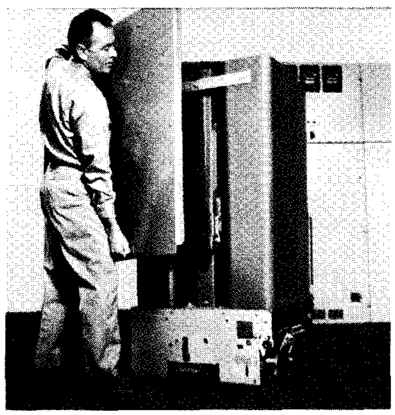


MANUAL SLOW CLOSE

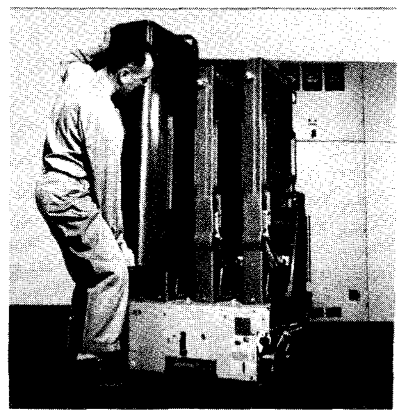
The mechanism design allows you to close the contacts slowly, by hand, for routine inspection or maintenance. With this slow-close attachment (1) contacts may be worked forward, free of spring pressure, and held at each stroke of the manual-charging lever by the ratchet. This allows complete check of contact sequence, alignment, and pressure—and it's a simple one-man job.

ONE-MAN MAINTENANCE

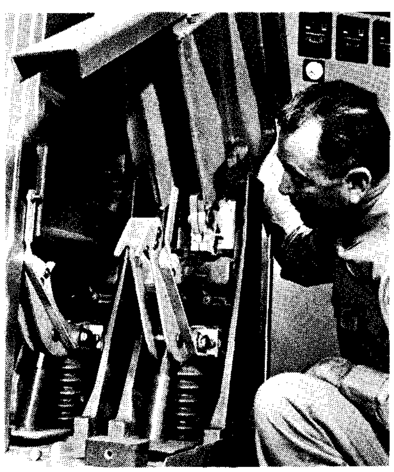
LOOK HOW EASILY ONE MAN CAN HANDLE EVEN THIS 13.8 KV, 500 MVA CIRCUIT BREAKER FOR MAINTENANCE



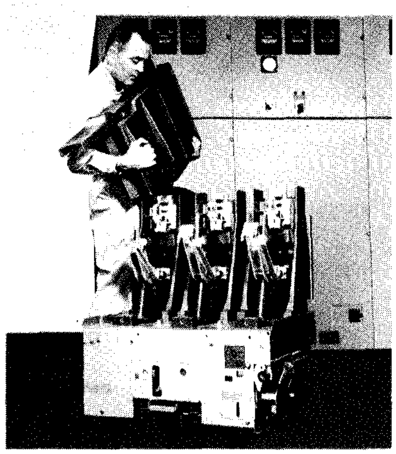
REMOVING THE FRONT SHIELD. Merely loosen two screws and lift the shield out. Convenient handle on front.



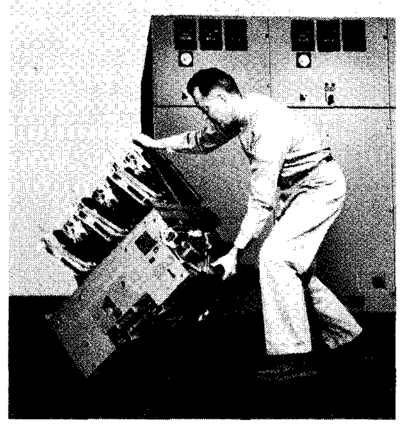
REMOVING THE INTERPHASE BARRIERS. They come off in two easy-to-handle light-weight sections.



TILTING THE ARC CHUTES. Balanced for easy tilting. Can be held up or supported in tilted position for easy inspection.



REMOVING ARC CHUTES. Light enough for one man to lift on all ratings up to and including 13.8 kv, 500 mva.



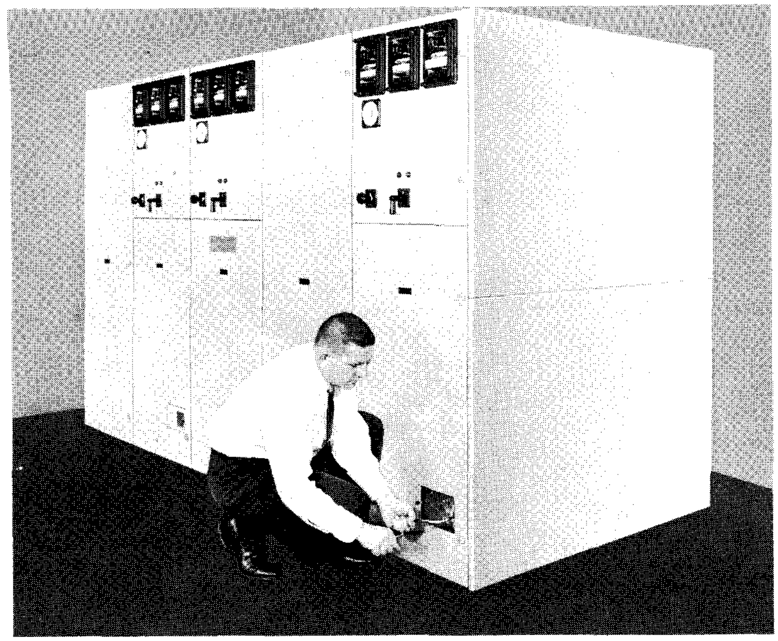
MANEUVERING FRAME. Use of modern light-weight materials keeps frame weight down. One man can maneuver into any position.

CLOSED-DOOR SAFETY

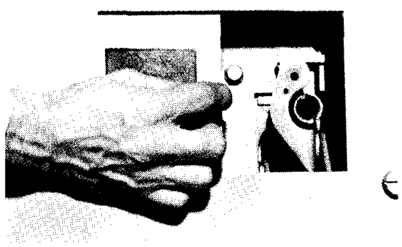
You get the extra safety of a solid steel barrier at ground potential during the drawout operation. You NEVER have to open the front door until after the breaker is fully disconnected. For added safety, the breaker cannot be moved unless it has been intentionally tripped and is open.

Test position is automatic in the drawout operation. The movable secondary contacts on the circuit breaker mate with the stationary contacts in the switchboard. Positive stops on the drawout mechanism assure perfect position in the connected, test and disconnected positions.

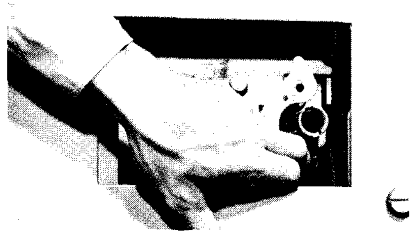
In addition, I-T-E's closed-door disconnect feature means no cluttered aisles from open doors and no risk of foreign matter getting into the breaker compartment.



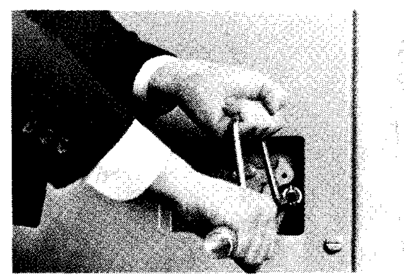
■ THREE EASY STEPS-FULLY INTERLOCKED



SLIDE BACK PANEL. A plainly marked legend on the outside shows the operation of the racking release lever and the racking screw. Regardless of breaker position, these controls are always close to the opening for easy access.

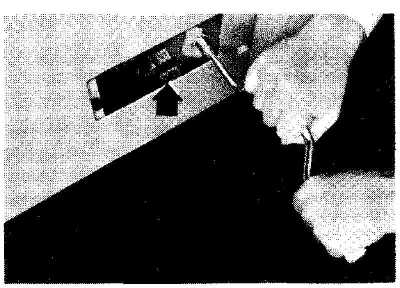


TURN RACKING RELEASE LEVER. This unlocks the racking screw so that it is free to turn, but cannot be done unless the breaker is tripped, insuring that breaker position can be changed only when the breaker contacts are open.

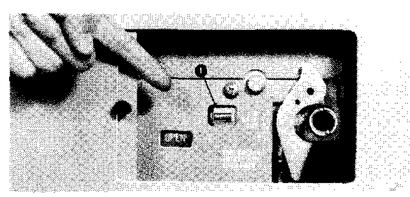


INSERT CRANK AND TURN. This easily moves the breaker from connected to disconnected positions. Locking lever provides automatic stop and lock in all positions. Breaker is trip free and cannot be operated at any point between positions.

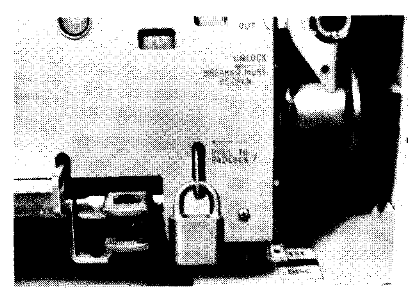
■ THREE EXTRA SAFETY PROVISIONS



BREAKER POSITION INDICATOR. Operator can tell immediately from this position indicator exactly where the breaker is without opening door.



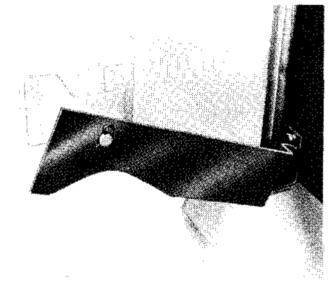
CONTACT POSITION INDICATOR. Through sliding panel opening, operator can see this indicator which shows the position of breaker contacts. Mechanical breaker operations counter (1) is a standard feature on all HK breakers.



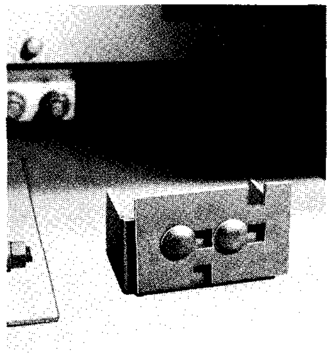
PADLOCKING*—breakers in test and disconnected positions provides safe unattended storage and prevents unauthorized removal and operation.

* **Optional**

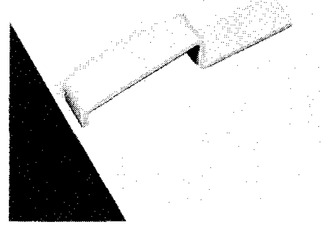
■ ADDITIONAL SAFETY INTERLOCKING THROUGHOUT



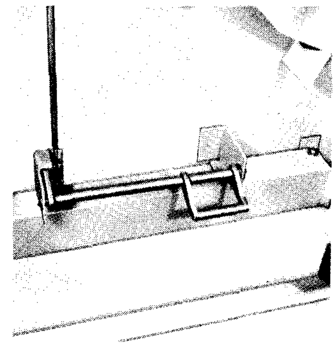
SHUTTER ACTUATOR — for shutter covering primary leads. Is forced closed as breaker is removed from the switchboard. Breaker cannot be removed from the cubicle unless shutter is completely closed.



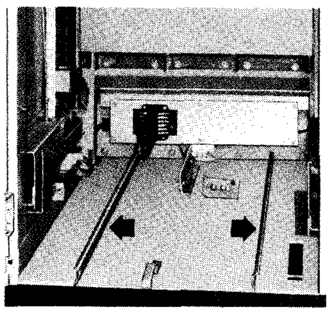
BREAKER INTERFERENCE BLOCK—allows only the correct rating breaker to be inserted into the compartment. it positively prevents inserting an incorrectly rated breaker.



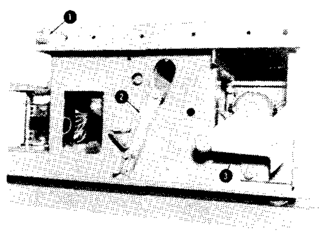
SPRING DISCHARGE CAM—(for switchgear rated up to 750 MVA) automatically discharges stored-energy springs as the breaker exits or enters the compartment. Breaker is always safe to handle immediately upon removal.



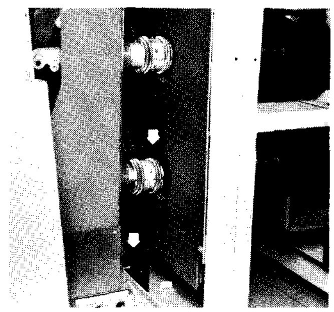
AUXILIARY SWITCH ACTUATOR — operates auxiliary switches in the instrument compartment when the breaker is in the connected position. It can also be arranged for test position operation.



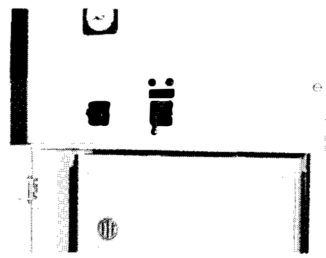
DUAL BREAKER GUIDE RAILS — guarantee positive alignment of the circuit breaker in its compartment, assuring proper mating of all primary, secondary and ground contacts every time.



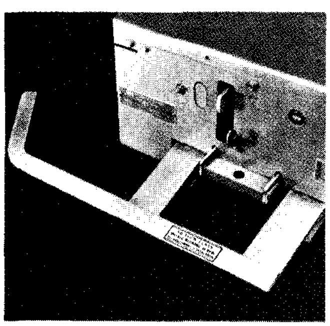
BREAKER TRUCK — Shutter roller (1) engages actuator to move safety shutter. MOC operator (2) responds to breaker contacts to operate auxiliary switch actuator. Racking cam (3) cooperates with switchboard racking slots to move breaker.



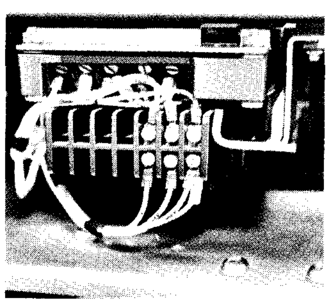
PRIMARY, SECONDARY, AND GROUND CONTACTS—on the circuit breaker mate sequentially in a straight line motion with counterparts within the switchboard insuring proper operation at each position.



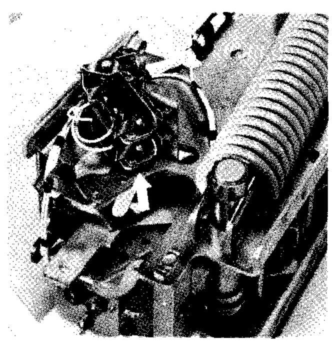
PERSONNEL SAFETY — interphase barrier assembly covering the circuit breaker current carrying parts cannot be removed while the breaker is in the compartment thus eliminating accidental contact with high voltage portions of the breaker.



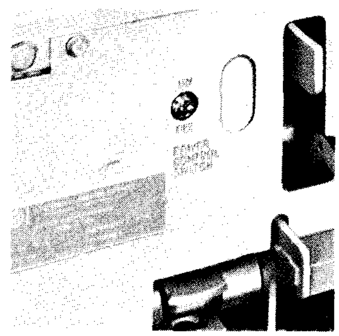
SLOW CLOSE INTERFERENCE BAR—prevents the slow closing operation with breaker in compartment. This prevents accidental slow contact closing of an energized breaker.



CONTROL RELAY—linkage and limit switch prevent closing the circuit breaker unless the closing springs are fully charged. Insures powerful closing force every time.



LATCH CHECK SWITCH*—signals the circuit when trip latch is reset. The breaker contacts cannot be closed until the trip latch is completely and properly reset.



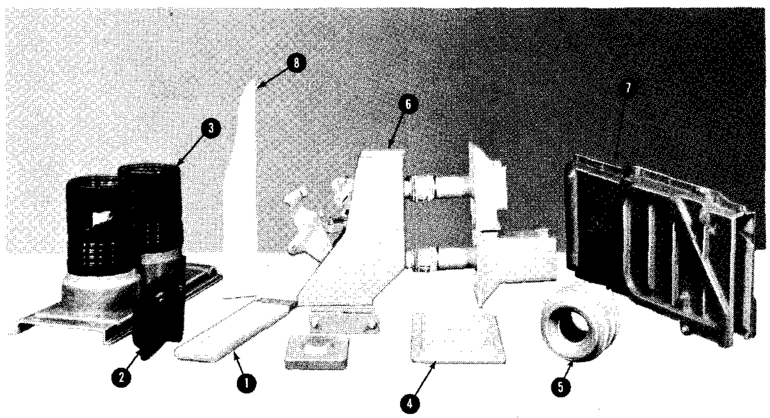
ON-OFF POWER CONTROL SWITCH—enables operator to shut off power to stored-energy charging motor. Without power, the springs cannot be accidently charged.

*Optional

Note: Kirk Key Interlocks which offer an unlimited number of interlocking arrangements between components of the switchgear are also available as an optional feature.

INCORPORATES THE LATEST IMPROVEMENTS IN:

- FLAME RETARDANCE
- TRACK RESISTANCE
- LOW MOISTURE ABSORPTION
- HIGH IMPULSE STRENGTH
- CORONA FREEDOM
- POWER FACTOR



The finest quality insulation materials are used throughout I-T-E metal-clad switchgear to ensure a well coordinated insulation system. Each specific insulation—polyester glass, epoxy, or ceramics—is designed for its own specific function and is integrated with the total insulation system.

GENERAL

Modern insulation not only must be mechanically and electrically strong, but it must remain strong under increasingly stringent conditions of size and surrounding atmosphere. It must be flame-retardant, anti-tracking, and must possess high dielectric strength and low power factor characteristics, particularly at elevated temperatures. It must be capable of withstanding more shock, vibration, corrosion, fungus, and neglect than insulation materials previously used in metal-clad switchgear. The performance and reliability of metal-clad switchgear is intimately linked with the quality of its insulation materials. To ensure integrity, I-T-E tests its insulation materials in conformance to applicable ASTM specifications.

DEFINITIONS

Insulation Characteristics

Track Resistance is the measure of the ability of the insulation material to resist failure by forming a carbonized path to ground under conditions of moisture and contamination.

Dielectric Strength is the measure of the ability of the insulation material to withstand voltage through its thickness.

Power Factor is the measure of losses in an insulator and indicates the likelihood of the insulating material to break down dielectrically during service.

Flame Retardancy is the relative ability of the insulating material to resist burning and to extinguish when the source of the fire is removed.

Mechanical Strength is the measure of the capability of an insulation material to withstand tensile, compressive or impact loads.

Forming Methods

Insulation materials such as polyesters, epoxies, or ceramics are formed by one of the following techniques:

Casting—A plastic composition is liquefied and poured into a mold and cured. Bushings and instrument transformers are formed in this manner.

Pre-Mix Molding—This is a plastic compression molding process where a dough-like charge of resin, clay and chopped glass is placed in the mold and distributed and cured throughout by heat and pressure. Lead support moldings are made by this method.

Pre-Form Molding—The fiber glass sub-strate is preformed into the desired shape, then placed in the tool and impregnated while under heat and pressure. Arc chutes and interphase barriers are pre-form moldings.

Laminating—A process where a number of layers of re-enforcing material, most generally glass matt, are placed in a die and impregnated with resin while under heat and high pressure. Flat sheets, angles and channels are molded by this method.

Wrapped Laminates—Layers of re-enforcement and resin are formed around a mandrel and cured. Bushings are formed by this technique also.

TYPES OF INSULATION MATERIALS

Polyesters

These are particularly adaptable to modern switchgear. They exhibit excellent electrical properties, are mechanically strong, easy to handle and fabricate, and are reasonable in cost. They may be formed by any of the five techniques but are predominantly used in the forms of laminates, pre-form and pre-mix.

The following table lists the range of physical and electrical properties of polyester made by various forming methods:

CHARACTERISTIC	PRE-FORM	PRE-MIX	LAMINATE
Flexural Strength, psi	18-20,000	14-15,000	18-20,000
Tensile Strength, psi	15,000	6-7,000	15,000
Compressive Strength, psi	20,000	23-27,000	30,000
Izod Impact, ft. lbs./in. of notch	8-12	3-6	8-12
Flame Retardancy	Yes	Yes	Yes
Dielectric Strength (Short Time) vpm ⅛" tk., 25°C	350-375	350-375	350-375
Dielectric Constant	4-6	4-7	4-6
Power Factor %, 60 Hz, 25°C	0.5-3	0.5-3	0.5-3
Power Factor %, 60 Hz, 105°C	3-7	2-7	3-7
Track Resistance hrs.	200+	200+	200+

Epoxies

The epoxy resins are some of the newest and most versatile of the modern plastics. Their chief advantages are their excellent electrical and mechanical properties. They are exceedingly tough, show excellent adhesion and excellent impregnating qualities. These resins give off no byproducts during cure and show very low cure shrinkage — less than 2%.

Epoxies are most generally formed by casting techniques. They are excellent for voltage and current transformers, bushings, and low volume items. They are particularly good in bonding applications. They are low enough in viscosity that they can be used to impregnate between fine wires used on transformers.

The following table compares the physical and electrical properties of epoxy systems formed by various methods:

CHARACTERISTIC	CASTING	LAMINATE	PRE-MIX (GLASS)
Flexural Strength, psi	17,000	40-50,000	24,000
Tensile Strength, psi	8,000	35-40,000	20,000
Compressive Strength, psi	22,000	60,000	32,000
Izod Impact, ft. lbs./in. of notch	.3-.5	8-30	8-15
Dielectric Strength (Short Time) vpm ⅛" tk., 25°C	450	500	350
Dielectric Constant	4	4	4
Power Factor %, 60 Hz, 25°C	1.0	1.5	1.5
Power Factor %, 60 Hz, 105°C	4.0	6.0	6.0

Ceramics

Because ceramics are relatively inert, except at exceedingly high temperatures, they are used in critical areas of the switchgear. The following table shows typical physical and electrical properties of ceramic materials.

CHARACTERISTIC	CORDIERITE	PORCELAIN
Flexural Strength, psi	8-10,000	10,500
Tensile Strength, psi	4,000	6,000
Impact ft., lbs./sq. in.	1	1.5
Specific Gravity, gms/cc	2.31	2.50
Moisture Absorption %	1-2	0
Thermal Expansion, in./in./°F 77-1290°F	2.8 x 10^{-6}	5.2 x 10^{-6}
Thermal Shock cycles 32-2300°F	100+	1
Dielectric Strength, vpm, 25°C	100	300
Dielectric Constant	5	6.1

SWITCHBOARD INSULATION*

Bus

All bus, including bends and odd configurations, is fully insulated with an epoxy compound (1). Bus joints, taps, and splices are covered with a low power factor, air filled vinyl boot (2). The boots are placed over the bus joints and are secured in place with nylon fasteners, thereby making joints accessible with a minimum of effort. 7.5 and 15 HK bus is supported by wet process procelain (3). The main bus is carried through the wall of the frame with porcelain bus supports imbedded in polyester glass. 5 HK bus is supported with track resistant polyester-glass angles and the main bus is carried through the wall of the frame with polyester-glass pre-mix parts (4).

Current Transformers

A rigid epoxy case is cast and the current transformer is potted in the base and encapsulated with a flexible epoxy resin (5).

Shutters and Primary Disconnects

The safety shutter covering the stationary primary disconnects of 5 and 15 HK switchgear through 750 MVA is made of a polyester laminate which exhibits high track resistance, high flexural strength, good dielectric strength and flame retardancy. For 15 HK 1000 switchgear, the shutter is aluminum. Directly behind the safety shutter are the stationary primary disconnects (3). 7.5 and 15 HK primary disconnects (up to 750 MVA) are porcelain housings mounted on track-resistant polyester-glass pre-forms bonded with an epoxy compound. 15 HK 1000 primary disconnect housings are mounted on aluminum. The primary conductors are mounted to the porcelain housings with an epoxy compound. The disconnect housings for 5 HK are made of polyester-glass pre-mix molding compound.

CIRCUIT BREAKER INSULATION*

Lead Assembly

Lead support moldings (6) are basically a polyester-glass pre-mix molding compound (through 750 MVA) which support the circuit breaker continuous current components and isolate them from ground. 15 HK 1000 MVA circuit breakers utilize epoxy bushings mounted to metal frames. Push rods are the insulating link between the breaker mechanism and the moving contact bridge. A wrapped laminate of epoxy glass cloth is used for the push rod. A gas deflector of highly track-resistant polyester is bonded to the rod to serve as a seal which prevents the possibility of ionized gases blowing into the operating mechanism.

Arc Chute Assembly

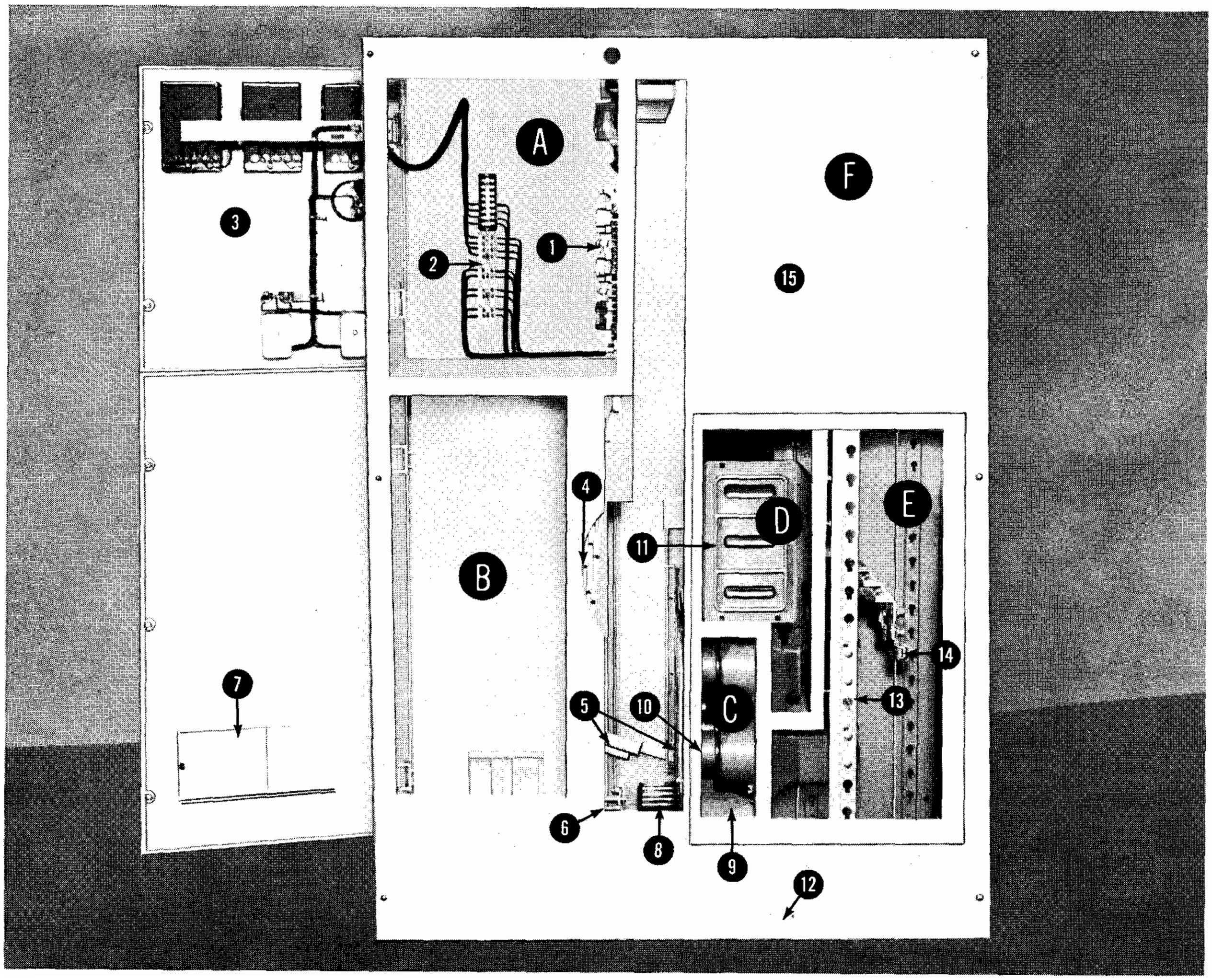
The arc chute and coil assembly (7) are made of high impact, track-resistant polyester pre-mix for 5 HK and preform for 7.5 and 15 HK. Arc chute halves are bonded together with epoxy and bolted, thereby preventing ionized gases from blowing through the joints. The arc chute is formed so that coils can be potted directly onto the shell and recesses are formed to receive the ceramic liners (8). The liners are cemented to the shell adjacent to the contacts. The arc plates are made of an exceptionally high heat shock material known as cordierite (see Ceramics above).

Interphase Barrier Assembly

The interphase barrier assembly has the primary function of increasing air strike distance between the phases. The front of the interphase barrier is pre-form molding polyester-glass. Polyester-glass laminates are bonded to either side of the pre-form with epoxy.

*Refer to photograph on page 10 for illustration of various insulators used in HK metal-clad switchgear.

I-T-E PROVES HOW CONVENIENT, SAFE, AND PROTECTIVE SWITCHGEAR CAN BE



Side View 5HK250 Switchboard

SAFE COMPARTMENTATION—
COMPLETE ACCESSIBILITY OF ALL COMPONENTS

Each single 5 HK switchboard frame has complete steel side sheets, shown here cut-away to illustrate compartmentation. This unit is divided into six completely segregated areas, with front and rear formed doors with concealed hinges.

A. INSTRUMENT COMPARTMENT

Isolated from high voltage

1. Ample Auxiliary Switches, Accessible Terminal Blocks, Control Power Cutoff and Control Bus
2. CT Short-Circuiting Blocks
3. Eye-level Instruments, Relays, and Control Switches

B. CIRCUIT BREAKER COMPARTMENT

4. Cable Trough for customer control cable (bottom entrance)
5. Positive Safety Shutter Actuator and Shutter
6. Auxiliary Switch Actuator
7. Sliding Panel for closed-door drawout
8. Secondary Disconnect

C. CURRENT TRANSFORMER COMPARTMENT

9. Toroidal type CT's
10. Primary Bushings—polyester glass

D. BUS COMPARTMENT

Accessible from front and rear

11. Polyester-glass Bus Supports, Mold-on Bus Insulation, No Compound Bus Joint Covers

E. CABLE COMPARTMENT

12. Ground Bus
13. Key Slotted Mounting Brackets
14. Cable Connections

F. AUXILIARY DEVICE COMPARTMENT

Space for:
Trunnion Type Drawout PT's, Lightning Arresters

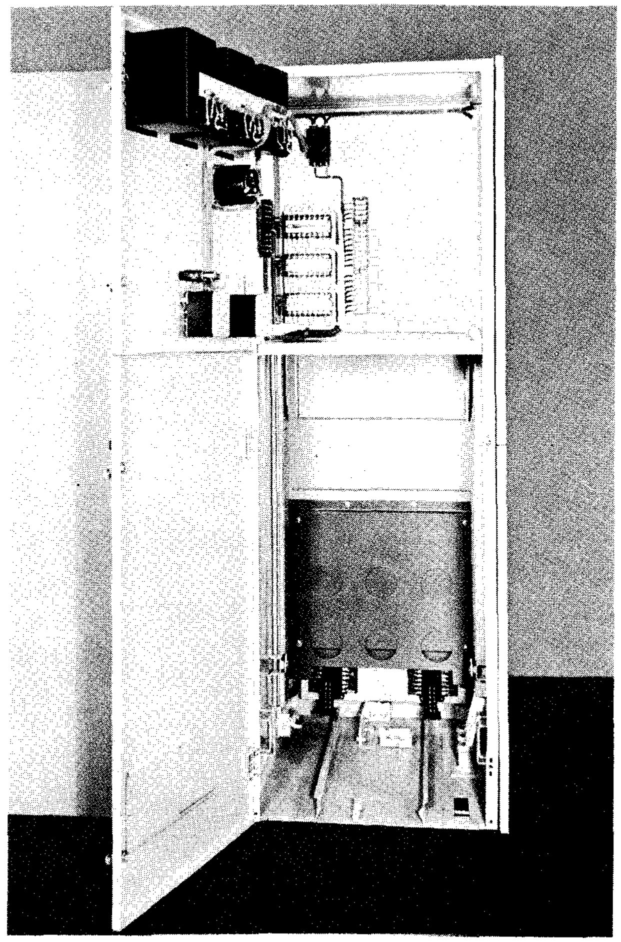
15. Bus Transition Space

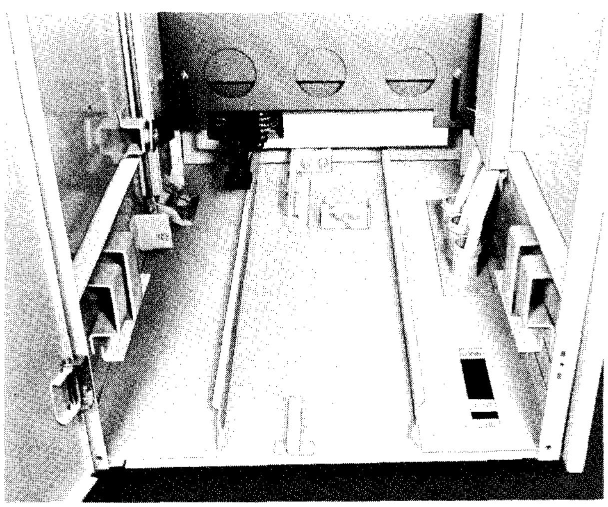
SEPARATE INSTRUMENT AND BREAKER COMPARTMENTS

The separate instrument compartment is completely isolated from the high voltage, and is closer to the ground for ease of accessibility. This "split" door concept allows the operator access to the instrument compartment without being exposed to the primary voltage. All secondary wiring including terminal and CT shorting blocks, and other devices are readily accessible from the front. They are mounted on removable panels. Here is switchgear with real elbow room for construction and maintenance men.

Customer's wire may enter directly from the top or through a covered cable trough from the bottom. Opening in compartment floor is provided for several large conduits. Ample room is available for 24 auxiliary switches. When you need an 80-inch instrument panel, I-T-E provides an 8-inch front extension with a single front door.

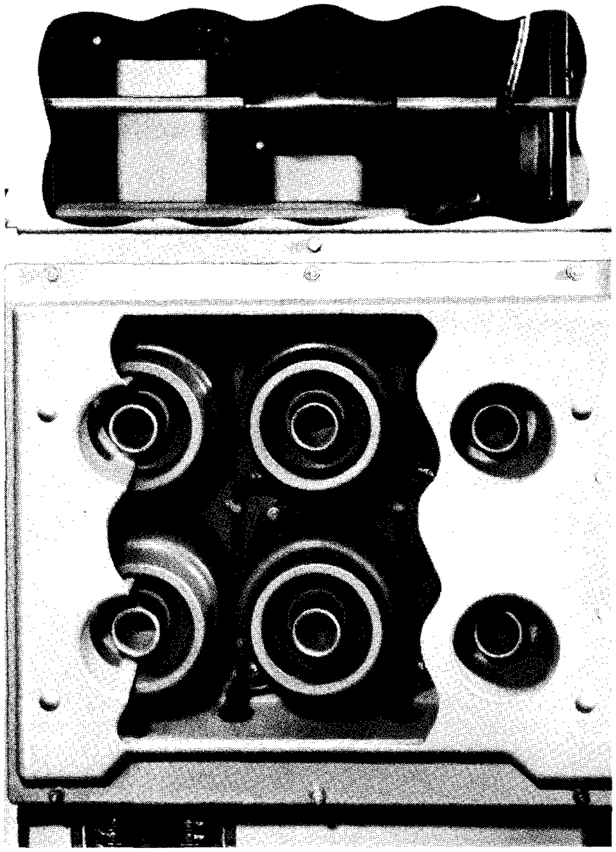
A safety shutter covers all high-voltage stationary primary disconnects. It is forced downward when the breaker is removed from the switchboard, and covers the primary leads with the breaker in the test or disconnect positions. You can work in the circuit-breaker enclosure and be perfectly safe from contact with high voltage. On the lower left is the actuator which operates the auxiliary switches mounted in the instrument compartment. It responds to the opening and closing of the circuit breaker contacts when the breaker is in the connected position. An actuator which responds to breaker movement in and out of the switchboard can be furnished on the lower right hand side of the circuit breaker compartment.





SAFE, SIMPLE, MAINTENANCE FREE DRAWOUT

No complex drawout mechanism is necessary in the switchgear. Simple stationary racking slots and guide rails are all that is required. An interference key on the floor allows only the correct rating breaker to be inserted. For complete safety, HK switchgear is designed so that the breaker closing springs are automatically discharged before the breaker enters or leaves the compartment. Stationary secondary contacts and ground bus at the rear automatically mate with circuit breaker in test and connected position.



CONVENIENT BUS LOCATION

This is a feature that makes switchgear installation and maintenance easier than ever. Bus can be reached from the back through the rear panel OR FROM INSIDE THE CIRCUIT BREAKER COMPARTMENT by simply removing the isolating metal barrier. The bus itself, silver plated for high-conductivity connections, is fully insulated with flame-retardant, track-resistant epoxy resin molded insulation. Vinyl bus joint covers with corona-free high-dielectric characteristics provide sealed joints without need for compound. All problems inherent in the taping of joints have been completely eliminated.

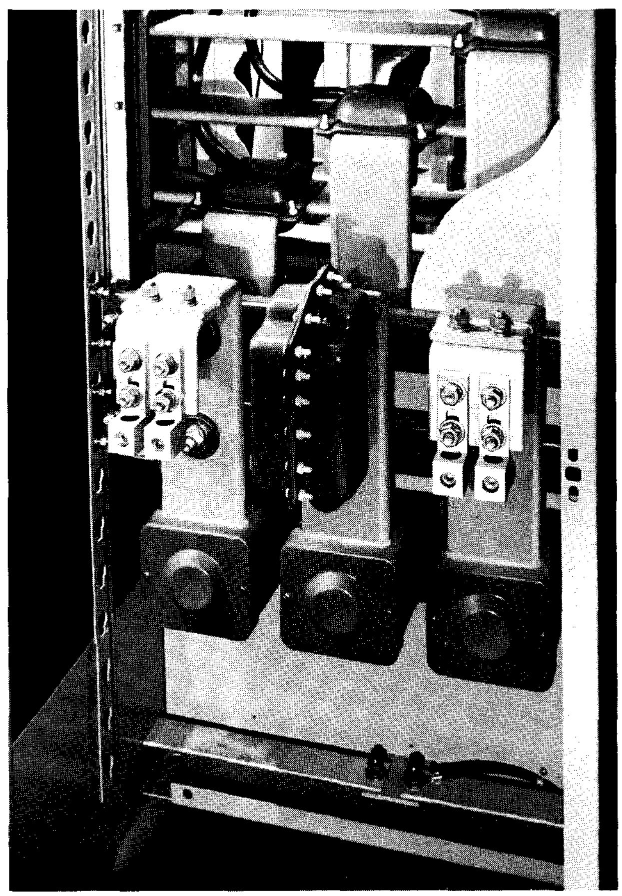
FRONT ACCESS TO CURRENT TRANSFORMERS

No need to disturb the main bus to change current transformer ratings. Just remove the shutter assembly covering the primary disconnects. The toroidal-type bushing current transformers easily slip over primary studs. Their large cores allow them to be used for most relays and instrument burdens and with unlimited short-circuit strength. They are insulated for full-voltage rating of the switchgear. As this cut-away view shows, you can locate them on both load and line sides of the circuit breaker. Thus, in a differential scheme the circuit breaker is included in the protected zone without the necessity for an extra frame. The primary lead support is made of a special, flame-retardent, track-resistant, polyester-glass molding.

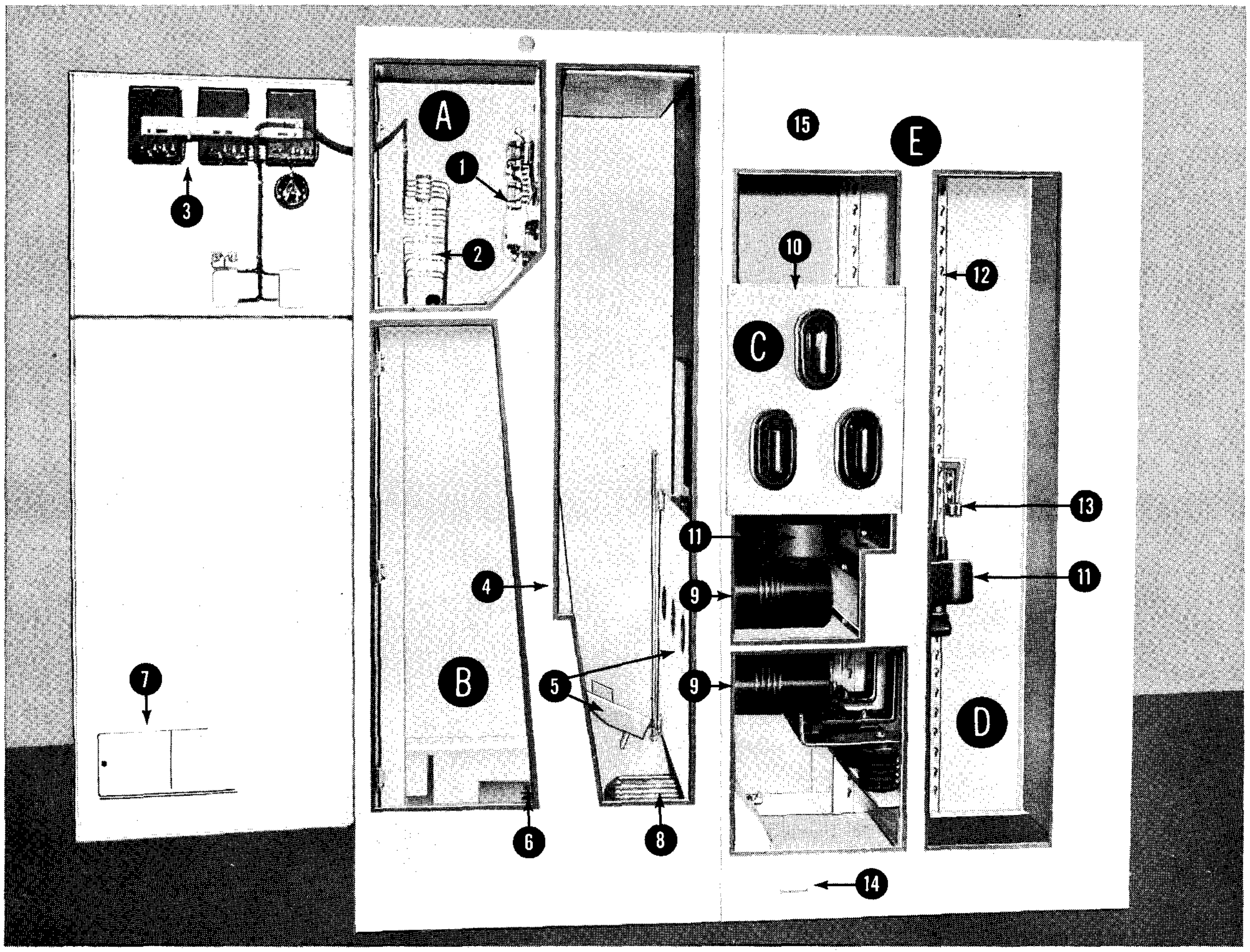
ACCESSIBILITY FOR ECONOMICAL INSTALLATION

No tight space when it comes to cable makeup. Entrance from either top or bottom. Top sheet is easily removed for drilling. Key slots running the full height of the compartment provide a simplified means for mounting cable supports or other equipment. When bottom entrance is used there's room at the top for trunnion type PT's and other auxiliary equipment.

There's ample room for a single pothead in the standard 56 in. depth. When a double pothead is required the rear is extended 8 in. Main bus compartment cover has been cut away in this view to show location of main bus. The vinyl boot shown on the termination of the middle phase is an optional feature.



COMPACT OUTSIDE ACCESSIBLE INSIDE



Side View—15HK500 Switchboard

SAFE COMPARTMENTATION— COMPLETE ACCESSIBILITY

Each single 7.5 and 15 HK switchboard frame has complete steel side sheets, shown here cut-away to illustrate compartmentation. This unit is divided into five completely segregated areas, with front and rear formed doors with concealed hinges.

A. INSTRUMENT COMPARTMENT
Isolated from high voltage

1. Ample Auxiliary Switches
   Accessible Terminal Blocks
   Control Power Cutoff and Control Bus
2. CT Short Circuiting Blocks
3. Instruments, Relays, and
   Control Switches

B. CIRCUIT BREAKER COMPARTMENT

4. Cable Trough for customer control cable (bottom entrance)
5. Positive Safety Shutter Actuator and Shutter
6. Auxiliary Switch Actuator
7. Sliding Panel for closed-door drawout
8. Secondary Disconnect

C. BUS COMPARTMENT
Accessible from front and rear

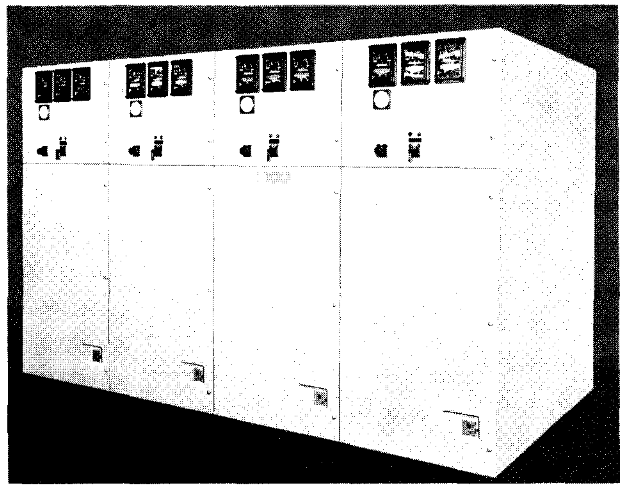
9. Porcelain Primary Bushing embedded in flame retardant track-resistant polyester glass
10. Porcelain Bus Supports
    embedded in
    polyester-glass.
    Molded-on Bus Insulation
    No Compound Bus Joint Covers

D. CABLE COMPARTMENT

11. Toroidal Type CT's
12. Key Slotted Mounting Brackets
13. Cable Connections
14. Ground Bus

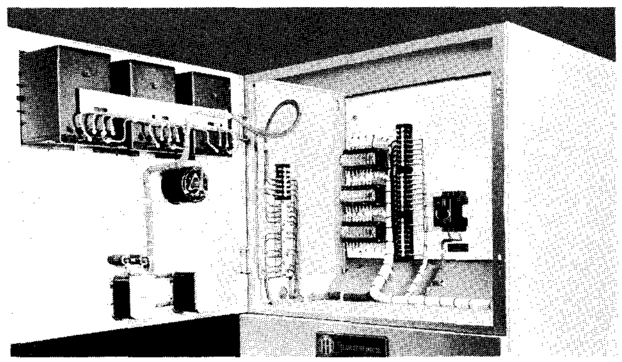
E. AUXILIARY DEVICE COMPARTMENT
Space for:
Trunnion Type Drawout PT's, Lightning Arresters

15. Bus Transition Space



RUGGED CONSTRUCTION— TRADITIONAL I-T-E QUALITY

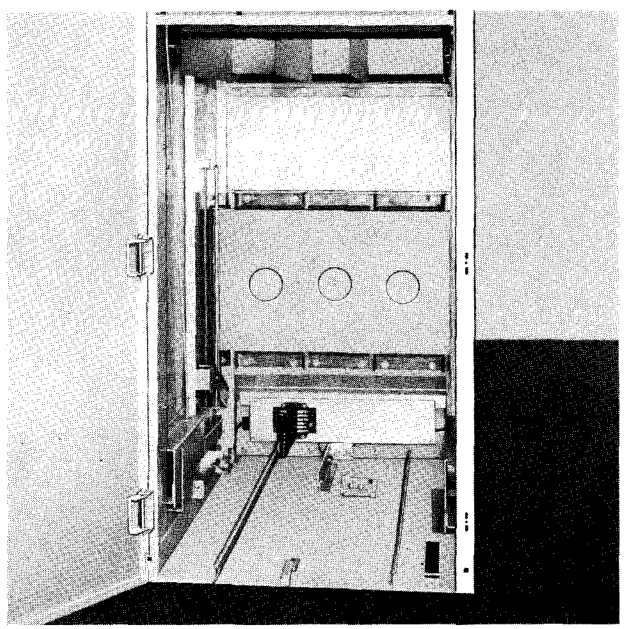
Start with the frame. Made to exacting tolerances for assured interchangeability and with the strength and rigidity of deep flanged formed steel. Full side sheets enclose each frame and provide complete isolation with two separate painted steel barriers between each unit. Notice the deep, hard, oven-baked epoxy enamel finish that maintains its lustre for years and provides an unexcelled corrosion-resistant finish. This paint finish is applied by I-T-E's exclusive electro-coating process. All surfaces are cleaned, coated with a phosphate sealer and finished in semi-gloss, gray epoxy enamel, ANSI #61.



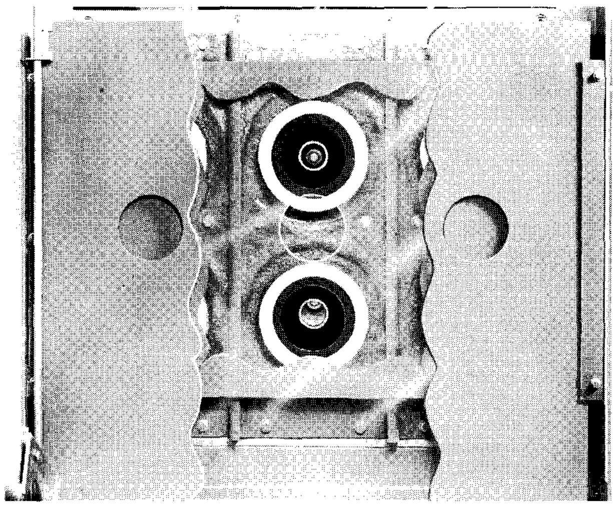
SEPARATE INSTRUMENT AND BREAKER COMPARTMENTS

The separate instrument compartment is completely isolated from the high voltage. All secondary wiring including terminal and CT shorting blocks, and other devices are readily accessible from the front. They are mounted on removable panels. Here is switchgear with real elbow room for construction and maintenance men.

Customer's wire may enter directly from the top or through a covered cable trough from the bottom. Opening in compartment floor is provided for several large conduits. Ample room is available for 24 auxiliary switches on 7.5HK500, 15HK500 and 15HK750 switchgear. 15HK1000 units can accommodate up to 16 auxiliary switches. When you need a 90-inch instrument panel, I-T-E provides an 8-inch front extension with a single front door.



A safety shutter covers all high-voltage primary connections. It is forced downward when the breaker is removed from the switchboard, and covers the primary leads with the breaker in the test or disconnected positions. You can work in the circuit-breaker enclosure and be perfectly safe from contact with high voltage. On the lower left is the actuator which operates the auxiliary switches mounted in the instrument compartment. It responds to the opening and closing of the circuit breaker contacts when the breaker is in the connected position. An actuator which responds to breaker movement in and out of the switchboard can be furnished on the lower right hand side of the circuit breaker compartment.

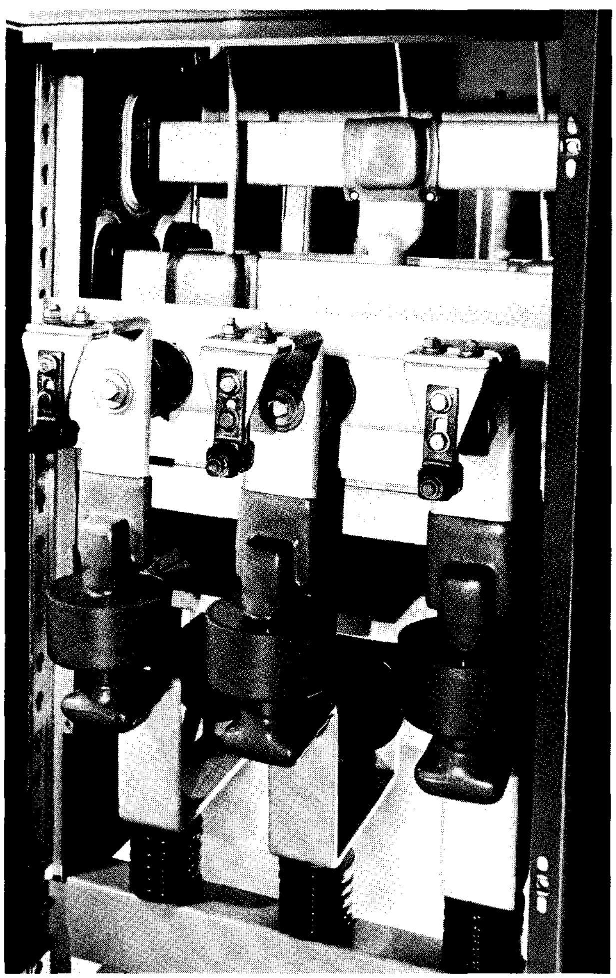


OPERATOR SAFETY—A PRIME REQUISITE

A safety shutter covers all high-voltage primary connections. (Shown here in plexiglass to illustrate closed position.) It's forced closed when the breaker is removed from the switchboard. Primary lead bushings, behind shutter, are FULL-RATED PORCELAIN embedded in a flame-retardant, track-resistant polyester-glass molding for 7.5 and 15HK switchgear up to 750MVA. Primary disconnect housings for 15HK1000 switchgear are mounted on aluminum.

BUS ACCESSIBLE FROM FRONT OR BACK

This is a feature that makes switchgear installation and maintenance easier than ever. Bus can be reached from the back through the rear panel OR FROM INSIDE THE CIRCUIT BREAKER COMPARTMENT by simply removing the isolating metal barrier (removed for photo). The bus itself, silver plated for high-conductivity connections, is fully insulated with flame-retardant, track-resistant epoxy resin molded insulation. Vinyl bus joint covers with corona-free high-dielectric characteristics provide sealed joints without need for compound.



PORCELAIN

ALL BUS SUPPORTS THROUGHOUT THE ENTIRE COMPARTMENT ARE PORCELAIN. Main bus supports between frames and primary bushings are porcelain embedded in track-resistant polyester-glass.

Wherever other bus supports are required the same high quality porcelain stand off insulators are used.

CURRENT TRANSFORMERS

Toroidal current transformers can be located on the bus risers on both line and load side of the circuit breaker. Transformers are insulated for full-voltage rating of the switchgear.

ACCESSIBILITY FOR ECONOMICAL INSTALLATION

No tight space when it comes to cable makeup. Entrance from either top or bottom. Top sheet is easily removed for drilling. Key slots running the full height of the compartment provide a simplified means for mounting cable supports or other equipment.

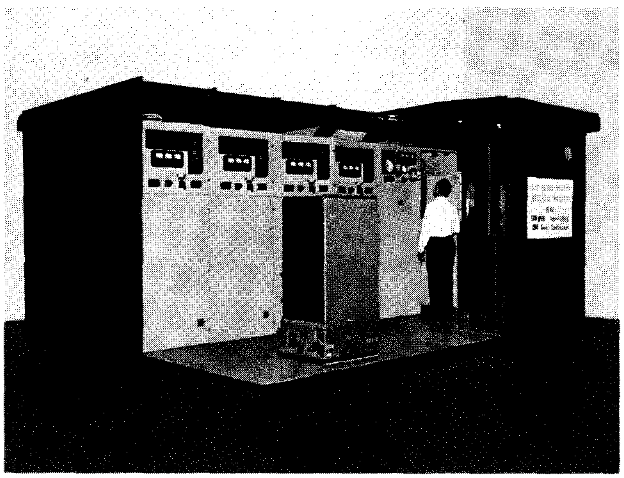
There's ample room for a single pothead in the standard 81 in. depth. When a double pothead is required the rear is extended 8 in.

OUTDOOR SWITCHGEAR

NON WALK-IN AND WALK-IN TYPES

ONLY I-T-E GIVES YOU ALL THESE ADVANTAGES:

- Doors, side sheets and frames sealed with long-lasting gaskets.
- All parts treated for rust resistance, painted and baked prior to assembly to protect the metal against rust and corrosion, even between overlapping points.
- Bottom of the entire unit undercoated.
- Front and rear doors hinged and louvered. Louvers include a cleanable metallic filter.
- Interiors equipped with lights, heaters, and convenience outlets.
- Structures strong enough to be pier mounted.



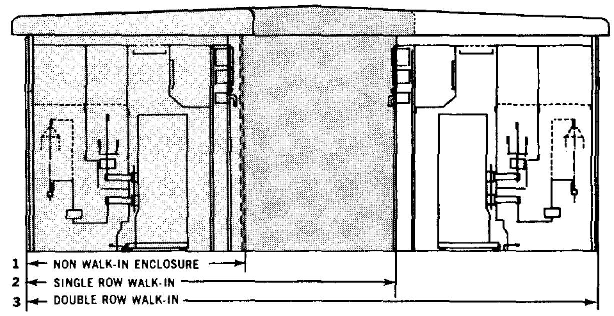
WALK-IN OUTDOOR CONSTRUCTION

Modern method of enclosure construction to facilitate maintenance of switchgear in any weather. Wide aisle inside for complete circuit breaker withdrawal and space to store an extra breaker. Lights, heat and convenience outlets are provided. Unit is so sturdily built that it may be pier mounted. End doors are provided with panic bar that permits opening even if exterior handle has been padlocked. Hinged rear doors provide easy access to bus and cable compartments. They have provisions for padlocking to prevent unauthorized entrance. (Note: cutaway view in photo above for illustrative purposes only.)

VENTILATION AND WEATHERPROOFING

Doors completely weather stripped for complete seal. Latches assure uniform tight fit. Generous filtered ventilation on door and overhang for maximum air circulation.

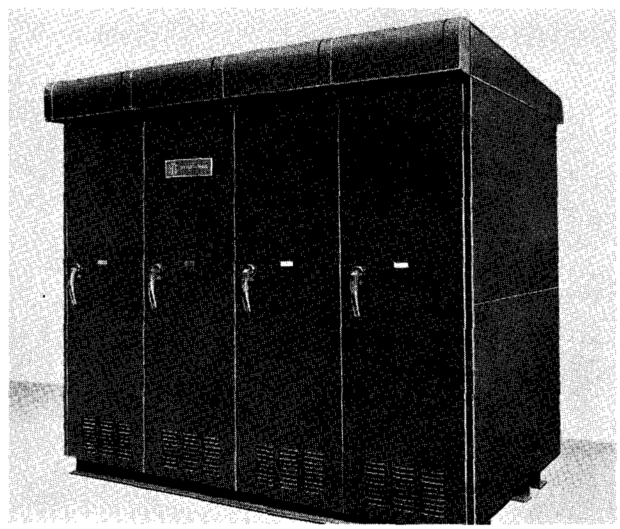
Strip heaters prevent moisture and condensation inside the compartment.



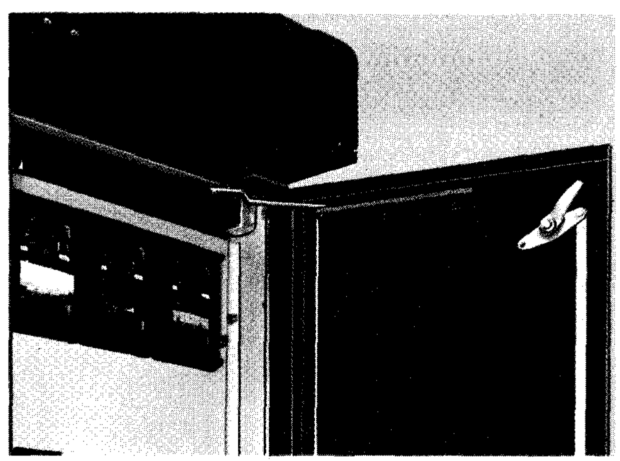
BUILDING BLOCK CONSTRUCTION

I-T-E outdoor construction consists of standard indoor switchgear contained within an outdoor enclosure.

Non walk-in outdoor enclosure (1) can be modified to single row walk-in (2) by the addition of the walk-in aisle. As load grows you can add switchgear frame to opposite side of aisle to form double row walk-in (3).

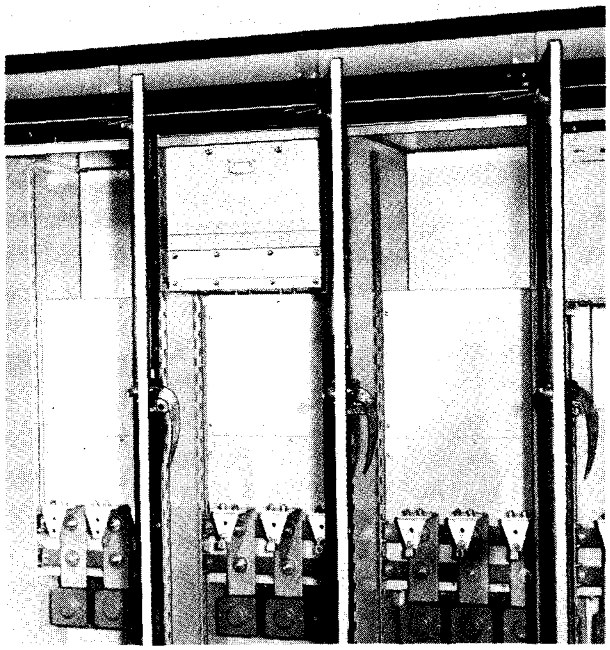


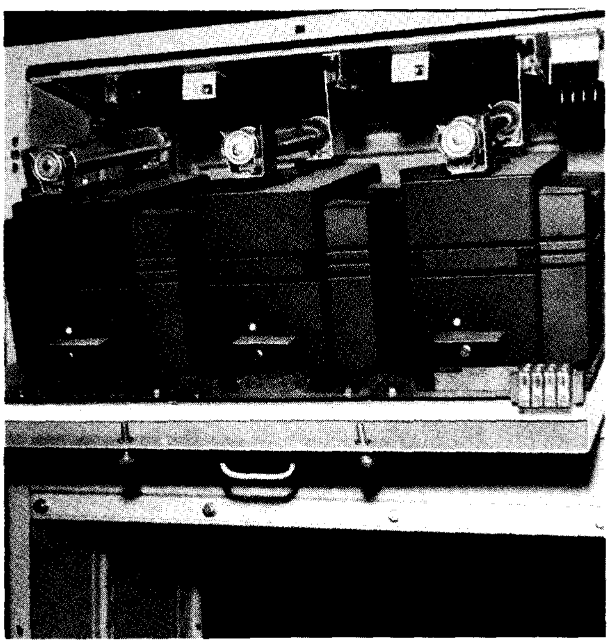
NON WALK-IN OUTDOOR CONSTRUCTION



AUXILIARY EQUIPMENT

Ample space is available in top rear compartment of circuit breaker unit for mounting potential transformers, lightning arresters and other auxiliary devices. Location charts for auxiliary frames are on pages 27 and 31.





TRUNNION-MOUNTED POTENTIAL TRANSFORMERS

Heavy potential transformers are no longer a problem. Trunnion-type mounting at the center of gravity assures effortless drawout. For safety when disconnected, fuses and potential transformers are automatically grounded.

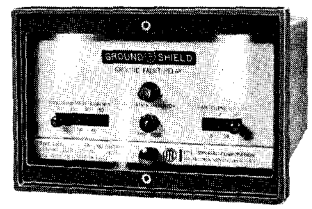
GROUND FAULT PROTECTION

For complete ground-fault protection against normally undetectable low-magnitude ground faults, I-T-E employs a solid-state relay in combination with a window-type core-balance current sensor. The system called GROUND-SHIELD™ provides coordinated ground-fault protection for solidly grounded, low and high-resistance grounded systems ranging up to 13,800V. In high-resistance grounded systems the relay can be used optionally for sounding an alarm only.

The relay is available in surface mounting as well as draw-out semi-flush panel mounting. It has a variety of combinations of time-current characteristics and current sensitivities. The sensors are available in a range of physical sizes.

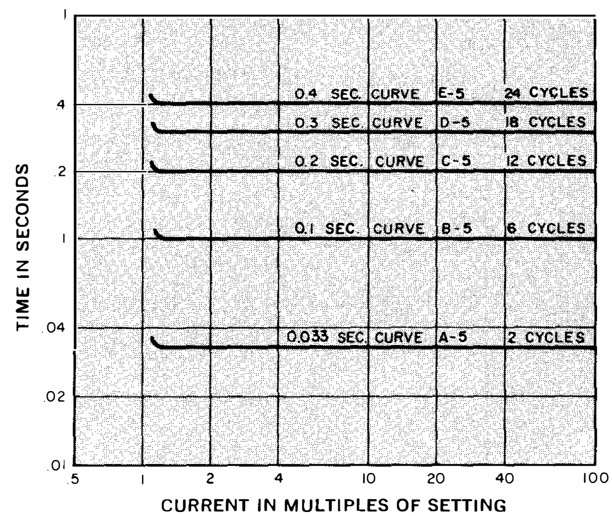
For more information on GROUND-SHIELD see I-T-E Bulletin No. 18.1.3-3

CURRENT SENSOR



GR-5 GROUND FAULT RELAY, DRAWOUT SEMI-FLUSH MOUNTING

TIME-CURRENT CHARACTERISTICS FOR GR-5 (5-50A) RELAY



NON-SEGREGATED PHASE BUS DUCT*

DEFINITION

Non-segregated phase bus is one in which all phase conductors are in a common metal enclosure without barriers between phases. Its construction is consistent with metal-clad switchgear practices.

USAGE

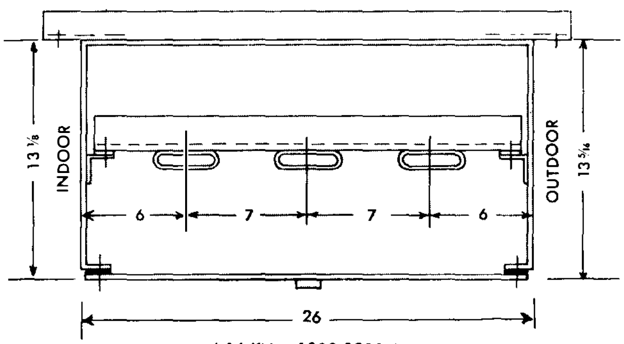
Non-segregated phase bus is used for generator leads to transformers, for connecting transformers to switchgear assemblies, for interconnecting switchgear assemblies, and for distribution of light and power in factories and office buildings. It provides a custom-designed, rigid conductor interconnection to give superior reliability in comparison to cable runs.

ADVANTAGES

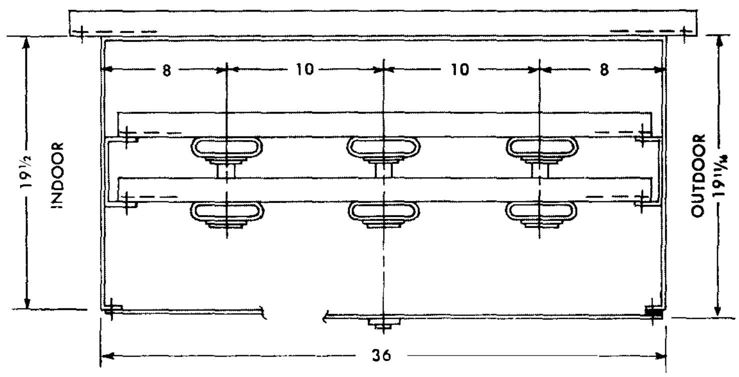
- A factory-standardized bus complies with a set design which has been proven to meet thermal, dielectric and mechanical requirements.
- Failure-vulnerable stress cones are eliminated.
- Insulating materials are superior, non-aging and kept up-to-date with advancements in the switchgear industry.
- All conductors are easily accessible for inspection or addition of tap-offs.
- Disconnect links, switches and grounding studs can easily be provided and coordinated with the bus design.
- Each bus is custom engineered to suit the installation requirements.

*For additional information on non-segregated phase bus duct refer to the nearest I-T-E district sales office.

TYPICAL NON-SEGREGATED PHASE BUS DUCT†
SECTION VIEW—4.16 KV



4.16 KV 1200-2000 A



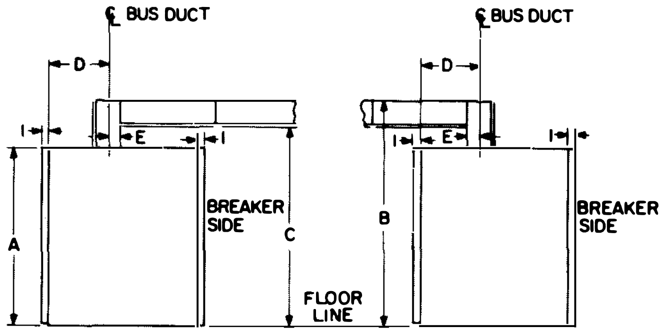
4.16 KV 3000 A

†Dimensions are approximate and subject to change without notice. Do not use for construction.

Table 2 **NON-SEGREGATED PHASE BUS DUCT**

Nominal System Voltage, kV	Bus Duct Nominal Voltage, kV	Bus Duct Maximum Voltage, kV	Continuous Current, A	Momentary Current Rating, kA	Insulation Level, kV: Power Frequency Withstand, kV (Dry, 1 Minute)	Insulation Level, kV: Impulse Withstand, kV BIL	Bus Duct Conductor Temperature Rise, °C (over 40°C ambient)
2.4 4.16	4.16	4.76	1200	60 or 80	19	60	65
			2000				
			3000				
			4000				
7.2 13.8	13.8	15.0	1200	60, 70 or 80	36	95	
			2000				
			3000				
			4000				

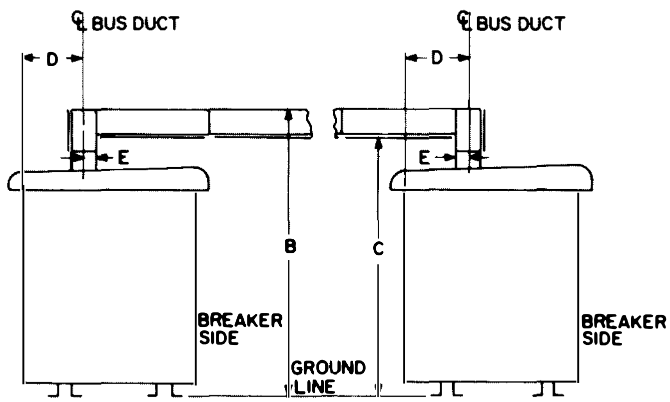
TYPICAL ARRANGEMENTS



5, 7.5 & 15HK INDOOR SWITCHGEAR CONNECTIONS, 1200 & 2000 A*

Type Δ	A	B	C	D†	E
5 HK-75 5 HK-250	80	106	$92\frac{7}{8}$	$13\frac{3}{8}$	$6\frac{1}{2}$
7.5 HK-500 15 HK-500 15 HK-750	90	126	$110\frac{1}{2}$	$32\frac{5}{16}$	$7\frac{11}{16}$

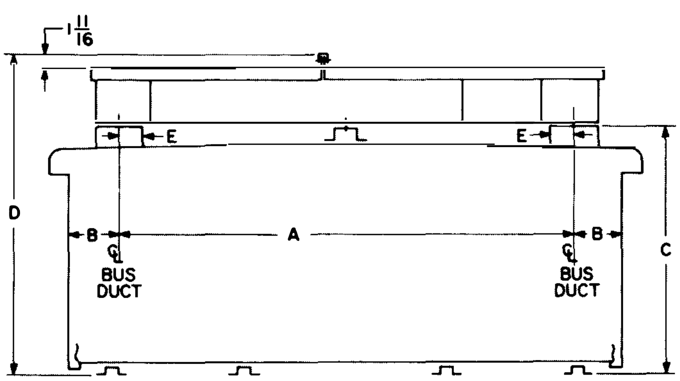
ΔRefer to nearest I-T-E district sales office for bus duct information relating to 5 HK-350 and 15 HK-1000 applications.
†Minimum and intermediate depth only. For extra depth switchgear, add 8″.



5, 7.5 & 15HK SWITCHGEAR CONNECTIONS FOR OUTDOOR NON WALK-IN, 1200 & 2000 A*

Type Δ	B	C	D†	E
5 HK-75 5 HK-250	131	$117\frac{11}{16}$	$16\frac{5}{8}$	$6\frac{1}{2}$
7.5 HK-500 15 HK-500 15 HK-750	$151\frac{5}{8}$	136	$45\frac{15}{16}$	$7\frac{11}{16}$

ΔRefer to nearest I-T-E district sales office for bus duct information relating to 5 HK-350 and 15 HK-1000 applications.
†Minimum and intermediate depth only. For extra depth switchgear, add 8″.



5, 7.5 & 15HK CROSS-OVER BUS DUCT (OUTDOOR WALK-IN, DOUBLE ROW) 1200 & 2000 A*

Type Δ	A°	B†	C	D	E
5 HK-75 5 HK-250	$161\frac{1}{4}$	$16\frac{5}{8}$	105	$122\frac{7}{16}$	$6\frac{1}{2}$
7.5 HK-500 15 HK-500 15 HK-750	$152\frac{5}{8}$	$45\frac{15}{16}$	$115\frac{5}{8}$	$135\frac{7}{16}$	$7\frac{11}{16}$

ΔRefer to nearest I-T-E district sales office for bus duct information relating to 5 HK-350 and 15 HK-1000 applications.
°Minimum and intermediate depth only. For extra depth switchgear, add 16″.
†Minimum and intermediate depth only. For extra depth switchgear, add 8″.

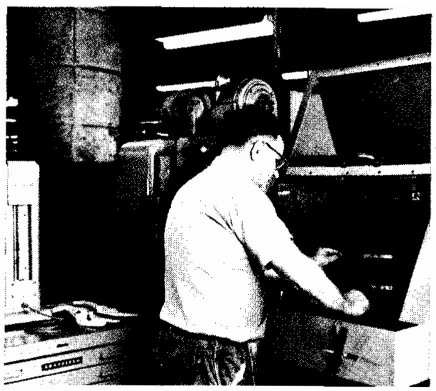
*Dimensions are approximate and subject to change without notice. Do not use for construction. All dimensions are in inches.

BEHIND THE
SUPERIOR PERFORMANCE
OF I-T-E SWITCHGEAR—

CAREFUL MANUFACTURE WITH QUALITY CONTROL EVERY STEP OF THE WAY

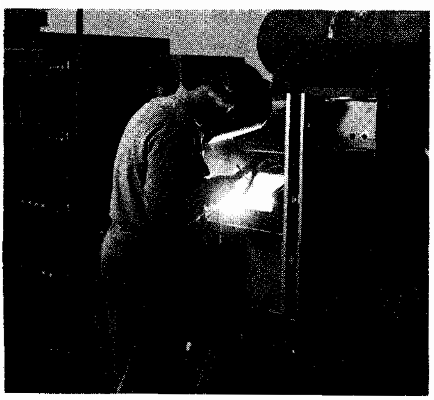
Manufacturing compliance with rigid quality control standards is but one phase of I-T-E's quality assurance program. Some quality control procedures applicable to the manufacture of metal-clad switchgear are outlined below.

I-T-E's quality assurance concept BEGINS with the **design** of its metal-clad switchgear. Our design objective was, and continues to be, a product offering which ensures safe, reliable protection of your electrical power system.



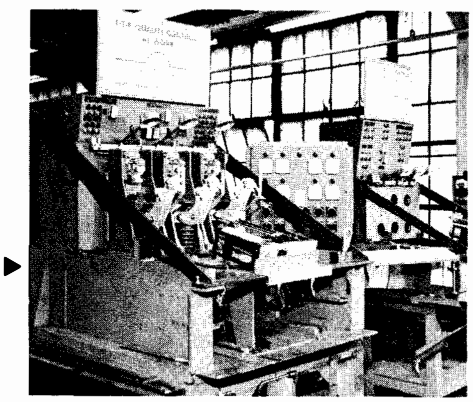
A TYPICAL CLOSE TOLERANCE BORING OPERATION. ◀ Using precision fixtures and tools means no unnecessary adjustments.

QUALITY CONTROL. As an integral part of this operation, each part is individually checked by operator for accuracy using a precision air gauge. ▶



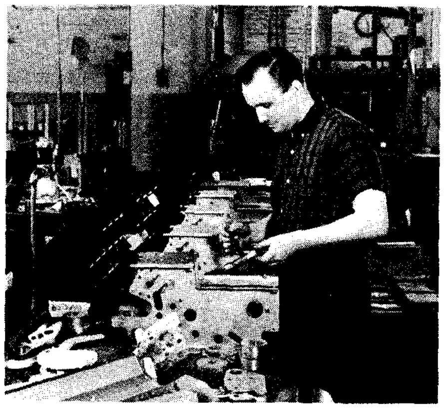
PRECISION WELDING. ◀ The individual parts of the HK Breaker Truck are held to close tolerance and accurately positioned during welding by fixtures. This insures complete interchangeability of breakers.

QUALITY CONTROL. Every finished breaker placed in final test & inspection jig to guarantee uniformity of dimensions that effect mating of breaker with the switchboard. ▶



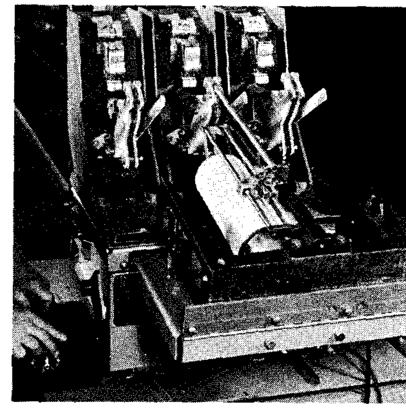
WIRING SUBASSEMBLIES. ◀ Illustrated is a circuit breaker control panel, one of several subassemblies. Specialized methods eliminate wire nicks and provides uniform wiring throughout.

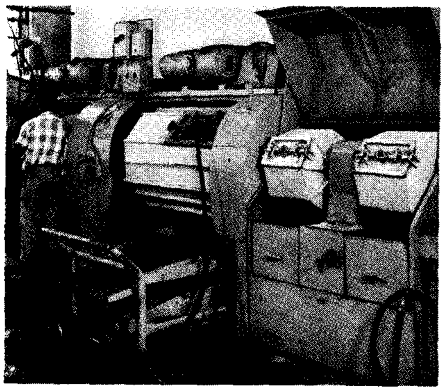
QUALITY CONTROL. Specially built electrical tester checks conformity and operation of control relay. ▶



LIFETIME LUBRICATION. All moving mechanism parts are lifetime lubricated with a high-molecular adhesive lubricant.

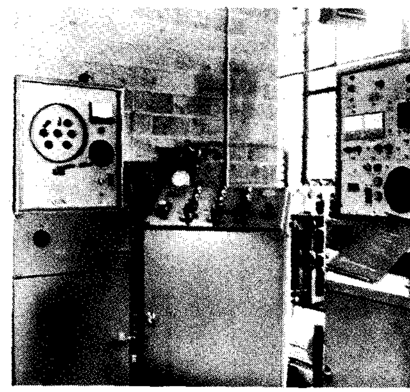
QUALITY CONTROL. This Cincinnati analyzer checks velocity of moving contacts, keeps permanent record of travel time characteristics of every breaker. Measures smoothness of operation.

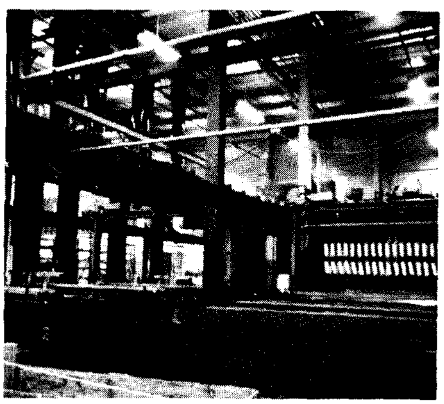




FINISHING OF PARTS. This tumble process is given to many small parts to insure smooth surfaces and freedom from burrs. One of several steps prior to final finish.

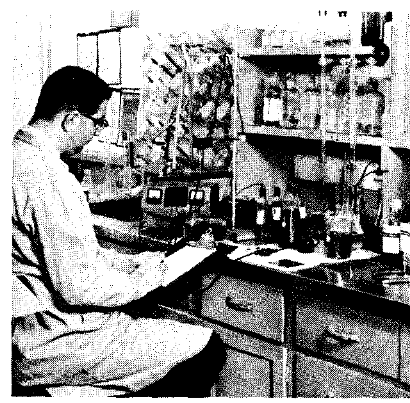
QUALITY CONTROL. I-T-E HK air-magnetic circuit breakers are tested for corona, power factor and radio influence. This testing exceeds industry standards. Some testing equipment is shown in adjoining photograph.





ELECTROPLATING. Processing equipment is completely automated to insure a generous plating of absolutely uniform thickness on all parts.

QUALITY CONTROL. Chemical laboratory tests solutions several times every day—to insure that they meet required standards.



ELECTROCOATING. This multi-stage cleaning and painting process is automatically controlled to provide uniform thickness on all parts. Part to be painted is completely immersed in a huge, electrically charged "gray river" of light gray ANSI #61 epoxy enamel paint.

QUALITY CONTROL. To determine paint's ability to prevent rust around scratches, parts are immersed in concentrated salt sprays. Insures that I-T-E switchgear will retain its good appearance for years of severe use.

QUALITY CONTROL. Paints are constantly quality checked. Includes such tests as viscosity, hardness, color fastness, abrasion resistance, adhesion and composition.

DIMENSIONS▲

5 HK INDOOR SWITCHGEAR

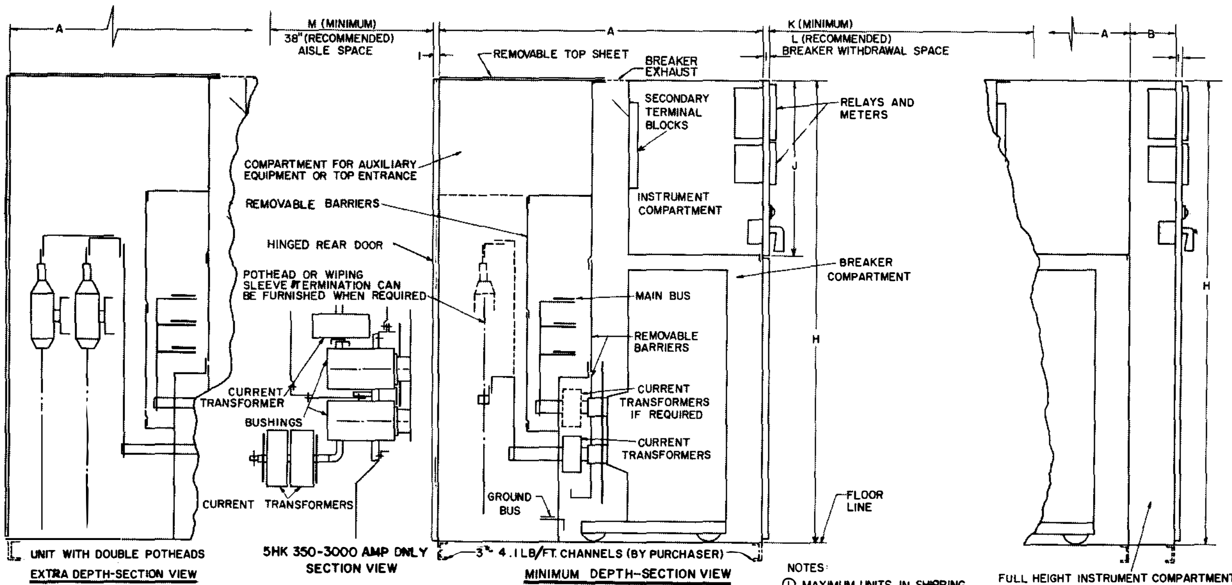
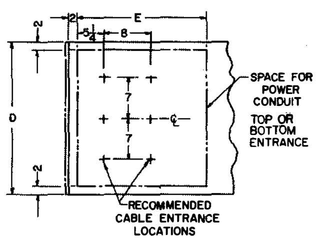
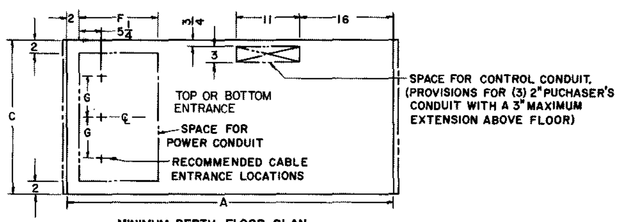


FIGURE 2 **FIGURE 2A** **FIGURE 1** **FIGURE 3**



FLOOR PLAN



MINIMUM DEPTH-FLOOR PLAN

DIMENSIONS

BREAKER TYPE	INDOOR CONSTRUCTION	A	B	C	D	E	F	G	H	J	K	L	M
5 HK 75 1200 AMP	MINIMUM DEPTH REFER TO FIGURE 1*	56	—	26	—	—	13½	7	80	30	36	60	28
5 HK 250 {1200 AMP 2000 AMP}	INTERMEDIATE DEPTH ‡ (FULL HEIGHT INSTRUMENT COMPARTMENT) REFER TO FIGURE 3	56	8	26	—	—	13½	7	80	—	36	60	28
	EXTRA DEPTH (SPECIAL APPLICATION) (FULL HEIGHT INSTRUMENT COMPARTMENT) (ADDITIONAL 8" IN REAR) REFER TO FIGURES 2-3	64	8	—	26	21½	—	—	80	—	36	60	28
5 HK 350 {1200 AMP 2000 AMP}	MINIMUM DEPTH REFER TO FIGURE 1*	56	—	26	—	—	13½	7	90	30	36	60	28
	INTERMEDIATE DEPTH ‡ (FULL HEIGHT INSTRUMENT COMPARTMENT) REFER TO FIGURE 3	56	8	26	—	—	13½	7	90	—	36	60	28
	EXTRA DEPTH (SPECIAL APPLICATION) (FULL HEIGHT INSTRUMENT COMPARTMENT) (ADDITIONAL 8" IN REAR) REFER TO FIGURES 2-3	64	8	—	26	21½	—	—	90	—	36	60	28
5HK 350 3000 AMP	MINIMUM DEPTH REFER TO FIGURE 2A	64	—	36	—	—	13½	10		28	52	66	38
	INTERMEDIATE DEPTH (FULL HEIGHT INSTRUMENT COMPARTMENT) REFER TO FIGURE 3	64	8	36	—	—	13½	10		28	52	66	38

* Add 4" to A when line-up includes minimum depth 5HK350, 3000A unit.
‡ Add 4" to B when line-up includes intermediate depth 5HK350, 3000A unit.

▲ Dimensions are in inches. They are approximate and should not be used for construction.

5 HK OUTDOOR NON WALK-IN SWITCHGEAR

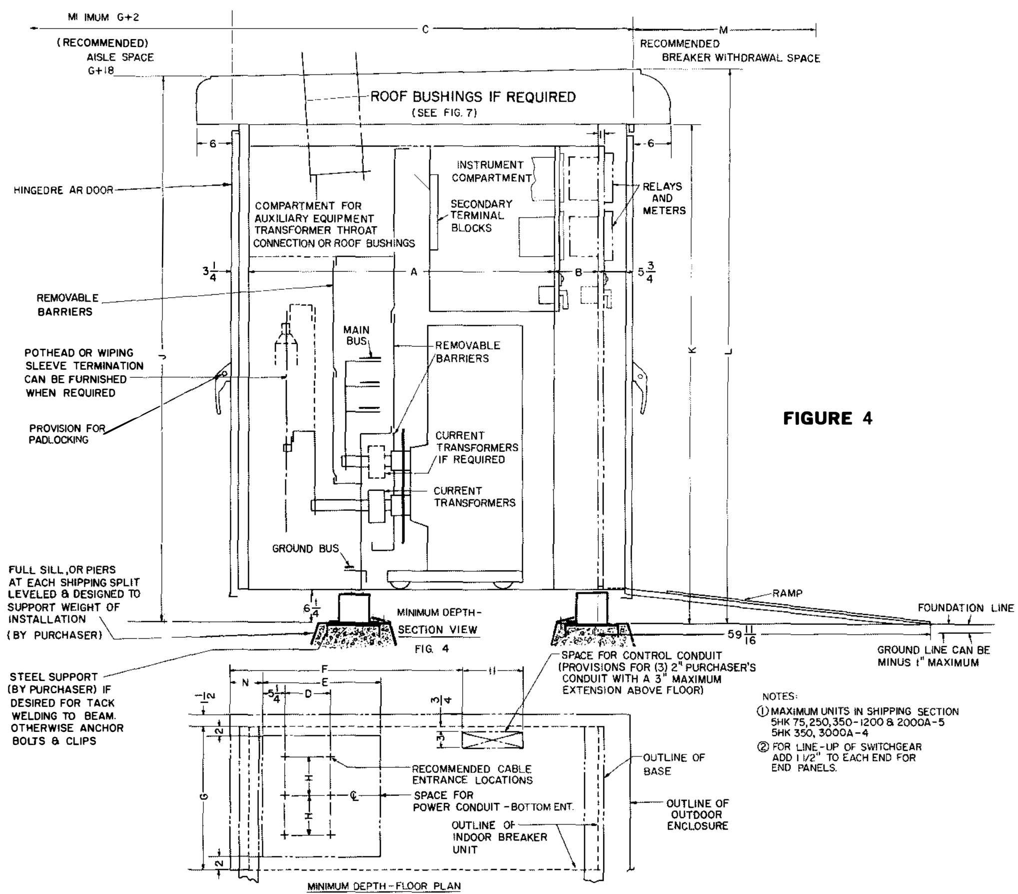


FIGURE 4

DIMENSIONS

BREAKER TYPE	OUTDOOR CONSTRUCTION	A	B	C	D	E	F	G	H	J	K	L	M	N
5 HK 75 1200 AMP 5 HK 250 {1200 2000} AMP	MINIMUM DEPTH *	56	—	65	—	13½	32¼	26	7	98 5/16	90¼	101¾	120	5¼
	INTERMEDIATE DEPTH ‡ (FULL HEIGHT INSTRUMENT COMPARTMENT)		8	73										
	EXTRA DEPTH (SPECIAL APPLICATION) (FULL HEIGHT INSTRUMENT COMPARTMENT) (ADDITIONAL 8" IN REAR)	64		81	8	21½	40¼							
5 HK 350 {1200 2000} AMP	MINIMUM DEPTH *	56	—	65	—	13½	32¼			108 5/16	100¼	111¾		
	INTERMEDIATE DEPTH ‡ (FULL HEIGHT INSTRUMENT COMPARTMENT)		8	73										
	EXTRA DEPTH (SPECIAL APPLICATION) (FULL HEIGHT INSTRUMENT COMPARTMENT) (ADDITIONAL 8" IN REAR)	64		81	8	21½	40¼							
5 HK 350 3000 AMP	MINIMUM DEPTH		—	73	—	13½		36	10				126	
	INTERMEDIATE DEPTH (FULL HEIGHT INSTRUMENT COMPARTMENT)		8	81										

* Add 8" to A and C and 4" to F and N when line-up includes minimum depth 5HK350, 3000A unit.
‡ Add 8" to A and C and 4" to F and N when line-up includes intermediate depth 5HK350, 3000A unit.

5 HK OUTDOOR WALK-IN SWITCHGEAR

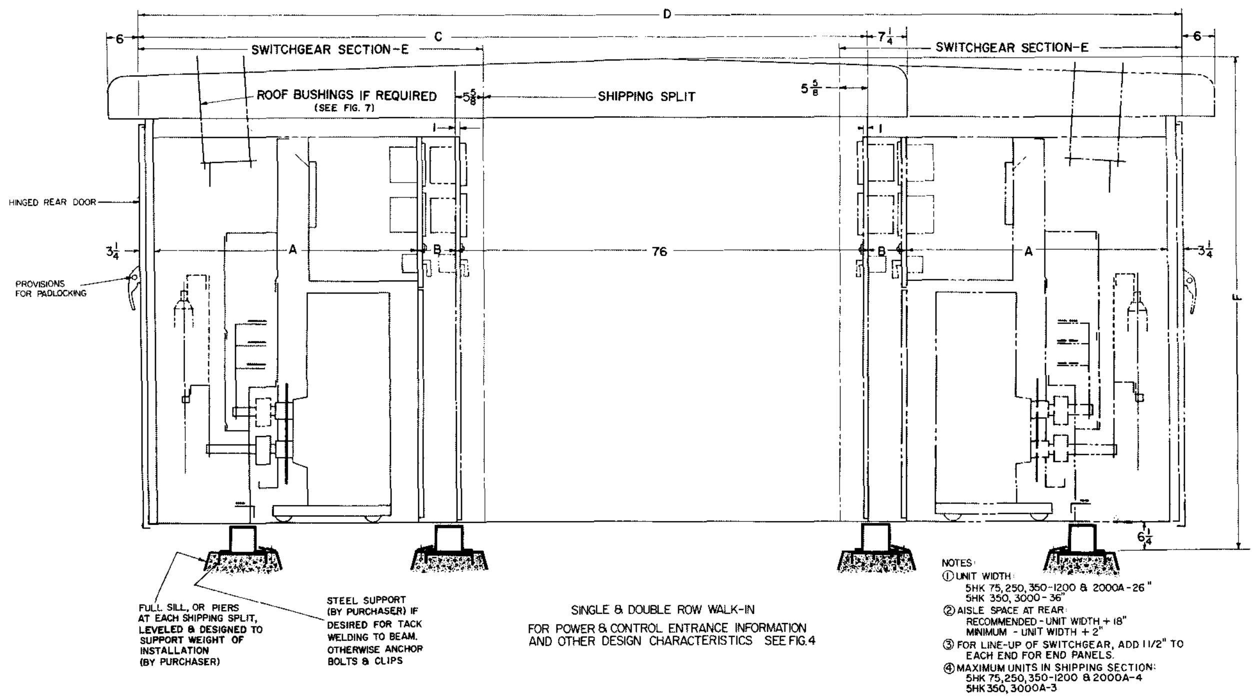


FIGURE 5

DIMENSIONS

<table>
<tr><th>BREAKER TYPE</th><th>OUTDOOR CONSTRUCTION</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td rowspan="3">5 HK 75 1200 AMP
5 HK 250 {1200 / 2000} AMP</td><td>MINIMUM DEPTH*</td><td rowspan="2">56</td><td>—</td><td>135¼</td><td>194½</td><td>64⅞</td><td rowspan="3">102¾</td></tr>
<tr><td>INTERMEDIATE DEPTH‡
(FULL HEIGHT INSTRUMENT COMPARTMENT)</td><td rowspan="2">8</td><td>143¼</td><td>210½</td><td>72⅞</td></tr>
<tr><td>EXTRA DEPTH (SPECIAL APPLICATION)
(FULL HEIGHT INSTRUMENT COMPARTMENT)
(ADDITIONAL 8" IN REAR)</td><td>64</td><td>151¼</td><td>226½</td><td>80⅞</td></tr>
<tr><td rowspan="3">5 HK 350 {1200 / 2000} AMP</td><td>MINIMUM DEPTH*</td><td rowspan="2">56</td><td>—</td><td>135¼</td><td>194½</td><td>64⅞</td><td rowspan="5">112¾</td></tr>
<tr><td>INTERMEDIATE DEPTH‡
(FULL HEIGHT INSTRUMENT COMPARTMENT)</td><td rowspan="2">8</td><td>143¼</td><td>210½</td><td>72⅞</td></tr>
<tr><td>EXTRA DEPTH (SPECIAL APPLICATION)
(FULL HEIGHT INSTRUMENT COMPARTMENT)
(ADDITIONAL 8" IN REAR)</td><td rowspan="3">64</td><td>151¼</td><td>226½</td><td>80⅞</td></tr>
<tr><td rowspan="2">5 HK 350 3000 AMP</td><td>MINIMUM DEPTH</td><td>—</td><td>143¼</td><td>210½</td><td>72⅞</td></tr>
<tr><td>INTERMEDIATE DEPTH
(FULL HEIGHT INSTRUMENT COMPARTMENT)</td><td>8</td><td>151¼</td><td>226½</td><td>80⅞</td></tr>
</table>

SINGLE ROW WALK-IN UNIT MAY BE CONVERTED TO DOUBLE ROW WALK-IN BY ADDING ADDITIONAL SWITCHGEAR SECTION TO OTHER SIDE OF AISLE AS SHOWN IN PHANTOM

*Add 8" to A and C when line-up includes minimum depth 5 HK-350, 3000A, unit.
‡Add 8" to A and C when line-up includes intermediate depth 5 HK-350, 3000A, unit.

5 HK SWITCHGEAR

LOCATION CHART FOR 5 HK AUXILIARY UNITS

PREFERRED EQUIPMENT LOCATIONS		
EQUIPMENT	ORDER OF PREFERENCE	
INCOMING LINE FROM ABOVE	E, F, & G (ALL)	
INCOMING LINE FROM BELOW	F, G & H (ALL)	
RELAYS & INSTRUMENTS	A-B-C-D-J	
DRAWOUT FUSES & MECH. INTERLOCKED ET BREAKER (FOR CPT.)	B-E-C	E & H NOT NORMALLY USED FOR DRAWOUT UNITS IN WALK-IN CONSTRUCTION
CONTROL POWER TRANSFORMER*	C & D (BOTH) OR G & H (BOTH)	
BATTERY CHARGER	C-J	
CONTROL OR TRIPPING BATTERY (48V)	C & D (BOTH)	
1, 2 OR 3 PT'S.	B-C-D-E-H	E, F, H & G NOT NORMALLY USED FOR DRAWOUT UNITS IN WALK-IN CONSTRUCTION F & G MAY BE USED IF THERE IS NO MAIN BUS
LIGHTNING ARRESTERS	H-E-D	

HEIGHT & DEPTH DIMENSIONS OF AUXILIARY UNIT TO MATCH ADJACENT BREAKER UNIT.

*Limited to 25 kVA. 1 ϕ max. For larger sizes, refer to nearest I-T-E district sales office.

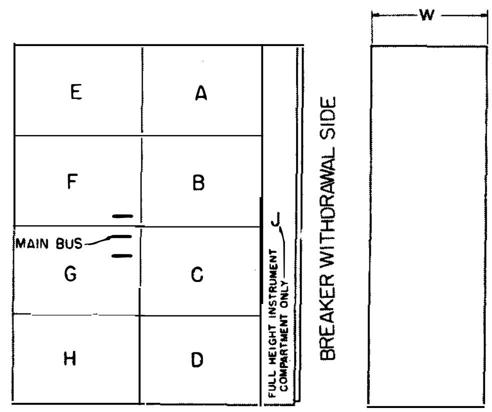
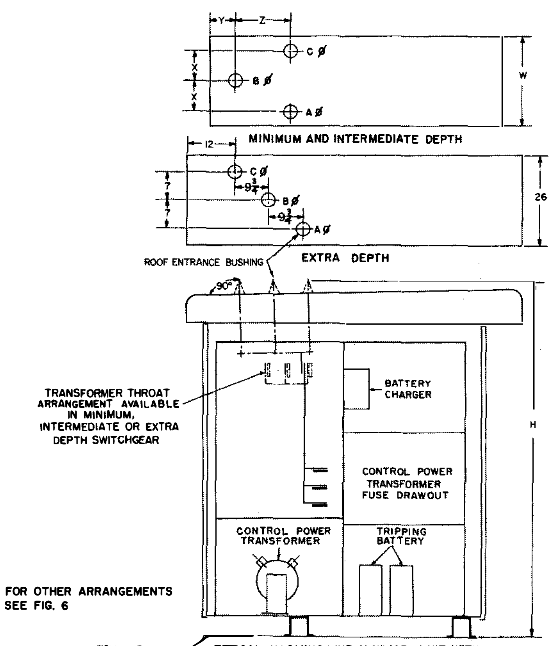


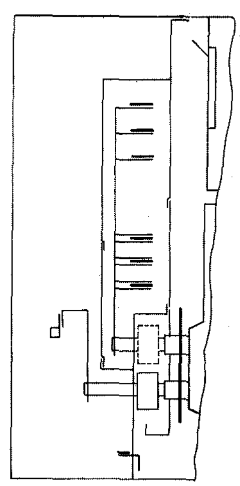
FIGURE 6

Breaker Type	X	Y	Z	W AC.B	W AUX	H
5 HK 75 1200 A						111
5 HK 250 1200 A						
5 HK 250 2000 A	7	11	12	26	26	113¼
5 HK 350 1200 A						121
5 HK 350 2000 A						123¼
5 HK 350 3000 A	10	11	13⅝	36	40	121



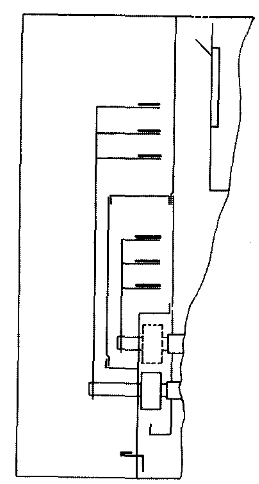
TYPICAL INCOMING LINE AUXILIARY UNIT WITH ROOF BUSHINGS OR TRANSFORMER THROAT

FIGURE 7



BREAKER UNIT ADJACENT TO BUS TIE UNIT WITH BUS TRANSITION (1200 OR 2000 AMP MAIN BUS)

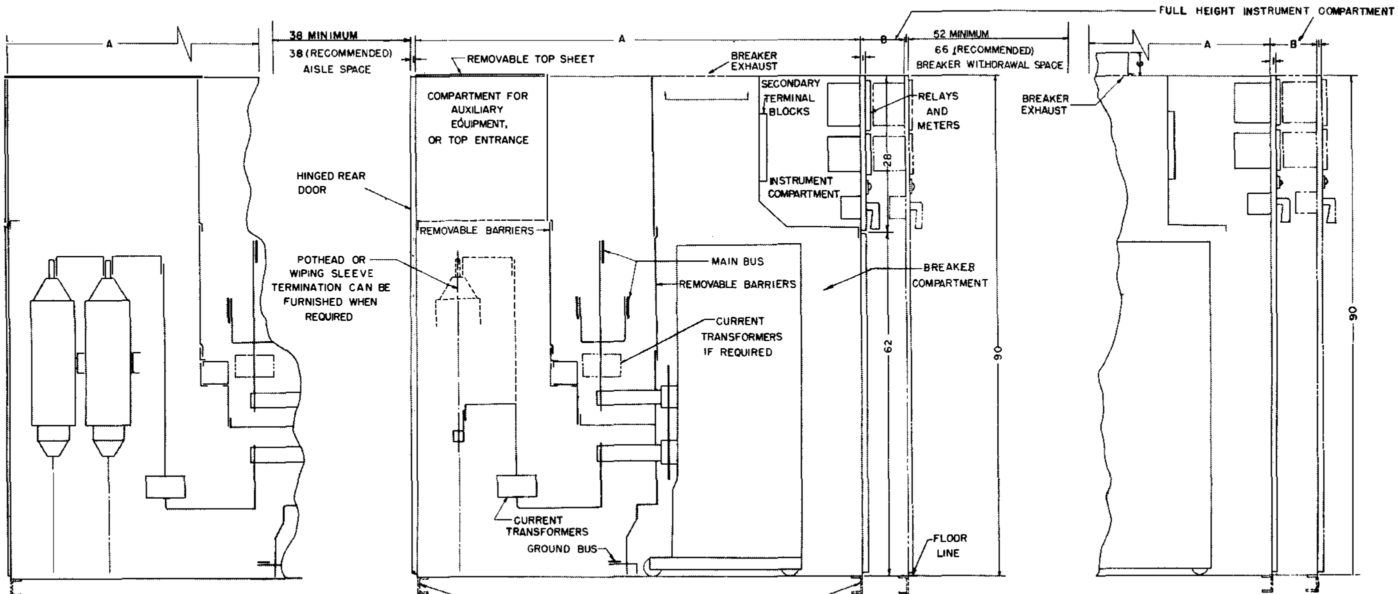
FIGURE 8



BREAKER UNIT BUS TIE (1200 OR 2000 AMP. MAIN BUS)

FIGURE 9

7.5 & 15 HK INDOOR SWITCHGEAR



UNIT WITH DOUBLE POTHEADS
EXTRA DEPTH — SECTION VIEW

FIGURE 11

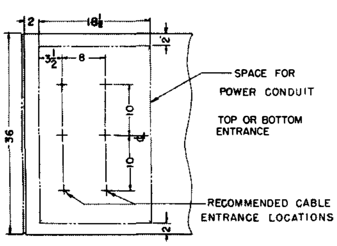
MINIMUM OR INTERMEDIATE DEPTH-SECTION VIEW

FIGURE 10

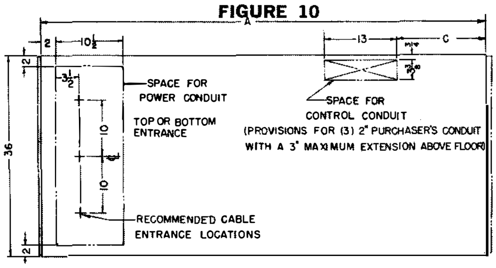
NOTES:
MAXIMUM UNITS IN SHIPPING SECTION IS 4.

FIG. 12 - SECTION VIEW 750 MVA ONLY
OTHERWISE SAME AS FIG. 10

FIGURE 12



FLOOR PLAN



MINIMUM DEPTH-FLOOR PLAN

DIMENSIONS

BREAKER TYPE	INDOOR CONSTRUCTION	A	B	C
7.5 HK 500 {1200 AMP 2000 AMP	MINIMUM DEPTH—REFER TO FIGURE 10	81	—	16
	INTERMEDIATE DEPTH (FULL HEIGHT INSTRUMENT COMPARTMENT) REFER TO FIGURE 12		8	
15 HK 500 {1200 AMP 2000 AMP	EXTRA DEPTH (FULL HEIGHT INSTRUMENT COMPARTMENT) (ADDITIONAL 8" IN REAR) REFER TO FIGURES 11 & 12	89		
15 HK 750 {1200 AMP 2000 AMP	MINIMUM DEPTH—REFER TO FIGURE 10		—	24
	INTERMEDIATE DEPTH (FULL HEIGHT INSTRUMENT COMPARTMENT) REFER TO FIGURE 12		8	
	EXTRA DEPTH (FULL HEIGHT INSTRUMENT COMPARTMENT) (ADDITIONAL 8" IN REAR) REFER TO FIGURES 11 & 12	97		

7.5 & 15 HK OUTDOOR SWITCHGEAR

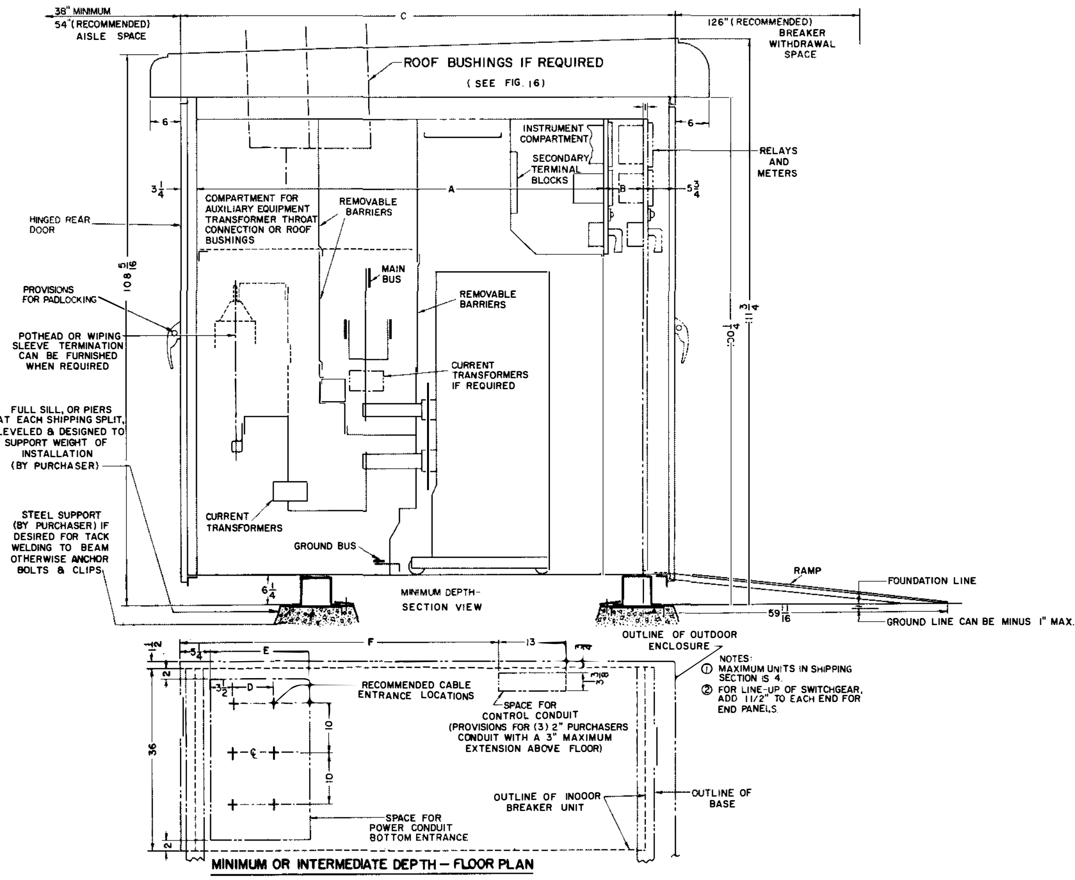


FIGURE 13

DIMENSIONS

BREAKER TYPE	OUTDOOR CONSTRUCTION	A	B	C	D	E	F
7.5 HK 500 {1200 AMP 2000 AMP	MINIMUM DEPTH	81	—	90	—	10½	55¼
	INTERMEDIATE DEPTH (FULL HEIGHT INSTRUMENT COMPARTMENT)		8	98			
15 HK 500 {1200 AMP 2000 AMP	EXTRA DEPTH (SPECIAL APPLICATION) (FULL HEIGHT INSTRUMENT COMPARTMENT) (ADDITIONAL 8" IN REAR)			106	8	18½	63¼
15 HK 750 {1200 AMP 2000 AMP	MINIMUM DEPTH	89	—	98			
	INTERMEDIATE DEPTH (FULL HEIGHT INSTRUMENT COMPARTMENT)		8	106	—	10½	55¼
	EXTRA DEPTH (SPECIAL APPLICATION) (FULL HEIGHT INSTRUMENT COMPARTMENT) (ADDITIONAL 8" IN REAR)	97		114	8	18½	63¼

7.5 & 15 HK OUTDOOR WALK-IN SWITCHGEAR

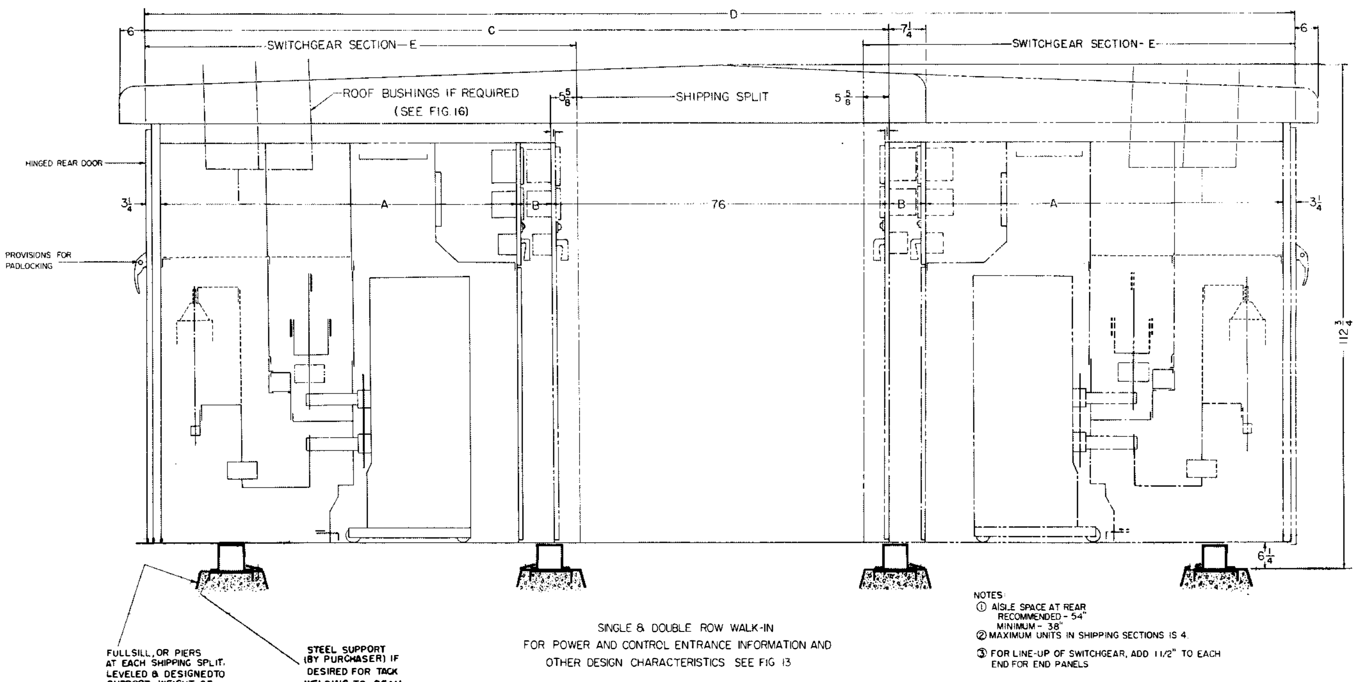


FIGURE 14

DIMENSIONS

BREAKER TYPE	OUTDOOR CONSTRUCTION	A	B	C	D	E
7.5 HK 500 {1200 AMP / 2000 AMP	MINIMUM DEPTH	81	—	160¼	244½	89⅞
15 HK 500 {1200 AMP / 2000 AMP	INTERMEDIATE DEPTH (FULL HEIGHT INSTRUMENT COMPARTMENT)		8	168¼	260½	97⅞
	EXTRA DEPTH (SPECIAL APPLICATION) (FULL HEIGHT INSTRUMENT COMPARTMENT) (ADDITIONAL 8" IN REAR)			176¼	276½	105⅞
15 HK 750 {1200 AMP / 2000 AMP	MINIMUM DEPTH	89	—	168¼	260½	97⅞
	INTERMEDIATE DEPTH (FULL HEIGHT INSTRUMENT COMPARTMENT)		8	176¼	276½	105⅞
	EXTRA DEPTH (SPECIAL APPLICATION) (FULL HEIGHT INSTRUMENT COMPARTMENT) (ADDITIONAL 8" IN REAR)	97		184¼	292½	113⅞

SINGLE ROW WALK-IN UNIT MAY BE CONVERTED TO DOUBLE ROW WALK-IN BY ADDING ADDITIONAL SWITCHGEAR SECTION TO OTHER SIDE OF AISLE AS SHOWN IN PHANTOM

7.5 & 15 HK SWITCHGEAR

LOCATION CHART FOR 7.5 & 15 HK AUXILIARY UNITS

PREFERRED EQUIPMENT LOCATIONS	
EQUIPMENT	ORDER OF PREFERENCE
INCOMING LINE FROM ABOVE	D-E & G (ALL)
INCOMING LINE FROM BELOW	F-E & G (ALL)
RELAYS & INSTRUMENTS	A-B-C-H
DRAWOUT FUSES & MECH. INTERLOCKED E.T. BREAKER (FOR C.P.T.)	B-F-C {F NOT NORMALLY USED FOR DRAWOUT UNITS IN WALK-IN CONSTRUCTION
CONTROL POWER TRANSFORMERS *	C-F
BATTERY CHARGER	A-H
CONTROL OR TRIPPING BATTERY (48V)	C
1, 2 OR 3 PTS.	B-C-F-D {D & F NOT NORMALLY USED FOR UNITS IN WALK-IN CONSTRUCTION DRAWOUT
LIGHTNING ARRESTERS	F-D-C

OVERALL DIMENSIONS OF AUXILIARY UNIT TO MATCH ADJACENT BREAKER UNIT

*Limited to 25 kVA, 1 ϕ max. For larger sizes, refer to nearest I-T-E district sales office.

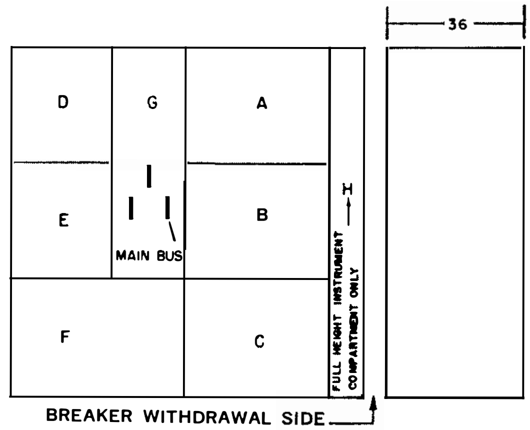
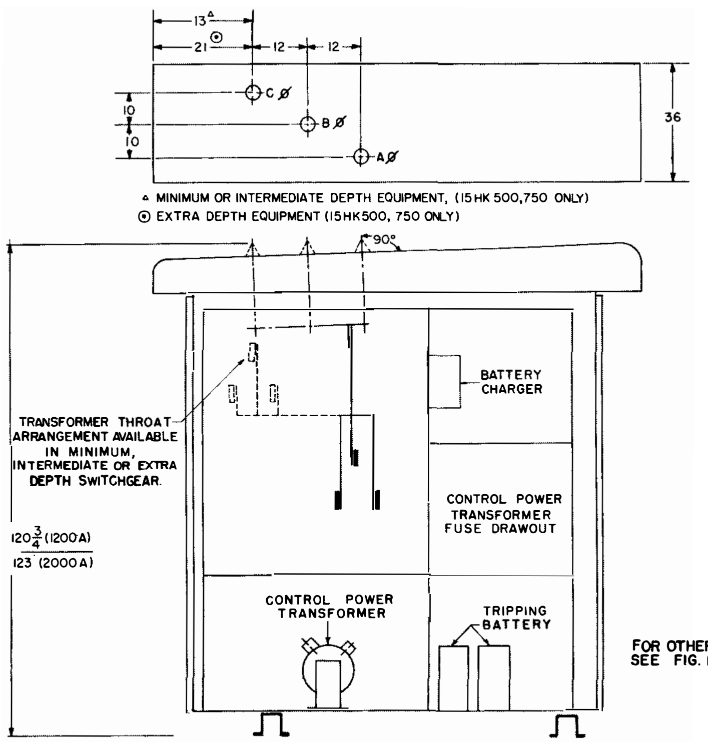


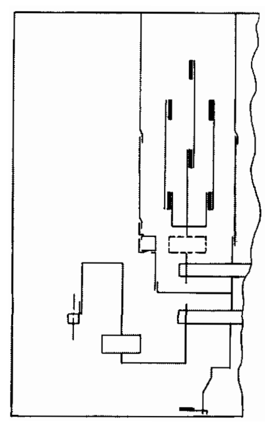
FIGURE 15



FOR OTHER ARRANGEMENTS SEE FIG. 15

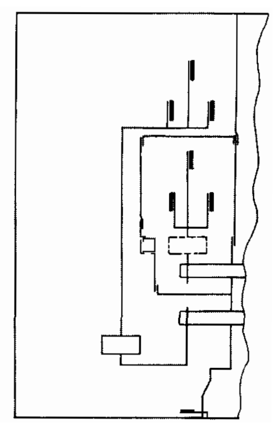
TYPICAL INCOMING LINE AUXILIARY UNIT WITH ROOF BUSHING OR TRANSFORMER THROAT

FIGURE 16



BREAKER UNIT ADJACENT TO BUS TIE UNIT WITH BUS TRANSITION (1200 OR 2000 AMP. MAIN BUS)

FIGURE 17

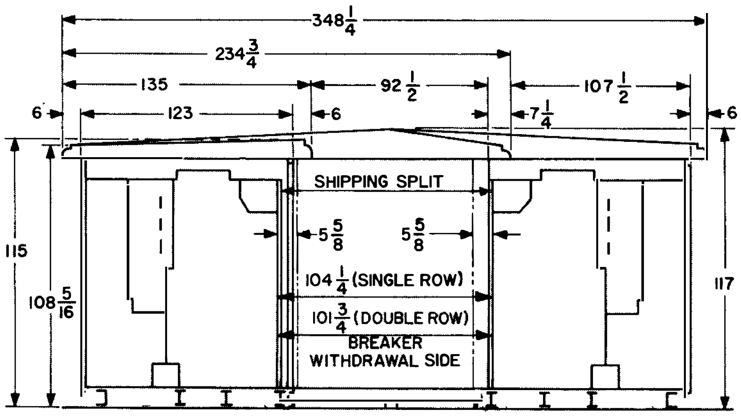


BREAKER UNIT BUS TIE (1200 OR 2000 AMP. MAIN BUS)

FIGURE 18

15 HK-1000 INDOOR AND OUTDOOR SWITCHGEAR

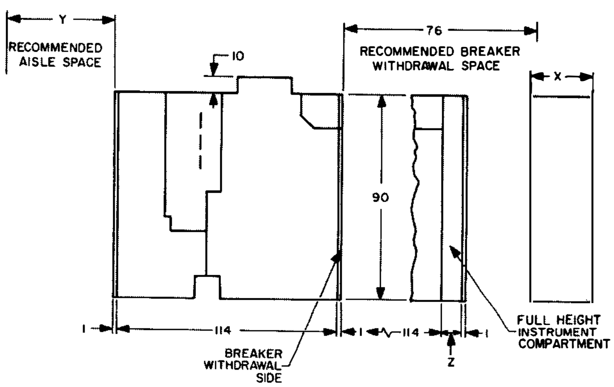
OUTDOOR METAL-CLAD SWITCHGEAR

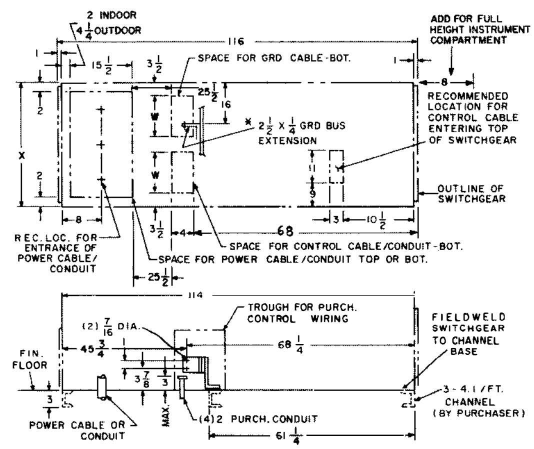


NOTES:

1. FOR LINE-UP OF SWITCHGEAR ADD 1½" TO EACH END FOR END PANELS.
2. FOR FULL HEIGHT INSTRUMENT COMPARTMENTS ADD 8" TO DEPTH. SEE Z BELOW.
3. RECOMMENDED BREAKER WITHDRAWAL SPACE FOR OUTDOOR NON WALK-IN IS 136".

INDOOR METAL-CLAD SWITCHGEAR





DIMENSIONS

BREAKER TYPE	CONSTRUCTION	X	Y	Z	W
15 HK 1000 {1200 AMP. 2000 AMP.	MINIMUM DEPTH	36	38	—	14
15 HK 1000–3000 AMP.		46	48	—	16
15 HK 1000 {1200 AMP. 2000 AMP.	INTERMEDIATE DEPTH	36	38	8	14
15 HK 1000–3000 AMP.	(FULL HEIGHT INSTRUMENT COMPARTMENT)	46	48	8	16

APPROXIMATE WEIGHTS

TABLE OF APPROXIMATE NET WEIGHTS -LBS.

Type of Breaker	Continuous Current Amperes	Breaker	SWITCHBOARD ASSEMBLY—FEEDER, INCOMING LINE OR AUXILIARY UNIT (Does Not Include Breaker)											
			Indoor			Non Walk-In Outdoor			Single Row Walk-In Outdoor			Double Row Walk-In Outdoor		
			56″	64″	72″	65″	73″	81″	135¼″	143¼″	151¼″	194½″	210½″	226½″
5 HK 75	1200	550	1325	1400	1475	1690	1775	1860	2148	2233	2318	3633	3803	3973
5 HK 250	1200	560	1325	1400	1475	1690	1775	1860	2148	2233	2318	3633	3803	3973
5 HK 250	2000	580	1458	1533	1608	1823	1908	1993	2281	2366	2451	3899	4069	4239
Add Per Switchboard for End Panels						545	606	667	1626	1687	1748	2208	2330	2452
5 HK 350	1200	750	1400	1485	1570	1790	1885	1980	2258	2353	2448	3823	4013	4203
5 HK 350	2000	760	1533	1618	1703	1923	2018	2113	2391	2486	2581	4089	4279	4469
5 HK 350	3000	1300	—	1995	2085	—	2495	2598	—	3050	3153	—	5240	5446
Add Per Switchboard for End Panels						590	650	710	1671	1731	1791	2298	2418	2538
			81″	89″	97″	90″	98″	106″	160¼″	168¼″	176¼″	244½″	260½″	276½″
7.5 HK 500	1200	995	2170	2260	2350	2675	2778	2880	3230	3333	3435	5600	5806	6010
7.5 HK 500	2000	1005	2411	2501	2591	2916	3019	3121	3471	3574	3676	6082	6288	6492
15 HK 500	1200	985	2170	2260	2350	2675	2778	2880	3230	3333	3435	5600	5806	6010
15 HK 500	2000	1005	2411	2501	2591	2916	3019	3121	3471	3574	3676	6082	6288	6492
Add Per Switchboard for End Panels						775	835	895	1912	1972	2032	2658	2778	2898
			89″	97″	105″	98″	106″	114″	168¼″	176¼″	184¼″	260½″	276½″	292½″
15 HK 750	1200	1345	2260	2350	2440	2778	2880	2982	3333	3435	3537	5806	6010	6214
15 HK 750	2000	1355	2501	2591	2681	3019	3121	3223	3574	3676	3778	6288	6492	6696
Add Per Switchboard for End Panels						835	895	955	1972	2032	2092	2788	2908	3028
			114″			123″			226¼″			344½″		
15 HK 1000	1200	2600	2650			3450			4950			8400		
15 HK 1000	2000	2660	2900			3700			5200			8650		
15 HK 1000	3000	3380	3300			4300			5900			10200		
Add Per Switchboard for End Panels						1200			2580			3780		

5 HK—Potential transformer drawout unit with 3 PT's—216 lbs. Deduct 32 lbs. for each PT not required.

15 HK—Potential transformer drawout unit with 3 PT's—515 lbs. Deduct 85 lbs. for each PT not required.

5 & 15 KV—Stationary mounted control power transformers to 15 KVA—305 lbs.

5 HK—Drawout fuse unit—160 lbs.

15 HK—Drawout fuse unit—295 lbs.

Breaker Impact Loading—twice the breaker weight (vertical loading); Switchboard impact loading—switchboard weight.

METAL-CLAD SWITCHGEAR APPLICATION GUIDE

GENERAL

Metal-clad switchgear featuring air-magnetic circuit breakers is most properly applied as protective equipment on power systems where the user requires (a) personnel safety; (b) system stability and reliability; (c) adaptability; (d) minimal maintenance; and, (e) low total cost. Personnel safety is one of the prime reasons for user insistence on metal-clad switchgear to perform the power system protective function. Electricity by its very nature is extremely dangerous and entails considerable personnel hazard if not adequately controlled. Metal-clad switchgear enhances system stability and reliability because of its basic construction features and the flexibility derived from the multitude of main bus configurations available to the user. It is adaptable to many applications because it is easily expanded and can be specified and designed with load location and load characteristics in mind. Reduced maintenance cost is a result of the drawout features of metal-clad switchgear, as well as superior accessibility of most components. There is no oil to test periodically—no need to incur the expense of changing oil after a major interruption. All this at a reduced total cost to the user. On the average, metal-clad switchgear represents approximately 5% of plant cost. This class of switchgear is generally shipped factory assembled and reduces the need for expensive field assembly.

The application of metal-clad switchgear is a relatively simple procedure in most cases. The following steps are normally taken in applying this equipment:

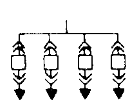
1. Develop single-line diagram and general arrangement (see page 43).
2. Determine required breaker based on continuous current and interrupting capability (see page 41).
3. Select main bus rating.
4. Select current transformers.
5. Select potential transformers.
6. Determine closing, tripping and power requirements.
7. Consider special applications.

BUS ARRANGEMENTS

Essentially all recognized basic bus arrangements are available in metal-clad switchgear to insure the desired system reliability and flexibility. A choice is made based on an evaluation of initial cost, operating procedures and system requirements. Refer to following for some basic bus arrangements and considerations to evaluate when making the ultimate choice.

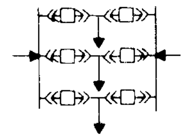
COMMON BUS ARRANGEMENTS

STRAIGHT BUS (RADIAL)



ADVANTAGES: • Low initial cost • Readily adapts to standard indoor or outdoor construction • High reliability factor due to simplicity of system design • Simplified coordination.
DISADVANTAGES: • Inspection, maintenance or repair requires interruption of service • Selectivity between feeders and main crucial if shutdown is to be prevented.

DOUBLE BUS-DOUBLE BREAKER

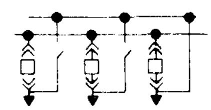


ADVANTAGES: • Good reliability factor • Lends itself to either outdoor (double row walk-in) or indoor metal-clad construction • Provides physical isolation between source buses • Allows inspection and maintenance without load interruption.
DISADVANTAGES: • High cost factor • Increased floor area • Complex operating procedures.

BREAKER AND HALF SCHEME

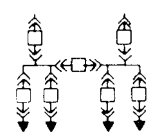
ADVANTAGES: • Good reliability factor • Inspection and maintenance without load interruption • Lends itself to a continuous line arrangement.
DISADVANTAGES: • High cost factor • Additional floor area may be required, depending on final equipment layout.

MAIN AND TRANSFER BUS



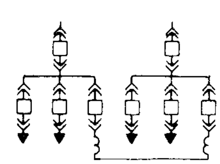
ADVANTAGES: • Provides switching flexibility at reduced cost • Can be provided in a continuous line arrangement • Adaptable to either indoor or outdoor construction • Breakers and disconnect switches can be located in common unit.
DISADVANTAGES: • Interlocking required involving sequential operation of breaker with interlocked switch • Breaker and switch operating mechanism on opposite sides of assembly • Relaying through transfer bus impractical with two or more switches closed • Fault condition on one circuit may cause interruption to several circuits being served by transfer bus.

SECTIONALIZED BUS



ADVANTAGES: • Single bus provides reduced cost over double bus arrangement • Intermediate flexibility and reliability attained through power transfer equipment • Extended reliability can be provided by paralleling feeders to critical loads • Adapts readily to standard construction configurations.
DISADVANTAGES: • Momentary load interruption probable during transfer operation • Delay in transfer may be required to allow decay in residual voltage on down side of tie breaker • Momentary paralleling of supplies may exceed breaker rating.

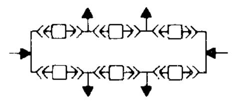
SYNCHRONIZING BUS



ADVANTAGES: • Basic advantages duplicate those of the sectionalized bus but with increased reliability through the addition of sources. Prime advantage is that reactor bus allows strategic installation of current limiting reactors.

DISADVANTAGES: • Basic disadvantages duplicate those of sectionalized bus with increased complexity in relaying of power transfer.

RING
BUS



ADVANTAGES: • Good reliability and flexibility • Low initial cost when compared to a double bus arrangement • Can be arranged in single row line-up when main bus is rated less than 3000 amperes • Adapts to either indoor or outdoor construction • Can be designed to accommodate a multiple-source arrangement.

DISADVANTAGES: • Main bus of 3000 amperes requires overhead bus duct • Relaying increases in complexity as sources are added.

BREAKER SELECTION

Usually, the principal function of power circuit breakers is to carry load current and provide a means for the interruption of short-circuit current. Continuous current ratings of power circuit breakers are generally contingent on feeder and main breaker loading. The breaker interrupting capacity (IC) must be sufficient to safely interrupt the maximum short circuit current that the power system can deliver with a three phase bolted fault applied to the terminals of the circuit breaker. Sometimes frequent switching or reclosing may be the determining factor in breaker selection, rather than the requirements of continuous current rating and/or short-circuit current interruption.

Unusual service conditions as defined in ANSI C37.04 must be considered when applying power circuit breakers. Such conditions should be brought to the attention of the circuit breaker manufacturer at the earliest possible time. Some special application considerations and unusual service conditions are discussed on page 39 and 40.

Power circuit breakers are sometimes used for reclosing duty to maintain service continuity. When applied in this manner, the interrupting capacity of the breaker must be derated in accordance with Figure 1.

A complete line of HK air-magnetic power circuit breakers is available. They are listed in Table 7. Repetitive duty capability and normal maintenance requirements are listed in Table 3.

CAPABILITY FACTORS FOR AUTOMATIC RECLOSING CIRCUIT BREAKERS

The following standard capability factors apply to all a-c high-voltage circuit breakers as shown in American National Standard Schedules of Preferred Ratings and Related Required Capabilities for AC High-Voltage Circuit Breakers, C37.06–1966, 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 I-T-E district sales 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 ANS C37.010–1964 for complete information.

Step #1 Determine the breaker symmetrical interrupting capability at the operating voltage from Table 7.

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 The symmetrical interrupting capability of the breaker for the operating voltage and duty cycle desired is now determined by multiplying the step #1 symmetrical interrupting capability by reclosing capability factor R from Fig. 2 (for duty cycles listed).

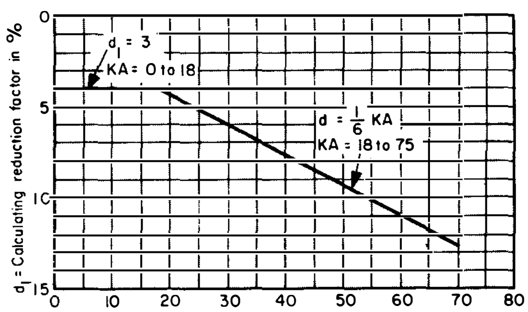


FIG. 1 AC High-Voltage Circuit Breaker Interrupting Capability Factors for Reclosing Service

$$R = 100 - D(\%)$$

$$D = d_1(n-2) + d_1\frac{(15-t_1)}{15} + d_1\frac{(15-t_2)}{15} + \ldots$$

D = total reduction factor in percent

d_1 = calculating factor for D in percent of breaker symmetrical interrupting capability at operating voltage

n = total number of openings

t_1 = first time interval less than 15 sec.

t_2 = second time interval less than 15 sec.

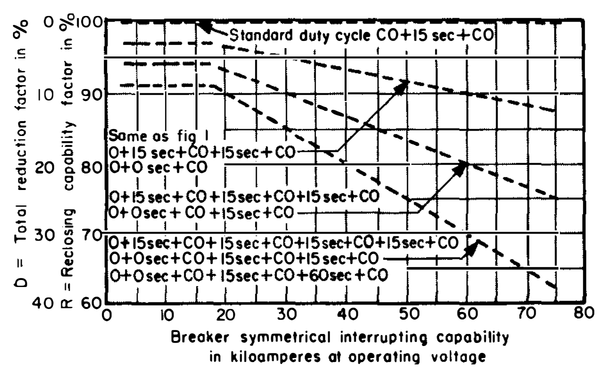


FIG. 2 Examples of Popular Reclosing Capabilities

REPETITIVE DUTY AND NORMAL MAINTENANCE FOR OTHER THAN ARC FURNACE SWITCHING

HK air-magnetic circuit breakers, when operating under usual service conditions, are capable of operating the required number of times given in Table 3. 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 ANS C37.06—1966.) As a guide for capacitor or reactor switching, use values listed in column 5 only. For back-to-back switching applications refer to the nearest I-T-E district sales office.

TABLE 3

Breaker		Maximum No. of Operations Between Servicing (Note A)	Number of Operations				
Type	Continuous Current, A		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
5HK-75	1200	2000	10000	5000	1000	3000	750
5HK-250	1200			5000		3000	
5HK-250	2000			3000		2000	
5HK-350	1200	1000	5000	2500	500	1500	400
5HK-350	2000						
5HK-350	3000						
7.5HK-500	1200	2000	10000	5000	1000	3000	750
7.5HK-500	2000			3000		2000	
15HK-500	1200	2000	10000	5000	1000	3000	750
15HK-500	2000			3000		2000	
15HK-750	1200	2000	10000	5000	1000	3000	750
15HK-750	2000			3000		2000	
15HK-1000	1200	1000	5000	2500	500	1500	400
15HK-1000	2000						
15HK-1000	3000						

Servicing

A. Servicing shall consist of adjusting, cleaning, lubricating, tightening, etc., as recommended by I-T-E. 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.

Condition 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.

MAIN BUS RATING

The continuous current rating of the switchboard main bus should match that of the circuit breaker. HK switchgear has standard, 60 Hz continuous current ratings of 1200, 2000 and 3000 amperes.

The rated continuous current of a switchgear assembly is the maximum current in rms amperes, at rated frequency, which can be carried continuously by the primary circuit components without causing temperatures in excess of limits specified in ANSI C37.20.

The main bus will be designed and rated for the full ampere capacity specified and will not be tapered for the purpose of reducing current densities. As power system facilities must be increased from time to time to serve larger loads, it is advisable to consider future expansion when selecting the bus continuous current rating.

The switchboard assembly should have momentary and short-time ratings equal to the close and latch capability and short-time rating of the circuit breaker. Applicable ratings of HK circuit breakers are listed in Table 7.

CURRENT TRANSFORMERS (See Table 10)

Current transformers are used to transform primary currents into secondary terms, usually 5 amperes. They are used in the application of instruments, meters and relays. In switchgear applications, they are of the wound-type, or through-type construction. They are also manufactured in single-secondary, double-secondary, and multi-ratio types, whichever is required. The double secondary type may be used where two transformers of the same ratio are required in the same location. This affords a saving of space.

Current transformers are used to isolate the primary circuit from the secondary auxiliary equipment and to lower the applicable amperes to a safe and usable value. They are selected so that all ratings such as impulse, dielectric, and voltage are to be equal to or greater than that of the circuit breaker; the primary current rating to be equal to approximately 125 per cent of the normal primary current in the circuit; the mechanical strength of the transformer is to be equal to or greater than that of the breaker; and, the metering and/or, relaying accuracy must be adequate for the imposed burdens.

POTENTIAL TRANSFORMERS (See Table 13)

Potential transformers are used to transform primary voltages into secondary terms, usually 120 volts. The primary rating of a potential transformer is that which is equal to, or higher than the system voltage. For instance, on a 13,800 volt system, a potential transformer with a standard 14,400 volt primary rating is used. As in the use of current transformers, potential transformers are used for instrumentation, metering, or relaying.

Potential transformers are used to isolate the primary circuit from the secondary auxiliary equipment and to lower the voltage to a safe and usable value. They are selected so that all ratings such as impulse, dielectric, etc., must be equal to or greater than the breaker; the accuracy of the transformers must be adequate; and, the primary voltage rating must be equal to or greater than the system voltage.

CONTROL POWER REQUIREMENTS (See Table 8)

GENERAL

The choice of the source of closing and tripping power used in metal-clad switchgear depends upon many factors. Among these factors are the number of circuit breakers in the installation, the number of breakers required to close simultaneously, control power requirements needed for purposes other than operating the circuit breakers, type of circuit breaker mechanism, availability of adequate housing facilities for a battery and its associated charging equipment, and future expansion of the system to justify a shift in economic preference from an a-c to d-c control power source.

HK air-magnetic power circuit breakers are held in the closed position by a mechanical latch. They are designed to close and latch up to the "close and latch" rating listed in Table 7. There is no requirement for a continuous supply of electric power to hold the circuit breaker in the closed position. This allows the circuit breaker to provide maximum continuity of service and speed of operation. However, closing power and a fully reliable source of electric power for tripping are needed. Closing and tripping power requirements of HK breakers are listed in Table 8.

CLOSING POWER

Due to the low-energy closing requirements of the HK stored-energy mechanism, a 48-volt d-c operating battery is an acceptable source of closing power for many applications of metal-clad switchgear. However, some applications, such as large industrial plants, and where d-c power will be used for circuit breaker tripping and closing or operating control, a 125-volt or 250-volt battery may be preferable. There are also instances where a dependable source of auxiliary control power may be required for various emergency services. A station battery is generally the only practical source of electric power for these requirements.

Often, the investment required to provide d-c closing power is unwarranted when compared to the initial cost of metal-clad switchgear. In these instances, a-c closing power supplied from current transformers connected to the switchgear's power system is more economical.

Some basic configurations for providing closing power are shown in Figures 3, 4, 5 and 6 below. Figure 3 represents a simplified schematic of a typical d-c closing power arrangement. Figure 4 shows a-c closing power derived from a control power transformer connected directly to the power system. Also, a-c operation of the stored-energy mechanism can be taken from a lighting or some other general purpose source as illustrated in Figure 5. The energy for the next closing operation is automatically stored in the closing springs, thereby allowing a trip-close-trip sequence of operations if closing power should be lost immediately following closure of the circuit breaker. The stored-energy mechanism also allows for complete manual operation as shown in Figure 6.

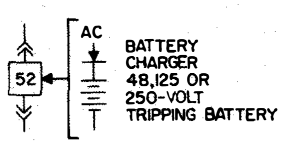


FIG. 3. D-C stored-energy close

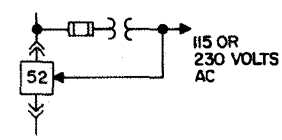


FIG. 4. A-C stored-energy close

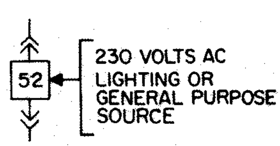


FIG. 5. A-C stored-energy close

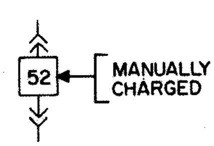


FIG. 6. Manually stored-energy close

TRIPPING POWER

Since a battery is not affected by the power circuit voltage and current conditions during time of fault, it is considered the most dependable source of tripping power. The battery is sometimes further provided with sufficient ampere-hour capacity to carry emergency lighting loads if a protracted outage of a-c power should occur.

Metal-clad switchgear applied in many electrical installations employs a 125- or 250-volt operating battery as the source of tripping power. Most of the smaller metal-clad switchgear installations, however, generally use 230-volt a-c power for control, indication and circuit breaker closing purposes, with a 24- or 48-volt tripping battery as the source of reliable power for circuit breaker tripping.

When a 125- or 250-volt d-c battery is used for closing power, it is generally also utilized for the breaker tripping circuits. A 48-volt tripping battery is recommended for tripping power applications where a 125-volt or 250-volt battery is not available or is not justifiable. It is particularly satisfactory if more than one lineup of metal-clad switchgear is being served or where appreciable distances are involved.

If a tripping battery must be housed in the metal-clad switchgear itself, and the distances involved are short, then a 24-volt battery could be used to conserve space. However, because of excessive voltage drop in the coil leads, contacts, and connections, the recommended use of a 24-volt battery should be limited to equipments with only one line-up of switchgear and with no more than five breakers. The usual application of a 24-volt tripping battery is for location in outdoor, walk-in metal-clad switchgear.

Reliable tripping power requires that the battery be properly maintained. Proper maintenance includes keeping the battery fully charged and the electrolyte maintained at the required level and density to ensure a long life. Also, care should be taken to avoid exposure of the battery to extremely low ambient temperatures which cause reduced voltage output, thereby jeopardizing the battery's circuit breaker tripping capability.

CAPACITOR TRIP

As discussed above, a tripping battery requires appreciable maintenance if it is to remain a dependable source of tripping power. Consequently, on some smaller metal-clad switchgear installations, a capacitor energized trip device has been employed. This device has the advantages of reduced spatial and minimum maintenance requirements. However, it has the serious limitation of being able to provide ample tripping power from the capacitor charge for only a short-time should the a-c control voltage fail.

Tripping power from the capacitor trip unit may not be available to trip a breaker when an attempt is made to re-energize a bus if a fault had occurred on a circuit while the bus was dead. This could occur during maintenance, construction or reconstruction, test operation or during a storm.

This limitation has further prevented the use of capacitor tripping schemes for many applications. It is important to note that when a capacitor-energized trip device is applied as a source of tripping power, it must be supplied on each breaker.

POWER FOR OTHER USES

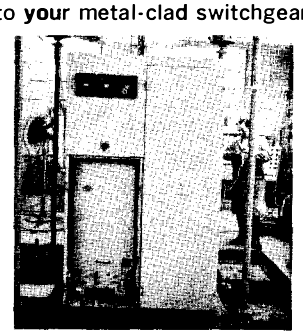
Closing or tripping power may be used for purposes other than closing or tripping power circuit breakers. Power for various control purposes such as space heaters, convenience outlets, lighting, indicating-lamp circuits, exhaust fan motors, sequential and interlocking circuits of automatic equipments, etc. is generally derived from the closing power source. However, should the circuits involved be an integral part of the protective scheme and not embody a continuously energized device, tripping power is used as the source of control power.

Space heaters are supplied as standard on outdoor metal-clad switchgear in accordance with Table 11. Often, ambient temperature or other environmental conditions dictate the use of space heaters in indoor metal-clad switchgear as well. When space heaters are furnished, it is recommended that they be continuously energized by an a-c power source. If a-c closing power is available this source can also be used for the heaters provided it is of sufficient capacity to supply the continuous current requirements of the space heaters and the inrush loading of breaker closing.

SEISMIC REQUIREMENTS

The incidence of seismic (earthquake) survival requirements for metal-clad switchgear installed in nuclear generating stations prompted I-T-E to undertake development of a seismic program. One of the objectives of this program was to conduct testing which gave assurance that I-T-E metal-clad switchgear, incorporating any necessary design modifications, complied with both structural and electrical operating needs arising from certain well defined seismic induced forces..

I-T-E's continuing seismic program has provided knowledge regarding the problem of designing metal-clad switchgear which is certified to withstand seismic experiences at specific locations within certain defined limits of acceleration levels and building natural frequencies. Now, I-T-E stands ready to assist in interpreting seismic requirements as they apply to **your** metal-clad switchgear needs!



THE FULL LINE OF I-T-E TYPE HK CIRCUIT BREAKERS ARE RATED ON A TRUE SYMMETRICAL BASIS

APPLICATION DATA

TABLE 7 **AIR-MAGNETIC POWER CIRCUIT BREAKERS**—Ratings on a symmetrical basis.

Type of Breaker	Nominal Rating		Rated Continuous Current 60 Hertz AMPS-RMS	Rated Voltages			Insulation Level Rated Withstand		Interrupting Ratings† AMPS-Symmetrical			Asymmetrical∅ Rating Factor	Short Time Rating 3 Sec. AMPS-RMS	Close and Latch Rating AMPS-RMS	Interrupting Time Cycles
	Three-Phase MVA	Voltage KV-RMS		Maximum Voltage KV-RMS	K-Factor Max. KV / Min. KV	Minimum Voltage KV-RMS	Low Frequency KV-RMS	Impulse△ 1.2 x 50MS KV-Crest	Maximum KV AMPS-RMS	Nominal KV AMPS-RMS	Minimum KV AMPS-RMS				
5 HK 75	75	4.16	1,200	4.76	1.36	3.50	19.	60.	9,100	10,500	12,500	1.2	12,500	20,000	5
5 HK 250	250	4.16	1,200	4.76	1.24	3.85	19.	60.	30,300	35,000	37,500	1.2	37,500	60,000‡	5
5 HK 250	250	4.16	2,000	4.76	1.24	3.85	19.	60.	30,300	35,000	37,500	1.2	37,500	60,000‡	5
5 HK 350	350	4.16	1,200	4.76	1.19	4.00	19.	60.	42,400	48,600	50,000	1.2	50,000	80,000	5
5 HK 350	350	4.16	2,000	4.76	1.19	4.00	19.	60.	42,400	48,600	50,000	1.2	50,000	80,000	5
5 HK 350	350	4.16	3,000	4.76	1.19	4.00	19.	60.	42,400	48,600	50,000	1.2	50,000	80,000	5
7.5 HK 500	500	7.20	1,200	8.25	1.25	6.6	36.	95.	35,000	40,000	44,000	1.2	44,000	70,000	5
7.5 HK 500	500	7.20	2,000	8.25	1.25	6.6	36.	95.	35,000	40,000	44,000	1.2	44,000	70,000	5
15 HK 500	500	13.8	1,200	15.0	1.30	11.5	36.	95.	19,300	21,000	25,000	1.2	25,000	40,000*	5
15 HK 500	500	13.8	2,000	15.0	1.30	11.5	36.	95.	19,300	21,000	25,000	1.2	25,000	40,000*	5
15 HK 750	750	13.8	1,200	15.0	1.30	11.5	36.	95.	28,900	31,500	37,500	1.2	37,500	60,000‡	5
15 HK 750	750	13.8	2,000	15.0	1.30	11.5	36.	95.	28,900	31,500	37,500	1.2	37,500	60,000‡	5
15 HK 1000	1,000	13.8	1,200	15.0	1.30	11.5	36.	95.	38,500	42,000	50,000	1.2	50,000	80,000	5
15 HK 1000	1,000	13.8	2,000	15.0	1.30	11.5	36.	95.	38,500	42,000	50,000	1.2	50,000	80,000	5
15 HK 1000	1,000	13.8	3,000	15.0	1.30	11.5	36.	95.	38,500	42,000	50,000	1.2	50,000	80,000	5

Notes: †—For operating voltages other than those listed the interrupting Current = Amps at Max. KV $\frac{\text{Max. KV}}{\text{Operating KV}}$ but in no case can this current exceed the Interrupting Current at Minimum KV.

*—60,000 Amp also available.

‡—80,000 Amp also available.

∅—Rating factor is based on breaker speed from initiation to contact parting with ½ cycle relay time. Multiply factor × symmetrical current to obtain asymmetrical current interrupting capability of breaker.

△—These values apply with circuit breaker in or out of switchboard.

TABLE 8

CONTROL POWER REQUIREMENTS						
	Closing Coil		Tripping Coil		Charging Motor	
Nominal Control Voltage	Voltage Range, Volts	Average Current, A	Voltage Range, Volts	Average Current, A	Voltage Range, Volts	Average Current A
24V D-C△	—	—	14-30	22.0	—	—
48 V D-C	35–50	10.7	28–60	10.7	35-50	20
125 V D-C	90–130	6.7	70–140	6.7	90–130	10
250 V D-C	180–260	2.2	140–280	2.2	180–260	5
115 V A-C	95–125	4.5	95–125	4.5	95–125	10
230 V A-C	190–250	2.3	190–250	2.3	190–250	5

△Unless the circuit breaker is located close to the battery and relay and adequate electrical connections are provided between the battery and trip coil, 24-volt tripping is not recommended.

TABLE 10

STANDARD CURRENT TRANSFORMERS						
RATIO*	RELAYING† ACCURACY	METERING ACCURACY†				
	10H	BO.1	BO.2	BO.5	B1	B2
75/5	10	0.6	1.2	—	—	—
100/5	10	0.6	1.2	—	—	—
150/5	20	0.3	0.6	1.2	—	—
200/5	20	0.3	0.6	1.2	—	—
300/5	50	0.3	0.3	0.3	0.6	1.2
400/5	50	0.3	0.3	0.3	0.3	0.6
600/5	100	0.3	0.3	0.3	0.3	0.3
800/5	100	0.3	0.3	0.3	0.3	0.3
1200/5	200	0.3	0.3	0.3	0.3	0.3
1500/5	200	0.3	0.3	0.3	0.3	0.3
2000/5	200	0.3	0.3	0.3	0.3	0.3
2500/5	200	0.3	0.3	0.3	0.3	0.3
3000/5	200	0.3	0.3	0.3	0.3	0.3
4000/5	200	0.3	0.3	0.3	0.3	0.3

*Front mounted CT's are available only up to 2000/5A.

†For higher accuracies, refer to the nearest I-T-E district sales office.

TABLE 12

Standard Single Phase Control Power Transformers	
KVA	Voltage
5	2400—240/120
	4160—240/120
10	4800—240/120
	7200—240/120
15	8400—240/120
	13200—240/120
25	13800—240/120

TABLE 9

HK BREAKER TIME CHARACTERISTICS				
Breaker	Av. Closing	Av. Tripping	Av. Spring Charging	Interrupting Time 0-100% of Rating
5 HK	4.5 Cycles	1.5 Cycles	2 Seconds	5 Cycles
7.5 & 15 HK	7.5 Cycles			
15 HK 1000	6 Cycles	2.0 Cycles	2 Seconds	5 Cycles

Closing Time—Between energizing closing coil and making of arcing contacts.
Tripping Time—Between energizing of trip coil and parting of arcing contacts.
Interrupting Time—Between energizing trip coil and complete interruption.

TABLE 11

Space Heaters for Outdoor Equipment*		
Type Unit	No. of Heaters Per Frame	Total Watts Per Frame
5 HK	2	300
7.5 & 15 HK	3	450

*Space heaters on indoor equipment are an optional addition.

TABLE 13

Standard Potential Transformers
2400/4160y—120
2400—120
4200—120
4800—120
7200—120
8400—120
12000—120
14400—120

LET'S EXAMINE THE DIFFERENCE BETWEEN ASYMMETRICAL, "CLASS" SYMMETRICAL AND "TRUE" SYMMETRICAL INTERRUPTING RATINGS.

Until mid-1964, ANSI standards called for asymmetrical ratings on all circuit breakers from 5 kV-75 MVA through 15 kV-1000 MVA. To achieve this rating, the circuit breaker MVA was calculated by use of the following formula:

Applied Voltage × Highest Asym. Phase Current × $\sqrt{3}$ = MVA

This approach led to some misapplication since it did not duplicate the conditions that occur on an actual system. The recovery voltage on a test circuit might drop considerably below the applied voltage. This is contrary to a real system where the recovery voltage would be almost equivalent to the applied voltage. I-T-E pioneered the use of recovery voltage (instead of applied voltage) and symmetrical currents (in place of asymmetrical) to calculate breaker ratings, and in 1959 began to test all of its breakers on this basis. In all tests, I-T-E used methods that produced recovery voltages equal to applied voltages.

Following this approach, I-T-E used the following formula to calculate its rating.

Recovery Voltage × Average Sym. Current × $\sqrt{3}$ = MVA

It is now easy to see that when these two methods are compared, the I-T-E rating and the ANSI rating were considerably different. I-T-E circuit breakers had a great plus value and the application to the system to be protected was considerably simplified.

Let's compare with the following example:

Test generator voltage (applied)	17.2 kV
Recovery voltage (normal frequency)	15.0 kV
Short-circuit current: Phase A	26.6 kA
Phase B	25.5 kA
Phase C	21.2 kA
Average a-c component (symmetrical)	21.2 kA
Total current (asymmetrical)	26.6 kA

From the following calculation, we will see that a circuit breaker could be rated 750 MVA on an asymmetrical basis; whereas, I-T-E would only rate the breaker 500 MVA symmetrical.

I-T-E "true" MVA = 21.2 kA × 15.0 kV × 1.73 = 550 MVA symmetrical

ANSI allowable MVA = 26.6 kA × 17.2 kV × 1.73 = 790 MVA asymmetrical

Further, the "true" asymmetrical rating of this breaker (using recovery voltage) should be only 690 MVA, i.e. "True" asymmetrical MVA = 26.6 kA × 15.0 kV x 1.73 = 690 MVA

In 1964 ANSI converted to a symmetrical system with the use of recovery voltage, but only on part of the full breaker line, 5 kV-75 MVA, 5 kV-250 MVA and 15 kV-500 MVA. Then in 1968 they added the 5 kV-350 MVA, 7.5 kV-500 MVA and the 15 kV-750 MVA.

In 1969 ANSI also converted the 15 kV-1000 MVA breaker to a symmeterical current rating basis.

To futher complicate matters, ANSI symmetrical calculations still do not fully meet the "true" symmetrical test. A compromise method of rating was reached whereby an arbitrary MVA value has been assigned.

EXAMPLE: on a 15 kV-500 MVA Breaker:
ANSI Standards Requirement—18,000 Sym. Ampere Interrupting
I-T-E "TRUE" Symmetrical Requirement—19,300 Sym. Ampere Interrupting

When you calculate the MVA rating of the breaker, you see that:

15 kV × 19,300 × $\sqrt{3}$ = 500 MVA—This is a full symmetrical rating which meets the "TRUE" symmetrical test

BUT:

15 kV × 18,000 × $\sqrt{3}$ = 468 MVA—This is all that is required by ANSI to call this a 500 MVA breaker.

Because the ANSI requirement does not meet a full symmetrical MVA rating, ANSI has introduced a new term to the industry called "Class" MVA .

Therefore, a breaker may be designated a 500 MVA "class" even though it cannot achieve a "true" full 500 MVA symmetrical rating.

I-T-E is the only manufacturer to rate its breakers on the "true" symmetrical basis.

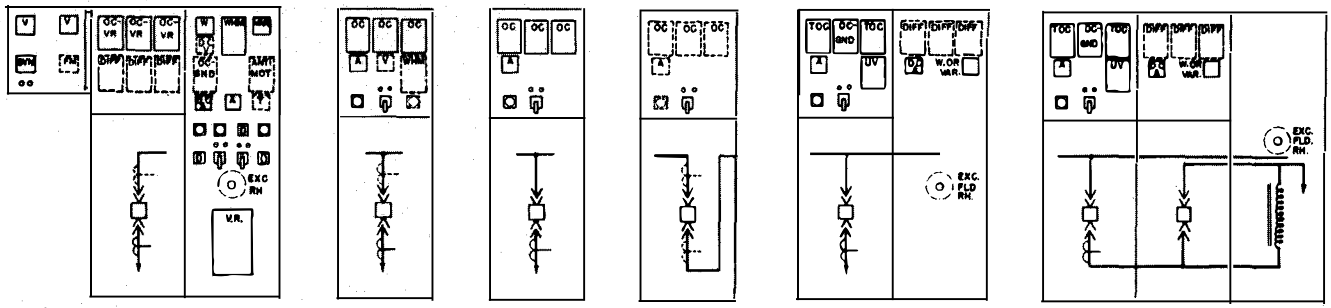
The following table demonstrates the superiority of I-T-E ratings compared with the present ANSI standards.

ANSI "CLASS" SYMMETRICAL STANDARD VS. I-T-E "TRUE" SYMMETRICAL STANDARD

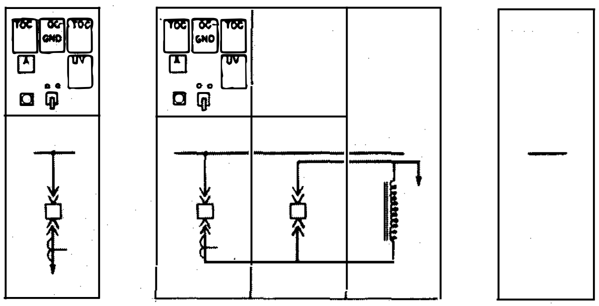
Type	ANSI "Class" Inter. Amperes Sym.	I-T-E Inter. Amperes Sym.	Calculated MVA of ANSI "Class" Ratings		I-T-E "True" MVA Sym.
			"Class" Sym.	Calculated Sym.	
5HK-75	8,800	9,100	75	72.6	75
5HK-250	29,000	30,300	250	239.1	250
5HK-350	41,000	42,400	350	338.0	350
7.5HK-500	33,000	35,000	500	471.5	500
15HK-500	18,000	19,300	500	467.7	500
15HK-750	28,000	28,900	750	727.4	750
15HK-1000	37,000	38,500	1000	960.2	1000

Remember, I-T-E's are the only circuit breakers that fulfill the "true" symmetrical rating throughout the entire line. For a more complete discussion of symmetrical ratings see I-T-E Bulletin No. A.3-1A.

PANEL ARRANGEMENTS



A SYNCHRONIZING PANEL
B GENERATOR & EXCITER
C INCOMING UNIT
D FEEDER UNIT
E BUS TIE UNIT
F SYNCHRONOUS MOTOR FULL VOLTAGE START
G SYNCHRONOUS MOTOR REACTOR START LINE-SERIES TYPE



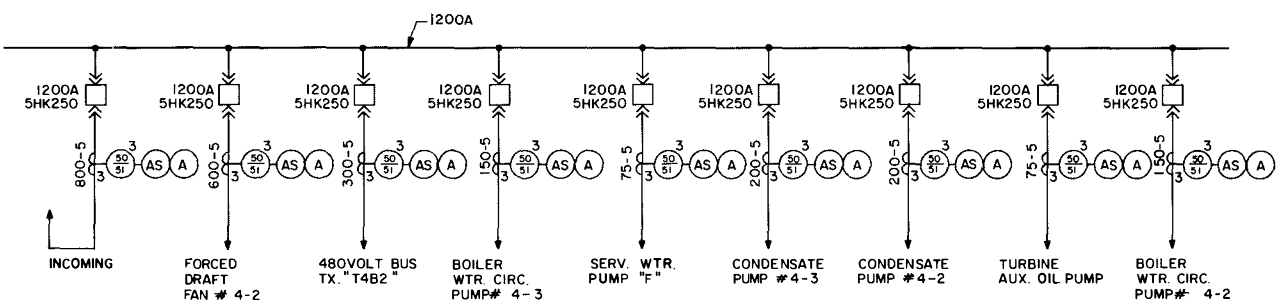
H INDUCTION MOTOR FULL VOLTAGE START
J INDUCTION MOTOR REACTOR START LINE-SERIES TYPE
K AUXILIARY UNIT

SYMBOLS

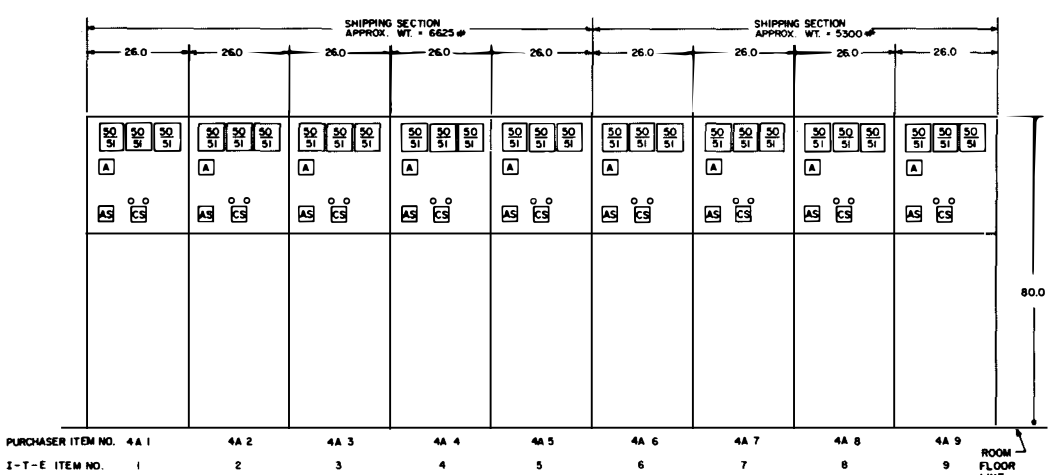
A	AMMETER (A. C. IF NOT MARKED)
V	VOLTMETER (A. C. IF NOT MARKED)
W	WATTMETER
VAR	VARMETER
WHM	WATTHOUR METER
T	TEMPERATURE METER
FM	FREQUENCY METER
SYN	SYNCHROSCOPE
VR	VOLTAGE REGULATOR
OC	OVERCURRENT RELAY
OC-GND	GROUND (RESIDUAL) O-C RELAY
TOC	THERMAL OVERCURRENT RELAY
OC-VR	OC RELAY WITH VOLT. RESTRAINT
UV	UNDERVOLTAGE RELAY
DIFF	PERCENTAGE DIFFERENTIAL RELAY
ANTI-MOT	ANTI-MOTORING (POWER DIR.) RELAY

Complete description of panel arrangements A through K appear in specifications on pages 44 and 45.

TYPICAL SINGLE-LINE DIAGRAM



TYPICAL GENERAL ARRANGEMENT DRAWING



TYPICAL 5, 7.5 & 15 HK METAL-CLAD SWITCHGEAR SPECIFICATIONS

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

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

GENERAL

(indoor — outdoor — outdoor walk-in) 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 horizontal drawout air-magnetic circuit breakers. The switchboard and circuit breaker either individually or as a unit shall have an impulse rating of (60 — 95) KV. The entire switchgear, including air circuit breakers, meters, relays, etc., shall be completely factory tested and breakers of like ratings shall be interchangeable.

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 providing two thicknesses of painted steel between units. Each breaker unit structure shall be segregated by metal-sheets into the following separate compartments:

(1) Circuit breaker
(2) Main bus
(3) Instrument
(4) Current transformer (5HK only)
(5) Auxiliary device
(6) Cable

CIRCUIT BREAKER COMPARTMENT

Each circuit breaker compartment shall be designed to house a horizontal drawout (4160 — 7200 — 13800) volt air-magnetic circuit breaker. The stationary primary disconnecting contacts shall be constructed of silver-plated copper. All movable contact fingers and springs shall be mounted on the circuit breaker where they may easily be inspected. The entrance to the stationary primary disconnecting devices shall be automatically covered by a shutter when the circuit breaker is withdrawn to the test position, disconnected position or removed from the switchboard.

CABLE COMPARTMENT

The lower primary disconnecting contacts shall be supported by means of flame-retardant, track-resistant polyester glass (5 HK) or porcelain (15 HK) bushings which extend into the cable compartment. (Clamp type cable terminals will be bolted to the outgoing bus by means of an adapter) (________ potheads suitable for terminating ________ cable will be furnished.) A completely silver-plated ground bus shall extend through the length of the switchgear.

BUS COMPARTMENT

Removable panels shall be provided for access to the bus compartment. The main bus shall be rated (1200 — 2000 — 3000) amperes. All bus bars shall be silver-plated, and bolted connections shall be used. The conductors shall be insulated by means of flame-retardant, track-resistant epoxy insulation. Flame-retardant, track-resistant polyesterglass (5 HK) or porcelain (15 HK) bus supports shall support the insulated bus.

DOORS AND PANELS—INDOOR

The relays, meters, instruments, control switches, etc. shall be mounted on a formed front hinged panel. The cable compartment shall have hinged doors. All surfaces shall be phosphate treated and painted with an oven baked, corrosion resistant epoxy enamel finish. Color of finish shall be light gray, ANSI #61.

DOORS AND PANELS—OUTDOOR

The relays, meters, instruments, control switches, etc. shall be mounted on a formed hinged panel. The panel shall be mounted in a compartment located on the same side of the switchgear as the circuit breaker compartment.

All weatherproof exterior doors shall be provided with suitable fasteners. Cleanable metallic filters and screens shall cover the louvers. All surfaces shall be phosphate treated and one finish coat of oven baked, corrosion resistant acrylic enamel paint shall be applied to all surfaces. The color of the finish coats shall be dark gray, ANSI #24.

CIRCUIT BREAKERS

The circuit breakers shall be rated (4160 — 7200 — 13800) volts, 60 Hertz, having a continuous current rating of (1200 — 2000 — 3000) amperes and interrupting rating of (75 — 250 — 350 — 500 — 750 — 1000) MVA. All circuit breakers of equal rating shall be completely interchangeable.

The circuit breaker shall be operated by means of a stored-energy mechanism, which is normally charged by a small universal motor, but which can also be charged by a manual handle for emergency manual closing or test. The mechanism shall be so arranged that the closing speed of the contacts is independent of both control voltage and of the operator.

The circuit breaker shall have three independent arc chutes, each containing face wound blowout coils to produce transverse flux during interruption of the circuit.

The circuit breaker shall be equipped with secondary disconnecting contacts which shall automatically engage in the operating and test position to complete circuits as required.

The circuit breaker shall have a means for racking in and out of the compartment and between positions. It shall furthermore be provided with a means for holding the circuit breaker in the compartment in all positions.

Interlocking shall be provided making it impossible to rack a closed circuit breaker to or from any position. As an optional feature, it is possible to padlock the circuit breaker in either the disconnect or the test position. An additional interlock shall be provided which shall assure automatic discharging of the closing springs upon insertion or removal of the breaker into or out of the compartment.

The circuit breaker shall be equipped with means for manually closing and manually opening the contacts and also to close the contacts slowly for inspection purposes.

The circuit breaker control voltage shall be: (48 — 125 — 250 d-c; 115 — 230 a-c, 60 Hertz) volts. (For 48 v d-c application, battery should be mounted in the switchboard.)

INSTRUMENT TRANSFORMERS

Current Transformers—The current transformers shall have ratios as indicated in the details of each switchboard unit. The transformers shall have mechanical rating equal to the momentary rating of the circuit breakers. The current transformers shall be insulated for full voltage rating of the switchgear. Relay and metering accuracy shall be as indicated on the details for each switchboard unit. Means shall be provided in the switchboard for conveniently shorting the secondary winding.

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

CONTROL WIRING

Switchgear wire shall be #14 AWG, except where larger is specified. The switchgear shall be provided with terminal blocks for outgoing control connections.

DRAWINGS

Promptly upon award of the contract, the manufacturer shall furnish drawings for (approval — record) showing the General Arrangement and Schematic Diagrams. These drawings shall supply all installation and coordination data required by Purchaser for the preparation of electrical and mechanical details necessary to the installation of the switchgear by Purchaser.

INSPECTION

The completed switchgear shall be available for Purchaser's inspection at the manufacturer's plant before shipment, if specified. The manufacturer shall submit satisfactory test data to the Purchaser, if required, to prove operation and performance of the switchgear in accordance with the specifications.

UNIT A—SWINGING INSTRUMENT PANEL.

A swinging steel instrument panel shall be mounted on the (right — left) hand end of the switchboard for the following instruments:

2 — Voltmeters, 0-________ volt scale.
1 — Synchroscope
2 — Indicating lights for synchronizing
1 — Frequency meter (optional)

UNIT B—GENERATOR AND EXCITER PANELS

The metal-clad switchgear for the 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 transformer ________-5 ratio to be connected in generator neutral for differential protection.

The auxiliary unit shall contain:

1 — A-c, ammeter, 0-________ scale.
1 — Polyphase indicating wattmeter.
1 — Polyphase watthour meter, ________ element.
1 — Polyphase varmeter.
1 — D-c field ammeter, 0-________ scale, and shunt.
1 — D-c voltmeter, 0-________ scale (optional).
1 — Temperature indicator, 0 ________ degrees scale (optional).
1 — Auxiliary tripping relay for differential protection (optional).
1 — Anti-motoring relay (required for parallel operation).
1 — Overcurrent ground relay (optional).
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 (optional).
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 (optional for bus potential)
1 — Set of insulated bus, ________ amp.
1 — Drawout field breaker, electrically operated

UNIT C—INCOMING LINE UNIT

The metal-clad switchgear for the control of an incoming line 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.
3 — Overcurrent relays, instantaneous and time overcurrent.
1 — Breaker control switch with red and green indicating lights.
1 — Ammeter, 0-________ scale.
1 — Ammeter transfer switch.
1 — Voltmeter (optional)
1 — Voltmeter switch (optional)
1 — Watthour meter, ________ element (optional)
3 — Directional overcurrent relays (with — without) instantaneous trip. (optional)
2, 3 Drawout potential transformers, ________-120 volt ratio. (optional)
Necessary cable terminations.

UNIT D—FEEDER UNIT

The metal-clad switchgear for the control of a feeder circuit 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.
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.

UNIT E—BUS SECTIONALIZING UNIT

The metal-clad switchgear for bus sectionalizing shall contain:
1 — (4160 — 7200 — 13800) 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.
3 — Current transformers, ________-5 ratio (optional)
3 — Overcurrent relays, instantaneous and time overcurrent (optional)
1 — Ammeter (optional)
1 — Ammeter switch (optional)

UNIT F—SYNCHRONOUS MOTOR CONTROL—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 — (4160 — 7200 — 13800) volt air circuit breaker, ________ amp, 3-pole, electrically operated stored energy.
1 — Set of insulated bus, ________ amp.
2 — Current transformers, ________-5 ratio, phase.
2 — Thermal overload relays with instantaneous trip type TMC.
1 — Overcurrent relay, instantaneous and/or 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 — A-c ammeter, 0-________ scale.
1 — Ammeter switch.
1 — Breaker control switch with red and green indicating lights.
3 — Overcurrent relays, long-time overcurrent (one relay to be equipped with instantaneous attachment) (optional—locked rotor or starting—use when motor characteristics are not matched by thermal relays.)
1 — Current transformer ________-5 ratio (optional for use with long time and instantaneous current relay).
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 (where necessary) field forcing equipment (where necessary) 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.
2, 3 Drawout potential transformers, ________-120 volt (optional, if needed for relaying)
Field forcing relays when required.
3 — Lightning arresters
1 — Surge capacitor, 3-phase
Necessary cable terminations.
For motors rated above 1500 HP and for motors rated above 500 HP when the service voltage exceeds 5 KV the following is recommended:
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).

UNIT G—SYNCHRONOUS MOTOR CONTROL—REACTOR START

(Line Series — Line Parallel — Neutral)
The following additional equipment (see Unit F) is required for reactor starting of a synchronous motor. The reactor shorting breaker unit shall contain:
1 — (4160 — 7200 — 13800) 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.
3 — Current transformers, ________-5 ratio (optional—necessary for line parallel-type connections)
The reactor unit shall contain: (In some cases this may be combined with the auxiliary compartment indicated as part of Unit F)
1 — 3-phase starting reactor, ________ duty.
1 — Set of necessary primary connections to shorting breaker.

UNIT H—INDUCTION MOTOR CONTROL—FULL VOLTAGE

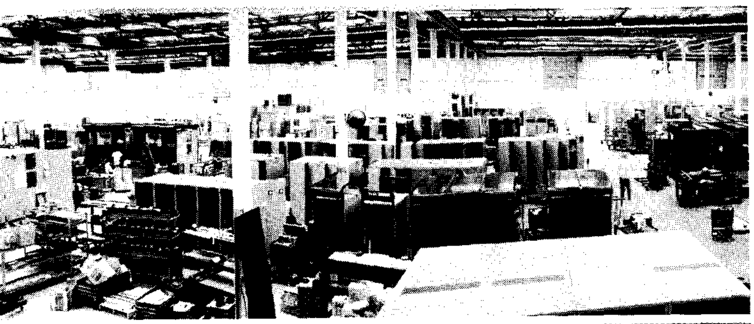
The metal-clad switchgear for the control of an induction motor shall contain:
1 — (4160 — 7200 — 13800) volt air circuit breaker, ________ amp, 3-pole, electrically operated stored energy.
1 — Set of insulated bus, ________ amp.
2 — Current transformers, ________-5 ratio, phase.
2 — Thermal overload relays with instantaneous trip type TMC.
1 — Overcurrent relay, instantaneous and/or 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 — A-c ammeter, 0-________ scale.
1 — Ammeter switch.
1 — Breaker control switch with red and green indicating lights.
3 — Overcurrent relays, long-time overcurrent (one relay to be equipped with instantaneous attachment) (optional—locked rotor or starting—use when motor characteristics are not matched by thermal relays.)
1 — Current transformer, ________-5 ratio (optional, for use with long time and instantaneous overcurrent relay.)
3 — Lightning arresters
1 — Surge capacitor, 3-phase
Necessary cable terminations.
For motors rated above 1500 HP and for motors rated above 500 HP when a service voltage exceeds 5 KV the following is recommended:
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.)

UNIT J—INDUCTION MOTOR CONTROL—REACTOR START

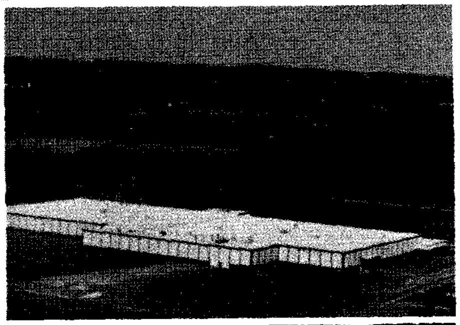
(Line Series — Line Parallel — Neutral)
The following additional equipment (See Unit H) is required for reactor starting of an induction motor. The reactor shorting breaker unit shall contain:
1 — (4160 — 7200 — 13800) volt air circuit breaker, ________ amp, 3-pole, electrically operated stored energy.
1 — Timing relay and necessary auxiliary relays.
1 — Set of insulated bus, ________ amp.
1 — Set of necessary primary connections to reactor.
3 — Current transformers, ________-5 ratio (optional—necessary for parallel type connection)
The reactor unit shall contain: (In some cases this may be combined with the auxiliary compartment indicated as part of Unit H)
1 — 3-phase starting reactor, ________ duty.
1 — Set of necessary primary connections to shorting breaker.

UNIT K—AUXILIARY COMPARTMENT

Auxiliary units shall be furnished (as required) to house the following equipment:
( ) Drawout potential transformers with current limiting fuses.
( ) Stationary mounted control power transformer with drawout current limiting fuses. (2400 — 4160 — 7200 — 13800 V)
( ) Tripping battery and charger. ( ) Utility company revenue metering.
( ) Bus Entrance. ( ) Annunciators.
( ) Lightning arresters. ( ) Surge capacitors.
( ) Instruments. ( ) Meters. ( ) Relays.

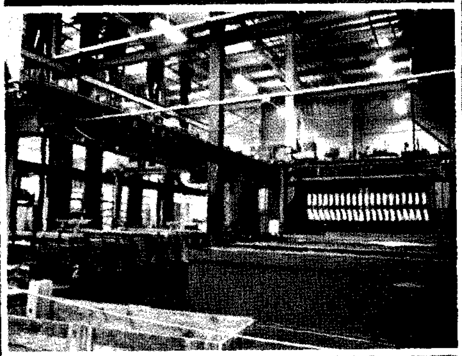


Final assembly and wiring work in process at Chalfont facility.



Aerial view of 300,000 sq. ft. Switchboard manufacturing plant located in Chalfont, Pa.

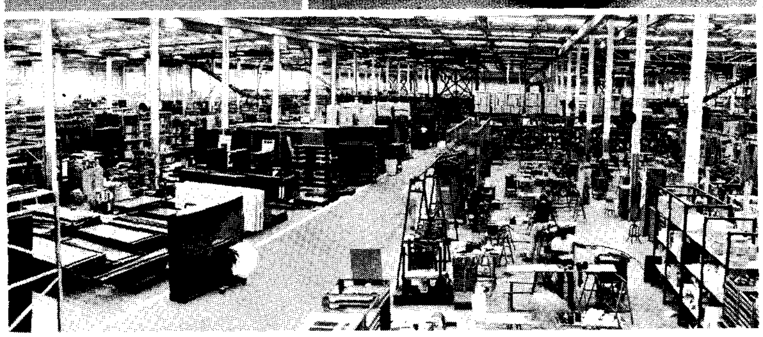
Fully automated electroplating system produces all silver-plated bus used in HK metal-clad switchgear.

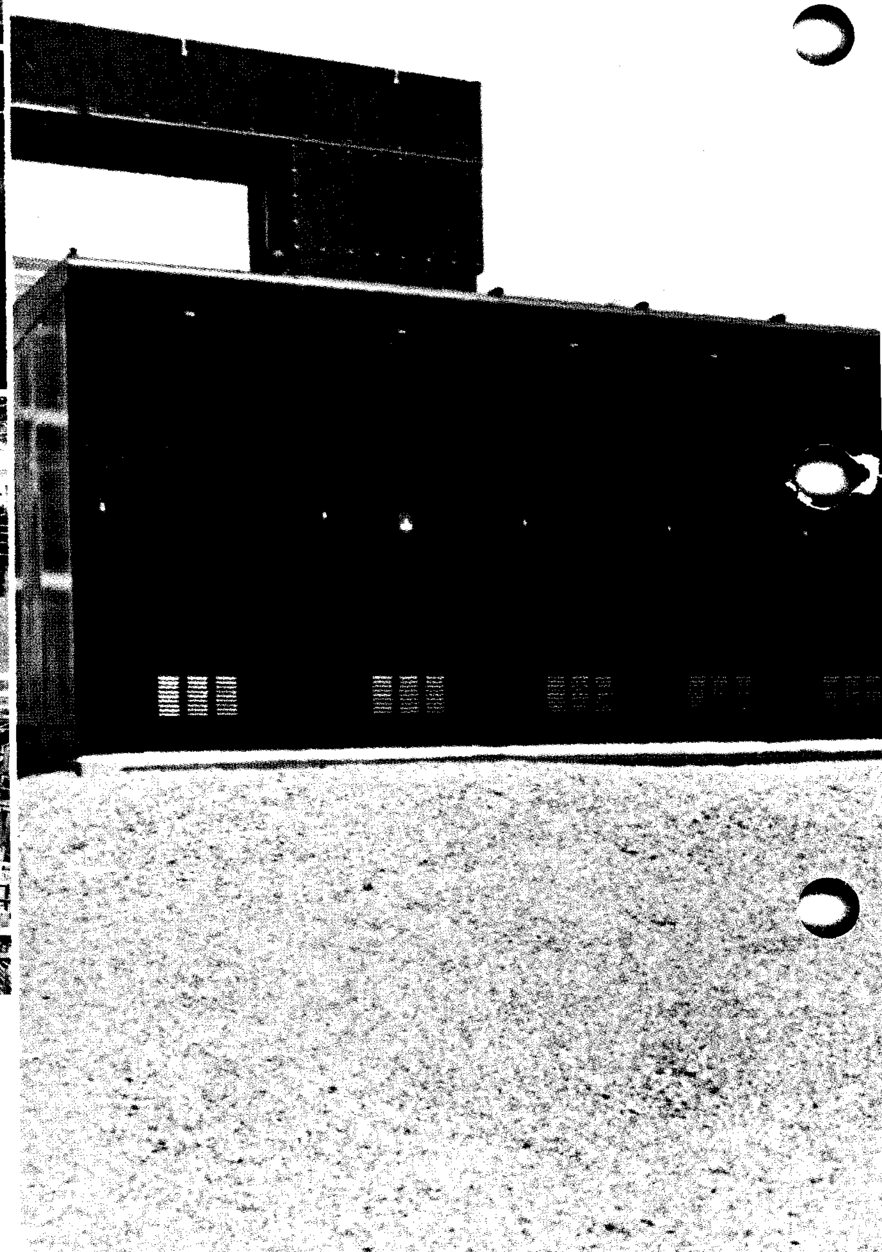


New fully automated "electro-coating" paint equipment in operation.

Numerically - controlled Wiedemann turret type metal press.

Chalfont sub-assembly area.





The Switchgear Division of I-T-E Imperial Corporation's Power Equipment Group manufactures and assembles switchboards for 5, 7.5 & 15 HK metal-clad switchgear in the ultra-modern plant located at Chalfont (suburban Philadelphia), Pa. Material flow through this facility is optimized by its single story construction, permitting raw stock input at one end of the building, complete manufacture and testing, and final product shipment from the other end.

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I-T-E Imperial Corporation

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