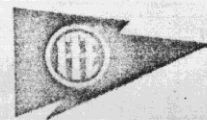
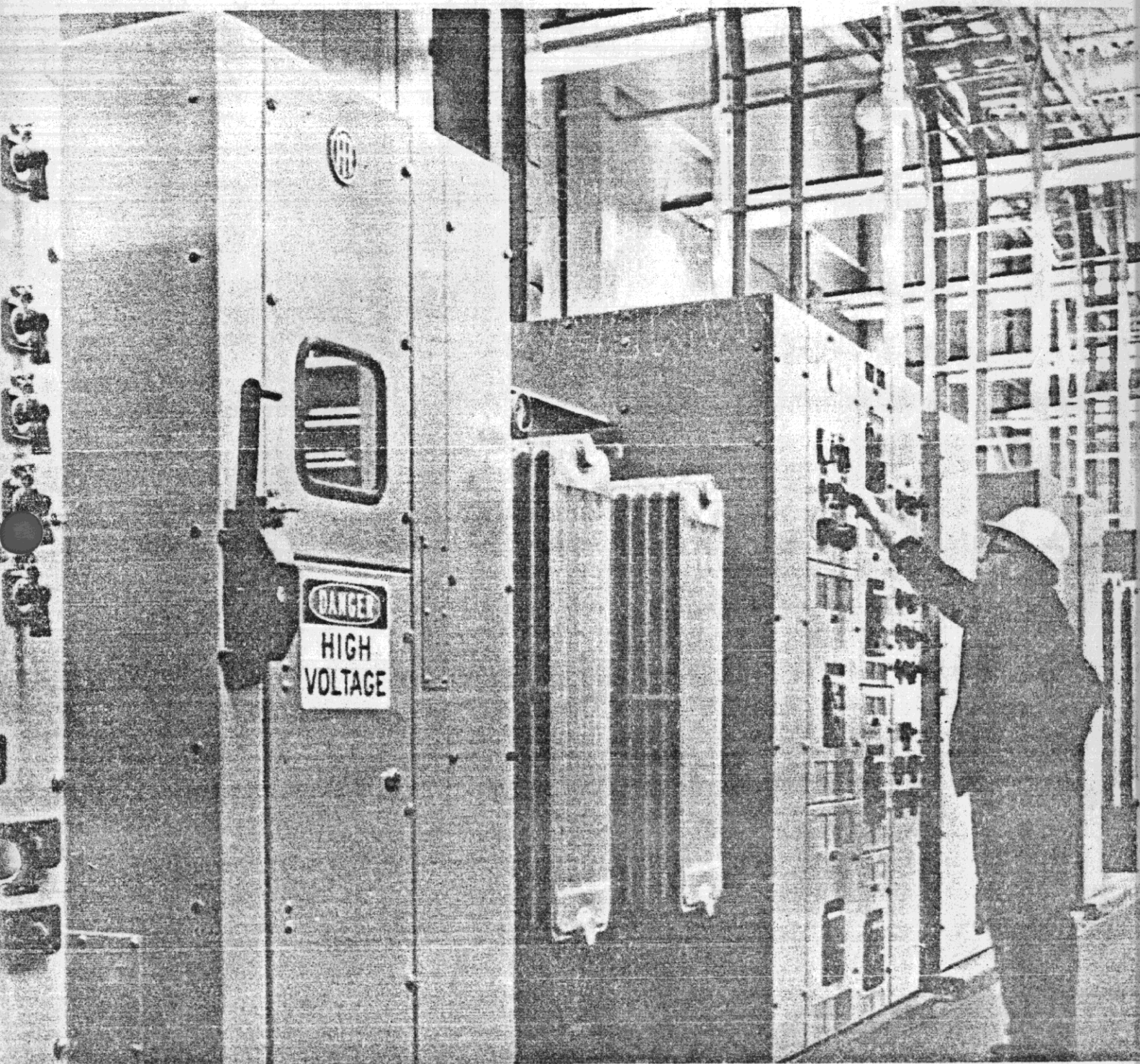


SECONDARY UNIT SUBSTATIONS

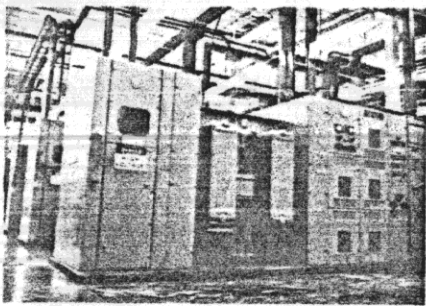


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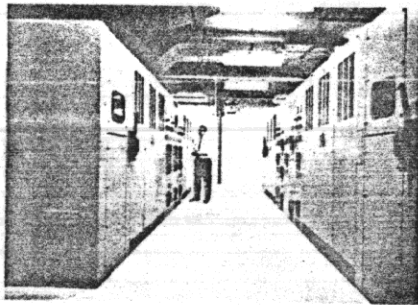
including Low-Voltage Metal-Enclosed Switchgear
with Drawout K-LINE® and K-DON® Power Circuit Breakers



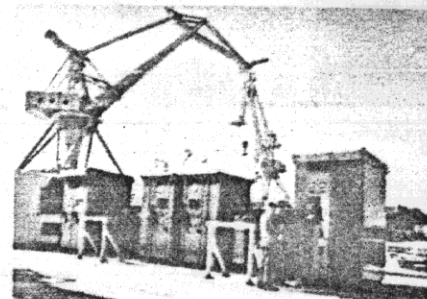
- 112½ — 2500 kVA
- Primary Voltage: 2.4 kV — 13.8 kV
- Secondary Voltage: 208/120 — 600 Volts
- Indoor or Outdoor Sheltered-Aisle, Walk-In
- Liquid, Ventilated or Sealed-Dry Transformers



Indoor Secondary Unit Substation consisting of Air Interrupter Switch, Askarel Transformer and Low-Voltage Switchgear.



Indoor Secondary Unit Substation consisting of Air Interrupter Switch, Ventilated-Dry Transformer and Low-Voltage Switchgear.



Outdoor Secondary Unit Substation installation.

I-T-E SECONDARY UNIT SUBSTATIONS

WHAT IS A UNIT SUBSTATION?

A unit substation is a substation consisting primarily of one or more transformers which are mechanically and electrically connected to, and coordinated in design with, one or more switchgear or motor control assemblies, or combinations thereof.

SECONDARY UNIT SUBSTATION

A secondary unit substation is a unit substation in which the outgoing low-voltage section is rated below 1000 volts. Principal areas of application include use in industrial plants, electric power generating stations, and commercial buildings.

An articulated secondary unit substation is a common type of secondary unit substation consisting of:

- An incoming line section which provides for the connection of one or more incoming high-voltage circuits, each of which may or may not be provided with a switching device or a switching and interrupting device.
- A transformer section which includes one or more transformers.
- An outgoing section which provides for the connection of one or more outgoing feeders, each of which is provided with a switching and interrupting device.

These sections are normally sub-assemblies intended for connection in the field.

PURPOSE OF SECONDARY UNIT SUBSTATIONS

The trend towards location of electrical distribution systems close to the

center of loads has become very prevalent in recent years. The secondary unit substation is compatible with this systems design concept because the wide array of components to select from allows tailoring it to your exact application needs. For example, the availability of askarel-filled and dry type transformers permit installation of secondary unit substations in buildings close to the load without the need of costly fire containment equipment. Secondary unit substations provide other benefits and advantages over older distribution methods:

- Reduced power losses.
- Improved continuity of service.
- Increased flexibility.
- Better voltage regulation.
- Less installation expense.
- Efficient space utilization.

FEATURES OF I-T-E SECONDARY UNIT SUBSTATIONS

I-T-E has been designing, engineering and manufacturing secondary unit substations since 1943. Throughout this long history of product manufacture, I-T-E has established itself as a reliable supplier of secondary unit substations. Some salient features of I-T-E secondary unit substations are:

- Lower transformer and switchgear weight.
- Reduced floor space.
- Increased personnel safety.
- Coordinated engineering.
- Simplified purchasing.
- Prompt delivery.
- Design flexibility.

SEISMIC REQUIREMENTS

The Low-Voltage, Metal-Enclosed Switchgear has successfully passed a seismic test plan which was prepared in accordance with IEEE Std. 344-1971. Extensive testing has been accomplished as recently as 1974, and certified test results are available.

QUALITY ASSURANCE

The Atomic Energy Commission has issued regulations pertaining to Quality Assurance Criteria for Nuclear Power Plants (10 CFR 50 Appendix B).

Further ANSI N 45.2-1971 defines Quality Assurance Program Requirements for Nuclear Power Plants.

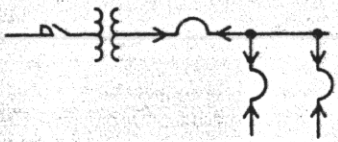
In addition, a working group has issued a draft of ANSI 45.2.14-1974 "Quality Assurance Program Requirements for the Manufacture of Class IE Instrumentation and Electrical Equipment for Nuclear Power Generating Systems." The last documentation has not been approved as yet but is being used as a guide.

These documents are used as references in the implementation of the I-T-E Imperial Corporation Switchgear Division Quality Assurance Program. Our quality assurance organization is aligned with the basic criteria of the documents mentioned above.

NEC & OSHA REQUIREMENTS

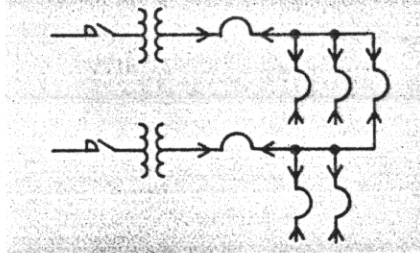
NEC generally describes parameters and techniques for a safe installation, which is also the concern of OSHA. I-T-E equipment is safe and reliable. If there are any questions regarding I-T-E equipment relative to above requirements, contact the Switchgear Division for latest information.

SELECT THE SYSTEM



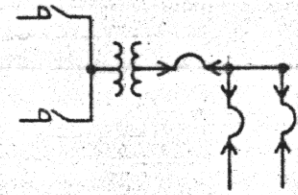
RADIAL

This system generally has a single incoming primary device, single stepdown transformer and an outgoing section for the connection of one or more outgoing power circuit breakers.



SECONDARY-SELECTIVE

This system generally has two incoming primary devices and two stepdown transformers. The outgoing side of each transformer is connected to a separate bus through a power circuit breaker. The two sections of bus are connected by a normally open power circuit breaker. Each bus has one or more outgoing power circuit breakers.



PRIMARY-SELECTIVE

This system contains two incoming primary devices connected to a single stepdown transformer and an outgoing section for the connection of one or more outgoing power circuit breakers.

SELECT THE COMPONENTS

INCOMING LINE SECTION

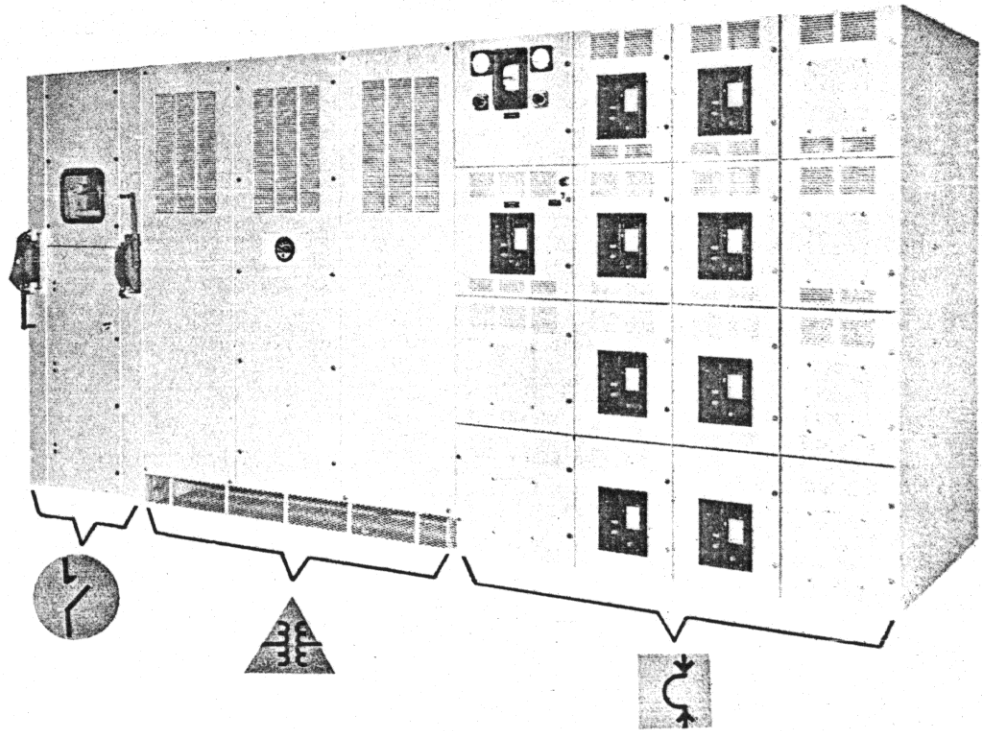
- Air Interrupter Switch
- Fused or Unfused
- Single or Duplex
- Air Interrupter Selector Switch
- Fused or Unfused
- Air Terminal Chamber
- Liquid Interrupter or Disconnect Switch
- Oil Cutouts
- Fused or Unfused
- Metal-Clad Switchgear

TRANSFORMER SECTION

- Liquid-Immersed
- Askarel
- Oil
- Ventilated-Dry
- Sealed-Dry, Gas-Filled

OUTGOING SECTION

- Low-Voltage, Metal-Enclosed Switchgear
- Drawout Air-Magnetic Power Circuit Breakers, Fused or Unfused
- Plug-in Molded-Case Circuit Breakers



INDEX — SECONDARY UNIT SUBSTATIONS

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INCOMING LINE SECTION

TABLE 1 — AIR INTERRUPTER SWITCH RATINGS

Nominal Voltage Rating, kV	Maximum Continuous Current Rating, A	Fault Closing Rating, kA Asym.	
		Switch Unfused	Switch Fused
4.8	600	40	Fuse Interrupting Rating (see Table 35, Page 32)
7.2	600	40	
13.8	600	40	

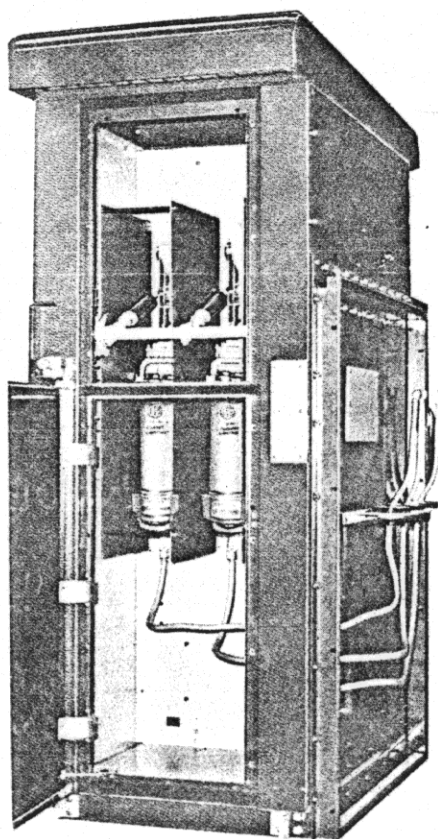
prevent opening of the fuse door while the switch is in the closed position. I-T-E type CL-14 current-limiting fuses are provided as standard. Fused or unfused switches are available with or without lightning arresters, can be equipped with cable lugs or potheads, and can be arranged for top or bottom entrance. (Lightning arresters are required for use with ventilated-dry type transformers).

Duplex switches are also available, consisting of two Kirk key-interlocked switches located side by side. These various switch assemblies are available in both indoor and outdoor construction, and can be applied to Secondary Selective or Primary Selective Systems.

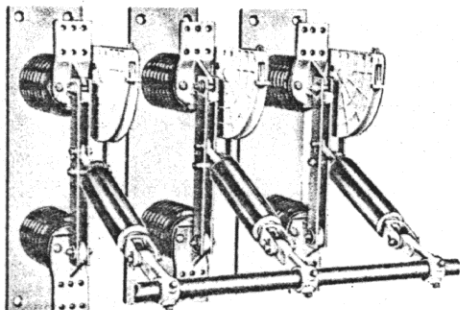
For complete information on this type equipment refer to I-T-E Bulletin 8.1-1.

AIR INTERRUPTER SELECTOR SWITCH

The air interrupter selector switch consists of a stationary rear-mounted, three-pole, two-position (Line 1—Line 2) switch, in series with a three-pole, two position (on-off) I-T-E type HPL-C interrupter switch. Visual indication on the front-mounted handle mechanism indicates Line 1 or Line 2.



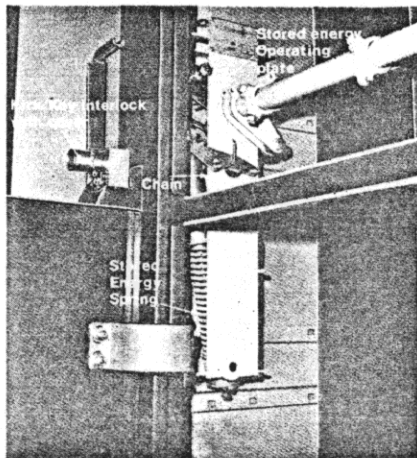
Outdoor Air Interrupter Switch



Three-Phase HPL-C Switch Assembly.

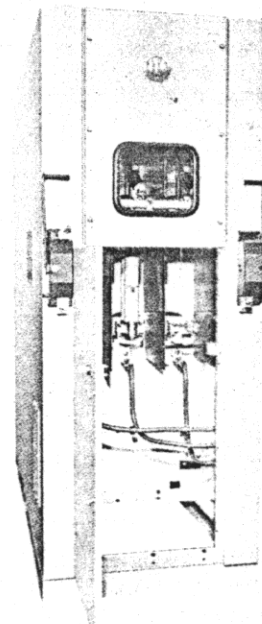
AIR INTERRUPTER SWITCH—SINGLE OR DUPLEX

The I-T-E type HPL-C air interrupter switch is a stationary mounted, three-pole, two-position (on-off) device which utilizes a snap-action quick-make, quick-break blade in combination with an arc chute for safe closing and interruption. It is available with or without current-limiting fuses. Visual indication through the safety-glass front window and on the handle mechanism shows the blade position. Fused switches are Kirk™ key interlocked to



Stored-Energy Operating Mechanism.

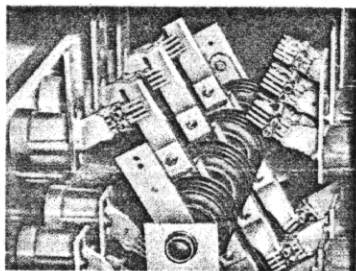
Note: For complete information on HPL-C switches see I-T-E Bulletin 1630-1; for CL-14 fuses see I-T-E Bulletin 14.1-2



The selector switch is Kirk™ key interlocked with the interrupter switch to prevent switching of lines with the load connected.

Fused arrangements are Kirk key interlocked to prevent opening of the fuse door while the interrupter switch is in the closed position. I-T-E type CL-14 current-limiting fuses are provided as standard. Fused or unfused switches are available with or without lightning arresters. Equipment may be supplied with cable lugs or potheads and arranged for top or bottom entrance. (Lightning arresters are required for use with ventilated-dry type transformers.

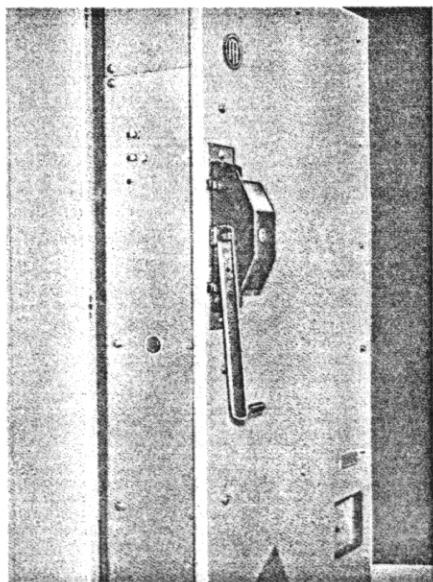
The selector arrangement is available in both indoor and outdoor construction, and is generally installed in Primary Selective systems.



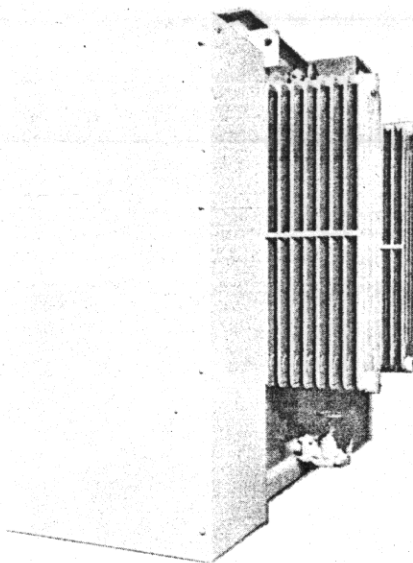
Cutaway of 3-pole selector switch shows blade positioned for connection to one incoming line.

HPL-C DRAWOUT LOAD BREAKER

The load-breaker is a 600A, 15kV maximum, three-pole, two-position (on-off) device which utilizes snap-action, quick-make, quick-break contacts. It is available with or without fuses.

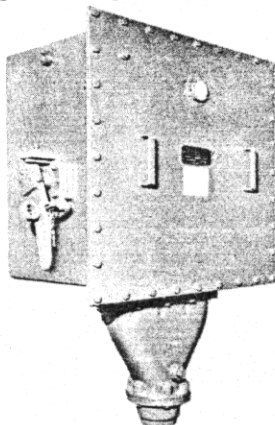


HPL-C Drawout Load Breaker



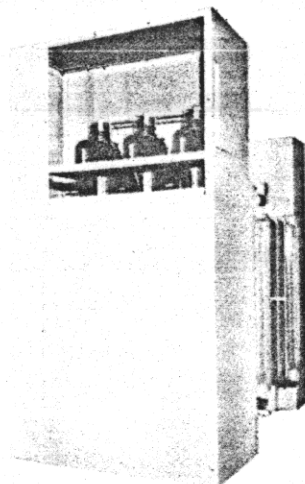
AIR TERMINAL CHAMBERS

Floor-mounted air terminal chambers come equipped with cable lugs or potheads and are directly connected to the high-voltage side of the transformer. They are available in indoor or outdoor construction, and can be arranged for top or bottom entrance.



LIQUID INTERRUPTER OR DISCONNECT SWITCH (OIL-ASKAREL)

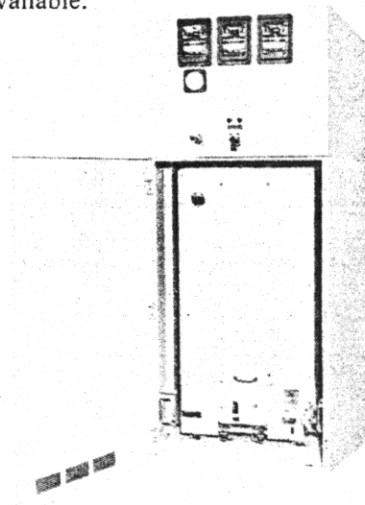
These switches can be provided on liquid-immersed transformers only. They are three-pole, two- or three-position assemblies. The switch enclosure is welded or bolted directly to the transformer tank. When oil filled, the switch can interrupt load currents up to 400 amperes. When filled with askarel, the switch has no interrupting capacity, but can be used as a disconnect switch to break magnetizing currents up to 10 amperes for five operations. After this the askarel must be replaced. Potheads are always provided for cable terminations. Oil or askarel is shipped in a separate container to eliminate the need of draining the switch to make cable connections.



OIL CUTOOTS—FUSED OR UNFUSED

Oil cutouts are supplied mounted in an air terminal chamber and have provisions for terminating one three-phase incoming cable. When fused, application of oil cutouts are limited to 500kVA at 2400 volts and 750kVA at 4160 volts and 1000kVA at 13.8kV. Unfused application as disconnects are limited to 750kVA at 2400 volts or 1000kVA at 4160 volts and 2000kVA at 13.8kV. Values are based on applying fuses at twice the full-load current rating of the transformer.

Indoor or outdoor construction is available.



METAL-CLAD SWITCHGEAR

For the ultimate in primary protection and personnel safety, specify I-T-E type HK metal-clad switchgear with stored-energy, drawout power circuit breakers.

HK switchgear is available for systems ratings of 4.16, 7.2 and 13.8kV, 75 to 1000MVA. For complete information on this type equipment, refer to I-T-E Bulletin 8.2-1.



TRANSFORMER SECTION

GENERAL

A complete line of secondary unit substation transformers is offered by I-T-E. Table 2 lists standard transformer ratings for the liquid-immersed (oil or askarel), ventilated-dry and sealed-dry units. Transformer dimensions and weights are given on pages 27 thru 29. Additional application data may be found on page 34.

Non-standard units are also available with special temperature rises, special insulation levels, special impedances and special voltages to meet specific application requirements. For weights, dimensions and performance characteristics contact factory.

LIQUID-IMMERSED

Liquid-immersed transformers have their core and coil immersed in either a flammable mineral oil or askarel—a synthetic non-flammable insulating liquid which is fire and explosion resistant. The oil-immersed transformer is generally applied outdoors but may also be used indoors when located in a vault designed to avoid any possible fire hazard. It is operated at 65°C rise and features lightweight and compact size. The askarel-immersed transformer is similar in construction and features to the oil-immersed type, except for the insulating liquid. It is intended primarily for indoor application, but can also be used outdoors near building walls or on roofs.

VENTILATED-DRY

A ventilated-dry transformer is one in which the windings are cooled by the natural circulation of ambient air through the transformer enclosure. While I-T-E ventilated-dry type transformers utilize a superior moisture resistant insulation system designed to operate at an average temperature of 150°C such units should not be applied in an area where heavy or conducting contaminants exist in the air. Ventilated type transformers feature reduced size and weight; and are fire, explosion and toxic resistant.

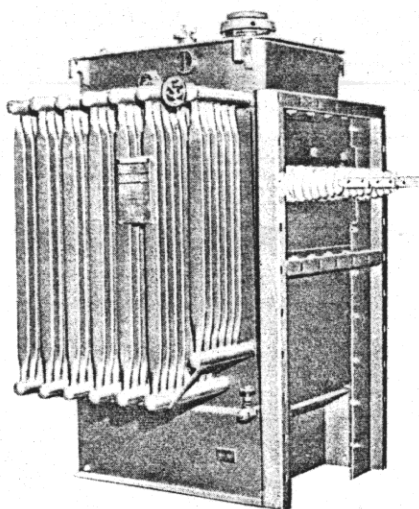
SEALED-DRY TRANSFORMERS

The windings of the standard I-T-E sealed-dry transformers are immersed in a fluorocarbon gas which is contained in a sealed tank to prevent intermingling with outside air. The gas acts as an efficient heat transfer agent and dielectric medium. Sealed-dry transformers are generally applied indoors but can also be utilized outdoors.

TABLE 2 — STANDARD TRANSFORMER RATINGS

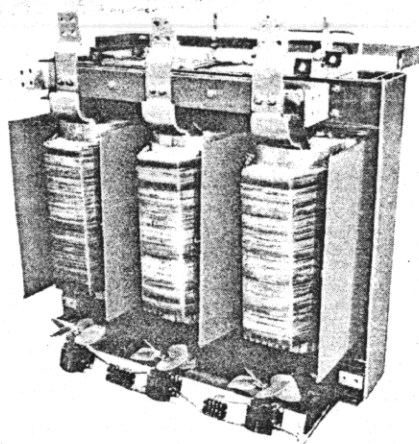
TYPE	Primary Voltage Delta	KVA 3-Phase Self-Cooled	KVA 3-Phase Forced-Air Cooled	SECONDARY VOLTAGE		Standard Impedance* % IZ	NEMA Sound Level, db	
				208Y/120 240 delta	480Y/277 480 delta		Self-Cooled	Forced-Air Cooled
Liquid-Immersed Oil or Askarel 65°C Rise †	2400	112½	—	x	x	2.25†	55	—
	4160	150	—	x	x	3.0†	55	—
	4800	225	—	x	x	4.5	55	—
	6900	300	—	x	x	5.0	55	—
	7200	500	—	x	x	5.0	56	—
	12000	750	862	x	x	5.75	58	67
	12470	1000	1150	x	x	5.75	58	67
	12470	1000	1150	x	x	8.0	58	67
	13200	1500	1725	x	x	5.75	60	67
	13800	2000	2300	x	x	5.75	61	67
Ventilated-Dry 150°C Rise †	2400	112½	—	x	x	3.0†	50	—
	4160	150	—	x	x	3.5†	50	—
	4800	225	—	x	x	4.5	55	—
	6900	300	—	x	x	5.0	55	—
	7200	500	667	x	x	5.0	60	67
	12000	750	1000	x	x	5.75	64	67
	12470	1000	1333	x	x	5.75	64	68
	12470	1000	1333	x	x	8.0	64	68
	13200	1500	2000	x	x	5.75	65	69
	13800	2000	2666	x	x	5.75	66	71
Sealed-Dry Gas-Filled 150°C Rise †	2400	300	—	x	x	5.0	57	—
	4160	500	—	x	x	5.0	59	—
	4800	750	—	x	x	5.75	63	—
	6900	1000	—	x	x	5.75	63	—
	7200	1000	—	x	x	5.75	63	—
	12000	1500	—	x	x	8.0	63	—
	12470	2000	—	x	x	5.75	64	—
	13200	2500	—	x	x	5.75	65	—
	13800	2500	—	x	x	5.75	66	—
	13800	2500	—	x	x	5.75	66	—

* Standard impedance tolerance is $\pm 7\frac{1}{2}\%$. † For application where the average ambient temperature is 30°C. ‡ Transformers with impedances of 4.0% or less are designed to withstand 25 times normal current for two seconds.



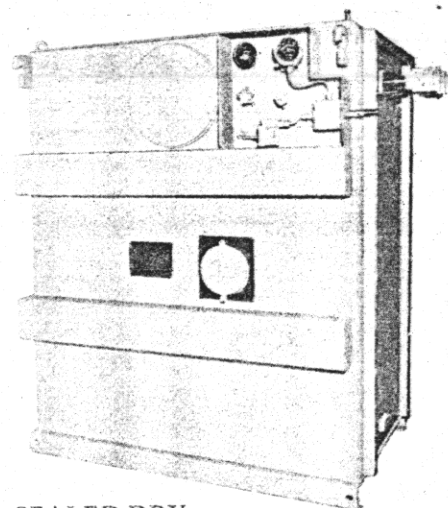
LIQUID-IMMERSED TRANSFORMER

- Proven insulation system
- Low operating temperature
- Low sound level
- Lighter weight
- Less floor space
- Constant bushing height



VENTILATED-DRY TRANSFORMER

- Moisture-resistant insulating materials
- Reduced size and weight
- Indoor application
- Toxic resistant
- Fire and explosion resistant



SEALED-DRY TRANSFORMER

- Fluorocarbon gas
- Liquid filled dielectric levels
- Minimum maintenance
- Toxic resistant
- Fire and explosion resistant

CHARACTERISTICS COMPARISON

Table 3 below provides an easily comprehensible framework for comparing pertinent capabilities of liquid-immersed, ventilated-dry and sealed-dry transformers. A standard oil-immersed transformer rated 1500 kVA,

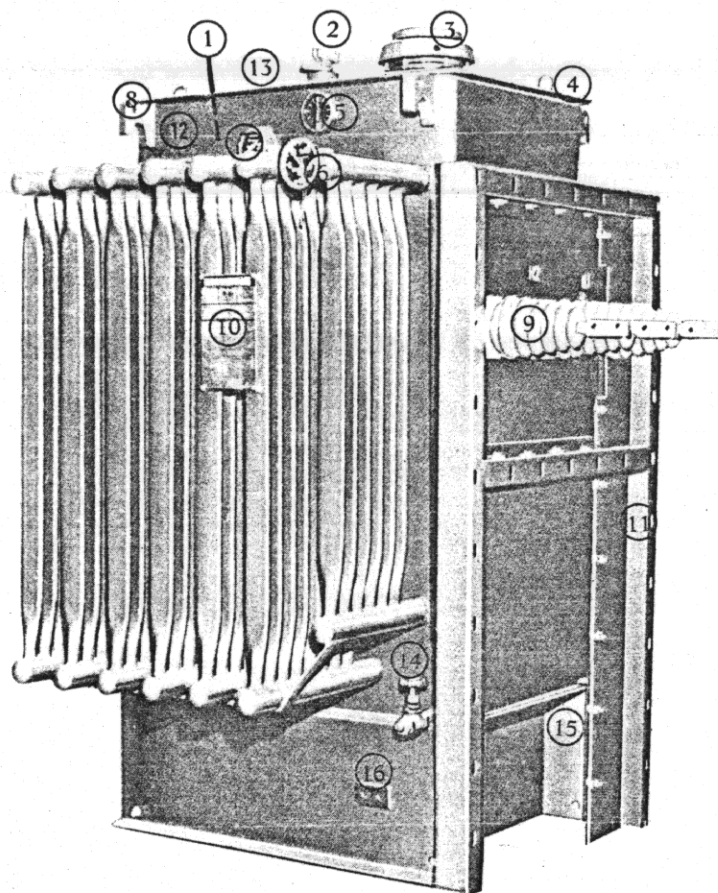
13.8 kV to 480 volt, was chosen as the base transformer because of its common usage in secondary unit substations. Approximate values of various base transformer characteristics are as follows:

Sound level (self-cooled)—60db
Weight—8,700 lbs.
Floor space—55" Wide x 87" Deep
Height—80"

TABLE 3—COMPARISON OF TYPICAL CHARACTERISTICS OF SECONDARY UNIT SUBSTATION TRANSFORMERS
1500 kVA, 13.8 kV to 480 Volts, Oil-Immersed Transformer as Base (See above)

Characteristics	Liquid-Immersed 65°C Rise		Ventilated-Dry 150°C Rise	Sealed-Dry 150°C Rise
	Oil	Askarel	Air	Gas
Impulse Strength	95 kV	95 kV	65 kV	95 kV
Losses @ operating temp. (20°C Ambient)	No Load Full Load	100% 100%	160% 130%	120% 110%
Temperature Ratings: Average Rise°, C Hottest Spot Rise°, C	65 80	65 80	150 180	150 180
Sound Level—Decibels	60	60	65	64
Weights	100%	116%	98%	166%
Dimensions: Floor Space Height	100% 100%	100% 102%	110% 112%	123% 130%
Application: Indoor, Outdoor	Indoor (vault only) Outdoor	Indoor Outdoor	Indoor (Limited)	Indoor Outdoor
Fire, Explosion Resistant	No	Yes	Yes	Yes
Toxic Resistant	No	No	Yes	Yes
Maintenance: Liquid Cleaning Internal External	Yes No Normal	Yes No Normal	No Yes Occasionally	No No Normal
Cost	100%	125%	125%	200%

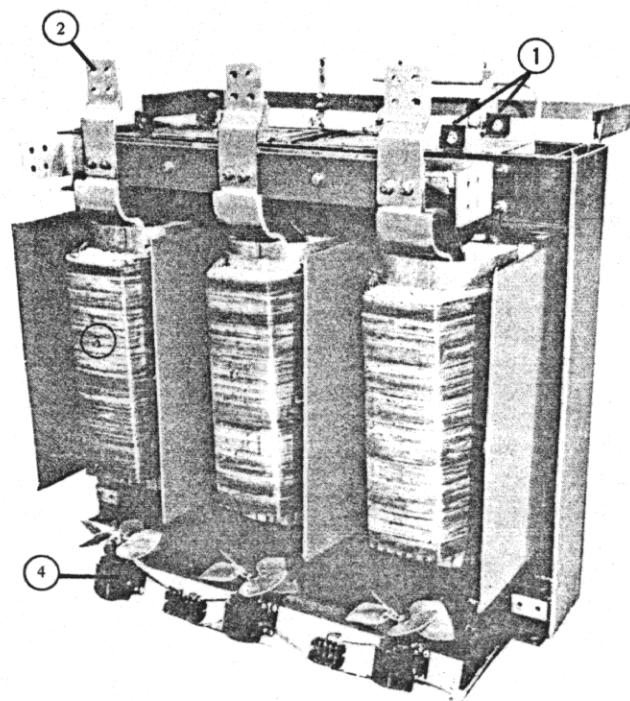
Note: Values stated are approximate average and subject to variation with kVA size, kV rating, etc.



Askarel-Immersed
Transformer-Indoor

LIQUID-IMMERSED TRANSFORMERS

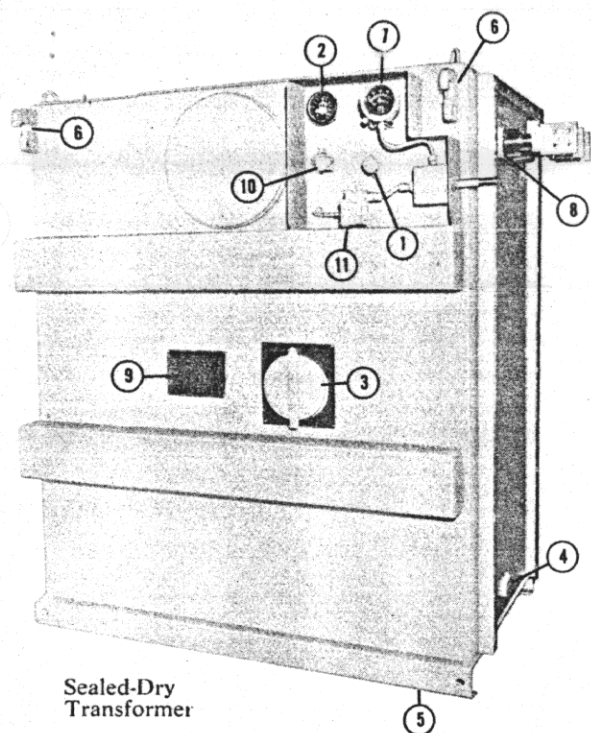
- ① Top Sampling Plug on Askarel Units Only (Not Visible)
- ② Padlockable No Load Tap Changer
- ③ Mechanical Relief Device is Standard on Askarel Filled Units—Optional on Oil Filled Units
- ④ Welded Tank Cover
- ⑤ Pressure Vacuum Gauge (Optional)
- ⑥ Dial Type Thermometer
- ⑦ Magnetic Liquid Level Gauge
- ⑧ Lifting Hooks and Loops
- ⑨ High Voltage Sealed Cast Resin Bushing
- ⑩ Stainless Steel Diagrammatic Nameplate
- ⑪ LV and HV Close Couple Molding
- ⑫ Provision For Forced Air Cooling is Standard on Transformers 750 Kva and Above
- ⑬ Upper Filter Press Connection (Not Visible)
- ⑭ One Inch Drain Valve With $\frac{3}{8}$ Inch Sampler
- ⑮ Base
- ⑯ Copper Faced NEMA Ground Pad



VENTILATED-DRY TRANSFORMERS

- ① Lifting eyes on upper core clamp
- ② Secondary low-voltage connections
- ③ High-voltage winding
- ④ Cooling fans

Ventilated-Dry
Transformer
Core and Coils Only

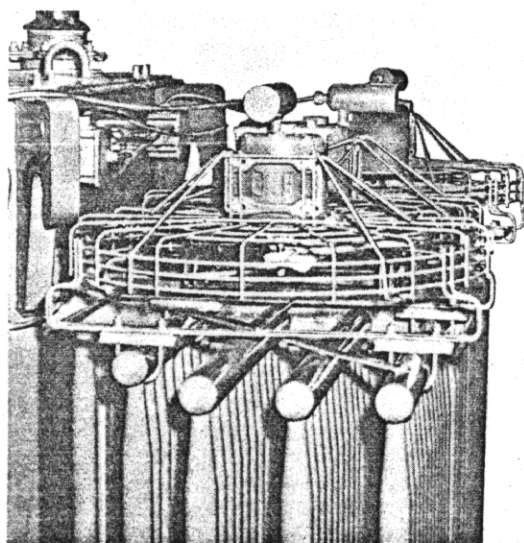


Sealed-Dry Transformer

SEALED-DRY TRANSFORMERS

- ① Filling and sampling valve
- ② Pressure-vacuum gauge
- ③ No-load, externally-operated tap changer*
- ④ Ground pad
- ⑤ Skid base with provision for jacking and towing
- ⑥ Transformer lifting hooks
- ⑦ Temperature indicator (optional)
- ⑧ Hermetically-sealed bushings
- ⑨ Diagrammatic nameplate
- ⑩ Pressure-relief valve
- ⑪ Pressure switch

*Accessible under sealed cover



Typical Radiator Fan Installation—
Liquid-Immersed Transformer.

PROVISIONS FOR FUTURE FORCED-AIR COOLING

All liquid-immersed transformers, 750kVA and above, and ventilated-dry transformers 500kVA and above, have provisions for the future installations of fans for forced-air cooled operation.

These provisions include:

1. Full forced-air cooled capacity in all current-carrying parts, including high-and low-voltage bushings.
2. Provision for mounting the balance of required equipment in the field.
3. Provision for the future automatic control of the fans as follows:
 - a. Liquid-immersed units—provision for incorporating a thermometer with contacts for control of the future fans from top liquid temperature.
 - b. Ventilated-dry units—provision only for mounting winding-temperature relay for control of future fans.
4. Control Voltage 240V AC

STANDARD PRODUCTION ELECTRICAL TESTS

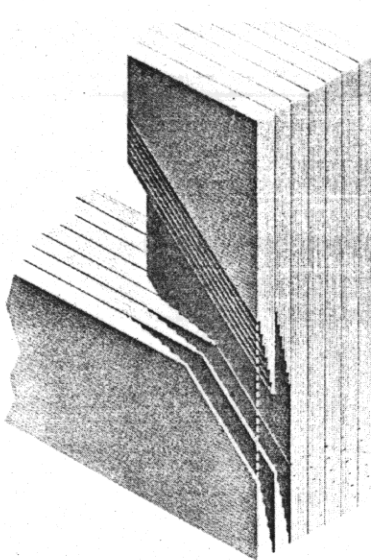
The following tests are performed on each transformer in accordance with the ANSI Standard Test Code:

1. Resistance Measurements
2. Ratio
3. Polarity and Phase Relation
4. No Load Loss
5. Exciting Current
6. Impedance and Load Loss
7. Applied Potential
8. Induced Potential
9. Temperature test or tests will be made on one unit of an order covering one or more units of a given rating. Tests will be made only when there is not available a record of a temperature test made in accordance with ANSI standards on a duplicate or essentially

OPTIONAL ACCESSORIES

Winding-temperature equipment
Gas absorbers for askarel-filled transformers.
Tap changer interlocks for liquid-immersed and sealed-dry transformers
Alarm contacts for:
Thermometer
Liquid-level gauges
Pressure-relief device
Sudden-pressure relay on liquid-immersed transformers
Pressure-relief device for oil-filled

DETAILS OF CONSTRUCTION — LIQUID-IMMERSED TRANSFORMERS



CORE CONSTRUCTION

The core of each I-T-E transformer is made of non-aging, high permeability, grain-oriented, cold-rolled, silicon steel specifically processed for optimum loss and noise performance.

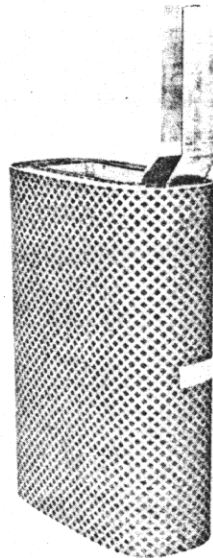
The thin gauge laminations are sheared with special high quality shear blades in such a manner that the flux path will be aligned with the axis of highest permeability in the steel. Each lamination is flat and free from burrs and is inorganically insulated on both surfaces to minimize eddy-current loss.

Core legs are assemblies of laminations with cross sections designed to accommodate the coils with the optimum combination of high space factor and coolant flow.

The upper and lower core yokes are rigidly clamped by welded assemblies of steel members consistent with bracing and supporting requirements. Core clamps are chemically cleaned to remove any dirt or impurities from the forming and welding operations. This assures that only clean, bright metal will be in contact with the cooling medium. Core clamps and all structural parts are insulated to prevent local circulating currents and are solidly bonded to ground and to the core to prevent development of potential in any part.

COIL CONSTRUCTION

The coil is of rectangular construction with sheet wound aluminum secondary windings and insulated wire wound aluminum primary windings.



This construction meets the following requirements:

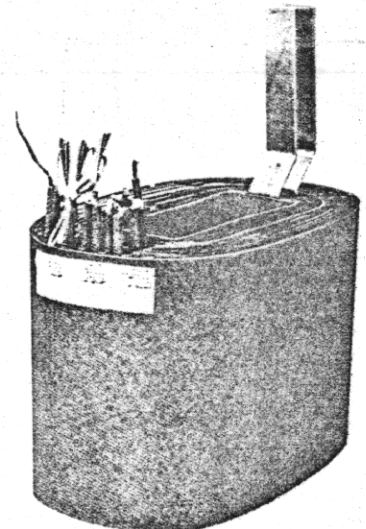
1. Stresses: Axial short-circuit stresses are virtually eliminated by the use of sheet-wound secondary and wire wound primary windings with no interleaved components. Coils are, therefore, wound with the secondary coil nearest the core and supported by a strong insulating cylinder. The primary is wound directly over the secondary coil with a suitable insulating full-length barrier between the primary and secondary windings. The coil wire is wound tightly and uniformly thru a tension device to insure maximum short-circuit strength.

Short circuit tests have been made on completed units in accordance with the latest test code for short circuit testing prepared by the IEEE Transformer Committee.

2. Cooling: The coils are equipped with cooling channels in both the high and low voltage windings in order to dissipate the heat generated in the coils. Sufficient cooling ducts are located throughout the coils to avoid hot spots in winding and to assure overload capability.

INSULATING MATERIAL

All insulating materials used have been thoroughly tested and proven with respect to their electrical and mechanical characteristics and are stable at operating temperatures and



compatible with the cooling medium.

In liquid-filled transformers, the insulation system is thermally upgraded. It is chemically modified to resist the effects of high temperature. The improved insulation enables the new, compact transformers to maintain full load-carrying ability at their higher operating temperature without affecting life expectancy.

Thermally-upgraded pressboard insulation is used for coil spacers, both longitudinal and radial, as well as ends. It is also used between layers and between high- and low-voltage coils. The porosity of the insulating materials permits the insulating liquid to penetrate the insulating materials giving it a high dielectric strength.

TAP CHANGER

The externally operated tap changer provides positive sequence line voltage changes under no-load conditions. The in-line assembly features through-type stationary contacts rigidly supported by a molded plastic channel. Moving contacts are spring loaded, silver plated copper which move along the stationary line by means of a rack and pinion.

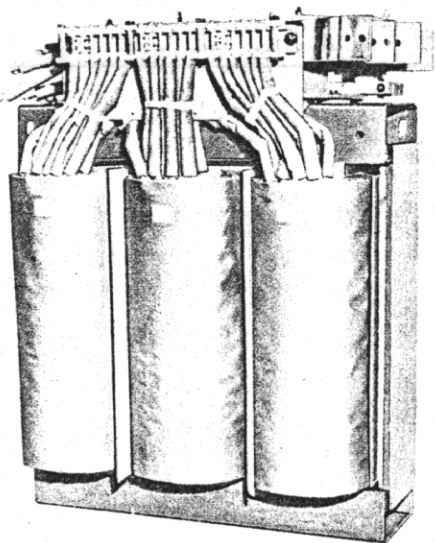
The design has no rivets, bolts or nuts, thus assuring the proper contact of current carrying parts when taps are changed.

TANK

The transformer tank is fabricated of heavy-gauge steel plates. A minimum number of plates are used to reduce the number of welded seams.

The tank base is fabricated of formed steel to receive and transmit

DETAILS OF CONSTRUCTION — VENTILATED-DRY-TYPE TRANSFORMERS



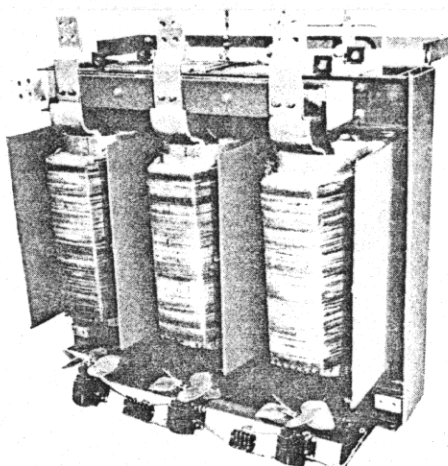
the core and coil weight to the mounting pad or foundation and provide for skidding or rolling in any direction. Facilities for jacking are at the ends of the base.

Formed structural members are welded to the side walls so that the complete tank will be sufficiently reinforced to withstand a test pressure 75% greater than normal operating pressure. This will prevent permanent tank distortion during operation or pressure testing. The top of the tank is fully strengthened by a flange which is used as a welding ring for securing the tank cover. An asbestos-type gasket is provided between the reinforced cover and the top flange and is compressed during the welding operation to prevent weld spatter from entering the tank. Lifting hooks are provided at the corners of the tank to permit the finished transformer, complete with liquid, to be handled by a crane.

Adequate convection surface is provided by cooling tubes to assure that the temperature rise of the liquid will not exceed the specified limit when the transformer is continuously operated at full load.

The entire tank is chemically cleaned before painting to remove any oil, dirt or other impurities from the forming and welding operation. Each tank is painted with a rust inhibitor prime coat and a finished coat in accordance with ANSI standards.

A flange is provided on the primary and secondary sides of the transformer for bolting to the primary and secondary sections to provide an uninterrupted lineup of equipment without openings.



CORE CONSTRUCTION

The core construction of each I-T-E transformer is made of non-aging, high-permeability, grain-oriented, cold-rolled, silicon steel specifically processed for consistently low losses.

The thin-gauge laminations are sheared with special high-quality shear blades in such a manner that the flux path will be aligned with the axis of highest permeability in the steel. Each lamination is flat and free from burrs and is inorganically insulated on both surfaces to minimize eddy-current losses.

Laminations are hand stacked on a specially designed table which ensures flatness and prevents the introduction of bending stresses while the finished core is being set in an upright position. Careful positioning of each lamination produces close fitting joints to fully minimize core loss and noise.

Core legs are assemblies of laminations with cross sections designed to accommodate the coils with the optimum combination of high space factor and air flow.

COIL CONSTRUCTION

The coil may be of rectangular or circle construction depending upon the kVA size. Where possible rectangular construction is used with sheet-wound aluminum secondary windings and insulated, wire-wound primary windings. This construction meets the following requirements:

1. Stresses: Where sheet windings are employed axial short-circuit stresses are virtually eliminated. The primary is wound directly on the low-voltage winding with

a suitable insulating barrier between the coils consisting of spacers and sheet insulation built up to the proper thickness.

Where the coils are wire wound adequate bracing is supplied at the end of the coils to assure full short circuit capability. Primary coils may be of the disk type construction with suitable disk spacers to provide coil to coil cancellation.

All coils are dried and compressed in preparation for varnish impregnation. A suitable varnish for the temperature rating of the unit is applied by dipping to provide a coil with moisture and dirt resistance. Extreme care is taken to avoid tiny air pockets in the coils where corona might start.

After dipping the varnish is completely cured in ovens to achieve the highest possible dielectric strength.

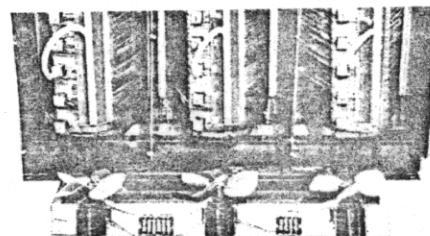
2. Cooling: Cooling is achieved in all ventilated dry type transformers by generous cooling ducts in both the primary and secondary coils. When forced air cooling is required the air is directed through the cooling ducts to achieve the forced air rating.

INSULATING MATERIAL

All insulating materials used have been thoroughly tested and proven with respect to their electrical or mechanical characteristics and are stable at operating temperatures and compatible with the cooling medium. All wire is Nomex paper-wrapped. All other insulating material in the core and coil is chosen for the temperature system of the transformer and capability for that point of application.

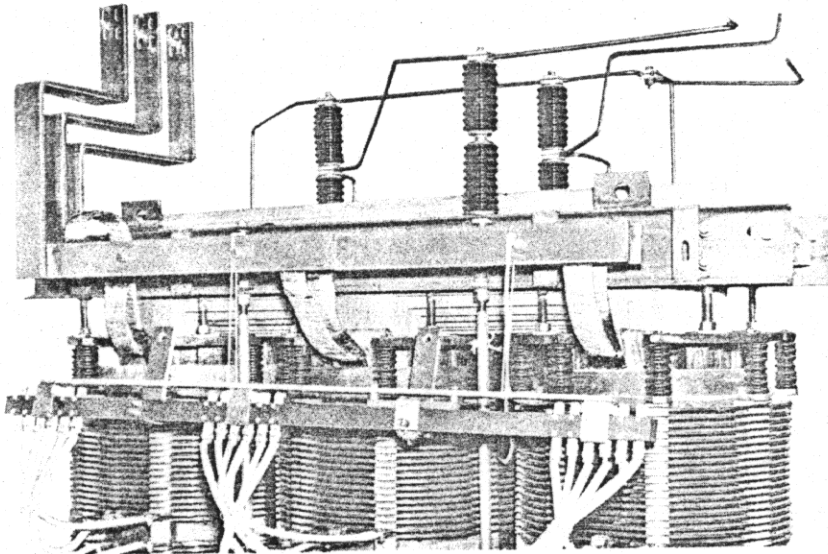
TAPS

Taps are applied on the face of the coil for link or cable connection to provide for adjustment in the primary winding to accommodate system voltage.



DETAILS OF CONSTRUCTION —SEALED-DRY-TYPE TRANSFORMERS

SEALED-DRY



Core and Coils—Sealed-Dry Assembly



Bushings

CORE CONSTRUCTION

The core construction for sealed-dry type transformers is similar to both the liquid-filled and ventilated-dry type transformers. The major exceptions being where a circular coil is applied.

Where a circular coil design is applied a cruciform core is used to achieve a high space factor.

COIL CONSTRUCTION

The coil construction for sealed-dry transformers is similar to the coil construction of the ventilated type transformers. Generally, circular coils are applied with disk type primary coils.

TAP CHANGER

A tap changer of the in-line type is supplied with an operating mechanism extending through the tank wall with a sealing means to prevent the loss of gas from the unit.

FLUOROCARBON GAS

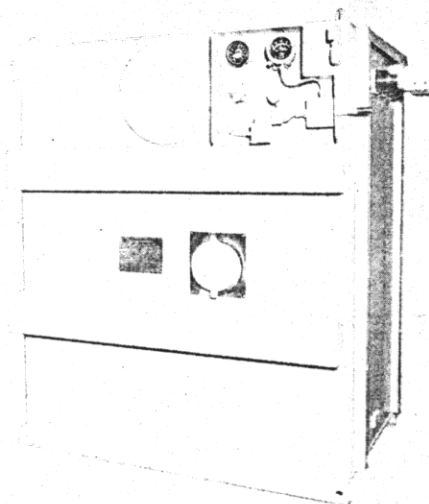
Fluorocarbon gas is applied as the dielectric medium for sealed-dry type transformers. Such gases have a dielectric capability in excess of 2 times the dielectric capability of air. This high dielectric capability results in di-

electric levels normally achieved in liquid-filled transformers.

In addition to being an excellent dielectric medium the gas has good heat transfer capability due to its higher molecular weight. In comparison to nitrogen the use of the fluorocarbon gas permits a smaller tank and a lighter unit for the same rating.

TANK

The tank of the sealed-dry type transformer is similar in construction to the liquid filled type. It, however, is designed to withstand 15 lbs. pressure or vacuum. Other features include; protective instrumentation, external stiffeners and welded bushings.





I-T-E COST-SAVING LOGICAL-SEQUENCE ASSEMBLY FOR VENTILATED-DRY TYPE TRANSFORMER ENCLOSURES

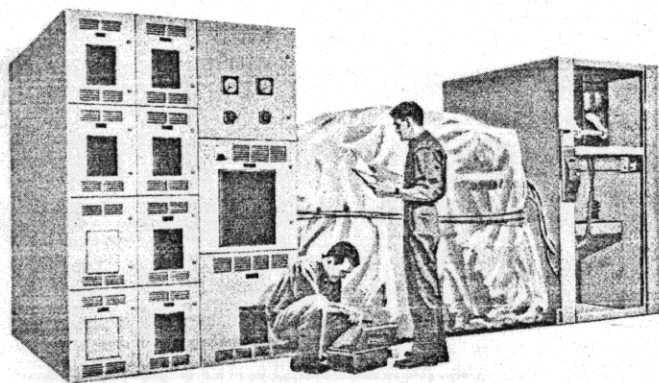
Saves installation time, money and floor space. Instead of shipping the enclosure already assembled around the transformer, I-T-E ships it *ready to assemble*.

You unpack the components *in a logical sequence* for easy assembly. That way you don't have to do the

double work of taking the enclosure apart, making the connections in tight quarters, then assembling it again. Installation is faster, easier, more economical—and you have a far better assurance of good results. Rigging is simplified and the transformer can more easily be moved under pipes,

through doors, onto elevators and into position. Just follow these simple steps.

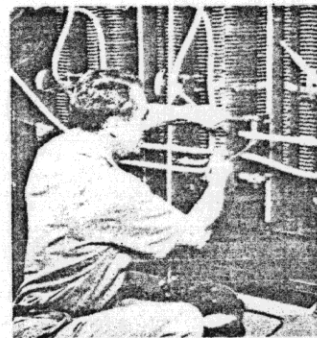
If project requirements dictate, transformer and enclosure can be shipped assembled for additional cost.



1. First step—position all components. Transformer is delivered wrapped in plastic to protect it from dirt.



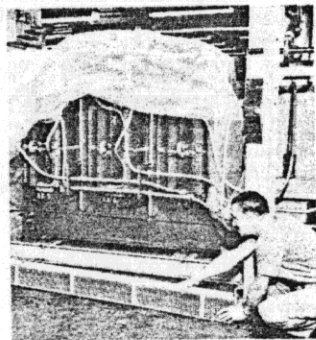
2. Make low-voltage connections.



3. Make high-voltage connections.



4. Connect low-voltage ground.



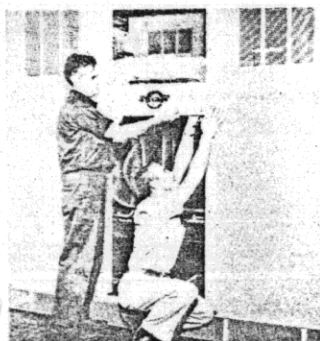
5. Assemble floor angle with screen attached.



6. Assemble corner panels.



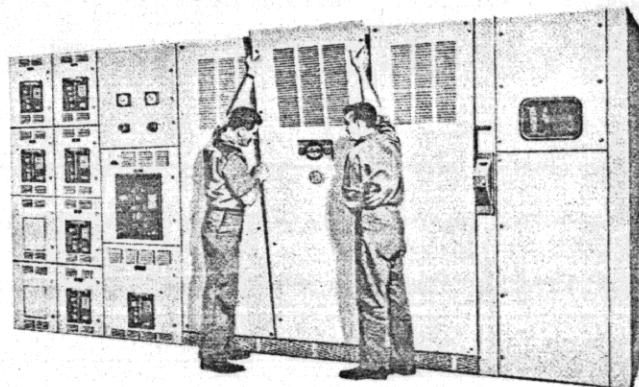
7. Assemble top cross angles.



8. Assemble temperature panel (if furnished).



9. Assemble top sheets.

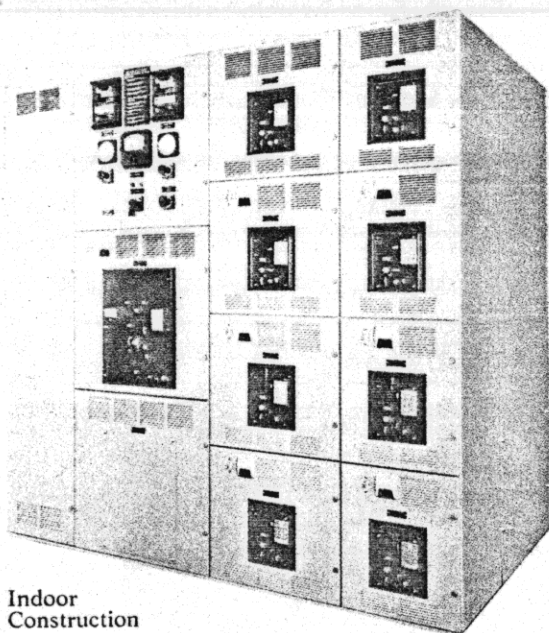


10. Assemble center panels. Job's done.

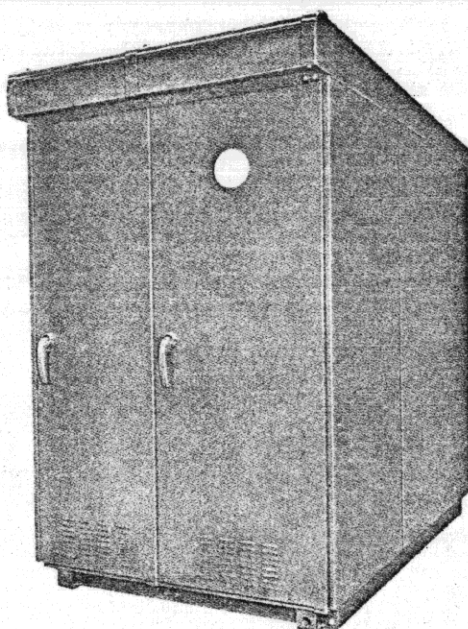


OUTGOING SECTION

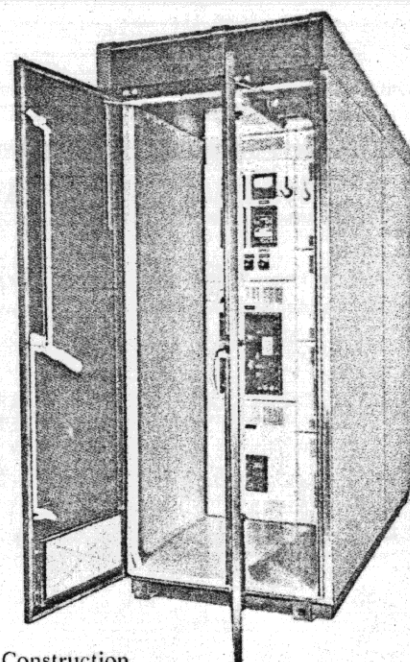
LOW-VOLTAGE SWITCHGEAR



Indoor Construction



Weatherproof Walk-In Construction



Compact I-T-E low-voltage metal-enclosed, drawout switchgear features time-tested, field-proven manually or electrically operated stored-energy K-LINE® and K-DON® air-magnetic power circuit breakers. The standard design offers various size circuit breakers mounted in 4-high compartments (see page 30 for low-voltage switchgear arrangements). In addition, modern insulating materials with high strength-to-weight ratios allow significant reduction in weight and floor space.

INDOOR CONSTRUCTION

Free-standing, indoor units offer complete isolation of breaker and instrument compartments. The versatility of compartments, frames and breaker ratings enables meeting your

exact application requirements. Notice the semi-flush circuit breaker handles do not project into the aisle, thereby reducing accidental breakage or false tripping. Also each feeder may be equipped with a panel-mounted ammeter and pushbutton phase selector for convenient reading.

WEATHERPROOF WALK-IN CONSTRUCTION

Weatherproof walk-in construction provides all-weather protection when the switchgear must be located outdoors. The same arrangement principles are used in weatherproof as in standard indoor construction. In addition, this construction provides approximately three feet of aisle space on the breaker side to protect equip-

ment and personnel from inclement weather. Also provided are large areas at the top and bottom of each frame for cable entry. Large working area is provided in the rear compartment for pulling and connecting cables.

Standard outdoor construction provides:

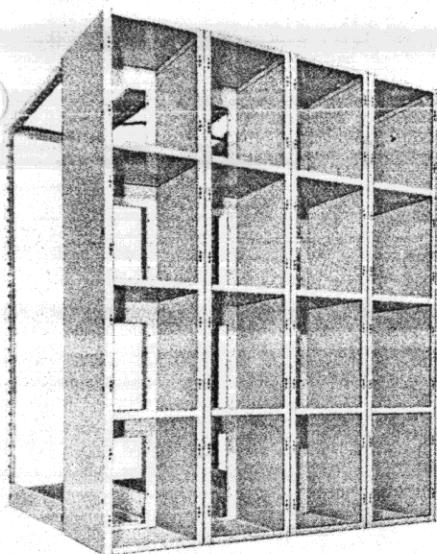
1. Manually-operated lifting device.
2. Filtered louvers and vents, front and rear.
3. Strip heaters to reduce condensation.
4. Convenience outlets and interior lighting.
5. Weatherproof gasketing throughout.

A control-power transformer may be mounted in an auxiliary compartment, if required, to furnish power to outlets and strip heaters.

TABLE 4 — SWITCHGEAR RATINGS

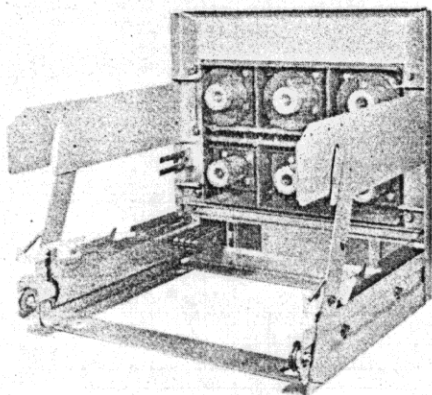
Switchboard Construction	① Circuit Breaker Type	Nominal Voltage Rating, V	Maximum Design Voltage, V	Maximum Continuous Current Rating, A	Insulation Levels, kV	Limit of Hottest Spot	
					Power Frequency Withstand (rms)	Temp. Rise (°C)	Total Temp. (°C)
Indoor	K-LINE	600	630	4000	2.2	65	105
Outdoor	K-DON	600	600	1600	2.2	65	105

① Available breaker ratings are listed on Page 18, Tables 5 and 6.



SWITCHGEAR FRAME

Individual frame consists of a bus and cable area and up to four circuit breaker compartments. Switchboards are assemblies of multiple individual frames. Each frame is welded in a fixture which assures rigid construction, strong enough to support switching equipment. Frames are erected and securely bolted to each other. This type of construction permits versatility in selecting unit sizes for shipment and duplicate manufacturing ensures complete interchangeability in field installations.



CIRCUIT BREAKER CRADLE

A cradle comprises main and secondary separable contacts, current transformers (if required) and all other drawout mechanisms in a complete jig-welded rigid assembly. There is no dependence upon the switchboard frame for any critical alignment. Any size cradle can be installed into any compartment of its own size or larger. Blank compartments not required for other functions may be converted to a circuit-breaker compartment by the installation of a cradle and necessary riser bus modifications.

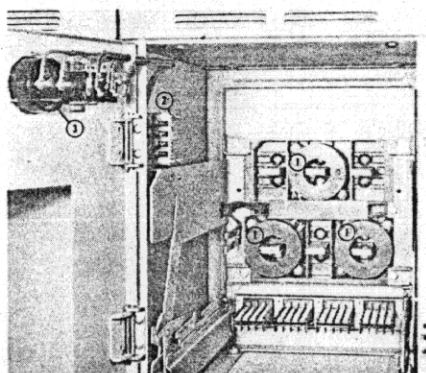
CIRCUIT-BREAKER COMPARTMENT

All individual circuit-breaker compartments are isolated from each other and from the bus area. Front door louvered grilles are scientifically designed to allow full air circulation. Hinged doors are flanged for greater rigidity. Hinges are completely concealed by being mounted inside the enclosure, and are adjustable for perfect door alignment. A removable pin within the hinge assembly provides easy door removal. Knurled panel screws fit easily into floating retainer nuts for quick, easy alignment. These screws offer the utmost in safety in keeping the doors securely closed even under the most severe fault conditions.

Control separable contacts are tiered, upper and lower, so you can mount twice as many within the narrower dimensions—as many as 32 in each compartment. This means auxiliary circuits for your use. Standardized wiring of circuit breakers and

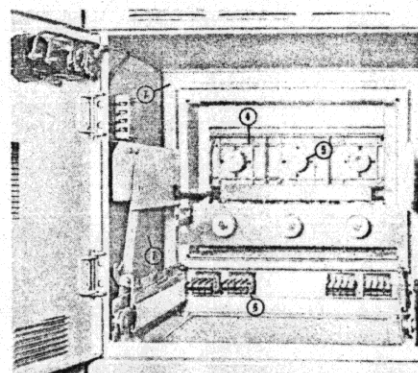
devices to particular terminals makes maintenance far easier. Notice also that the control contacts are located at the bottom where they are safe. They are front removable to make replacement or modification easily accomplished from within the circuit-breaker compartment.

Fully-insulated, high-dielectric epoxy-molded toroidal current transformers are located on the stationary primary leads within the circuit-breaker compartment. Convenient location and accessibility makes changing a minor maintenance procedure. Standard low-voltage current transformers have metering accuracies in conformance with ANSI C37.20. Current transformer short-circuiting block has safe, convenient location. It is placed at front of circuit-breaker compartment and can be easily reached with circuit breaker still in compartment.



K-600 Compartment

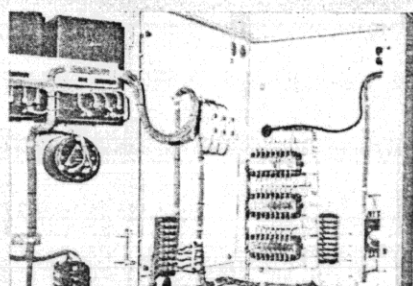
- ① Current transformers are front mounted and easily accessible from the circuit-breaker compartment.
- ② Current transformer short-circuiting block is conveniently located behind circuit-breaker compartment door.
- ③ Feeder ammeter is located directly on feeder compartment door for easy reading and space saving. Rear view of ammeter is shown.
- ④ Modern polyester-glass insulation



K-DON-1600 Compartment

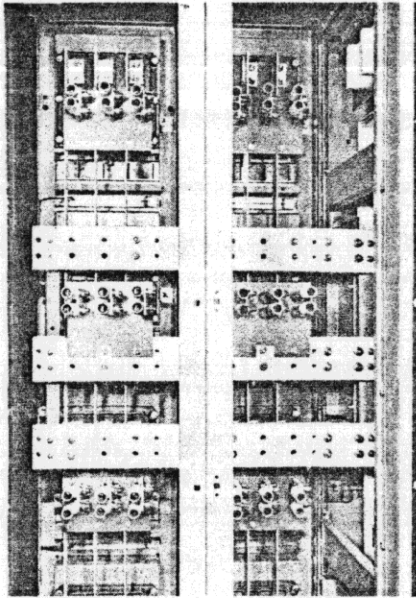
system is used throughout switchgear.

- ⑤ Stationary primary leads mate with movable primary leads mounted on circuit breaker.
- ⑥ Secondary disconnects are removable from the front for ease of accessibility.
- ⑦ Complete compartment isolation is provided between each K-LINE® or K-DON® circuit breaker and main bus compartment.



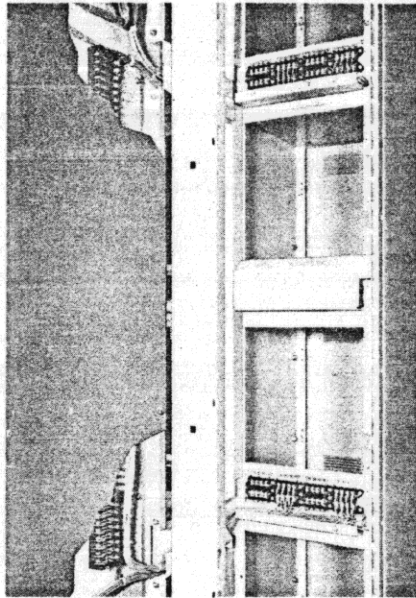
Low-Voltage Metal-Enclosed Switchgear with Auxiliary Instrument Compartment Showing Electrical Connections.

BUS AND CABLE COMPARTMENT



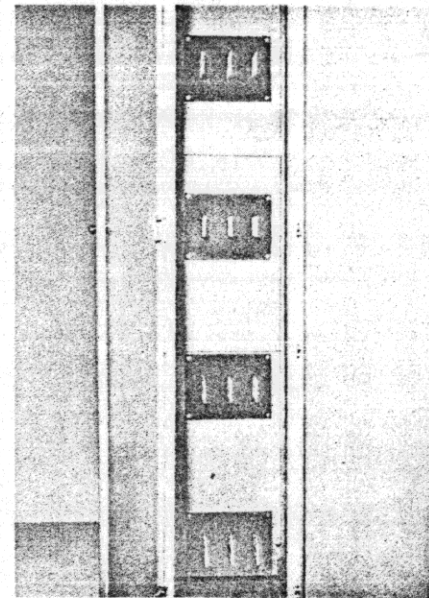
POLYESTER-GLASS INSULATION SYSTEM

All insulating parts of the switchgear are made of high-strength polyester glass. Each insulated part is specially designed in shape and strength to fulfill its part of a totally integrated insulation system.



ENCLOSED SECONDARY WIRING TROUGHS (optional)

All secondary wiring and terminal blocks located in the bus compartment are enclosed in completely covered metal troughs to afford complete isolation from the switchgear bus.



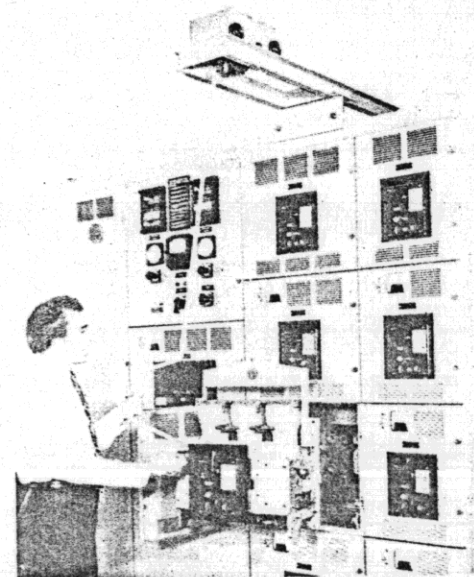
REAR BARRIERS (optional)

For those who prefer to have a completely isolated cable area, rear barriers are available. The primary leads are extended through slotted polyester-glass inserts which are mounted in a solidly-grounded metal isolating panel. Note that hinged rear doors are standard.

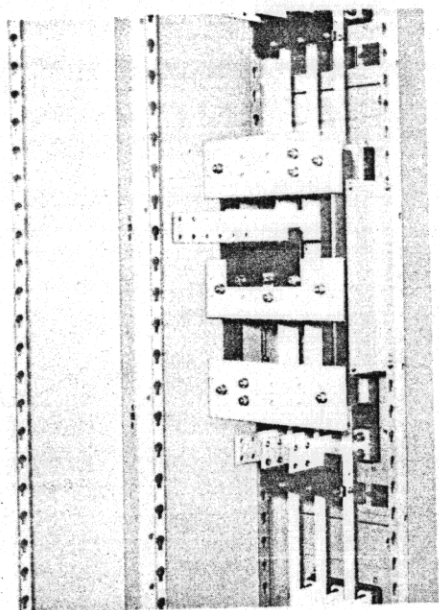
OVERHEAD LIFT DEVICE

For ease of handling K-LINE circuit breakers, a traveling overhead lift device can be provided. This device is supported from the front section of the switchgear assembly and will not affect any incoming power or control cables at the rear bus section. The hoist can be moved the full length of the switchgear and with the aid of a lifting yoke, the breaker can be

lifted from the floor or from the completely withdrawn breaker cradle. Lifting power is provided through a removable hand-crank, worm-driven mechanism and sturdy flexible cable. Although the driving mechanism is designed for easy hand operation, the weight of the breaker cannot accidentally move the mechanism even when the crank is unattended or removed.



Overhead Lift Device on Indoor Switchgear



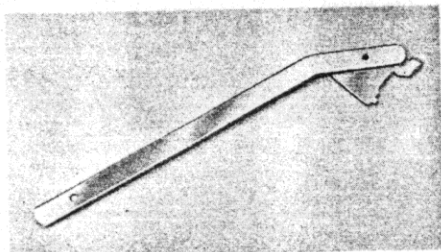
VERTICAL BUS ARRANGEMENT

The three-phase main horizontal bus is vertically arranged one above the other and is located as close to front of switchgear as possible, providing large area for auxiliary equipment and cable makeup. Vertical mounting of bus provides maximum

ventilation, and freedom from dust. Bus is designed for an allowable temperature rise of 65°C above an average 40°C ambient. All insulating parts of the switchgear are made of *high-strength polyester-glass*. Each insulated part is specially designed in shape and strength to fulfill its part of a truly integrated insulation system. A section of the top sheet of each frame is removable to facilitate installation of overhead conduit and cable. All rear leads are easily accessible for simple connection with a minimum of cable bending.

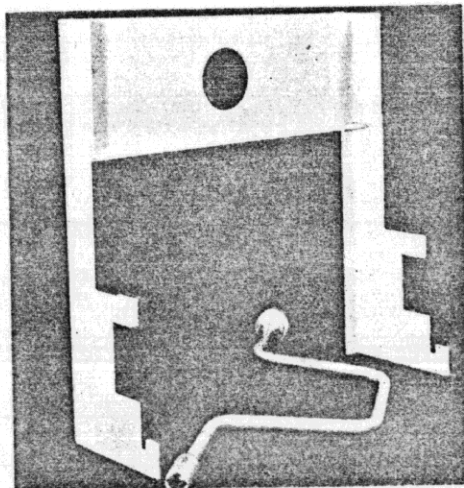
Aluminum bus is silver-plated and is braced against movement in any direction under all possible short-circuit conditions. Pre-slotted mounting members permit flexibility to add mounting supports when required in the field for incoming cables, etc. Vertical risers connecting breakers to the main bus are welded for space saving. The connections of the vertical risers to the main bus and breaker terminals are bolted.

ACCESSORIES



Spring-Charge Maintenance Handle

Each factory-assembled switchgear is shipped with circuit-breaker racking crank and lifting yoke as standard accessories. A maintenance handle for manual spring charging is included on electrically-operated breakers only.

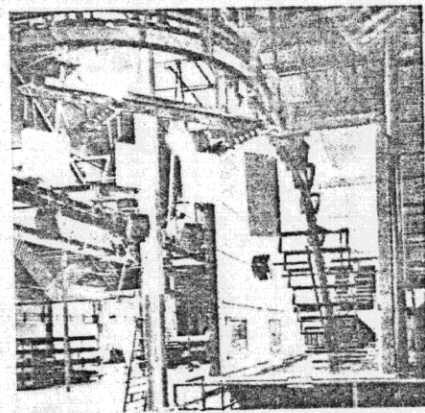


Circuit Breaker Racking Crank and Lifting Yoke.

A PAINT FINISH TO MATCH TRADITIONAL I-T-E QUALITY

- Smooth, uniform paint finish
- Complete paint penetration
- Corrosion-resistant
- Electro-chemical bonding of paint to metal
- Long-lasting paint finish

All standard low-voltage switchgear frames are painted by an automated, industry-first electro-deposition paint process. This multi-stage cleaning and painting operation is automatically controlled to provide uniform paint thickness throughout. The metal frame is completely immersed in a huge, electrically charged "gray river" of light gray, ANSI #61, epoxy enamel paint. Current flow from paint to part immediately bonds the epoxy paint to every exposed surface of the metal. Termed "electrocoating", this process provides an attractive and durable paint finish of the highest quality.



Switchgear Being Immersed in "Gray River"

The electrocoating process entails preparation of the metal and application of the color coat. The metal receives a series of alternate alkaline cleansing and water rinse operations, followed by a phosphatizing treatment. After the metal is properly prepared, the frame is immersed in light gray, ANSI #61, epoxy enamel paint for a specified time period. Following another water rinse, the paint finish is baked dry.

All standard switchgear frames and other metal work used in outdoor switchgear are painted in the manner described. In addition, the weather-proof enclosure for outdoor low-voltage switchgear also receives a spray application of dark gray, ANSI #24, baked acrylic enamel.

POWER CIRCUIT BREAKERS

TABLE 5 — K-LINE® POWER CIRCUIT BREAKER RATINGS

① Circuit Breaker Type	Maximum Continuous Current Rating, A	Interrupting Capacity, Symmetrical RMS Amperes		
		240 Volts	480 Volts	600 Volts
K-225	225	25,000	22,000	14,000
K-600	600	42,000	30,000	22,000
K-1600	1600	65,000	50,000	42,000
K-2000	2000	85,000	65,000	55,000
K-3000	3000	85,000	65,000	65,000
K-4000	4000	130,000	85,000	85,000
K-600S	600	42,000	30,000	22,000
K-1600S	1600	65,000	50,000	42,000
K-2000S	2000	85,000	65,000	55,000
K-3000S	3000	85,000	65,000	65,000
K-4000S	4000	130,000	85,000	85,000

① K-LINE breakers equipped with a POWER-SHIELD solid-state overcurrent trip device have their normal designations suffixed with an S.

K-LINE®

K-LINE circuit breakers have been developed for the protection of feeder circuits and for use as main breakers where the interruption requirements are within the ratings shown in Table 5.

This modern line of low-voltage, air-magnetic, drawout power circuit breakers offers a selection of either manually or electrically (motor charged) operated spring-closing mechanisms, which provide positive quick-make operation. K-LINE circuit breakers can be provided with either a direct-acting, electro-mechanical or a solid-state overcurrent trip device. They are compact and come equipped with many other features which are particularly adaptable to general low-voltage switchgear applications.

For application information on K-LINE circuit breakers, refer to pages 35 and 36.

K-DON®

The K-DON circuit breaker is a compact, versatile protective device which incorporates all of the features of the K-LINE circuit breaker and the current-limiting characteristics of the Amp-Trap† fuse. The current-limiting fuses are integrally mounted on, and physically connected in series with, the breaker. Each K-DON circuit breaker is equipped with an anti-single-phase device to prevent single phasing. No external tripping power is required to operate the anti-single-phase device.

The circuit breaker performs its normal function of time delay and instantaneous tripping throughout its entire range of interrupting capacity. When properly applied, the fuse takes over protection for currents at or above the circuit-breaker short-circuit current rating up to 200,000 amperes. For currents within the circuit-breaker interrupting capability, the fuse will not open unnecessarily thus saving nuisance replacements. This system affords vast flexibility in applying pinpoint protection to any type of electrical apparatus. For application information on K-DON circuit breakers, refer to Pages 37-41.

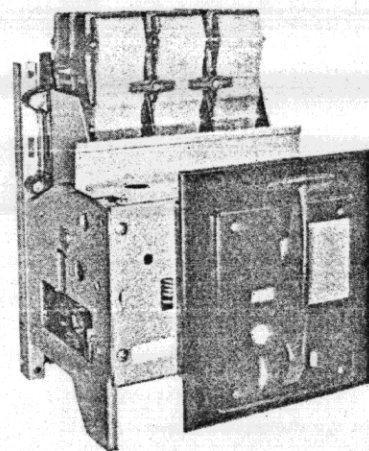
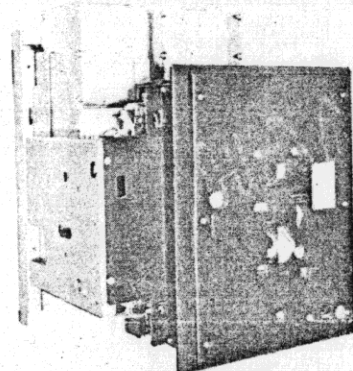
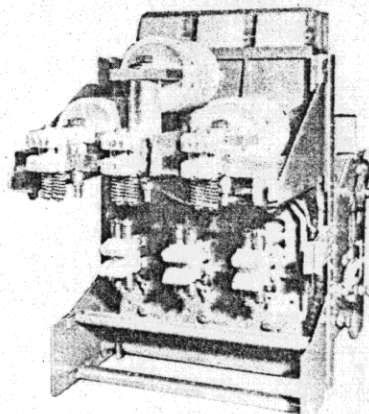
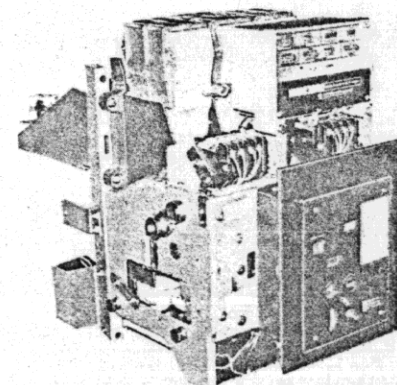
† Registered Trademark—Chase-Shawmut Co.

TABLE 6 — K-DON® POWER CIRCUIT BREAKER RATINGS①

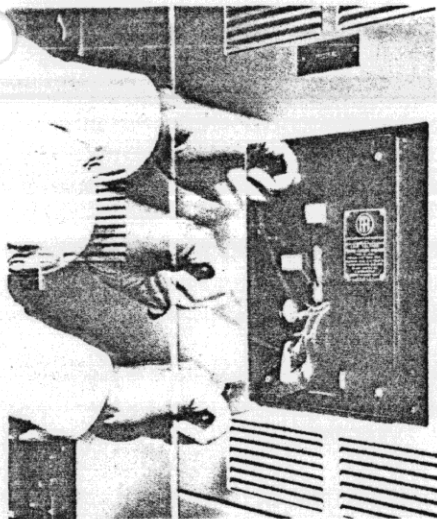
② Circuit Breaker Type	Maximum Continuous Current Rating, A	Interrupting Capacity, Symmetrical RMS Amperes
		240, 480, and 600 Volts
K-DON-600	600	200,000
K-DON-1600	1600	200,000
K-DON-600S	600	200,000
K-DON-1600S	1600	200,000

① Fused circuit breakers with 2000, 3000 and 4000A continuous current ratings are available with separately mounted, drawout, current-limiting fuses. Refer to Page 30 for arrangement information and Page 40 for application data.

② K-DON breakers equipped with a POWER-SHIELD solid-state overcurrent trip device have their normal designations suffixed with an S.

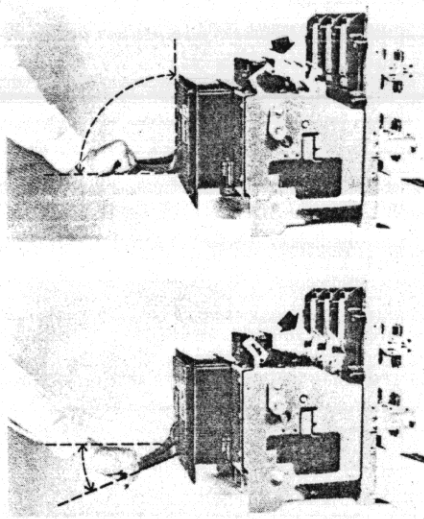

Manually Operated K-600

Electrically Operated K-3000

Rear View Manually Operated K-Don-600

**Electrically Operated K-Don 1600S
with SS5 Power Shield Unit**

MANUAL STORED-ENERGY GIVES QUICK-MAKE, QUICK-BREAK OPERATION



LESS UPKEEP, LONGER CONTACT LIFE

Manually-charged, stored-energy breakers offer many advantages to its users. Of primary importance is the added safety for operating personnel. This quick-make mechanism also provides longer contact and breaker life and increases the scope of application for manual breakers. K-LINE® breakers cannot be teased into the closed position. A pair of powerful springs actually close the contacts. For breakers with frame size ratings from 225 through 2000 amperes, the operator simply supplies energy to the device



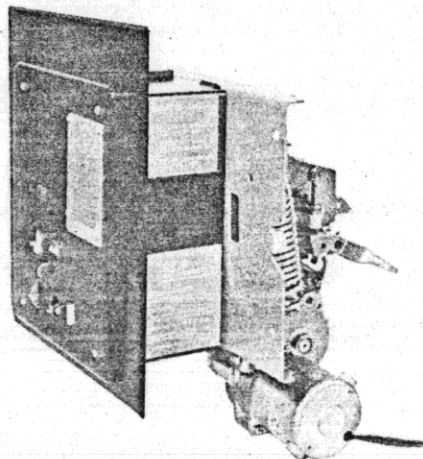
by pulling the semi-flush closing handle downward to approximately 100°. The initial 90° fully charges the closing springs and the remaining motion releases the spring energy to drive the contacts into the closed position by a smooth cam action. The fully-charged springs develop sufficient energy to close and latch the breaker safely under any conditions within the breaker rating. A flush-mounted manual trip button is located on the easily-accessible breaker escutcheon. It is also equipped with a hand-reset automatic trip indicator which provides for visual indication of automatic trip operation.

ELECTRICAL OPERATION

All K-LINE circuit breakers are also available with motor-charged, stored-energy closing mechanisms to be used when remote control or local electrical control is required. The normal control power required by this mechanism is only a fraction of the power requirement for a solenoid closing mechanism.

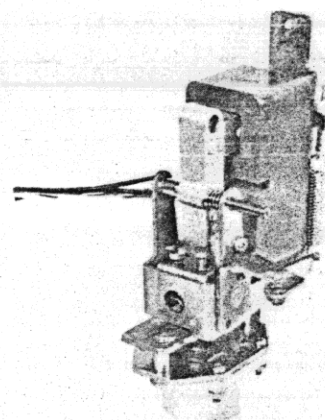
A fractional-horsepower motor with enclosed speed-reduction gears provides the closing energy. The high-torque, high-speed output easily charges the powerful closing springs. The springs are retained in a fully-charged condition until the energy is required for closing. Upon tripping, the springs are again recharged automatically by the mechanism. An emergency charging handle is provided for manual charging if control power is lost. A manual closing lever on the escutcheon permits simple manual close with the compartment door

closed. All stored-energy springs are automatically discharged for safe breaker maintenance when the circuit breaker is racked to the disconnect position.

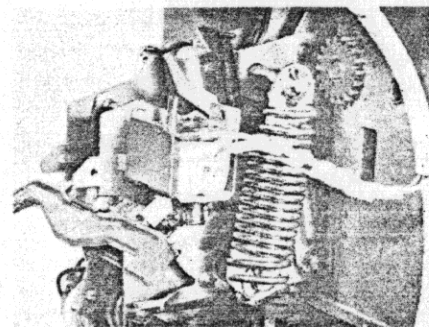


Electrical-Operating Mechanism

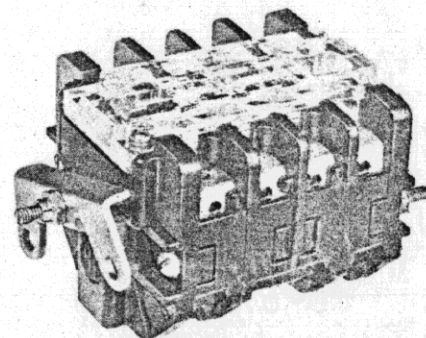
BREAKER COMPONENTS



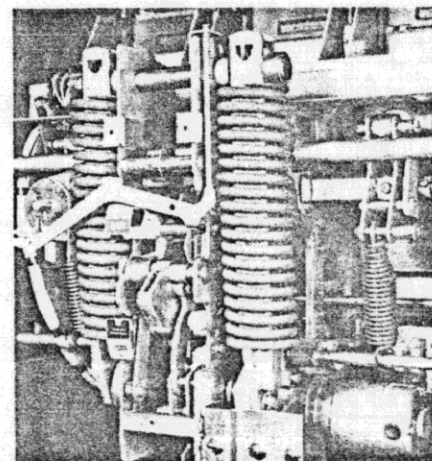
Undervoltage Trip Device



Shunt Trip Device



Auxiliary Switch



K-3000 Motor-Charged Stored-Energy Operating Mechanism

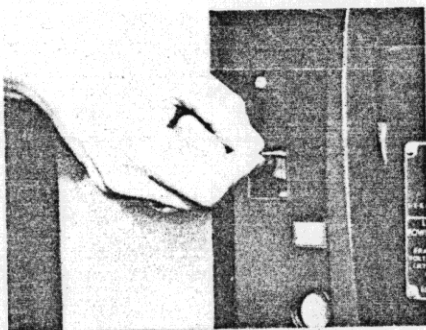
SAFE, EFFICIENT, CLOSED-DOOR DRAWOUT

The circuit-breaker compartment door need never be opened while moving the K-LINE® circuit breaker from the completely connected through test into the disconnected position. Unique construction reduces I-T-E switchgear to three basic components: frame, breaker and a removable cradle on which the breaker rolls for drawout. The mechanism permits racking the breaker into connected, test and disconnected positions without ever opening the compartment door. It facilitates testing and maintenance and promotes safe operation. A lift shutter is provided on the breaker escutcheon which permits in-

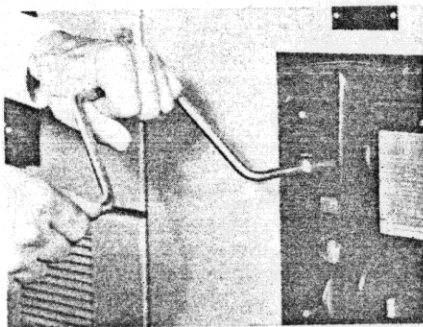
sertion of a racking crank to move the breaker. It is completely interlocked, i.e., the shutter cannot be lifted while the circuit breaker is closed and the circuit breaker cannot be closed while the shutter is lifted. When open, the breaker can be padlocked in the connected, test or disconnected positions. When padlocked, the breaker cannot be closed or moved to any other position.

The extendable escutcheon mounted on the circuit breaker slides through an opening into the compartment door while the spring-loaded cover plate surrounding the escutcheon is held in

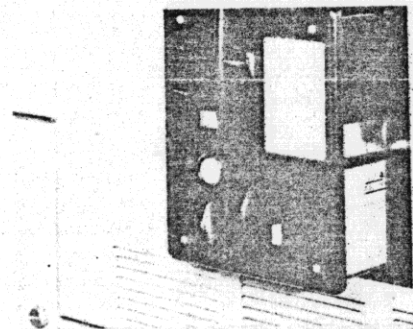
place by the door. Visual indication on the side of the breaker denotes all three positions. Compartment doors may be opened, if desired, when the breaker is in any position. To remove the breaker from its compartment, it must be racked to the fully-disconnected position, the door opened and the breaker pulled manually to the fully-withdrawn position while it is supported by extended sliding rails. After release of the safety latch, the breaker may be lifted directly from the rails by means of an overhead lift device and moved with a transfer truck or be handled completely with a combination lift device and transfer truck.



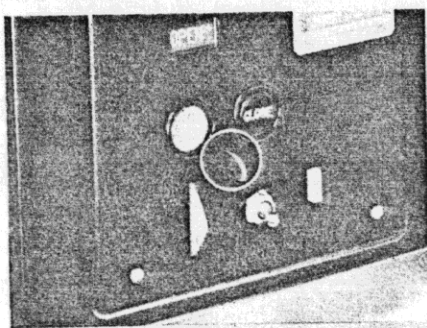
LIFT SHUTTER must be raised to insert breaker racking crank. It cannot be raised when breaker contacts are closed.



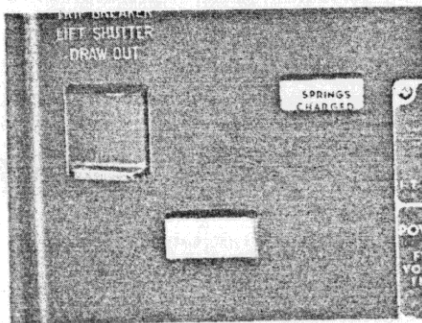
INSERT CRANK to move breaker between positions. Crank cannot be inserted without raising lift shutter.



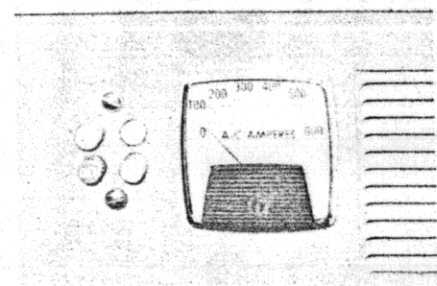
READ BREAKER POSITION from target on the right side of escutcheon. When breaker is in disconnected, test or connected positions, lift shutter will close. Breaker contacts cannot be closed until lift shutter is closed.



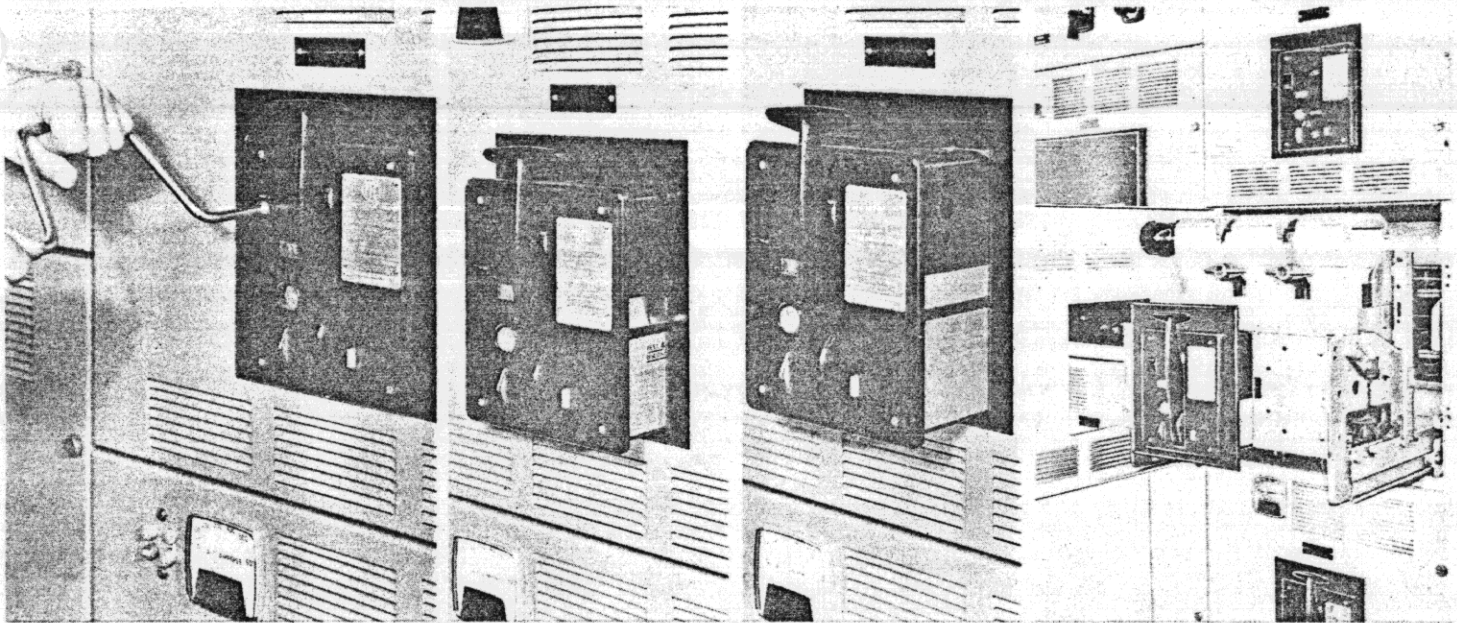
MANUAL CLOSING LEVER. All electrically operated breakers can be closed manually with the compartment door closed, if control power is lost, by simply pulling the closing lever. Closing springs can also be charged manually with a hand lever.



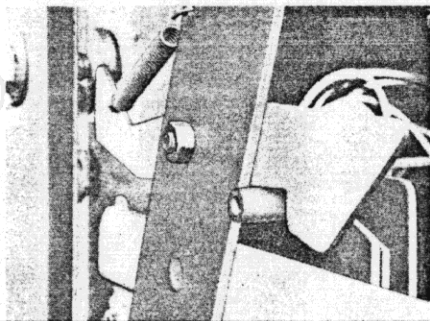
SPRING-CHARGED INDICATOR shows condition of stored-energy springs on electrically-operated breakers. **OPEN-CLOSED INDICATOR** visually shows position of breaker contacts directly on front of escutcheon.



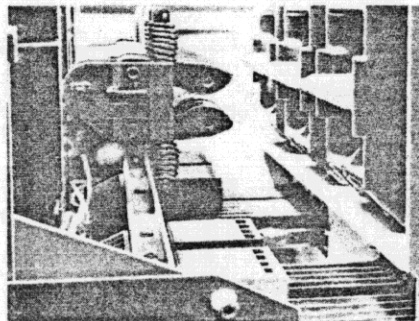
FEEDER AMMETER. Each feeder compartment can be equipped with a door-mounted ammeter and push-button switch for easy, convenient reading and space saving.



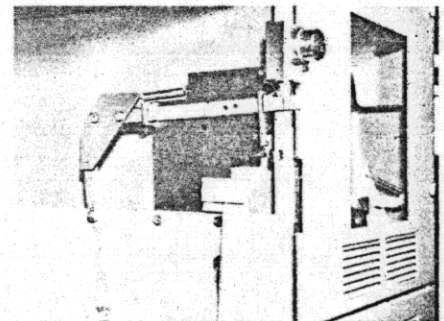
CONNECTED TEST DISCONNECTED FULLY WITHDRAWN



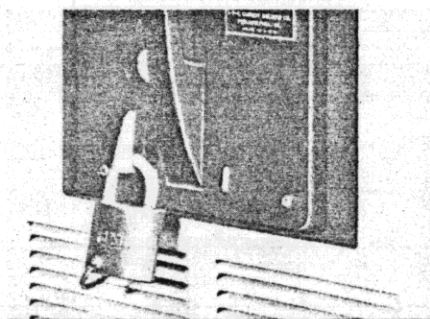
RAIL LATCH prevents breaker from rolling off track when breaker is fully withdrawn. Latch must be released to lift breaker from rails.



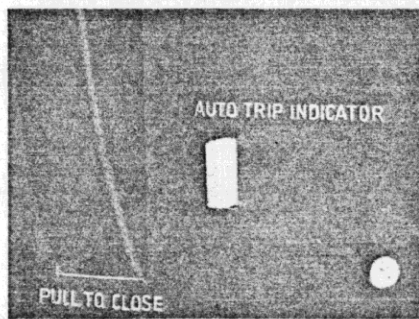
PRIMARY, SECONDARY AND GROUND CONTACTS on the circuit breaker mate sequentially in a straight-line motion with counterparts within the switchgear. This insures proper breaker operation at each position.



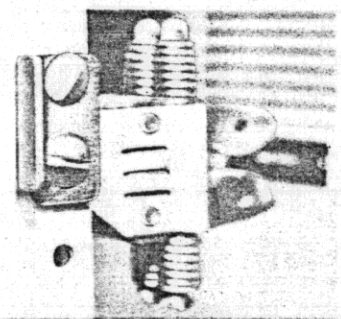
KIRK™ KEY INTERLOCKS offer an unlimited number of interlocking arrangements between all components of the switchgear. They are particularly adaptable to sequential operations or prevention of unauthorized operation.



PADLOCK PROVISION. The circuit breaker, when open, can be padlocked (with up to three locks) in all three positions. When padlocked, it cannot be closed or moved to any other position.



AUTOMATIC-TRIP INDICATOR gives visual indication when the breaker has tripped from a fault or other overcurrent conditions.



INTERFERENCE KEY on the breaker mates with slot on cradle allowing only the proper rated breaker to be inserted into the compartment. It is virtually impossible to insert a lower rating into any compartment.

OD—ELECTRO-MECHANICAL OVERCURRENT TRIP DEVICE

K-LINE® type OD electro-mechanical overcurrent trip devices have been designed to provide dependable performance with virtually noiseless and vibration-free operation. I-T-E low-voltage power circuit breakers equipped with this rugged device are available in any desired combination of long-time delay, short-time delay and instantaneous tripping. Each overload is individually calibrated, tested and certified by Quality Control to assure "as designed" performance and service.

OD-3 and OD-300 Dual-Magnetic Direct-Acting Trip Device

The OD-3 and OD-300 are fully adjustable, dual-magnetic overcurrent trip devices. They employ a dual armature. One is connected to an oil-displacement dashpot to provide long-time delay. A second armature provides instantaneous trip characteristics. The overload on each pole has independent adjustment for long-time delay pick-up, instantaneous pick-up, and the amount of time delay. It is a self-contained, direct-acting, electro-mechanical device which depends on its own circuit for tripping power. No external tripping power is required.

Expanded-range calibration is incorporated to provide a greater number

of usable calibrated long-time pick-up settings. Conventional trip devices provide only two calibrated pick-up settings (80% and 100%) which may be used continuously without excessive overheating. Table 59, page 43, shows the increased number of calibrated long-time pick-up settings within 100% of the continuous current rating of each trip coil. This feature permits a user to select a device with a trip coil rating which provides adequate protection for present power requirements and also permits an increase in capacity by means of simple adjustments.

A wide range of adjustment makes this rugged unit ideal for protection of motors and equipment which require close protection.

Production units have been subjected to more than 4,000,000 welding type pulse test cycles without failure—thus proving a long-life design! OD-3 and OD-300 units now in service have proven themselves in many difficult application including heavy-duty welding circuits.

OD-4 and OD-400 Dual-Selective Direct-Acting Trip Devices

The OD-4 and OD-400 direct-acting trip devices combine the fluid-displacement type time delay with mechanical-

escapement time delay to provide a composite time-delay device in which it is possible to closely control the time-delay over a range of current values from normal load current to the full interrupting current rating.

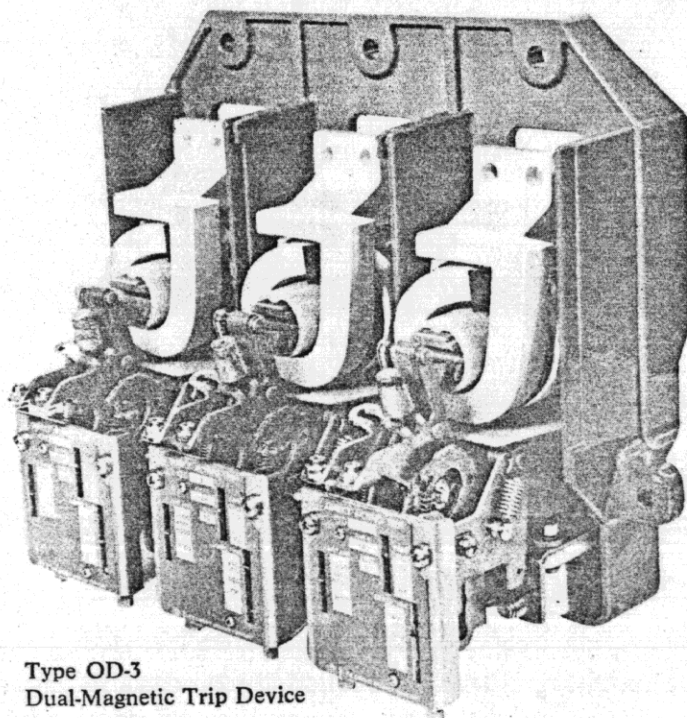
This allows the direct-acting trip devices of circuit breakers in series to be set so as to permit selective tripping of the circuit breaker closest to the fault. Thus maximum continuity of electrical service may be provided where such continuity is mandatory.

EASY TO ADJUST

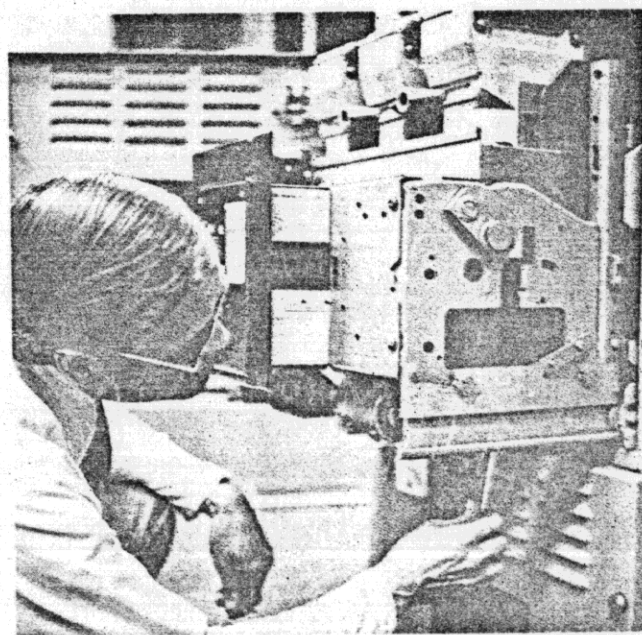
Trip devices are clearly visible and within easy reach from the front of the circuit breaker. Even on electrically-operated circuit breakers, they are readily accessible to the operator for quick, easy adjustment.

EASY TO SERVICE

The three-phase overcurrent trip device assembly is mounted on a one-piece, impact-resistant polyester-glass molding for breaker sizes up to K-600. On larger size breakers the overcurrent trip device assembly consists of three individual units. If repair or replacement is required, the assembly is easily removed from the back of the breaker. Associated devices need not be disturbed.



Type OD-3
Dual-Magnetic Trip Device



Adjusting and servicing OD device is simple and convenient.

POWER-SHIELD® - SOLID-STATE OVERCURRENT TRIP DEVICE

GENERAL INFORMATION

POWER-SHIELD is a three-phase solid-state, overcurrent trip device designed for low-voltage power system protection against damage caused by overload and short-circuit conditions. It can be integrally mounted on K-LINE® and K-DON® low-voltage power circuit breakers. The logic assembly of the POWER-SHIELD system is mounted on the shelf above and behind the breaker escutcheon for easy accessibility to the control panel. POWER-SHIELD is suitable for application on low-voltage circuits rated up to 600V ac, 50/60 Hertz. Available standard types and their related trip functions are shown in Table 61 page 44.

The POWER-SHIELD solid-state overcurrent trip system consists of current sensors, logic assembly, magnetic latch release and interconnecting wiring. There are two current sensors mounted on the breaker lower base molding around each primary conductor. One sensor supplies the logic assembly with a signal current proportional to the primary current, and is referred to as the signal sensor. The other sensor, designated the power supply sensor, supplies the power required to operate the magnetic-latch release and solid-state circuitry. The logic assembly contains the circuitry

and various tap-blocks used to set the overcurrent trip levels and time delays. A transparent cover is provided over the tap blocks. The magnetic-latch release is similar in function to a shunt-trip device, but is powered by the fault current through the power-supply sensors, and is actuated by the logic assembly system.

SIMPLE TAP CHANGING

The wide rating range of each device, coupled with its simplified field adjustment, allows almost unlimited load growth within each breaker frame size. Only seven different sizes are required for the full range of 35 thru 4000 amperes (see page 44). Field setting is accomplished by insertion of tap plugs into the front of the logic unit. All settings are made in this fashion, including the **ampere tap** which selects the continuous rating of the current sensor. This setting is shown directly in primary amperes, giving the user a positive indication of the continuous current rating of his circuit breaker. The long-time, short-time and instantaneous functions are then adjusted by tap plugs which are a percentage of this ampere tap setting. In addition, three time-delay bands, minimum, intermediate and maximum can be selected for both the long-time and short-time functions. All

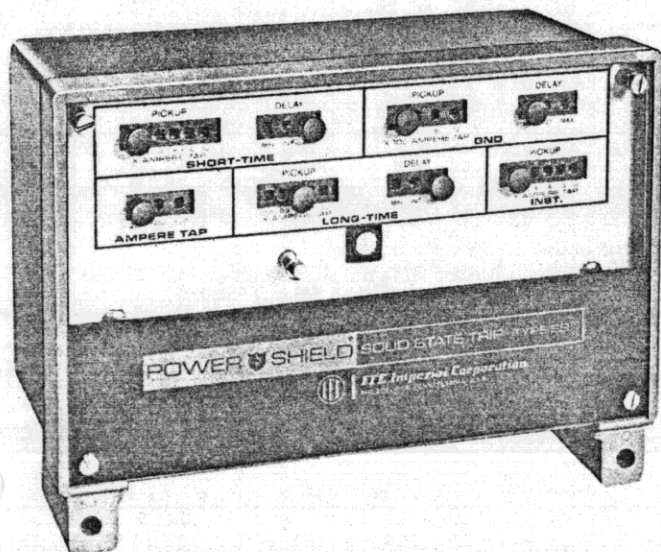
time-current curves are straight lines, asymptotic at the pick-up point to produce optimum coordination with other protective devices. Coordination is made even more positive by the wide separation between all time-delay bands.

Optional ground and/or short time-instantaneous operation indicators are available.

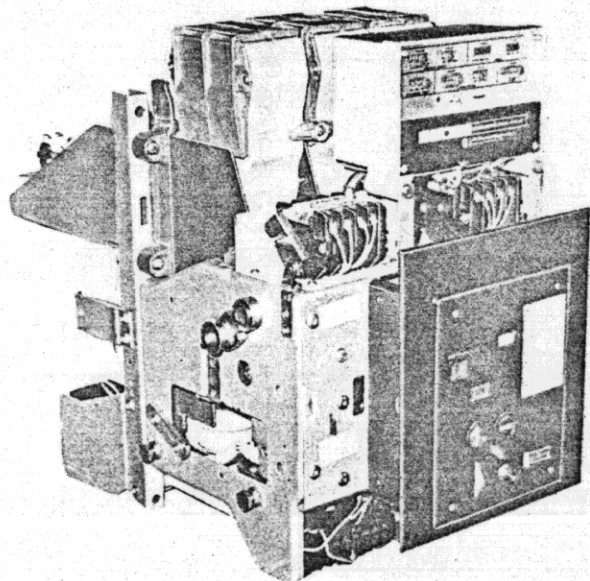
Also available as an option is an alarm contact for remote indication.

GROUND-FAULT PROTECTION

POWER-SHIELD is available with multiple ampere taps for a wide range of pick-up currents. The ground function can be included in the logic assembly for those applications in which it is desirable to protect the system against faults to ground. These are often damaging arcing faults which result in current magnitudes below the pick-up of the long-time trip function. 3-wire applications with ground protection do not require any additional sensors. For 4-wire applications, one ground sensor is remotely mounted around the neutral conductor and is wired to the logic assembly through a breaker secondary disconnect. The ground function is tap selected directly in amperes, and is independent of the ampere tap setting.



Front view of SS-5G POWER-SHIELD logic assembly.



Front view of K-DON-1600 S electrically-operated breaker equipped with SS-5 POWER-SHIELD unit.

GROUND-SHIELD® - SOLID-STATE GROUND FAULT PROTECTION

GROUND-SHIELD is the registered family trademark for a variety of solid-state relay systems designed to protect electrical distribution circuits and electrical loads from the damage caused by the inadvertent flow of ground-fault currents. Three (3) systems are offered: (1) **GR-5** and **GR-200**, (2) **GRM**—motor circuit applications, and (3) **GRD**—three-phase differential.

The GR-5 and GR-200 GROUND-SHIELD Systems offer fast, sensitive protection against ground-faults including destructive, low-magnitude, arcing ground-faults in solid and resistance grounded distribution systems. They consist of a special-design, core-balancing current transformer (sensor) and a low-burden, solid-state ground relay.

The ground sensors are available with small or large-window configurations designed to enclose all phase and neutral bus or cable conductors. These sensors will respond only to ground-fault currents. Balanced or unbalanced load currents, two-phase or three-phase short circuits not involving a ground return conductor, will have no effect on the sensor. Two (2) pickup

ranges are available, one with 5 ampere minimum sensitivity, and one with 200 ampere minimum sensitivity. The 5A system (GR-5 relay) with 5-50A pickup adjustment (special pickup ranges of 2-40A and 20-200A are also available) is used for protection of individual loads such as motors and transformers. On high-resistance grounded systems the 5-50A relay is used for both circuit and load protection. The 200 ampere system (GR-200) relay with 200-1200A pickup adjustment is used for circuit protection.

The 5A system provides five time-current curves of definite time shape. Four time-current curves are available for the 200A system. All relay calibrations are in primary amperes. Tripping of the desired breaker (coordination) is obtained by applying relays with successively faster curves progressing from source to load circuits. Relays are available for surface mounting and semi-flush panel mounting.

GRM System offers fast, sensitive and inexpensive protection against ground faults in individual motor starter and contactor circuits (type GRM-NC) and electrical distribution

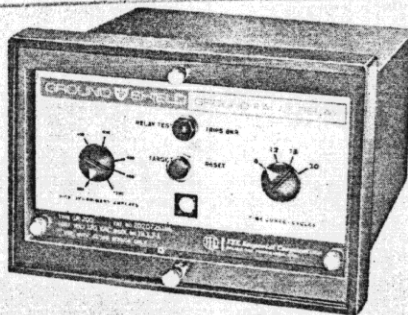
systems using molded-case circuit breakers with shunt trips (type GRM-FC).

The system consists of a special small diameter current transformer (sensor) and an instantaneous, mechanically latched ground relay with a 10 ampere sensitivity. The ground sensor, which encircles all phase conductors, comes in 2" (GSM-1) and 3" (GSM-2) inside diameters.

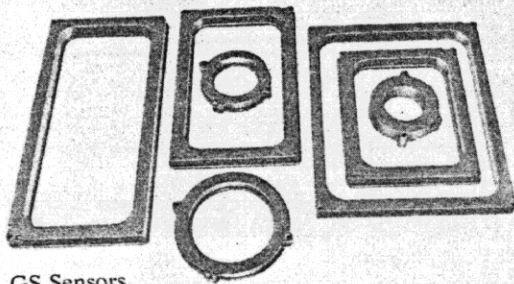
GRD Differential System provides fast, sensitive protection against phase-to-phase or phase-to-ground faults occurring in 3-phase motors, generators, reactors, etc. This system consists of three solid-core current sensors type GS-5 and one 3-phase, solid-state ground differential relay type GRD, which operates the shunt-trip device on the circuit breaker. The ground differential relay and the associated current sensors are connected in a self-balancing scheme. The GROUND-SHIELD differential system has a sensitivity of 2 amperes primary fault current, operates in 2 cycles, and is significantly more economical than comparable conventional differential relays operated from current transformers.



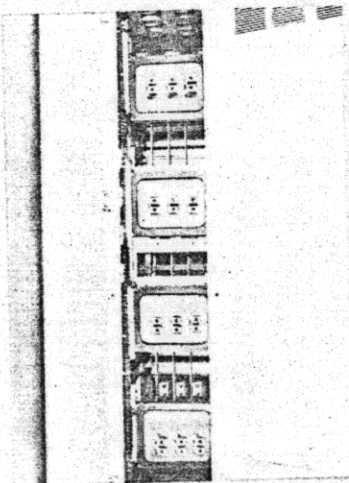
GR-200, Surface Case



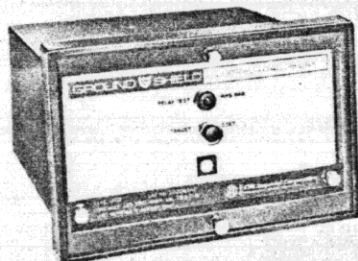
GR-5, Drawout Case



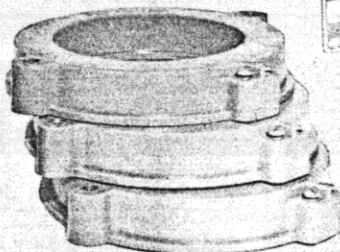
GS Sensors



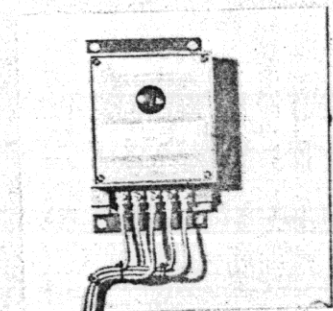
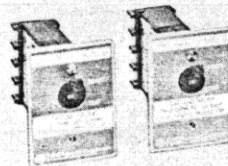
GS sensors mounted in cable compartment.



GRD Differential System



GRM Motor and Contactor System



GR surface relay mounted in instrument compartment.

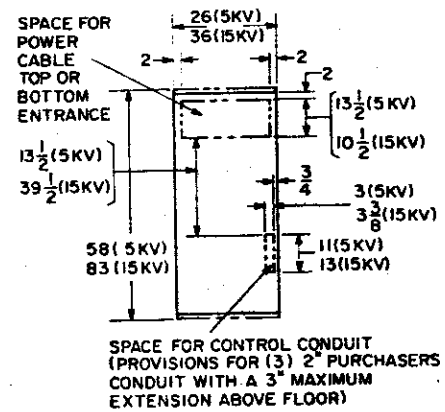
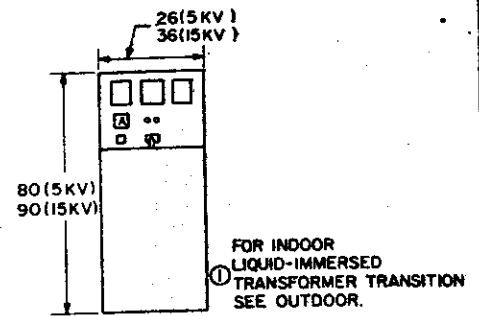
FEATURES OF STORED-ENERGY K-LINE[®] AND K-DON[®] CIRCUIT BREAKERS

		K-225 K-600 K-1800 K-2000	K-3000 K-4000	K-DON- 600 1600	K-600S K-1600S K-2000S	K-3000S K-4000S	K-DON-600S K-DON-1600S
	STANDARD FEATURES INCLUDE:						
MANUALLY OPERATED	Springs charged and breaker closed with manual handle	X	No	X	X	No	X
	Springs charged only with manual handle	No	X	No	No	X	No
	Manual close lever—door closed	No	X	No	No	X	No
	Springs-charged indicator	No	X	No	No	X	No
ELECTRICALLY OPERATED	Springs charged with motor—after trip	X	X	X	X	X	X
	Electrical closing release	X	X	X	X	X	X
	Manual close lever—door closed	X	X	X	X	X	X
	Shunt-trip device	X	X	X	X	X	X
	Control relay	X	X	X	X	X	X
	Charging-motor disconnect switch	X	X	X	X	X	X
	Springs-charged indicator	X	X	X	X	X	X
	Secondary disconnects (operating and test position)	X	X	X	X	X	X
	4-Contact auxiliary switch	X	X	X	X	X	X
	Provision for manual spring charge	X (Door Open)	X (Door Closed)	X (Door Open)	X (Door Open)	X (Door Closed)	X (Door Open)
MANUALLY OR ELECTRICALLY OPERATED	Manual trip button	X	X	X	X	X	X
	Breaker contact-position indicator	X	X	X	X	X	X
	Breaker racking-position indicator	X	X	X	X	X	X
	Racking interlock (breaker must be open prior to racking)	X	X	X	X	X	X
	Positive racking stops	No	X	No	No	X	No
	Padlock hasp—up to three locks (locks breaker trip-free and in position)	X	X	X	X	X	X
	Breaker interchangeability interlock	X	X	X	X	X	X
	Direct-acting overcurrent trip devices (dual-magnetic, other combinations, except dual-selective)	X	X	X	No	No	No
	Solid-State overcurrent trip device (long-time and instantaneous, SS-3)	No	No	No	X	X	X
	Automatic trip indicator (overcurrent and undervoltage trip)	X	X	X	X	X	X
	Primary disconnects—(operating position only)	X	X	X	X	X	X
	Ground disconnect—(operating and test position only)	X	X	X	X	X	X
	Manual slow-close provision	X	X	X	X	X	X
	Actuator to discharge springs on withdrawal from switchboard	X	X	X	X	X	X
	Amp-trap, current-limiting fuses	No	No	X	No	No	X
	Anti-single-phase device	No	No	X	No	No	X
ADDITIONAL OPTIONAL FEATURES (E.O. or M.O. except as noted)	Local electrical trip button—(on escutcheon)	X	X	X	X	X	X
	Shunt trip with 4-contact auxiliary switch (2 spares)—M.O. only	X	X	X	X	X	X
	Dual-selective, direct-acting overcurrent trip device	X	X	X	No	No	No
	Solid-State overcurrent trip device (Dual-Selective, SS-4 and SS-5)	No	No	No	X	X	X
	Operation indicator (target) and load alarm for solid-state trip	No	No	No	X	X	X
	Mechanical lockout on automatic trip (reset by indicator)	X	X	X	X	X	X
	—Overcurrent and undervoltage trip	X	X	X	X	X	X
	—Overcurrent alone (special trip for undervoltage)	X	X	X	X	X	X
	Alarm switches—1 N.O. and 1 N.C. (reset by indicator)	X	X	X	X	X	X
	—Overcurrent and undervoltage trip	X	X	X	X	X	X
	—Overcurrent alone (special trip for undervoltage)	X	X	X	X	X	X
	Auxiliary switches—spares	X	X	X	X	X	X
	—4 or 8 Contacts—E.O. only	X	X	X	X	X	X
	—4, 8 or 12 Contacts—M.O. only	X	X	X	X	X	X
	Undervoltage-trip device	X	X	X	X	X	X
	—Instantaneous	X	X	X	X	X	X
	—Time delay—Adjustable 0 - 15 sec.	X	X	X	X	X	X
	Operation counter	X	X	X	X	X	X
	Remote electrical-close release—M.O. only	No	X	No	No	X	No
	Wiring change to charge springs when breaker closes	X	X	X	X	X	X
	Hinged door interlock—door locked when breaker closed	X	X	X	X	X	X
	Mechanical-transfer interlock—two breakers using flexible cable arrangement	X	X	X	X	X	X
	Additional secondary disconnects up to 32 maximum total	X	X	X	X	X	X
	Secondary disconnects—operating and/or test position only	X	X	X	X	X	X
	Key interlocks—switchboard mounted—2 maximum	X	X	X	X	X	X
STANDARD ACCESSORIES	Racking crank	X	X	X	X	X	X
	Lifting yoke	X	X	X	X	X	X
	Maintenance spring-charge handle—E.O. only	X	X	X	X	X	X
	Slow-close bracket	No	X	No	No	X	No
OPTIONAL ACCESSORIES	Transfer and lift truck	X	X	X	X	X	X
	Overhead lift device—(standard outdoor)	X	X	X	X	X	X
	Floor dolly	X	X	X	X	X	X
	Test set for solid-state trip	No	No	No	X	X	X

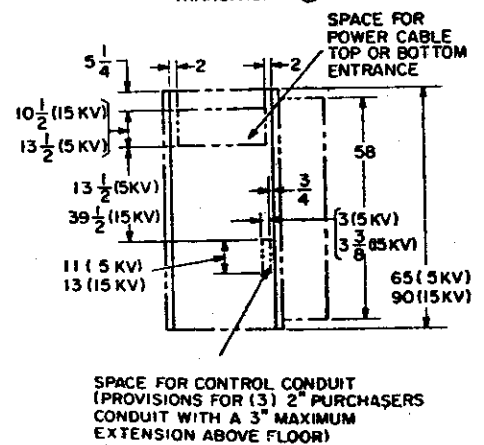
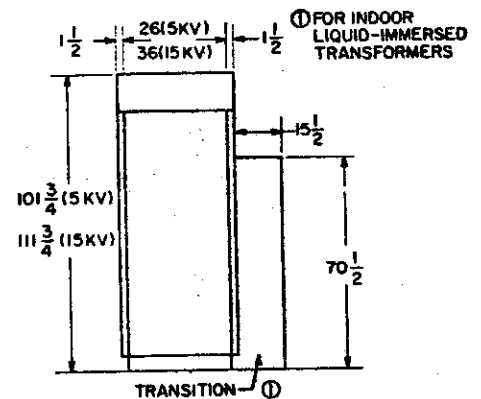
DIMENSIONS [▲]

METAL-CLAD SWITCHGEAR

Indoor



Outdoor



INCOMING LINE SECTION

OIL CUTOUTS

Indoor — Outdoor

TRANSFORMER TANK WALL AND BUSHINGS

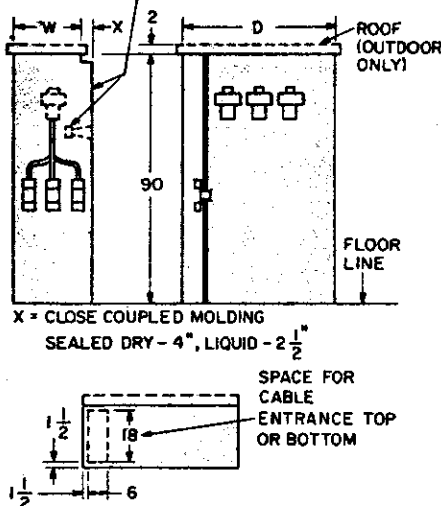


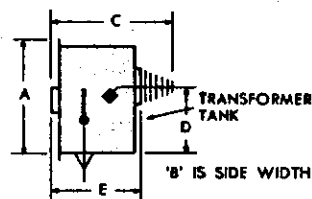
TABLE 7 — OIL CUTOUTS

Device	Liquid		Ventilated and Sealed-Dry	
	W	D	W	D
5 kV — 100, 200A	22 1/2	48	21	48
5 kV — 300A	44 1/2	58	43	58
15 kV — 100, 200A				

LIQUID SWITCHES

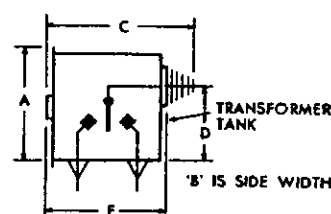
Indoor — Outdoor

TWO POSITION



kV	A	B	C	D	E
5	21 1/4	30 1/2	23	13 3/4	17 3/4
15	26	34 1/2	24	16 1/4	18 3/4

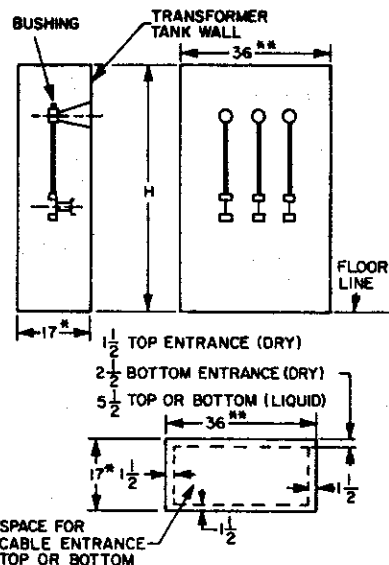
THREE POSITION



kV	A	B	C	D	E
5	22 1/4	28	25 3/4	14 3/4	20 1/4
15	26	32	28 3/4	17 1/4	23 1/4

AIR TERMINAL CHAMBER

Indoor — Outdoor

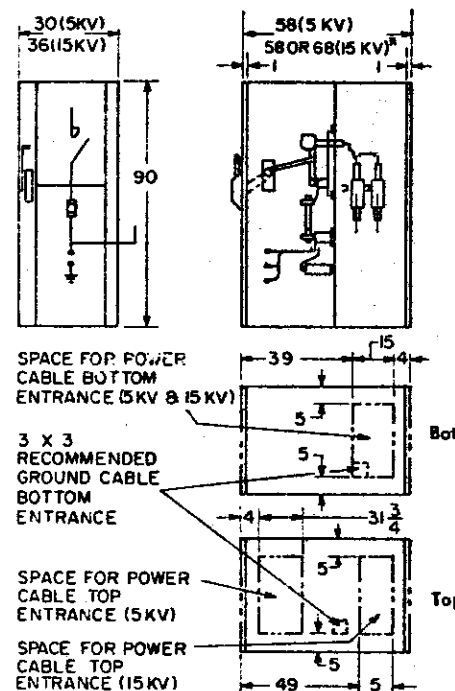


*ADD 1" ON ALL VENTILATED-DRY TRANSFORMERS
**WHEN USED WITH VENTILATED-DRY TRANSFORMER—MATCH TRANSFORMER DEPTH

TABLE 8 — AIR TERMINAL CHAMBER

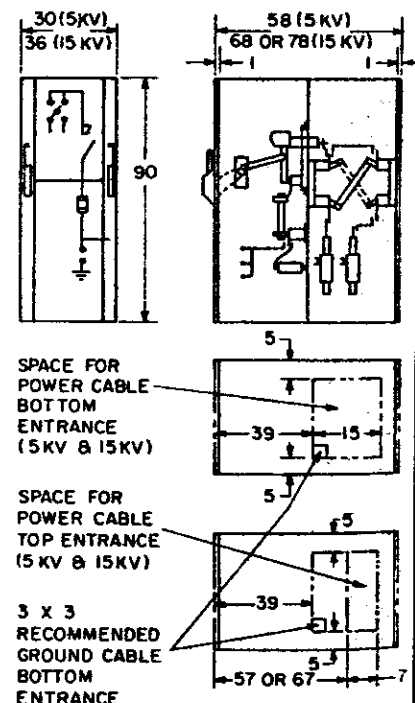
Trsfr. Dim.		Liquid H	Sealed-Dry H	Vent. Dry H
kVA	KV	Top or Bott Entrance	Top or Bott Entrance	Top or Bott Entrance
500 to 2500	5 or 15	94	110	90

AIR INTERRUPTER SWITCH—Indoor

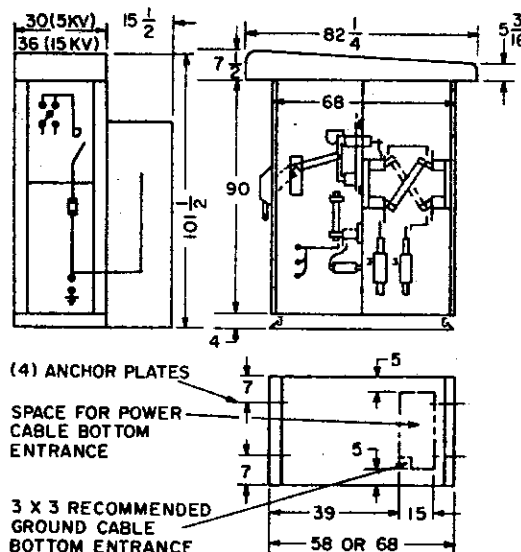


*DOUBLE POTHEAD TOP ENTRANCE

SELECTOR SWITCH—Indoor



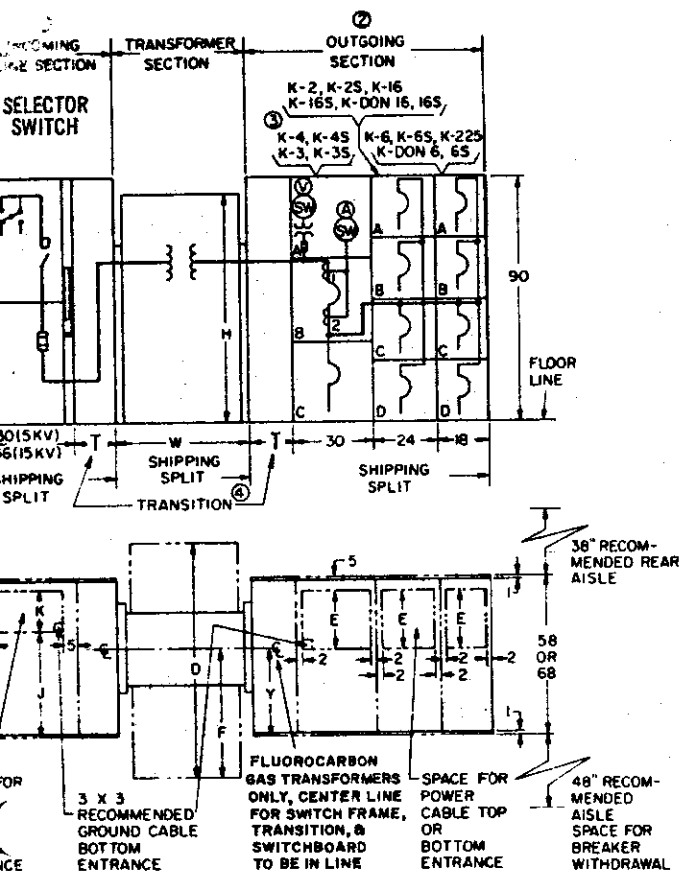
SELECTOR SWITCH—Outdoor



▲ Dimensions are in inches. Both Dimensions and Weights are approximate

CONDARY UNIT SUBSTATION ARRANGEMENTS

10 (ASKAREL) AND SEALED-DRY—Indoor



**TABLE 9 — AIR INTERRUPTER
SELECTOR SWITCH**

Voltage	Cable Entrance	G	J	K
5kV	Bottom	58	39	15
5kV	Top	68	57	7
15kV	Bottom	68	39	15
15kV	Top	78	67	7

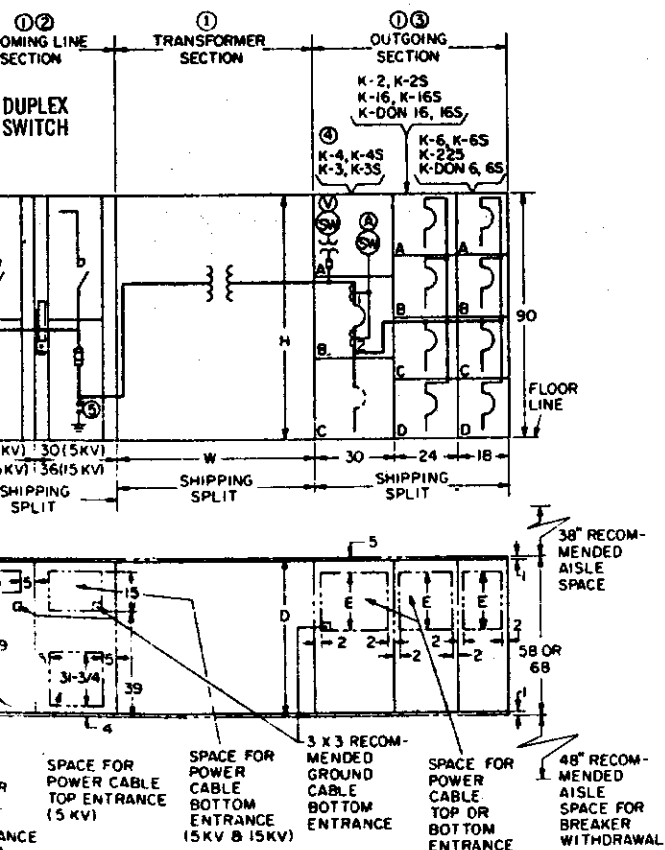
- ① Incoming Section (15kV) must be 68" deep when furnished with 2-3/c potheads for top entrance.
- ② When main bus is over 4000 amperes, consult I-T-E district sales office.
- ③ K4000 (2-45" high compartments) breaker located in bottom compartment.
- ④ Transition units are supplied assembled to the Incoming Line Section and Outgoing Section.

TABLE 10—ASK

kVA	Incomi Section
500	5 kV or 15 kV
750	
1000	
1500	
2000	
2500	

* For 208Y/120 volts
Δ For 8% impedance,

VENTILATED-DRY—



**TABLE 13 — VENTILATED-DRY TRANSFORMER
150°C RISE**

kVA	Incoming Section	Dimensions, in.		
		W†	H	D
500	5 kV or 15 kV	78	90	58
750				
1000		90	96	68
1500				
2000		102	108	
2500				

† An 18" wide transition unit must be supplied when no main breaker is used.

TABLE 14 — LOW-VOLTAGE SWITCHGEAR

Circuit Breaker Type	Frame Width Inches	"E" DIMENSION, in.							
		Without		With		Feeder with Ground or Neutral Sensor		Neutral 3ø4w with Main Bus Barrier†	
		Main Bus Barrier							
		Switchgear Depth, in.							
		58	68	58	68	58	68	58	68
K3 & K3S, K4 & K4S	30	21*	31*	12	22	—	17½	7½	17½
K2 & K2S, K16 & K16S	24	21	31	12	22	—	17½	7½	17½
K-225 K6 & K6S,	18	21	31	12	22	—	17½	7½	17½
K-DON 16 & 16S	24	16½	26½	—	17½	—	13	—	13
K-DON 6 & 6S	18	16½	26½	—	17½	—	13	—	13

* With bottom entrance to K-3000 in compartment C, subtract 6".
† For main breaker unit or with K-3000 in compartment C.

- ① Incoming, Transformer and Outgoing Sections will always have their fronts aligned.
- ② Incoming Section (15 kV) must be 68" deep when furnished with 2-3/c potheads for top entrance.
- ③ When main bus is over 4000 amperes, consult I-T-E district sales office.
- ④ K-4000 (2-45" high compartments) breaker located in bottom compartment.
- ⑤ Distribution-type lightning arresters are always required.

AND SEALED-DRY TRANSFORMER

Askarel 65°C Rise				Sealed-Dry 150°C Rise			
W	H	D	T	W	H	D	T
46	86	68	15½	82	84	58	14
49		84		84			
54		97		88		60	
55		100		96		62	
61		105		100		65	
65		110		104		68	

ation, add 8".
½".

TABLE 11 — LOW-VOLTAGE SWITCHGEAR

Dimension	
Without Main Breaker with K-LINE® Feeders	32
With Main Breaker with K-LINE or K-DON Feeders	
Without Main Breaker with K-DON® Feeders	36½

TABLE 12 — LOW-VOLTAGE SWITCHGEAR

Circuit Breaker Type	Frame Width, in.	"E" Dimension					
		Without		With		Feeder Ground or Neut. Sensor	
		Main Bus Barrier					
		Switchgear Depth, in.					
		58	68	58	68	58	68
K3 & K3S, K4 & K4S	30	21*	31*	12†	22†	—	17½
K2 & K2S, K16 & K16S	24	21	31	12	22	—	17½
K6 & K6S, K-225	18	21	31	12	22	—	17½
K-DON 6, 6S	18	16½	26½	—	17½	—	13
K-DON 16, 16S	24	16½	26½	—	17½	—	13

* With bottom entrance to K-3000 in compartment C, subtract 6".

† With K-3000 in compartment C & 3φ, 4w system, subtract 4½".

LIQUID (OIL & ASKAREL) Outdoor

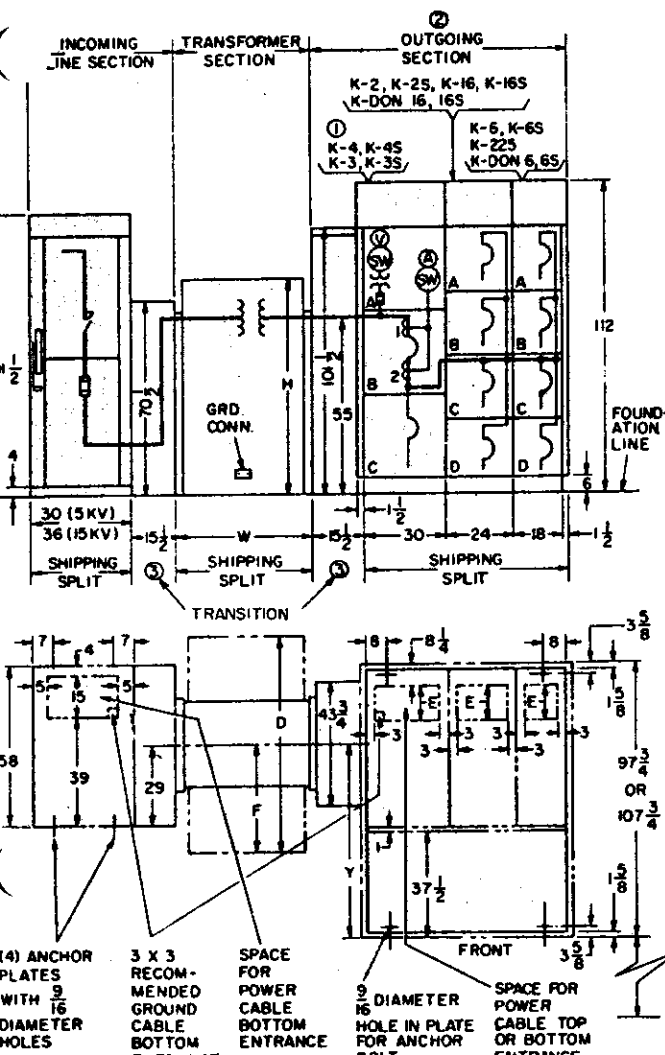


TABLE 15 — OIL & ASKAREL TRANSFORMER — 65°C RISE

KVA	W	H OIL	H ASK.	D
500	46	84	86	68
750	49			84
1000	54			97
1500	55			100
2000	61			105
2500	65			110

TABLE 16 — LOW-VOLTAGE SWITCHGEAR

"Y" Dimension	
Without Main Breaker with K-LINE Feeders	69½
With Main Breaker with K-LINE or K-DON Feeders	
Without Main Breaker with K-DON Feeders	74

TABLE 17 — LOW-VOLTAGE SWITCHGEAR

Circuit Breaker Type	Frame Width	"E" Dimension					
		Without		With		Feeder with Ground or Neutral Sensor	
		Main Bus Barrier					
		Switchgear Depth, in.					
		97%	107%	97%	107%	97%	107%
K3 & K3S, K4 & K4S	30	18*	18*	11†	18†	—	13½
K2 & K2S, K16 & K16S	24	18	18	11	18	—	13½
K6 & K6S, K-225	18	18	18	11	18	—	13½
K-DON 6 & 6S	18	15½	18	—	16½	—	12
K-DON 16 & 16S	24	15½	18	—	16½	—	12

* With bottom entrance to K-3000 in compartment C subtract 6".

† With K-3000 in compartment C & 3φ 4w system subtract 4½".

- ① K-4000 (2-45" high compartments) breaker located in bottom compartment.
- ② When main bus is over 4000 amperes, consult I-T-E district sales office.
- ③ Transitions shipped disassembled.

WEIGHTS▲

INCOMING LINE SECTION

TABLE 18 — PRIMARY DEVICE WEIGHTS, LBS.

Type Primary Device	Depth, in.				3 Fuses	3 L.A.	1-3/4 3-1/c Pothead
	Indoor		Outdoor				
	58	68	58	68			
5 kV Unfused Switch	900	1000	1350	—	200	50	100
15 kV Unfused Switch	1200	1300	1800	—			
5 kV Unfused Selector	1100	1200	1550	—			
15 kV Unfused Selector	—	1600	—	2250			
Air Terminal Chamber	400						
Liquid Switches	2-Position		3-Position				
5 kV	450		500				
15 kV	515		640				
Oil Fused Cutout 5 kV—100, 200A	900						
Oil Fused Cutout 5 kV—300A 15 kV—100, 200A	1300						

TRANSFORMER SECTION

TABLE 20 — TRANSFORMER WEIGHTS, LBS.

Transformer Type	Volts, kV	TRANSFORMER kVA					
		500	750	1000	1500	2000	2500
Ventilated-Dry	5 or 15	5000	5800	7000	8500	10000	11500
Liquid-Askarel	5 or 15	5900	6900	8400	10100	12100	14500
Liquid-Oil	5 or 15	4900	5900	7200	8700	10500	12600
Sealed-Dry	5 or 15	8500	10000	12500	14400	18000	22000

OUTGOING SECTION

TABLE 21 — LOW-VOLTAGE SWITCHGEAR WEIGHTS, LBS.

Type Unit	Frame Width, Inches	Switchgear Depth, in.			
		Indoor		Outdoor	
		58	68	97¾	107¾
*K-225, K-6 & 6S, K-DON 6 & 6S	18	750	850	1300	1420
		900	1000	1450	1570
*K-16 & 16S, K-2 & 2S, K-DON 16 & 16S	24	1000	1200	1650	1880
*K-3 & 3S, K-4 & 4S	30	1550	1750	2300	2535
		1600	1800	2350	2585
Auxiliary Units (Bus Transition) Includes Bus	18	700	800	1250	1370
	24	800	900	1450	1580
	30	900	1000	1650	1785
End Panels	1½	—		1000 Per Swbd	1125 Per Swbd
Overhead Lifting Device	—	100 Per Switchboard			
†Terminal Block Pans	—	110			
Main Bus Barriers	18	65			
	24	90			
	30	110			

*Switchgear only. Does not include breakers. For breaker weights, see Table 23.

†For electrically operated circuit breakers.

TABLE 19 —
METAL-CLAD SWITCHGEAR WEIGHTS, LBS.

Circuit Breaker Type	Cont. Current, A	Breaker Weight	Depth		End Panels
			Indoor	Outdoor	
			58"	65"	
5HK75	1200	550	1325	1690	545
5HK250	1200	560	1325	1690	
5HK250	2000	580	1458	1823	
5HK350	1200	750	1400	1790	590
5HK350	2000	760	1533	1923	
			83"	90"	775
7.5HK500	1200	995	2170	2675	
7.5HK500	2000	1005	2411	2916	
15HK500	1200	925	2170	2675	
15HK500	2000	1005	2411	2916	
			91"	98"	835
15HK750	1200	1345	2260	2778	
15HK750	2000	1355	2501	3019	
AUXILIARY EQUIPMENT					
5HK—Potential transformer, drawout unit with 3 PT's—216 lbs.					
15HK—Potential transformer, drawout unit with 3 PT's—515 lbs.					
5 & 15 kV—Stationary-mounted, control-power transformers to 15 kVA—305 lbs.					
5HK—Drawout fuse unit—160 lbs.					
15HK—Drawout fuse unit—295 lbs.					

TABLE 22—TRANSITION UNIT WEIGHTS, LBS.

14"		15½"	
Switchgear Depth		Indoor	Outdoor
58"	68"		
400	450	425	475

TABLE 23—CIRCUIT BREAKER WEIGHTS, LBS.

Type	Manual Operation	Electrical Operation
K-225	102	123
K-6 & 6S	112	133
K-16 & 16S	185	206
K-2 & 2S	204	225
K-DON 6 & 6S	142	163
K-DON 16 & 16S	264	285
K-3 & 3S	520	548
K-4 & 4S	533	561

ARRANGEMENTS—OUTDOOR SECTION

TWO-HIGH

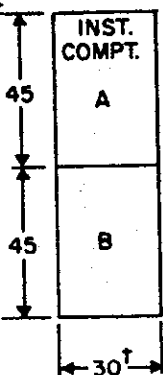


TABLE 24

Each 30" Wide x 45" High Compartment Can Be Fitted With		
Quan.	Type	
1	K-4000	Compt. B
1*	Drawout Fuse	Compt. A
1	KP, HP, HR, CP or CR (KP & HP PLUG-IN ONLY)	
2	HM or CM	
4	KM, HK or CJ	
6	JJ, JL, HJ or HL	
12	FJ or CE	
20	EF, EH or HE	

* Fuse size 6000A, 4000A maximum continuous current rating.

† Power Co. metering compt. 40".

THREE-HIGH

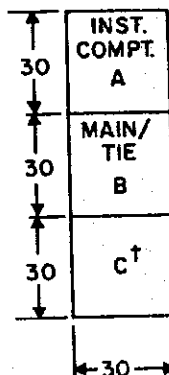


TABLE 25

Each 30" Wide x 30" High Compartment Can Be Fitted With		
Quan.	Type	
1*	K-2000	Compt. C
1*	K-3000	Compt. C
1	K-3000	Compt. B
1*	Drawout Fuses	Compt. B
1	KP, HP, HR, CP or CR (KP & HP PLUG-IN ONLY)	
2	KM, HM, CJ or CM	
4	JJ, JL, HJ or HL	
8	FJ or CE	
12	EH, EF or HE	

* When used with drawout fuse units.

* Fuse sizes 5000-4000A (K-2000).

* Fuse sizes 4000-6000A (K-3000).

3000A maximum continuous current rating.

† Can be equipped with any lower rated breaker.

FOUR-HIGH

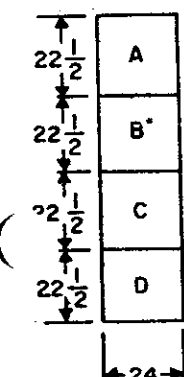


TABLE 26

Each 24" Wide x 22 1/2" High Compartment Can Be Fitted With		
Quan.	Type	
1	K-16	
1	KD-16	
1	K-2	
1	KP, HP or HR (KP & HP Plug-in only)	
2	JJ, JL, KM, HJ, HK, HL, CJ	
4	FJ or CE	
8	EF, EH or HE	

NOTES:

All frames may be fitted with the same size circuit breaker in each compartment except as follows:

1—Only one K-2000 breaker in each 24" wide frame.

*2—Main and Tie must be located in compartment B.

LEGEND

K-6 = K-225, K-600 & K-600S

K-16 = K-1600 & K-1600S

K-2 = K-2000 & K-2000S

KD-6 = K-DON-600 & K-DON-600S

KD-16 = K-DON-1600 & K-DON-1600S

TABLE 27

Each 18" Wide x 22 1/2" High Compartment Can Be Fitted With		
Quan.	Type	
1	K-6	
1	KD-6	
1	JJ, JL, KM, HJ, HK, HL or CJ	
3	FJ or CE	
6	EF, EH or HE	

Preferred arrangement for the same size breakers in each 18" or 24" W compartment is as follows:

No. of same size circuit breakers	Compartment
1	B
2	B, C
3	B, C, D

TABLE 28 — K-6, K-16 AND K-2 ARRANGEMENTS

Compt.	Type Breaker											
A	K-16	K-6	K-6	K-6	K-16	K-6	K-6	—	—	—	—	—
B	K-2	K-2	K-2	K-2	K-2	K-2	K-2	K-2	K-2	K-2	K-2	—
C	K-16	K-16	K-16	K-6	K-16	K-16	K-6	K-16	K-16	K-6	K-16	K-2
D	K-16	K-16	K-6	K-6	—	—	—	K-16	K-6	K-6	—	K-16

TABLE 29 — K-6 AND K-16 ARRANGEMENTS

Compt.	Type Breaker							
A	K-6	K-6	K-6	K-6	K-6	—	—	—
B	K-16	K-16	K-16	K-16	K-16	K-16	K-16	K-16
C	K-16	K-16	K-6	K-16	K-6	K-16	K-6	K-16
D	K-16	K-6	K-6	—	—	K-6	K-6	K-6

TABLE 30 — KD-6 AND K-16 ARRANGEMENTS

Compt.	Type Breaker							
A	KD-6	KD-6	KD-6	KD-6	KD-6	—	—	—
B	K-16	K-16	K-16	K-16	K-16	K-16	K-16	K-16
C	K-16	K-16	KD-6	K-16	KD-6	K-16	KD-6	KD-6
D	K-16	KD-6	KD-6	—	—	KD-6	KD-6	KD-6

TABLE 31 — KD-6 AND KD-16 ARRANGEMENTS

Compt.	Type Breaker							
A	KD-6	KD-6	KD-6	KD-6	KD-6	—	—	—
B	KD-16	KD-16	KD-16	KD-16	KD-16	KD-16	KD-16	KD-16
C	KD-16	KD-16	KD-6	KD-16	KD-6	KD-16	KD-6	KD-16
D	KD-16	KD-6	KD-6	—	—	KD-6	KD-6	KD-6

TABLE 32 — K-16, K-2 AND KD-6 ARRANGEMENTS

Compt.	Type Breaker							
A	KD-6	KD-6	KD-6	KD-6	KD-6	—	—	—
B	K-2	K-2	K-2	K-2	K-2	K-2	K-2	K-2
C	K-16	K-16	KD-6	K-16	KD-6	K-16	KD-6	KD-6
D	K-16	KD-6	KD-6	—	—	KD-6	KD-6	KD-6

METAL-ENCLOSED BUS DUCT

I-T-E low-voltage metal-enclosed bus duct is available in continuous current ratings of 600A through 3000A at 600 volts. Standard construction includes silver-plated aluminum bus mounted on polyester-glass bus supports. Outdoor bus duct is weatherproofed and is provided with heaters to reduce condensation.

- Indoor or outdoor construction
- 3- or 4-wire
- Polyester-glass bus supports
- Silver-plated aluminum bus
- Removable access cover

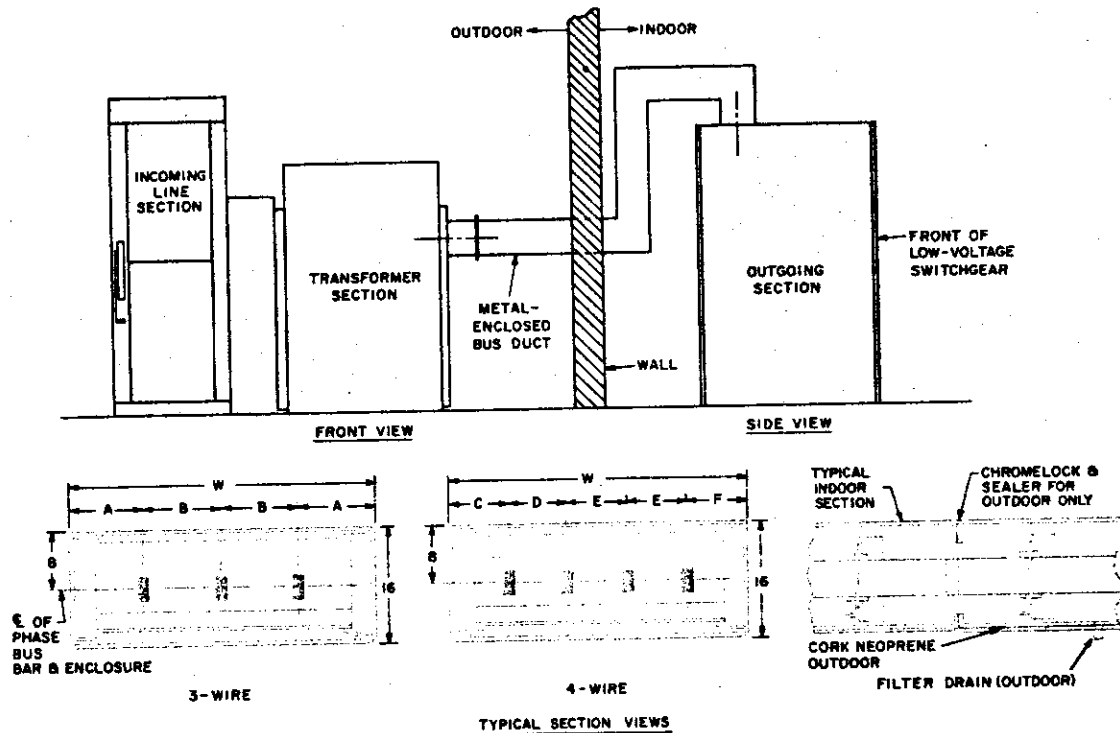


TABLE 33 — INDOOR-OUTDOOR 600-3000 Amperes

Type	Dimensions							Current Rating, A	Housing Material	Removable Cover
	W	A	B	C	D	E	F			
3-Wire	22	6	5	—	—	—	—	600-2500 3000*	12 Ga. Steel	600-1600A 12 Ga. Steel 2000-3000A 1/8" Aluminum
4-Wire 50%-100% Neutral	27	—	—	6	5	5	6	600-2500 3000*	12 Ga. Steel	
4-Wire Split Phase 50% Neutral	39	—	—	6	7	9	8	3000	11 Ga. Steel	
4-Wire Split Phase 100% Neutral	43	—	—	8	9	9	8	3000	11 Ga. Steel	1/8" Aluminum
3-Wire Split Phase	34	8	9	—	—	—	—	3000	11 Ga. Steel	

* Copper only

TABLE 33A—WEIGHTS

Capacity (Amps)	Weights (lbs/3 Phase Ft)					
	Aluminum Bus			Copper Bus		
	3-Wire	4-Wire 50% NEUT.	4-Wire 100% NEUT.	3-Wire	4-Wire 50% NEUT.	4-Wire 100% NEUT.
600	40	45	45	44	50	50
800	41	46	46	48	54	55
1000	41	46	47	46	53	54
1200	41	46	48	49	56	58
1600	46	51	53	55	63	66
2000	42	46	48	62	69	76
2500	50	56	59	70	78	86
3000	63	69	77	85	95	107

SELECTION AND APPLICATION

INCOMING LINE SECTION

AIR INTERRUPTER SWITCHES

TABLE 34 — AIR INTERRUPTER SWITCH RATINGS (Fused or Unfused)

Voltage Rating				Current Rating				Interrupting Life on Close-Open Duty Cycle Number of Interruptions					Fault Closing With Spring Operator	
Nominal kV	Max. Design kV	Withstand		Con- tinuous Current, A	At kV	10 Cycle Momentary Rms Asym. kA	4 Sec. Short-Time Rms Sym. kA	At kV	Power Factor	200A	400A	600A	Unfused Rms Asym. kA	Fused
		60 Cycle kV	Impulse kV											
4.8	5.5	19	60	600 1200	5.5	61	38	5.5	0.8	1000	1000	750	40	Fuse Inter- rupting Rating
7.2/13.8	14.5	36	95	600 1200	14.5			14.5		800	400	300		

TABLE 35 — CL-14 CURRENT-LIMITING FUSE RATINGS, (50/60 Hertz) Non-Disconnect Type

Max. Design kV	System kV	Interrupting			Max. Cont. Current		
		Amperes		Nom. Equiv. 3-Phase MVA	Single Barrel	Double Barrel	Triple Barrel
		Rms Sym.	Asym.				
5.5	2.4	60,000	96,000	250	10E	—	—
	4.16			430	Thru		
	4.8			500	400E		
15.5	6.9	40,000	64,000	480	10E Thru 100E	125E	150E 200E
	7.2			500			
	11.5			800			
	12.0			830			
	12.47			860			
	13.2			910			
	13.8			955			
	14.4			1000			

TABLE 36A — POWER FUSE SELECTION® *

TABLE 36A — POWER FUSE SELECTION																					
System kV		2.4				4.16				4.8				6.9				7.2			
Transformer		Fuse Size				Fuse Size				Fuse Size				Fuse Size				Fuse Size			
kVA	Impedance	FL	Min.	133%	Max.	FL	Min.	133%	Max.	FL	Min.	133%	Max.	FL	Min.	133%	Max.	FL	Min.	133%	Max.
112.5	4.5	27	30E	40E	65E	16	20E	20E	30E	14	20E	20E	30E	9	15E	15E	20E	9	15E	15E	20E
150	4.5	36	40E	50E	80E	21	25E	30E	40E	18	25E	25E	40E	12	15E	20E	25E	12	15E	20E	25E
225	4.5	54	65E	80E	100E	31	40E	40E	65E	27	30E	40E	50E	19	25E	25E	40E	18	20E	25E	40E
300	5.0	72	80E	100E	125E	42	50E	65E	80E	36	40E	50E	80E	25	30E	40E	50E	24	30E	40E	50E
500	5.0	120	150E	200E	200E	69	80E	100E	125E	60	65E	80E	100E	42	50E	65E	80E	40	50E	65E	80E
750	5.75	180	200E	250E	300E	104	125E	150E	150E	90	100E	125E	150E	63	80E	100E	100E	60	80E	80E	100E
1000	8.0	241	300E	—	300E	139	200E	200E	200E	120	150E	—	150E	84	100E	—	100E	80	100E	—	100E
1000	5.75	241	300E	400E	400E	139	200E	200E	250E	120	150E	200E	200E	84	100E	125E	150E	80	100E	125E	150E
1500	5.75	361	400E	—	—	208	250E	300E	400E	180	200E	250E	300E	126	150E	200E	200E	120	150E	200E	200E
2000	5.75	482	—	—	—	278	400E	400E	400E	241	300E	400E	400E	167	200E	—	200E	160	200E	200E	200E
2500	5.75	602	—	—	—	348	400E	—	—	300	400E	400E	400E	209	—	—	—	201	—	—	—
3000	5.75	722	—	—	—	416	—	—	—	362	400E	—	—	251	—	—	—	241	—	—	—

Self-cooled kVA rating of the transformer as shown above should be used.

① Minimum fuse size shown will clear transformer magnetizing inrush current. 133% fuse size permits overload operation of transformer up to 133% of rating. Maximum fuse size provides transformer fault protection for phase-phase, 3-phase and phase-ground faults on secondary windings of standard 3-phase transformers. Suffix E denotes NEMA standard fuse rated 30°C rise above 40°C average ambient.

*When selecting a CL-14 fuse as a replacement for a CL-13, it is important to carefully check these selection tables. Although the CL-14 and CL-13 are physically interchangeable, several internal changes have resulted in either larger or smaller fuse "E" rating requirements at several kVA and voltage ratings.

② The self-cooled kVA rating of the transformer as shown above should be used in selection of fuse size on forced-air cooled transformer applications. Also, on such applications, the 133% fuse size must be chosen for proper coordination.

③ Per cent impedance on self-cooled kVA base.

TABLE 36B—POWER FUSE SELECTION① •

			20						25						30						35						40					
			Fuse Size						Fuse Size						Fuse Size						Fuse Size						Fuse Size					
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
112.5	4.5	5.7	10E	10E	10E	5.4	10E	10E	10E	5.2	10E	10E	10E	4.9	10E	10E	10E	4.7	10E	10E	10E	4.5	10E	10E	10E	4.5	10E	10E	10E	10E	10E	10E
150	4.5	7.5	10E	10E	15E	7	10E	10E	15E	7	10E	10E	15E	6.6	10E	10E	15E	6.2	10E	10E	15E	6	10E	10E	15E	6	10E	10E	15E	10E	10E	10E
225	4.5	11.3	15E	15E	25E	10.8	15E	15E	20E	10.4	15E	15E	20E	9.8	10E	15E	20E	9.4	15E	15E	20E	9	15E	15E	20E	9	15E	15E	20E	15E	20E	10E
300	5.0	15.1	20E	20E	30E	14.4	20E	20E	30E	14	15E	20E	30E	13	15E	20E	30E	12.6	15E	20E	25E	12	15E	20E	25E	12	15E	20E	25E	20E	25E	10E
500	5.0	25.1	30E	40E	50E	24	30E	40E	50E	23	25E	30E	50E	22	25E	30E	50E	21	25E	30E	40E	20	25E	30E	40E	20	25E	30E	40E	30E	40E	10E
750	5.75	37.7	50E	50E	80E	36	40E	50E	80E	35	40E	50E	65E	33	40E	50E	65E	32	40E	50E	65E	30	40E	50E	65E	30	40E	40E	65E	40E	65E	10E
1000	8.0	50.3	65E	80E	80E	48	65E	65E	80E	46	50E	65E	65E	44	50E	65E	65E	42	50E	65E	65E	40	50E	65E	65E	40	50E	65E	65E	65E	65E	10E
1000	5.75	50.3	65E	80E	100E	48	65E	65E	100E	46	50E	65E	80E	44	50E	65E	80E	42	50E	65E	80E	40	50E	65E	80E	40	50E	65E	80E	80E	80E	10E
1500	5.75	75.4	100E	100E	125E	72	80E	100E	125E	70	80E	100E	125E	66	80E	100E	100E	63	80E	100E	100E	60	65E	80E	100E	60	65E	80E	100E	100E	100E	10E
2000	5.75	101	125E	150E	150E	96	125E	150E	150E	92	100E	125E	150E	88	100E	125E	150E	84	100E	125E	150E	80	100E	125E	150E	80	100E	125E	150E	150E	150E	10E
2500	5.75	126	125E	200E	200E	120	150E	200E	200E	116	150E	150E	200E	109	125E	150E	150E	105	125E	150E	150E	100	125E	150E	150E	100	125E	150E	150E	150E	150E	10E
3000	5.75	151	200E	200E	200E	144	200E	200E	200E	139	200E	200E	200E	131	150E	200E	200E	125	150E	200E	200E	120	150E	200E	200E	120	150E	200E	200E	200E	200E	10E

* ①②③ See notes at bottom of page 32.

FUSE CURVES

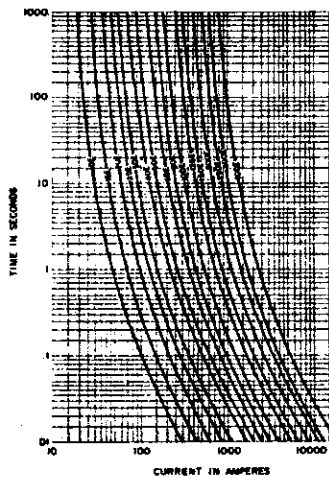


Figure 1—Minimum Melt Time-Current Characteristic Curves. For Type CL-14 Current-Limiting Fuse Units—Voltage Rating 4.8KV.

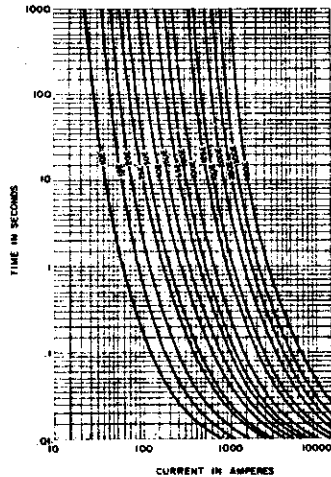


Figure 2—Total Clearing Time-Current Characteristic Curves. For Type CL-14 Current-Limiting Fuse Units—Voltage Rating 4.8KV.

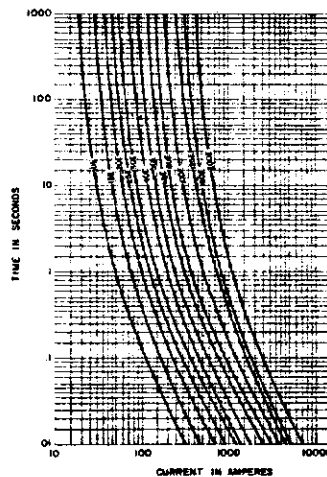


Figure 3—Minimum Melt Time-Current Characteristic Curves. For Type CL-14 Current-Limiting Fuse Units—Voltage Rating 14.4KV.

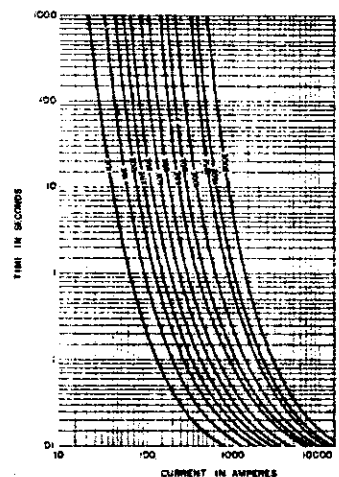


Figure 4—Total Clearing Time-Current Characteristic Curves. For Type CL-14 Current-Limiting Fuse Units—Voltage Rating 14.4KV.

OIL CUTOUTS

TABLE 37 — FUSE INTERRUPTING RATINGS

Nominal Full Winding Voltage	Fuse Interrupting Rating		kVA Limitations	
	Ampères (rms) Asymmetrical	Equivalent MVA Symmetrical	Fused	Unfused
2.4	10,000	42	500	750
4.16	10,000	72	750	1000
13.8	4,000	99	1000	2000

METAL-CLAD SWITCHGEAR

For application information, see I-T-E Bulletin 8.2-1

LIQUID SWITCH

TABLE 38 — RATINGS

Voltage Rating, kV	Maximum Continuous Current Rating, A	Interrupting Capacity, A	
		Oil-filled	Askarel-filled
5	400	400	①
15	400	400	①

① When liquid switch is askarel-filled, it has no interrupting capacity. It can break magnetizing currents of up to 10A for five times without replacement.

TRANSFORMER SECTION

TABLE 39 — STANDARD TRANSFORMER RATINGS

TYPE	Primary Voltage Delta	KVA 3-Phase Self-Cooled	KVA 3-Phase Forced-Air Cooled	SECONDARY VOLTAGE		Standard Impedance*	NEMA Sound Level, db	
				288Y/120 248 delta	480Y/277 480 delta		Self-Cooled	Forced-Air Cooled
Liquid-Immersed Oil or Askarel 65°C Rise †	2400	112½	—	x	x	2.25†	55	—
	4160	150	—	x	x	3.0†	55	—
	4800	225	—	x	x	4.5	55	—
	6900	300	—	x	x	5.0	55	—
	7200	500	—	x	x	5.0	56	—
	12000	750	862	x	x	5.75	58	67
	12470	1000	1150	x	x	5.75	58	67
	13200	1000	1150	x	x	8.0	58	67
	13800	1500	1725	x	x	5.75	60	67
		2000	2300	x	x	5.75	61	67
		2500	3125	x	x	5.75	62	67
Ventilated-Dry 150°C Rise †	2400	112½	—	x	x	3.0†	50	—
	4160	150	—	x	x	3.5†	50	—
	4800	225	—	x	x	4.5	55	—
	6900	300	—	x	x	5.0	55	—
	7200	500	667	x	x	5.0	60	67
	12000	750	1000	x	x	5.75	64	67
	12470	1000	1333	x	x	5.75	64	68
	13200	1000	1333	x	x	8.0	64	68
	13800	1500	2000	x	x	5.75	65	69
		2000	2666	x	x	5.75	66	71
		2500	3333	x	x	5.75	68	71
Sealed-Dry Gas-Filled 150°C Rise †	2400	300	—	x	x	5.0	57	—
	4160	500	—	x	x	5.0	59	—
	4800	750	—	x	x	5.75	63	—
	6900	1000	—	x	x	5.75	63	—
	7200	1000	—	x	x	8.0	63	—
	12000	1500	—	x	x	5.75	64	—
	12470	2000	—	x	x	5.75	65	—
	13200	2500	—	x	x	5.75	65	—
	13800			x	x	5.75	66	—

* Standard impedance tolerance is $\pm 7\frac{1}{2}\%$.

† Average ambient temperature of 50°C.

‡ Transformers with impedances of 4.0% or less are designed to withstand 25 times normal current for two seconds.

TABLE 40 — LIGHTNING ARRESTERS

kV Rating of Arrestor	Line to Line kV Ungrounded System	Line to Line kV Grounded System
Station and Intermediate Type ①		
3	2.4	4.16
6	4.8	7.2
9	7.2	12.47
12	11.5	13.8
15	13.8	18.0
Distribution Type ②③		
3	3.0	4.5
6	6.0	9.0
9	9.0	12.8
12	12.0	15.0
15	15.0	18.0

① For use with liquid-immersed transformers.

② For use with sealed-dry transformers.

③ Distribution type arresters with special characteristics are furnished as standard on ventilated-dry transformers.

TABLE 41 — TEMPERATURE GUARANTEES

Transformer Type	Ambient*	Rise†	Hot Spot Rise
Liquid-immersed	30°C	65°C	80°C
Ventilated-dry	30°C	150°C	180°C
Sealed-dry	30°C	150°C	180°C

Altitudes must not exceed 1000 meters or 3300 feet.

* The temperature of the cooling air (ambient temperature) must not exceed 40°C and the average temperature of the cooling air for any 24-hour period must not exceed 30°C.

† Degrees rise is the average winding temperature rise by resistance. See NEMA Standard TR-1 and ANSI C57.12.00.

TABLE 42 — DIELECTRIC TESTS

Transformer Type	Voltage Class, kV	Applied Test 60 Cycle All kVA Ratings	Basic Impulse Levels 1.2 x 50 ms	Induced Test 7200 Cycles, All kVA Ratings
Liquid-Immersed or Sealed-Dry	1.2	10 kV	30 kV	Twice normal voltage
	2.5	15 kV	45 kV	
	5.0	19 kV	60 kV	
	8.66	26 kV	75 kV	
Ventilated-Dry	15.0	34 kV	95 kV	Twice normal voltage
	1.2	4 kV	10 kV	
	2.5	10 kV	20 kV	
	5.0	12 kV	25 kV	
	8.66	19 kV	35 kV	
	15.0	31 kV	50 kV	

TABLE 43 — STANDARD HIGH-VOLTAGE TAPS

Rated Voltage	Rated kVA HV Taps, Volts			
2400	2520	2460	2340	2280
4160	4360	4260	4055	3950
4800	5040	4920	4680	4560
6900	7245	7070	6730	6555
7200	7560	7380	7020	6840
12000	12600	12300	11700	11400
12470	13095	12780	12160	11845
13200	13860	13530	12870	12540
13800	14400	14100	13500	13200

OUTGOING SECTION—K-LINE[®] CIRCUIT BREAKERS

TABLE 44—K-LINE CIRCUIT BREAKER RATINGS

① Circuit Breaker Type	A-C Volts	Frame Size, A	Symmetrical Interrupting Rating With		Sym- metrical Close and Latch & 30-Cycle Short- Time Rating, A
			Instan- taneous Trip, A	Delayed Trip, A	
K-225	208 and 240	225	25,000	14,000	14,000
K-600		600	42,000	22,000	22,000
K-1600		1,600	65,000	50,000	50,000
K-2000		2,000	85,000	55,000	55,000
K-3000		3,000	85,000	65,000	65,000
K-4000		4,000	130,000	85,000	85,000
K-225	480	225	22,000	14,000	14,000
K-600		600	30,000	22,000	22,000
K-1600		1,600	50,000	50,000	50,000
K-2000		2,000	65,000	55,000	55,000
K-3000		3,000	65,000	65,000	65,000
K-4000		4,000	85,000	85,000	85,000
K-225	600	225	14,000	14,000	14,000
K-600		600	22,000	22,000	22,000
K-1600		1,600	42,000	42,000	42,000
K-2000		2,000	55,000	55,000	55,000
K-3000		3,000	65,000	65,000	65,000
K-4000		4,000	85,000	85,000	85,000

① Recommended maximum continuous current rating of largest feeder breaker in per cent of transformer (self-cooled) rated current, when primary power fuses are included is 40% for current-limiting type and 50% for non-current-limiting type.

TABLE 45—K-LINE S CIRCUIT BREAKER RATINGS

① Circuit Breaker Type	A-C Volts	Frame Size, A	Symmetrical Interrupting Rating With		Sym- metrical Close and Latch & 30-Cycle Short- Time Rating, A
			Instan- taneous Trip, A	Delayed Trip, A	
K-600S	208 and 240	600	42,000	22,000	22,000
K-1600S		1,600	65,000	50,000	50,000
K-2000S		2,000	85,000	55,000	55,000
K-3000S		3,000	85,000	65,000	65,000
K-4000S		4,000	130,000	85,000	85,000
K-600S	480	600	30,000	22,000	22,000
K-1600S		1,600	50,000	50,000	50,000
K-2000S		2,000	65,000	55,000	55,000
K-3000S		3,000	65,000	65,000	65,000
K-4000S		4,000	85,000	85,000	85,000
K-600S	600	600	22,000	22,000	22,000
K-1600S		1,600	42,000	42,000	42,000
K-2000S		2,000	55,000	55,000	55,000
K-3000S		3,000	65,000	65,000	65,000
K-4000S		4,000	85,000	85,000	85,000

① Recommended maximum continuous current rating of largest feeder breaker in per cent of transformer (self-cooled) rated current, when primary power fuses are included is 40% for current-limiting type and 50% for non-current-limiting type.

TABLE 46—CIRCUIT BREAKER CONTROL-POWER REQUIREMENTS

Circuit Breaker Type	Nominal Control Voltage	Average Closing-Motor Current, A	Shunt Trip Current, A	Closing-Relay Current, A		Closing-Circuit Voltage Range, Volts	Trip-Circuit Voltage Range, Volts	Recommended Control Circuit Fuse Size, A
				Anti-Pump	Release			
K-225	120 V ac	10	6.5	.15	1.5	104-127	50-127	10
K-600, S	240 V ac	5	1.15	.075	.75	208-254	208-254	10
K-1600, S	48 V dc	25	3.14	.11	1.33	38-56	28-56	15
K-2000, S	125 V dc	10	1.3	.06	.7	100-140	70-140	10
K-DON-600, S	250 V dc	5	.65	.03	.3	200-280	140-280	10
K-3000, S	120 V ac	10	10.0	.15	4.0	104-127	50-127	10
and	240 V ac	5	1.84	.075	1.84	208-254	208-254	10
K-4000, S	48 V dc	25	5.0	.11	5.0	38-56	28-56	15
	125 V dc	10	2.0	.06	2.0	100-140	70-140	10
	250 V dc	5	1.0	.03	1.0	200-280	140-280	10

TABLE 47—UNDERVOLTAGE TRIP DEVICE

Nominal Control Voltage	Current at Rated Volts, A	Minimum Pick-up Voltage Value, Volts	Dropout Voltage Value, Volts	
			Minimum	Maximum
120 V ac	0.50	102	36	72
240 V ac	0.20	204	72	144
480 V ac	0.10	408	144	288
48 V dc	0.32	41	15	29
125 V dc	0.20	106	38	75
250 V dc	0.10	212	75	150

SELECTION OF LOW-VOLTAGE POWER CIRCUIT BREAKERS IN LOW-VOLTAGE DRAWOUT SWITCHGEAR†

CHARACTERISTICS

The degree of service continuity available from a low-voltage distribution system depends on the degree of coordination between circuit-breaker tripping characteristics.

Three methods of tripping coordination are in general use, each representing a different degree of service continuity and of initial cost.

These methods, or systems, combine breaker ratings and tripping characteristics as follows:

FULLY-RATED SYSTEM

A fully-rated system is one in which both the main and feeder breakers have adequate interrupting capacity for the fault current available at the point of application.

All breakers are equipped with long-time delay and instantaneous overcurrent trips. Ordinarily only the breaker nearest the fault will open. The main breaker will trip, however, when the fault current exceeds its instantaneous trip setting, and service continuity may be lost.

CASCADED SYSTEM
A cascaded system is one in which only the main breaker has adequate interrupting capacity. Not recommended.

SELECTIVE SYSTEM

A selective system is one in which both the main and feeder breakers have adequate interrupting capacity for the fault current available at the point of application.

Application Tables 48A and 48B provide for proper selection of the circuit-breaker type required. They should be used as follows:

Use Table 48A for a fully-rated system

Use Table 48A for a fully-rated system
Use Table 48B for a selective system

Use Table 48B for a selective system
Having chosen the right table, refer to that part of it which covers the
system voltage.

Manually-charged, stored-energy-closed circuit breakers may be applied within their 600 v, 480 v, or 240 v interrupting rating, provided their instantaneous trips are set below their short-time ratings.

Note: For solid-state trip devices any available amp tap may be used regardless of voltage within the short circuit current rating of the circuit breaker.

Load Continuous Current Rating																																		
15	20	30	40	50	70	90	100	125	150	175	200	225	250	300	350	400	500	600	800	1000	1200	1600	2000	2500	3000	4000								
K-225													K-600							K-1600					K-2000	K-3000	K-4000							
					K-225										K-600							K-1600					K-2000	K-3000	K-4000					
										K-225										K-600							K-1600					K-2000	K-3000	K-4000
													K-600							K-1600					K-2000	K-3000	K-4000							

The manually-charged, stored-energy-closed circuit breakers with delayed trip may be applied within their short-time ratings.
Note: For solid-state trip devices any available amp tap may be used regardless of voltage within the short circuit current rating of the circuit breaker.

[illegible]

The main breaker is equipped with overcurrent trip devices having long-time delay and short-time delay functions. The feeder breakers are equipped with overcurrent trip devices having long-time delay and instantaneous functions unless they are required to be selective with other protective devices nearer the load. In this case, the feeders are equipped with trip devices having both long-time and short-time delay.

In a selective system, only the breaker nearest the fault trips. Service continuity is thus maintained through all other breakers.

The main breaker trips only on a bus fault.

The selective system offers a maximum of service continuity, with a slightly higher initial cost than the fully-rated or cascaded systems.

SELECTION OF BREAKER TYPE

The following three basic factors determine the selection of a breaker after a decision has been reached on the type of system required:

System voltage and frequency

System Voltage and Continuous current

Available fault current

† Selection and application information is for low-voltage power circuit breakers equipped with OD direct-acting, electro-mechanical overcurrent trip devices. In general, however, these application rules apply to breakers with POWER-SHIELD® solid-state overcurrent trip devices except for differences in available ampere taps and long-time, short-time and instantaneous pick-up settings.

Look for the horizontal line listing an available fault current nearest the one required at the point of application (let the nearest one be higher, rather than lower than the exact fault current needed).

Then select the circuit-breaker type listed where the Available Fault Current line crosses the vertical column headed with the wording: Load Continuous Current Rating.

K-DON® CIRCUIT BREAKERS

TABLE 49 — K-DON BREAKER RATINGS

Circuit Breaker Type	Frame Size, A	Voltage A C	Maximum Continuous Current, A	Maximum Interrupting Symmetrical Rating, Rms Amperes	Range of Circuit Breaker Pickup, A	Amp-trap Continuous Rating, A
K-DON-600 K-DON-1600	600 1600	up to 600 up to 600	600 1600	200,000 200,000	40-600 120-1600	300-1200 300-2500
K-DON-600S K-DON-1600S	600 1600	up to 600 up to 600	600 1600	200,000 200,000	40-600 200-1600	300-1200 600-2500

The following step by step procedure is to be used as a guide for proper circuit breaker and fuse selection.

A. CIRCUIT-BREAKER SELECTION

- 1—Determine the system short-circuit capacity in symmetrical rms amperes.
- 2—Determine from Table 50 columns 3, 4 and 5 respectively the approximate continuous current rating and the time-delay and instantaneous overcurrent trip settings.
- 3—Select from Tables 51* or 52, columns 1, 2, 3 and 4 respectively the frame size, proper coil rating, time-delay and instantaneous settings as follows:

- (a) When there is a choice of breaker frame size the larger will provide maximum flexibility in case of load growth.
- (b) The coil rating should be equal to or greater than the value determined in Table 50, column 3.
- (c) Time-delay setting should be set at a value nearest to that determined in Table 50, column 4.
- (d) Instantaneous setting should be set at a value nearest to that determined in Table 50, column 5. However, this value may have to be adjusted downward to coordinate with Amp-trap to be selected in step B.

* Table 51 is to be used for K-DON breakers with electro-mechanical overcurrent trip devices; Table 52 is for K-DON breakers with solid-state overcurrent trip device.

†Registered Trademark—Chase-Shawmut Co.

TABLE 50 — CIRCUIT-BREAKER APPLICATION

1		2		3	4	5
Type of Application		Purpose of Circuit Breaker		Continuous Current Rating of Circuit Breaker	Settings of Overcurrent Trip Device	
					Time Delay	Instantaneous
Service entrance (general)		(a) To protect source transformer windings from overheating, due to overload or fault current flow. (b) To protect circuit conductors from effects of overcurrent flow. (c) To provide safe and rapid means for connecting and disconnecting of load circuit.		Based upon 125% of the transformer current rating	125% of the transformer current rating	1000% of circuit-breaker current rating
Service feeder (general)		(a) To protect circuit conductors from effects of overcurrent flow. (b) To protect connected electrical equipment from effects of fault current flow.		Based upon 115% of estimated load current	115% of estimated load current	1000% of circuit-breaker current rating
BRANCH CIRCUITS (GENERAL)	Individual motor circuit	(a) To protect motor windings from overheating due to overcurrent or fault current flow. (b) To protect circuit conductors and other connected electrical equipment from overload or fault current flow. (c) To provide safe and rapid means of connecting and disconnecting motor circuit.		Based upon 115% of rated full-load current of motor	115% of rated full-load current of motor	1000% of circuit-breaker current rating
	Group motor circuit	(a) To protect circuit conductors from overheating. (b) To protect circuit conductors, motor windings and other connected electrical equipment from fault current flow. (c) To provide safe and rapid means of connecting and disconnecting common motor circuit from supply source.		Based upon 115% of largest motor full-load current plus sum of other motor currents	100% of circuit-breaker current rating	1000% of circuit-breaker current rating
	Combined motor and lighting circuit	(a) To protect circuit conductors from overheating. (b) To protect circuit conductors, motor windings and other connected electrical equipment from fault current flow. (c) To provide safe and rapid means of connecting and disconnecting common load circuit from supply source.		Based upon 115% of largest motor full-load current plus sum of other motor and lighting load currents	100% of circuit-breaker current rating	1000% of circuit-breaker current rating
	Lighting circuit	(a) To protect circuit conductors from effects of overload or fault current flow. (b) To provide safe and rapid means of connecting and disconnecting lighting circuit from supply source.		Based upon 125% of estimated maximum lighting current	100% of circuit-breaker current rating	1000% of circuit-breaker current rating

K-DON® CIRCUIT BREAKERS

3. AMP-TRAP† SELECTION

Table 51 or 52 is to be used for selecting the correct fuse sizes to coordinate with the instantaneous setting of the overload device to provide proper coordination between the circuit breaker and fuse. It was developed to provide the greatest range of coordination possible, taking advantage of maximum fuse sizes whose let-thru current can be withstood by the circuit breaker.

Figure 6, Page 41, is a second aid in the selection of the proper Amp-Trap fuse sizes. However, Fig. 6 is not to be used as the only criterion if, as in the case of molded-case circuit breakers, there is an I²t limitation in the equipment to be protected by the fuse (See Figure 7).

There are two basic considerations in selecting an Amp-Trap fuse size.

1—The peak let-thru current must not exceed 2.3 times the symmetrical short-circuit withstand of the equipment to be protected by the K-DON circuit breaker.

a. If the equipment protected by the circuit breaker has a symmetrical short-circuit withstand rating at least equal to that of the circuit breaker,* fuse size selection may be made by using Table 51 or 52.

b. If the equipment protected by the circuit breaker has a symmetrical short-circuit withstand rating less than the circuit breaker, Fig. 6 must be used to determine the maximum fuse size.

Draw a vertical line on Fig. 6 representing the available symmetrical RMS amperes. Establish the intersection of this line with the peak amperes that the equipment is capable of withstanding. The fuse size represented by the fuse let-thru curve passing below this intersection is the maximum fuse size that should be used. Of course, the smallest fuse size, consistent with coordination, provides the best protection.

2—The second consideration is that the fuse size coordinates with the circuit-breaker overload time-current characteristic. Proper application of Table 51 or 52 and their associated notes will assure coordination and, therefore, avoid needless fuse replacements for current levels within the interrupting rating of the breaker.

For application using special instantaneous settings, a breaker-fuse coordination curve should be drawn.

Fuse curves are normally plotted with time as the ordinate and current in amperes as the abscissa. However, the abscissa of the overcurrent device time-current curves is the ratio of actual current to current tap or to coil rating or to pickup setting. There are so many combinations of settings as to render it completely impractical to publish general coordination curves for fuses and overcurrent trip devices.

When it is desired to plot specific coordination curves, the following procedure is suggested.

a. Replot the overcurrent device curve using actual amperes as the abscissa based on pick-up settings selected. The curves may be moved right or left to accommodate settings not plotted on published curves. A transparent overlay is helpful in this procedure.

b. Enter the fuse melting time-current curve from Figure 7, Page 41, on this newly plotted overcurrent device curve and examine for proper coordination.

c. When fuse size is dictated by protection needs, the fuse curve should be plotted first and the overcurrent device settings are then determined by trial and error, by replotting the overcurrent device curves.

NOTES:

① Maximum allowable fuse sizes listed in Tables 51 or 52 are based on an available RMS symmetrical short-circuit current of 200kA. If available current is less than 200kA larger fuse sizes may be used based on let-thru of Figure 6 as illustrated in the following table. Note that this does not apply to K-DON breakers equipped with solid-state trip.

Frame Size	600	600	1600
Avail. kA	130	85	100
Max. Fuse Size, Amps.	1600	2000	3000

② When fused circuit breakers are used on high-inrush circuits such as motor starting, for extended periods, the maximum allowable fuse size from Tables 51 or 52 should be used regardless of instantaneous setting. Otherwise these fuses and other unblown fuses, after a short-circuit, may have melting times less than "when new". In this case, fuse replacement should be considered if the coordination is critical.

C. APPLYING LOW-VOLTAGE POWER CIRCUIT BREAKERS WITH SEPARATELY MOUNTED CURRENT LIMITING FUSES

(Note that this applies to the K-2000, K-3000 and K-4000 only. Lower rated breakers (not K-225) will be coordinated in the same manner as the K-DON breakers in Tables 51 or 52.

The interrupting capability of the proper combination of low-voltage power circuit breakers and current-limiting fuses is appreciably higher than the capability of the circuit breaker alone. The following guidelines are offered for combining Chase-Shawmut Amp-Trap current-limiting fuses, NEMA Class L, with modern I-T-E low-voltage power circuit breakers:

1—Avoid or at least minimize overlap of time-current characteristics (fuse vs. overcurrent device) at currents less than the circuit-breaker interrupting rating to keep needless fuse blowing to a minimum. Adding a short-time element often helps to obtain coordination.

2—The total clearing time of the fuse must be equal to or less than the total clearing time of the circuit breaker at a current equal to the interrupting rating of the circuit breaker at the voltage of the application.

3—The peak let-through current of the fuse must not exceed 2.3 times the withstand rating of the circuit breaker.†

4—The fuses should preferably be on the source side of the circuit breaker. When this is not possible, the two should be located as close as practical to each other, and the installation should minimize the exposure to a fault between the breaker and the fuse.

NOTE:

In order to obtain selective protection when fuses are applied in series, it is necessary that the fuse nearer the source have a current rating at least two times that of the fuse nearer the load, providing that both fuses are Chase-Shawmut Class L. The two-times ratio is applied to fuse ratings up to 2000A; but for fuse ratings of 2500A to 6000A the ratio may be reduced to 1½ times.

† K-2000 — 85,000A, Sym.

K-3000 — 130,000A, Sym.

K-4000 — 130,000A, Sym.

† Registered Trademark—Chase Shawmut Co.

* K-DON-600, 42,000A Sym; K-DON-1600, 65,000A Sym.

SELECTION AND APPLICATION

TABLE 51 —
K-DON COORDINATION (ELECTRO-MECHANICAL OD-3)

Circuit Breaker Type	Breaker Coil Rating, A	Long-Time Pickup Settings, A	Instantaneous Pickup Settings, A	Coordinating Fuse Size, A (See Note 1)	
				Min.	Max.
K-DON-600	70	40, 50, 60, 70 or 90	250	300	600
			500	300	600
			750	300	600
			1100	300	600
	125	70, 90, 100, 125 or 160	450	300	800
			800	300	800
			1200	400	800
			1900	600	800
	225	120, 150, 175, 200, 225 or 285	750	300	1200
			1500	400	1200
			2400	600	1200
			3400	1000	1200
	400	250, 300, 350, 400 or 500	1250	400	1200
			2000	600	1200
			4000	1200	1200
			6000	See Note 2	
	600	400, 500, 600 or 750*	2500	800	1200
			4000	1200	1200
			6000	See Note 2	
			9000	See Note 2	
K-DON-1600	225	120, 150, 175, 200, 225 or 285	750	300	1600
			1500	400	1600
			2400	600	1600
			3400	1000	1600
	400	250, 300, 350, 400 or 500	1250	400	2500
			2000	600	2500
			4000	1200	2500
			6000	1600	2500
	800	400, 500, 600, 800 or 1000	2500	800	2500
			5000	1600	2500
			8000	2500	2500
			12000	See Note 2	
	1600	800, 1000, 1200, 1600 or 2000*	5000	2500	2500
			10000	2500	2500
			16000	See Note 2	
			24000	See Note 2	

*Setting above maximum breaker frame size is available for coordination, if needed, but is not thermally self-protecting.

NOTES TO TABLES 51 AND 52:

- ① The minimum fuse size column indicates the minimum fuse size that will coordinate with the instantaneous trip setting directly along side it at the 100% long-time pickup setting. Even though a lower fuse size might appear to coordinate by use of minimum or intermediate time bands or lower instantaneous setting or lower long-time pickup setting, a fuse size lower than listed is not recommended.
- ② The maximum fuse for the frame size will not coordinate with the instantaneous trip setting listed. (See Note 4.)
- ③ The instantaneous setting selected should not be less than five nor more than fifteen times the long-time pickup setting selected.

TABLE 52 —
K-DON COORDINATION (SOLID-STATE SS-3)

Circuit Breaker Type	Breaker AMPERE TAP Settings, A	Long-Time Pickup Settings, (X Ampere Tap) A	Instantaneous Pickup Settings, (X Ampere Tap) A	Coordinating Fuse Size, A (See Notes 1 & 5)	
				Min.	Max.
K-DON-600S	50, 70, 100	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	300	1200
				300	1200
				400	1200
	150	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	300	1200
				400	1200
				600	1200
	225	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	400	1200
				600	1200
				800	1200
	250	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	600	1200
				800	1200
				1000	1200
	400	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	800	1200
				1000	1200
				1200	1200
K-DON-1600S	250	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	600	2500
				800	2500
				1000	2500
	400	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	800	2500
				1000	2500
				1200	2500
	600	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	1200	2500
				1600	2500
				2000	2500
	1000	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	2000	2500
				2500	2500
				2500	2500
	1600	0.7, 0.8, 0.9, 1.0, 1.1†	4, 5, 6, 8, 10 or 12	2500	2500
				See Note 2	
				See Note 2	

† Setting above maximum ampere tap rating and breaker frame size is available for coordination, if needed, but is not thermally self-protecting.

- ④ When the selected settings and indicated fuse size will not coordinate, the following applies:
 - a. Determine the degree of overlap by drawing a breaker-fuse coordination curve.
 - b. If the degree of overlap is not deemed critical (low probability of needless fuse blowing), accept the overlap.
 - c. If the degree of overlap is deemed critical, utilize a short-time delay element in conjunction with the long-time and instantaneous elements to achieve coordination.
- ⑤ For the solid-state device the coordinating fuse size is based on the ampere-tap setting. If a higher tap setting is planned for future load growth, the maximum fuse size for the sensor range should be used to maintain proper coordination.

SELECTION AND APPLICATION

Tables 53 and 54 can be used along with the notes of Table 51 and 52 to assure coordination. Table 53 is to be used when applying separately fused circuit breakers with electro-mechanical overcurrent trips.

**TABLE 53 —
COORDINATION OF SEPARATELY MOUNTED FUSES AND
BREAKERS (Electro-Mechanical)**

Circuit Breaker Type	Breaker Coil Rating, A	Long-Time Pickup Settings, A	Instantaneous Pickup Settings, A	Coordinating Fuse Size (See Table 51, Note 1)	
				Min.	Max.
K-2000	2000	1200, 1600, 1800, 2000 or 2500*	10,000 15,000 20,000 30,000	3000 See Note A See Note A See Note A	3000
K-3000	3000	1600, 2000, 2500, 3000 or 3800*	10,000 20,000 28,000 36,000	4000 6000 See Table 51, Note 2 See Table 51, Note 2	6000 6000
K-4000	4000	2000, 3000, 3500, 4000 or 5000*	20,000 30,000 40,000 48,000	6000 See Table 51, Note 2 See Table 51, Note 2 See Table 51, Note 2	6000

* Setting above coil rating is available for coordination, if needed, but is not thermally self protecting.

Table 54 is for separately fused circuit breakers with solid-state overcurrent trip devices.

**TABLE 54 —
COORDINATION OF SEPARATELY MOUNTED FUSES AND
BREAKERS (Solid-State)**

Circuit Breaker Type	Breaker AMP-ERE TAP Set, A	Long-Time Pickup Settings, (X Ampere Tap) A	Instantaneous Pickup Settings, (X Ampere Tap) A	Coordinating Fuse Size (See Table 51, Note 1)	
				Min.	Max.
K-2000S	800	0.7, 0.8	4, 5, 6, 8, 10, 12	2000	3000
	1200	0.9, 1.0	4, 5, 6, 8, 10, 12	3000	3000
	2000	1.1†	4, 5, 6	3000	3000
	2000		8, 10, 12	See Note A	
K-3000S	2000	0.7, 0.8	4, 5, 6, 8, 10, 12	5000	6000
	3000	0.9, 1.0	4, 5, 6, 8	6000	6000
	3000	1.1†	10, 12	See Table 51, Note 2	
K-4000S	3000	0.7, 0.8	4, 5, 6, 8	6000	6000
	3000	0.9, 1.0	10, 12	See Table 51, Note 2	
	4000	1.1†	4, 5, 6	6000	6000
	4000		8, 10, 12	See Table 51, Note 2	

† Setting above maximum ampere-tap rating is available for coordination, if needed, but is not thermally self protecting.

A. Maximum fuse sizes listed are based on an available RMS symmetrical short-circuit current of 200kA. However, if the available current is only 115kA, a 4000A fuse may be used with the K-2000S breaker frame size for coordination with a higher instantaneous setting.

To illustrate the use of Fig. 6—Amp Trap Let-Thru Curves, assume a fault current of 80,000 Amp symmetrical using a 300 Amp current-limiting fuse. Enter table at 80,000 Amp sym. and project to the intersection of this line with the curve for the 300 Amp fuse; then project this point horizontally to a value of 30,000 peak let-thru amp. To obtain the fault current let-thru amp sym., divide the peak let-thru value by 2.3.

$$\frac{30,000}{2.3} = 13043 \text{ Amp sym.}$$

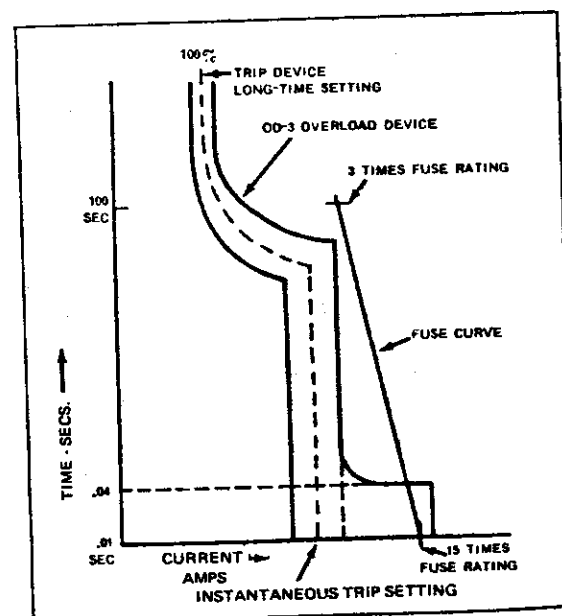


Figure 5. Typical Breaker Amp-Trap

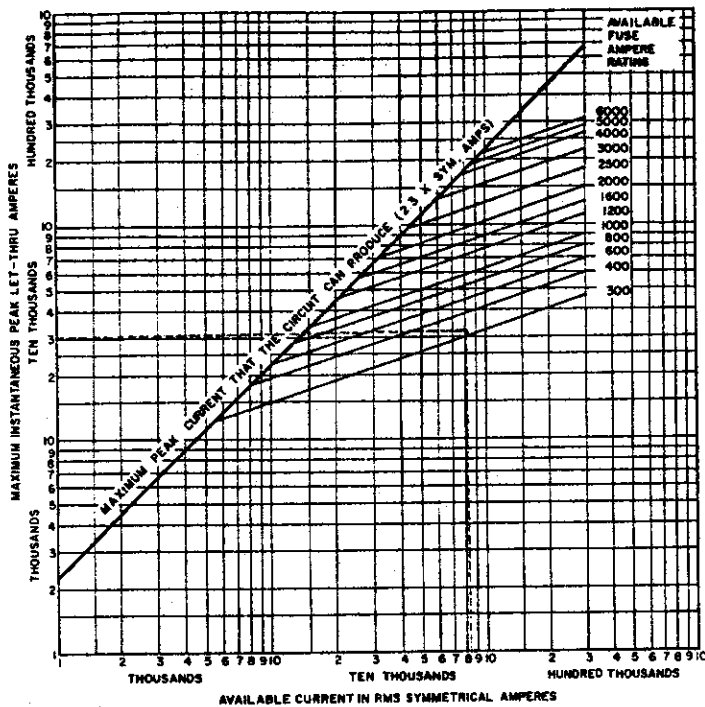


Figure 6—Amp-Trap Let Thru Curves

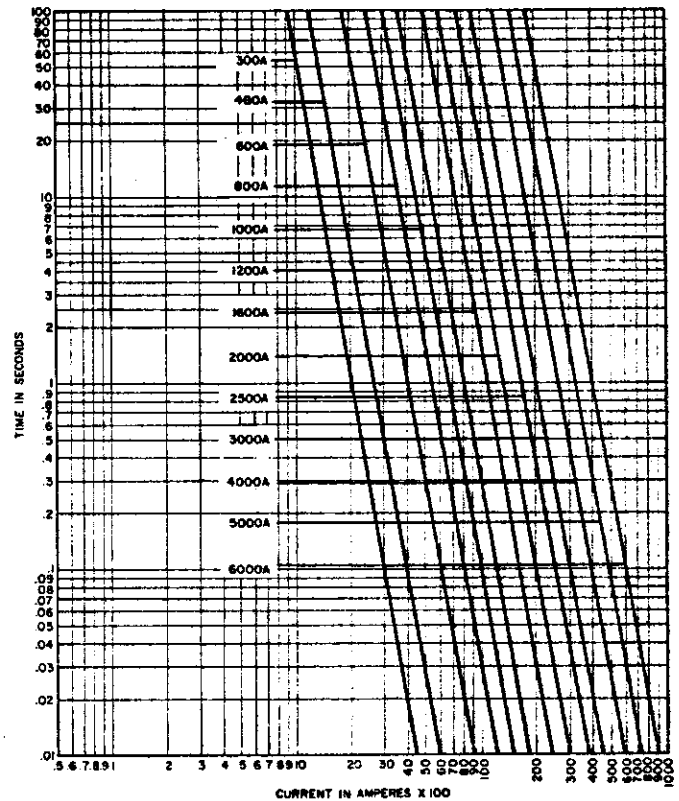


Figure 7—Melting Time-Current Characteristic Curves

TABLE 53— PROTECTION OF MOLDED-CASE CIRCUIT BREAKERS IN SWITCHGEAR, MOTOR CONTROL CENTERS AND PANELBOARDS*

Molded Case Circuit Breaker		K-DON-600		K-DON-1600	
Type	Trip Rating, A	Maximum Coil Rating, A	Maximum Amp-Trap Rating, A	Maximum Coil Rating, A	Maximum Amp-Trap Rating, A
EF	15-100	225	300	—	—
FJ	70-150	400	400	—	—
	175-225			400	400
JL	70-125	600	1000	800	1000
	150-225				
	250-400				
KM	250-275	600	1000	800	1000
	300-800	—	—		
HE	15-50	600	800	—	—
	70-100			800	800
HJ	125	600	1200	800	1200
	150-175				
	225-400				
HM	400-800	—	—	800	1200

TABLE 56— PROTECTION OF LOW-IMPEDANCE BUS DUCT SYSTEMS*

Bus Duct	K-DON-600		K-DON-1600	
Ampere Rating	Maximum Coil Rating, A	Maximum Amp-Trap Rating, A	Maximum Coil Rating, A	Maximum Amp-Trap Rating, A
Plug-In Type				
225	400	300	—	—
400	600	1200	—	—
600	600	2500	800	2500
800	—	—	1600	2500
1000	—	—	1600	2500
1200	—	—	1600	2500
1350	—	—	1600	2500
1600	—	—	1600	2500
Feeder-Type				
800	—	—	1600	2500
1000	—	—	1600	2500
1200	—	—	1600	2500
1350	—	—	1600	2500
1600	—	—	1600	2500

*Based on available short-circuit current of 100,000 amperes at 480 volts. For available fault currents above 100,000 amperes symmetrical, consult I-T-E district sales office.

OD—ELECTRO-MECHANICAL OVERCURRENT TRIP DEVICE

GENERAL-PURPOSE, DUAL-MAGNETIC DIRECT-ACTING OVERCURRENT TRIP DEVICE (OD-3 AND OD-300)

This device combines long-time delay (50-125% of coil rating) and instantaneous (500-1500% of coil rating). It can be used in almost any feeder application including welding and motor circuits.

DUAL-SELECTIVE, DIRECT-ACTING OVERCURRENT TRIP DEVICE (OD-4 AND OD-400)

This device combines long-time delay (80-160% of coil rating) and short-time delay (400-1000% of coil rating). Its prime application is for use on selective-tripping systems where service continuity is of major significance.

SPECIALIZED-SELECTIVE AND GENERAL-PURPOSE, DUAL-MAGNETIC DIRECT-ACTING OVERCURRENT TRIP DEVICES (OD-5, OD-500, OD-6 AND OD-600)

The OD-5 and OD-500 combine long-time delay (80 to 160% of coil rating), short-time delay (400-1000% of coil rating) and instantaneous (500-1500% of coil rating). The OD-5 and 500 is a modified selective device. The addition of the instantaneous trip allows it to be applied above the short-time rating while sacrificing only a minor degree of selectivity.

The OD-6 and OD-600 are similar to the OD-3 and OD-300 general-purpose devices except for the more limited range of the long-time pickup.

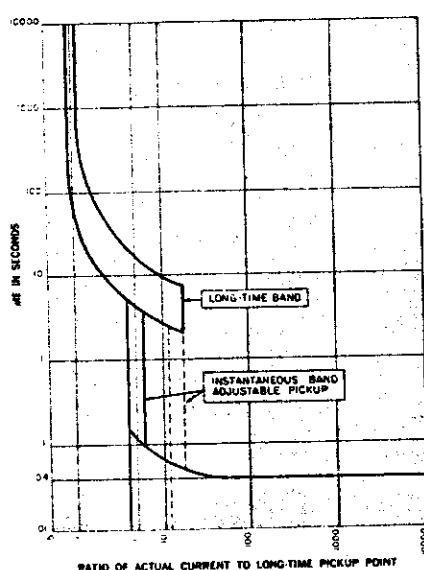


Figure 8—General Purpose Types OD-3 and OD-300

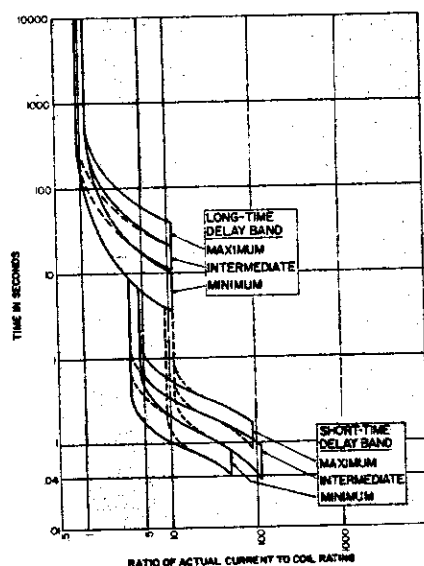


Figure 9—Dual Selective Types OD-4 and OD-400

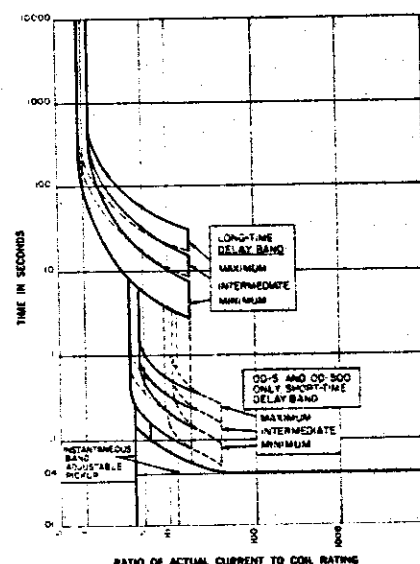


Figure 10—Specialized Selective Types OD-5, 500 and OD-6, 600

Note: Each individual OD device operates within $\pm 10\%$ of its pickup setting. This narrow $\pm 10\%$ band will always fall within the wider bands shown in Figures 8, 9, and 10.

TABLE 57—OD ELECTRO-MECHANICAL APPLICATION PARAMETERS

Circuit Breaker Type	A-C Volts	Frame Size, A	Direct-Acting Trip Devices				
			Maximum Coil Rating, A	Inst. Trip, A (OD-3)	Minimum Coil Ratings with Delayed Trip (OD-4)		
					Minimum Band, A	Intermediate Band, A	Maximum Band, A
K-225	208 and 240	225	225	40	90	90	150
K-600		600	600	225	150	150	250
K-1600		1,600	1,600	400	300	300	500
K-2000		2,000	2,000	800	300	300	500
K-3000		3,000	3,000	3000	3000	3000	3000
K-4000		4,000	4,000	4000	4000	4000	4000
K-225	480	225	225	20	90	90	150
K-600		600	600	125	150	150	250
K-1600		1,600	1,600	400	300	300	500
K-2000		2,000	2,000	400	300	300	500
K-3000		3,000	3,000	3000	3000	3000	3000
K-4000		4,000	4,000	4000	4000	4000	4000
K-225	600	225	225	20	90	90	150
K-600		600	600	40	150	150	250
K-1600		1,600	1,600	225	300	300	500
K-2000		2,000	2,000	400	300	300	500
K-3000		3,000	3,000	3000	3000	3000	3000
K-4000		4,000	4,000	4000	4000	4000	4000

**TABLE 58 —
DUAL-MAGNETIC, DUAL-SELECTIVE AND INSTAN-
TANEOUS ELECTRO-MECHANICAL OVERCURRENT-
TRIP-DEVICE CHARACTERISTICS**

Circuit Breaker Type	Trip Device Type	Characteristic		
		Long-Time	Short-Time *	Instantaneous
K-225 K-600 K-1600 K-2000	OD-3	50-125%		500-1500%
	OD-4	80-160%	400-1000%	
	OD-5	80-160%	400-1000%	500-1500%
	OD-6	80-160%		500-1500%
	OD-7			500-1500%
	OD-8			80-250%
K-3000 K-4000	OD-300	50-125%		500-1200%
	OD-400	80-160%	400-1000%	
	OD-500	80-160%	400-1000%	500-1200%
	OD-600	80-160%		500-1200%
	OD-700			500-1200%
	OD-800			80-250%

* Special 200-500% short-time pick-up settings for specialized coordination applications are also available.

**TABLE 60 —
TYPES OD-4, 400 THRU OD-8, 800 COIL RATINGS**

Circuit Breaker Type	OD-4, 400 Coil Ratings, A	Circuit Breaker Type	OD-5, 500, 6, 600, 7, 700 and 8, 800 Coil Ratings, A ^①
K-225	90	K-225	15
	100		20
	125		
K-225 K-600	150	K-225 K-600	30
	175		40
	200		50
	225		70
			90
K-600	250	K-225 K-600 K-1600	100
			125
			150
			175
			200
K-600 K-1600 K-2000	300	K-600-1600	225
	350		250
	400		
	450		300
	500		350
K-1600 K-2000	600	K-600 K-1600 K-2000	400
			450
			500
			600
K-1600 K-2000	800	K-1600 K-2000	800
	1000		1000
	1200		1200
	1600		1600
K-2000	2000	K-1600 K-2000	2000
K-3000	2500 *	K-2000	2500
	3000		3000
K-4000	4000	K-3000	4000
			4000

① Refer to Table 57 for application parameters.

* Refer to I-T-E district sales office for application parameters.

② Adjustable down to 1600A.

**TABLE 59 —
TYPE OD-3 AND OD-300 DUAL-MAGNETIC ELECTRO-
MECHANICAL OVERCURRENT-TRIP-DEVICE PICK-UP
POINTS**

Circuit Breaker Type	Maximum Continuous Coil Rating, A	Adjustable Long-Time Delay Pickup Points, A	Adjustable Instantaneous Pickup Points, A
K-225	20	12	75
		15	125
		18	200
		20	300
		25	
K-225 K-600	40	20	150
		25	250
		30	400
		40	600
		50	
K-225 K-600	70	40	250
		50	500
		60	750
		70	1100
		90	
K-225 K-600	125	70	450
		90	800
		100	1200
		125	1900
		160	
K-225 K-600 K-1600	225	120	750
		150	1500
		175	2400
		200	3400
		225	
K-600 K-1600 K-2000	400	250	1250
		300	2000
		350	4000
		400	6000
		500	
K-600	600	400	2500
		500	4000
		600	6000
		750*	9000
K-1600 K-2000	800	400	2500
		500	5000
		600	8000
		800	12000
		1000	
K-1600 K-2000	1600	800	5000
		1000	10000
		1200	16000
		1600	24000
		2000*	
K-2000	2000	1200	10000
		1600	15000
		1800	20000
		2000	30000
		2500*	
K-3000	3000	1600	10000
		2000	20000
		2500	28000
		3000	36000
		3800*	
K-4000	4000	2000	20000
		3000	30000
		3500	40000
		4000	48000
		5000*	

① Refer to Table 57 for application parameters.

* Setting above maximum breaker frame size is available for coordination, if needed, but is not thermally self-protecting.

POWER-SHIELD® — SOLID-STATE TRIP DEVICE

Figure 11—General Purpose (SS-3) Time-Current Characteristics

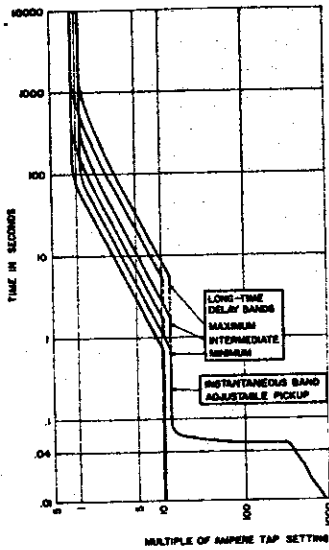


Figure 12—Dual Selective (SS-4 and SS-5) Time-Current Characteristics

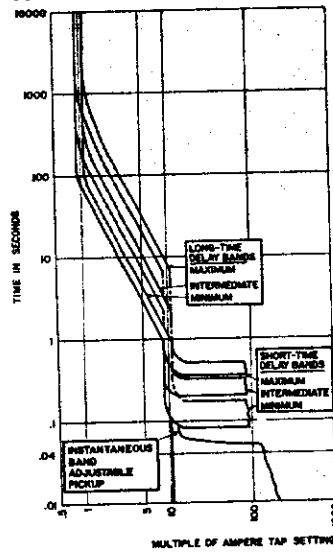


Figure 13—Ground Time-Current Characteristics

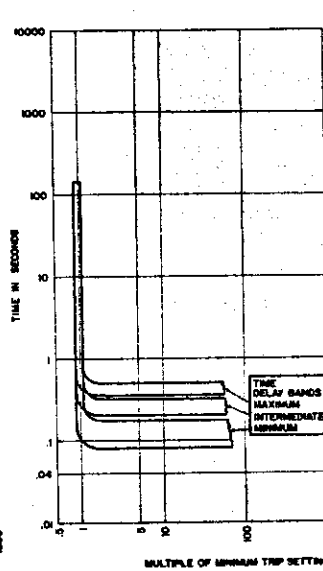


Figure 14—General Purpose (SS-13) Time-Current Characteristics (special)

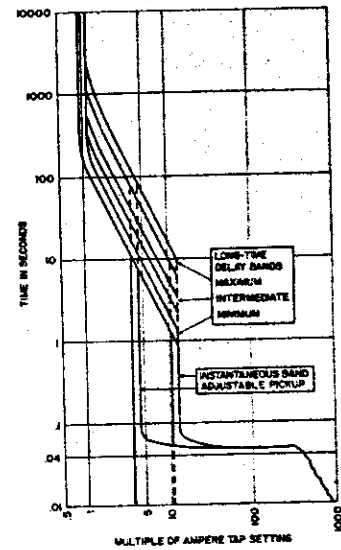


TABLE 61—STANDARD TYPES

Type *	Designation	Trip Functions
SS-3:	General Purpose	Long-time; Instantaneous
SS-4:	Dual Selective	Long-time; Short-time
SS-5:	Triple Selective	Long-time; Short-time; Instantaneous
SS-3G	—	Same as SS-3, with Ground (3- or 4-wire)
SS-4G	—	Same as SS-4, with Ground (3- or 4-wire)
SS-5G	—	Same as SS-5, with Ground (3- or 4-wire)

* Special longer long-time delays (SS-13, SS-14, SS-15) are also available for special coordination.

TABLE 63—TIME-DELAY CHARACTERISTICS

Trip Function	Time-Delay Band	Time Delay
Long-Time *	Maximum Intermediate Minimum	15 seconds† 5 seconds† 2 seconds†
Short-Time	Maximum Intermediate Minimum	0.35 seconds§ (21 cycles) 0.20 seconds§ (12 cycles) 0.08 seconds§ (4.8 cycles)
Instantaneous	Maximum Intermediate Minimum	No Intentional Delay
Ground	Maximum Intermediate Minimum	0.35 seconds§ (21 cycles) 0.20 seconds§ (12 cycles) 0.08 seconds§ (4.8 cycles)

† Measured at six (6) times ampere-tap setting and at the lower limit of maximum, intermediate or minimum long-time time delay bands.

§ Measured at the lower limit of maximum, intermediate, or minimum short-time and ground time delay bands at any point above pick-up.

* Special long-times for SS-13, -14 and -15 are 30, 10 and 4 seconds.

TABLE 62—PHASE AMPERE TAP AND GROUND PICK-UP RANGES

Circuit Breaker Type	Available Ampere Tap Settings, A	Pick-Up Range†			
		Long-Time	Short-Time	Instantaneous	Ground Amperes
K-600S	50	0.7	2	4	
	70	0.8	3	5	100
	100	0.9	4	6	300
	150	1.0	6	8	600
	225	1.1*	8	10	1200
K-1600S	250		10	12	
	400	0.7	2	4	100
	600	0.8	3	5	300
		0.9	4	6	600
		1.0	6	8	1200
K-2000S	600	1.1*	8	10	300
	1000		10	12	600
	1600				900
		0.7	2	4	1200
		0.8	3	5	
K-3000S	800	0.9	4	6	300
	1200	1.0	6	8	600
	2000	1.1*	8	10	900
			10	12	1200
		0.7	2	4	
K-4000S	2000	0.8	3	5	500
	3000	0.9	4	6	800
		1.0	6	8	1000
		1.1*	8	10	1200
			10	12	

* Setting above maximum ampere tap rating and breaker frame size is available for coordination, if needed, but is not thermally self-protecting.

† The tolerance on all calibrated pick-up settings for long-time, short-time, instantaneous and ground functions is $\pm 10\%$ through the temperature range of -20°C to 55°C .

GROUND-SHIELD® GROUND-FAULT PROTECTION APPLICATION

TIME-CURRENT CHARACTERISTICS

The time-current curves shown in Figures 15 & 16 are designed to provide maximum protection against ground faults with minimum disturbance to unfaulted circuits. Use GR-5 relay for all individual loads (such as motors and transformers) and for high-resistance grounded systems. Use GR-200 relay for main, feeder and branch circuits on solidly or low-resistance ground systems.

INTERRUPTER TYPES

Common interrupting devices which can be used with ground-fault relays are (1) high-voltage power circuit breakers, (2) low-voltage power circuit breakers, (3) molded-case circuit breakers, (4) service protectors, (5) contactors, and (6) certain load-break, switch-fuse combinations. First, care should be taken to insure that the switch interrupting rating is sufficient to handle ground faults of all magnitudes which would be cleared faster than the associated fuse maximum clearing curve. Also, it is necessary that the interrupter switch be equipped with a fast shunt-tripping mechanism and ability to interrupt the ground fault within several cycles from energization of trip coil. Circuit breaker and fuse combinations equipped with shunt-trip coils are well adapted to the GROUND-SHIELD Protection System.

BASIC NEED FOR GROUND-SHIELD

The basic need for ground-fault protection in low-voltage systems is illustrated in Figure 17. Shown is a 1000 kVA service transformer with a 1600-ampere main breaker (with typical long-time and short-time characteristics) and fuse. A 1500A ground fault (Point I) on the 480Y/277 grounded neutral system would not be detected by this breaker. A 4000A ground fault (Point II) could persist for about 33 seconds even if the

minimum long-time band were used. An 8,000 ampere ground fault (Point III) would be cleared within about .2 to .4 seconds by the short-time device, assuming it is present, otherwise, between 8 to 20 seconds would elapse before the fault is cleared. For the assumed 8,000A fault, even though the current values are the calculated result using all source, circuit and arc impedances, the actual RMS current values passing through the circuit breaker can be considerably lower. This is because of the spasmodic nature of the fault caused by (1) arc elongating blow-out effects, (2) physical flexing of cables and some bus structures due to mechanical stresses, (3) self-clearing attempts and arc re-ignition, and (4) shifting of the arc terminals from point to point on the grounded enclosure (as well as on the faulted conductors for non-insulated construction). All of these effects tend to reduce the RMS value of fault currents. Figure 17 also illustrates that a ground fault which would normally produce 8,000A under stabilized conditions and which results in an effective value of only 4000A (Point II) would have a max. clearing time of 33 seconds instead of the normally expected max. of .4 seconds.

Other fault interrupting devices such as fuses (Note from Figure 17 that a 1600A fuse takes 5 minutes to clear a 4000A fault) which have far slower operating times as low fault currents, have even a greater need for supplementary ground-fault protection. Most of these devices have time-current characteristics which delay tripping for about 100 seconds for fault currents 200% to 300% of normal continuous-current rating.

Note the interrupting time for a curve C, GR-200 relay would be about .2 seconds on a 4000 ampere ground fault and less than .4 seconds on a 1500 ampere ground fault.

GROUND-SHIELD ground fault sensing and relaying equipment is UL listed.

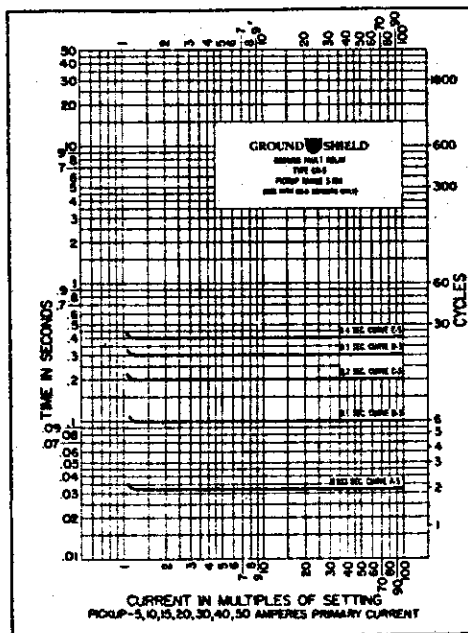


Figure 15—GR-5 Time-Current Characteristics
Standard pick-up range, 5-50A
Optional pick-up range, 2-40A or 20-200A

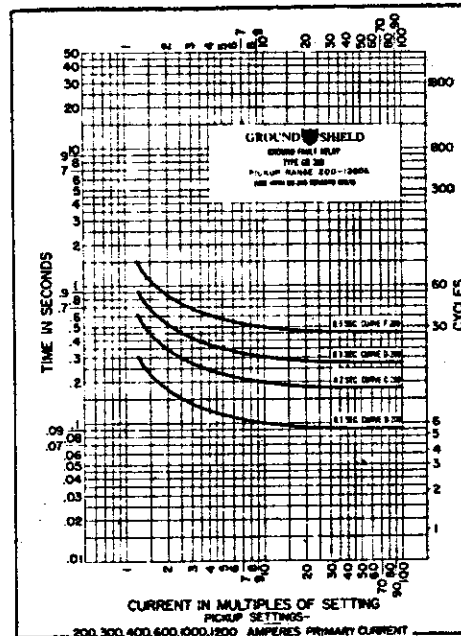


Figure 16—GR-200 Time-Current Characteristics
Standard pick-up range, 200-1200A
Optional pick-up range, 120-1200A

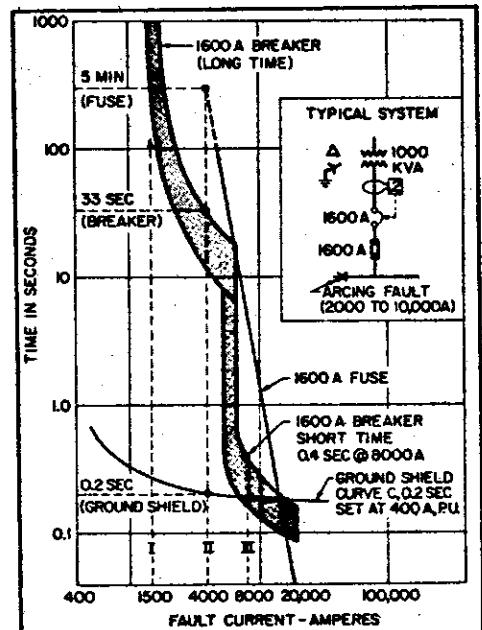


Figure 17—Ground-Shield System
Coordination Curves

MOLDED-CASE CIRCUIT BREAKERS

TABLE 64 — MOLDED-CASE BREAKER RATINGS

Max. Amperes A-C Max. Voltage	Circuit Breaker Frame	Current Continuous Amperes	A-C Volts	Maximum Interrupting Rating Sym. Rms Amperes	3-Pole Circuit Breaker (not including mounting) Size, Inches
100 Amp 480 Volt	EH†	15-150	240	18,000	W 4½
			480	14,000	H 6
100 Amp 600 Volt	EF†	15-100	240	18,000	D 3⅞
			480	14,000	W 4½
			600	14,000	H 6
	HE†	15-100	240	65,000	D 3⅞
			480	25,000	W 4½
			600	18,000	H 6
225 Amp 600 Volt	FJ†	70-225	240	22,000	D 4⅞
			480	18,000	W 4½
400 Amp 600 Volt	JJ†	250-400	240	42,000	H 10
			480	30,000	D 4⅞
			600	22,000	W 9
			600	22,000	H 11
	JL*	70-400	240	42,000	D 4⅞
			480	30,000	W 9
			600	22,000	H 11
			600	22,000	D 4⅞
450-600 Amp 600 Volt	HJ	125-400	240	65,000	W 9
			480	35,000	H 11
			600	25,000	D 4⅞
	CJ Cordon	125-400	240	200,000	W 9
			480	200,000	H 15⅞
			600	100,000	D 5⅞
800 Amp 600 Volt	LL	450-600	240	42,000	W 9
			480	30,000	H 11
	HL	450-600	240	65,000	D 4⅞
			480	35,000	W 9
1200 Amp 600 Volt	KM	250-800	240	42,000	H 11
			480	30,000	D 4⅞
			600	22,000	W 9
	HM	400-800	240	65,000	H 15½
			480	35,000	D 4⅞
			600	25,000	W 9
1600 Amp 600 Volt	CM Cordon	400-800	240	200,000	H 22
			480	200,000	D 5¾
	KP	600-1200	240	200,000	W 9
			480	200,000	H 26⅞
2000 Amp 600 Volt	HR	1800-2000	240	100,000	D 6⅞
			480	42,000	W 9
	CR Cordon	1800-2000	240	65,000	H 15½
			480	50,000	D 4¾

† Non-interchangeable trip.
 * 70, 90 and 100 ampere breakers have interrupting ratings of 30,000 amperes asymmetrical, 23,000 amperes symmetrical at 240 volts ac; 25,000 amperes

asymmetrical, 22,000 amperes symmetrical at 480 and 600 volts ac

TABLE 65A

LOW-VOLTAGE POWER CIRCUIT BREAKER APPLICATION — 208 VOLTS

Transformer Rating, 3-ph KVA and Impedance Per Cent	Primary System Max. Short- Circuit kVA	Normal Load Continuous Current, A	Short-Circuit Current Total RMS Symmetrical Amperes			Minimum Frame Size Air Circuit Breaker Recommended		
			Transformer Alone	Motor Load	Combined	Main Breaker	Feeder with Instant. Trip	Feeder with Selective Trip
112.5 2.25%\$	50,000	312	13,160	600	13,770	K-600 K-600S	K-225 K-600S	K-225 K-600S
	100,000		13,480		14,080			
	150,000		13,640		14,240			
	250,000		13,760		14,330			
	500,000		13,840		14,440			
	Unlimited		13,870		14,470			
150 3.00%\$	50,000	416	11,280	800	12,080	K-600 K-600S	K-225 K-600S	K-225 K-600S
	100,000		11,580		12,380			
	150,000		11,640		12,440			
	250,000		11,820		12,620			
	500,000		12,000		12,800			
	Unlimited		13,870		14,670			
225 4.5%	50,000	625	12,640	1200	13,840	K-1600 K-1600S	K-225 K-600S	K-225 K-600S
	100,000		13,120		14,320			K-600 K-600S
	150,000		13,360		14,560			
	250,000		13,600		14,800			
	500,000		13,760		14,960			
	Unlimited		13,890		15,090			
300 5.0%	50,000	834	14,880	1700	16,580	K-1600 K-1600S	K-225 K-600S	K-600 K-600S
	100,000		15,680		17,380			
	150,000		16,000		17,700			
	250,000		16,240		17,940			
	500,000		16,400		18,100			
	Unlimited		16,680		18,380			
500 5.0%	50,000	1388	23,120	2800	25,920	K-1600 K-1600S †	K-600 K-600S	K-1600 K-1600S
	100,000		25,200		28,000			
	150,000		26,000		28,800			
	250,000		26,640		29,440			
	500,000		27,200		30,000			
	Unlimited		27,760		30,560			
750 5.75%	50,000	2080	28,640	4200	32,840	K-3000 K-3000S	K-600 K-600S	K-1600 K-1600S
	100,000		32,000		36,200			
	150,000		33,360		37,560			
	250,000		34,400		38,600			
	500,000		35,280		39,480			
	Unlimited		36,170		40,370			
1000 5.75%	50,000	2780	35,840	5600	41,440	K-3000 K-3000S	K-600 K-600S	K-1600 K-1600S
	100,000		41,120		46,720		K-1600 K-1600S	
	150,000		43,360		48,960			
	250,000		45,200		50,800			
	500,000		46,720		52,320			
	Unlimited		48,350		53,950		K-2000, S	

TABLE 65B

240 VOLTS

112.5 2.25%\$	50,000	271	9,600	1100	10,700	K-600 K-600S	K-225 K-600S	K-225 K-600S
	100,000		11,680		12,780			
	150,000		11,840		12,940			
	250,000		11,920		13,020			
	500,000		12,020		13,120			
	Unlimited		12,050		13,150			
150 3.00%\$	50,000	361	11,280	1400	12,680	K-600 K-600S	K-225 K-600S	K-225 K-600S
	100,000		11,460		12,860			
	150,000		11,650		13,050			
	250,000		11,800		13,200			
	500,000		11,910		13,310			
	Unlimited		12,030		13,430			
225 4.5%	50,000	541	10,930	2200	13,130	K-600 K-600S †	K-225 K-600S	K-225 K-600S
	100,000		11,460		13,660			K-600 K-600S
	150,000		11,630		13,830			
	250,000		11,790		13,990			
	500,000		11,990		14,190			
	Unlimited		12,020		14,220			
300 5.0%	50,000	722	12,880	2900	15,780	K-1600 K-1600S	K-225 K-600S	K-1600 K-1600S
	100,000		13,600		16,500			
	150,000		13,920		16,820			
	250,000		14,080		16,980			
	500,000		14,320		17,220			
	Unlimited		14,440		17,340			
500 5.0%	50,000	1203	20,080	4800	24,880	K-1600 K-1600S	K-225 K-600S	K-1600 K-1600S
	100,000		21,840		26,640		K-600 K-600S	
	150,000		22,560		27,360			
	250,000		23,120		27,920			
	500,000		23,600		28,400			
	Unlimited		24,060		28,860			
750 5.75%	50,000	1804	24,960	7200	32,160	K-2000 K-2000S †	K-600 K-600S	K-1600 K-1600S
	100,000		27,760		34,960			
	150,000		28,880		36,080			
	250,000		29,920		37,120			
	500,000		30,640		37,840			
	Unlimited		31,380		38,580			
1000 5.75%	50,000	2406	31,120	9600	40,720	K-3000 K-3000S	K-600 K-600S	K-1600 K-1600S
	100,000		35,680		45,280		K-1600 K-1600S	
	150,000		37,520		47,120			
	250,000		39,120		48,720			
	500,000		41,360		50,960			
	Unlimited		41,840		51,440			K-2000, S

*§† See Page 49 for note references.

TABLE 66 — LOW-VOLTAGE POWER CIRCUIT BREAKER APPLICATION — 480 VOLTS

Transformer Rating, 3-ph kVA and Impedance Per Cent	Primary System Max. Short-Circuit kVA	Normal Load Continuous Current, A	Short-Circuit Current Total RMS Symmetrical Amperes			Minimum Frame Size Air Circuit Breaker Recommended			
			Transformer Alone	100% Motor Load	Combined	M ²			
						Main Breaker	Feeder with Instant Trip	Feeder with Selective Trip	
112.5 2.25% ⁵	50,000	135	5,720	500	6,220	K-225 K-600S	K-225 K-600S	K-225 K-600S	
	100,000		5,840		6,340				
	150,000		5,880		6,380				
	250,000		5,960		6,460				
	500,000		6,000		6,500				
	Unlimited		6,000		6,500				
150 3.0% ⁵	50,000	180	5,400	700	6,100	K-225 K-600S	K-225 K-600S	K-225 K-600S	
	100,000		5,790		6,490				
	150,000		5,865		6,565				
	250,000		5,895		6,595				
	500,000		5,955		6,655				
	Unlimited		6,000		6,700				
225 4.5% ⁵	50,000	271	5,460	1100	6,560	K-600 K-600S	K-225 K-600S	K-225 K-600S	
	100,000		5,720		6,820				
	150,000		5,800		6,900				
	250,000		5,900		7,000				
	500,000		5,960		7,060				
	Unlimited		6,020		7,120				
300 5.0%	50,000	361	6,480	1400	7,880	K-600 K-600S	K-225 K-600S	K-225 K-600S	
	100,000		6,800		8,200				
	150,000		6,960		8,360				
	250,000		7,040		8,440				
	500,000		7,120		8,520				
	Unlimited		7,220		8,620				
500 5.0%	50,000	601	10,000	2400	12,400	K-1600 K-1600S	K-225 K-600S	K-225 K-600S	
	100,000		10,960		13,360		K-600 or K-600S		
	150,000		11,280		13,680				
	250,000		11,600		14,000				
	500,000		11,840		14,240				
	Unlimited		12,020		14,420				
750 5.75%	50,000	902	12,400	3600	16,000	K-1600 K-1600S	K-225 K-600S	K-600 K-600S	
	100,000		13,840		17,440				
	150,000		14,480		18,080				
	250,000		14,960		18,560				
	500,000		15,360		18,960				
	Unlimited		15,690		19,290				
1000 5.75%	50,000	1203	15,600	4800	20,400	K-1600 K-1600S	K-225 K-600	K-600, S	
	100,000		17,920		22,720		K-600 K-600S	K-1600 K-1600S	
	150,000		18,800		23,600				
	250,000		19,600		24,400				
	500,000		20,240		25,040				
	Unlimited		20,920		25,720				
1000 8.0%	50,000	1203	12,030	4800	16,830	K-1600 K-1600S	K-225 K-600S	K-600 K-600S	
	100,000		13,350		18,150				
	150,000		13,980		18,750				
	250,000		14,315		19,115				
	500,000		14,555		19,355				
	Unlimited		15,040		19,840				
1500 5.75%	50,000	1804	20,640	7200	27,840	K-2000 K-2000S †	K-600, S	K-1600 K-1600S	
	100,000		24,960		32,160		K-1600 K-1600S		
	150,000		26,800		34,000				
	250,000		28,480		35,680				
	500,000		29,840		37,040				
	Unlimited		31,370		38,570				
2000 5.75%	50,000	2406	24,720	9600	34,320	K-3000 K-3000S	K-1600 K-1600S	K-1600 K-1600S	
	100,000		30,560		40,160				
	150,000		34,080		43,680				
	250,000		36,720		46,320				
	500,000		38,960		48,560				
	Unlimited		41,840		51,440				
2500 5.75%	50,000	3010	27,900	12000	39,900	K-4000 K-4000S	K-1600 K-1600S	K-1600 K-1600S	
	100,000		36,300		48,300		K-2000 or K-2000S		
	150,000		40,400		52,400		K-2000 K-2000S	K-3000 K-3000S	
	250,000		44,500		56,500				
	500,000		48,100		62,100				
	Unlimited		52,350		64,350				

*†† See Page 49 for note references.

SELECTION AND APPLICATION

TABLE 67 — LOW-VOLTAGE POWER CIRCUIT BREAKER APPLICATION — 600 VOLTS

Transformer Rating, 3-ph KVA and Impedance Per Cent	Primary System Nom. Short-Circuit KVA	Normal Load Continuous Current, A	Short-Circuit Current Total and Symmetrical Amperes			Minimum Frame Size Air Circuit Breaker Recommended		
			Transformer Alone	100% Motor Load	Combined	Main Breaker	Feeder with Instant. Trip	Feeder with Selective Trip
112.5 2.25%§	50,000	108	4,580	400	4,980	K-225 K-600S	K-225 K-600S	K-225 K-600S
	100,000		4,680		5,080			
	150,000		4,720		5,120			
	250,000		4,760		5,160			
	500,000		4,780		5,180			
	Unlimited		4,800		5,200			
150 3.00%§	50,000	144	4,500	600	5,100	K-225 K-600S	K-225 K-600S	K-225 K-600S
	100,000		4,650		5,250			
	150,000		4,695		5,295			
	250,000		4,740		5,340			
	500,000		4,770		5,370			
	Unlimited		4,800		5,400			
225 4.5%	50,000	217	4,380	900	5,280	K-225 K-600S †	K-225 K-600S	K-225 K-600S
	100,000		4,590		5,490			
	150,000		4,670		5,570			
	250,000		4,730		5,630			
	500,000		4,770		5,670			
	Unlimited		4,820		5,720			
300 5.0%	50,000	289	5,160	1200	6,360	K-600 K-600S	K-225 K-600S	K-225 K-600S
	100,000		5,450		6,650			
	150,000		5,560		6,760			
	250,000		5,640		6,840			
	500,000		5,710		6,910			
	Unlimited		5,780		6,980			
500 5.0%	50,000	481	8,020	1900	9,920	K-600 K-600S	K-225 K-600S	K-225 K-600S
	100,000		8,740		10,640			
	150,000		9,020		10,920			
	250,000		9,250		11,150			
	500,000		9,430		11,330			
	Unlimited		9,620		11,520			
50 5.75%	50,000	722	9,960	2900	12,860	K-1600 K-1600S	K-225 K-600S	K-225 K-600S
	100,000		11,110		14,010			
	150,000		11,550		14,450			
	250,000		11,930		14,830			
	500,000		12,240		15,140			
	Unlimited		12,560		15,460			
1000 5.75%	50,000	962	12,410	3800	16,210	K-1600 K-1600S	K-225 or K-600S	
	100,000		14,250		18,050		K-600 K-600S	K-1600 K-1600S
	150,000		14,980		18,780			
	250,000		15,640		19,440			
	500,000		16,170		19,970			
	Unlimited		16,730		20,530			
1500 5.75%	50,000	1444	16,500	5800	22,300	K-2000 K-2000S	K-1600 K-1600S	K-600 K-600S
	100,000		19,920		25,720			
	150,000		21,390		27,190			
	250,000		22,740		28,540			
	500,000		23,870		29,670			
	Unlimited		25,110		30,910			
2000 5.75%	50,000	1924	19,730	7700	27,430	K-2000 K-2000S	K-1600 K-1600S	K-600 K-600S
	100,000		24,830		32,530			
	150,000		27,180		34,880			
	250,000		29,370		37,070			
	500,000		31,280		38,980			
	Unlimited		33,630		41,330			
2500 5.75%	50,000	2406	22,380	9600	31,980	K-3000 K-3000S	K-1600	K-1600
	100,000		29,160		38,760		K-1600S	K-1600S
	150,000		32,430		42,030		K-2000 K-2000S	K-2000 K-2000S
	250,000		35,640		45,240			
	500,000		38,500		48,100			
	Unlimited		41,840		51,440			

* The transformer main secondary breakers are in most cases determined by continuous current instead of fault current. For this reason breakers in the M column are usually larger than those listed in the I column. The values listed in the M column allow a breaker continuous rating approximately 25% above the transformer self-cooled full-load current. If the transformer has a fan cooled rating a main secondary breaker larger than indicated by column M may be required.

§ Short-circuit currents are calculated with impedances shown applying to liquid-immersed transformers only. Refer to Table 39, Page 34, for ventilated-dry type impedances.

† Motor load contribution for 208 volts is based on 50%. 240 volt application table is based on 100% motor load contribution.

‡ These circuit breakers are applied at less than 25% above transformer full-load rating. If 25% is required, use the next larger frame size.

SELECTION AND APPLICATION

SHORT-CIRCUIT CURRENTS IN LOW-VOLTAGE SYSTEMS

To determine the interrupting-capacity requirements of low-voltage, air-magnetic power circuit breakers it is necessary to obtain information, at the point of application, of the short-circuit condition of every part of a distribution system. A set of 32 curves (available on request) provides a graphical means of determining the value of short-circuit currents and the corresponding power factor for various sizes of transformers and various voltages, in combination with different sizes and lengths of cable. In Table 70 is given the multiplying factor to use in obtaining the asymmetrical values of current at different power factors.

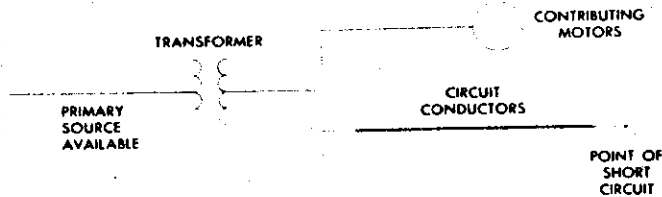


Figure 18

In the study diagrammed above, these basic characteristics are assumed:

1. Primary source available is 500 MVA at the primary of the transformer, with a source circuit X/R ratio of 25.
2. Transformer kVA covers a range of six standard sizes; 500, 750, 1000, 1500, 2000, 2500.
3. Distribution voltages of 208, 240, 480, and 600 v are assumed; 3-phase, 60 Hertz.
4. Minimum transformer impedances are 5.0% up through 500 kVA and 5.75% for 750 kVA and higher, less the standard allowable tolerance of $-7\frac{1}{2}\%$. X/R ratios are selected from typical data furnished by several transformer manufacturers from which the characteristics in Table 68 (following) are calculated. The data is based on liquid-immersed, self-cooled transformers. Dry-type transformers generally have higher resistance, and the results of this study should be conservative for systems in which they are used.
5. Motor impedance is based on an equivalent reactance of 25 and an X/R ratio of 6.
6. Feeder conductors chosen are at least 115% of the size normally required for the standard frame sizes of low-voltage, air-magnetic power circuit breakers. Calculations in this study are based on 3-phase conductors, of minimum insulation thickness, in magnetic ducts. Table 69 gives the conductor sizes and alternate arrangements for which this study can be used.
7. Short-circuit duty can be read direct from the set of 32 curves. The short-circuit current available, in symmetrical amperes, and the corresponding short-circuit power factor are shown for any distance, in circuit feet, from the terminals of the transformer up to 5000 ft. These values include the current contributed by the connected motors.
8. Asymmetrical short-circuit currents, if desired, can be found from the symmetrical values above by using a multiplying factor read from Figure 19 and corresponding to the short-circuit power factor at the point of fault. Use the multiplying factor from Curve M_A to find the average 3-phase asymmetrical amperes and Curve M_M to find the

maximum asymmetrical amperes in one phase with the greatest possible offset. For accurate values of M_A and M_M , use the values in Table 70.

9. Short-circuit current at the terminals of transformers may be determined from Table 71. This gives the symmetrical rms amperes, the 3-phase average asymmetrical rms amperes, and the maximum obtainable asymmetrical rms amperes in one phase at the terminals.

TABLE 68 — TRANSFORMER CHARACTERISTICS

Transformer Rating kVA	X/R	R (%)	X (%)	Z (%) *
500	3.4	1.3	4.4	4.6
750	3.9	1.3	5.1	5.3
1000	4.2	1.2	5.1	5.3
1500	5.2	1.0	5.2	5.3
2000	6.1	.85	5.2	5.3
2500	6.5	.80	5.2	5.3

* Minimum value takes impedance tolerance into account.

TABLE 69 — CIRCUIT CONDUCTORS

Circuit Rating Amperes	Conductor Size	Conductor Insulation	Alternate Conductor Sizes
50	# 4 AWG	Type R	—
100	# 0 AWG	Type R	—
225	250 MCM	Type RH	—
400	2-250 MCM	Type RH	—
600	2-500 MCM	Type RH	3-# 4/0 AWG
600	2-500 MCM	Type RH	4-# 2/0 AWG
1600	4-750 MCM	Type RH	3-2000 MCM
1600	4-750 MCM	Type RH	5-400 MCM
1600	4-750 MCM	Type RH	6-300 MCM

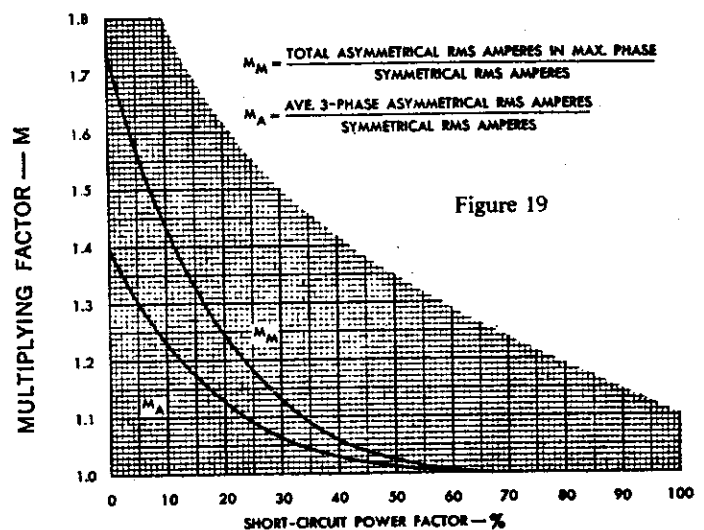


Figure 19

Multiplying Factors to obtain short-circuit asymmetrical current from symmetrical values, at an instant $\frac{1}{2}$ cycle (60 cycle basis) after initiation of a fault.

TABLE 70 — SHORT-CIRCUIT MULTIPLYING FACTORS

Short-Circuit Power Factor Per Cent	Short Circuit X/R Ratio	Multiplying Factor		Short-Circuit Power Factor Per Cent	Short Circuit X/R Ratio	Multiplying Factor	
		Maximum 1-Phase RMS Amperes at ½ Cycle (Curve M _a)	Average 3-Phase RMS Amperes at ½ Cycle (Curve M _a)			Maximum 1-Phase RMS Amperes at ½ Cycle (Curve M _a)	Average 3-Phase RMS Amperes at ½ Cycle (Curve M _a)
0	∞	1.732	1.394	29	3.3001	1.139	1.070
1	100.00	1.696	1.374	30	3.1798	1.130	1.066
2	49.993	1.665	1.355	31	3.0669	1.121	1.062
3	33.322	1.630	1.336	32	2.9608	1.113	1.057
4	24.979	1.598	1.318	33	2.8606	1.105	1.053
5	19.974	1.568	1.301	34	2.7660	1.098	1.049
6	16.623	1.540	1.285	35	2.6764	1.091	1.046
7	14.251	1.511	1.270	36	2.5916	1.084	1.043
8	12.460	1.485	1.256	37	2.5109	1.078	1.039
8.5	11.723	1.473	1.248	38	2.4341	1.073	1.036
9	11.066	1.460	1.241	39	2.3611	1.068	1.033
10	9.9501	1.436	1.229	40	2.2913	1.062	1.031
11	9.0354	1.413	1.216	41	2.2246	1.057	1.028
12	8.2733	1.391	1.204	42	2.1608	1.053	1.026
13	7.6271	1.372	1.193	43	2.0996	1.049	1.024
14	7.0721	1.350	1.182	44	2.0409	1.045	1.022
15	6.5912	1.330	1.171	45	1.9845	1.041	1.020
16	6.1695	1.312	1.161	46	1.9303	1.038	1.019
17	5.7967	1.294	1.152	47	1.8780	1.034	1.017
18	5.4649	1.277	1.143	48	1.8277	1.031	1.016
19	5.1672	1.262	1.135	49	1.7791	1.029	1.014
20	4.8990	1.247	1.127	50	1.7321	1.026	1.013
21	4.6557	1.232	1.119	55	1.5185	1.015	1.008
22	4.4341	1.218	1.112	60	1.3333	1.009	1.004
23	4.2313	1.205	1.105	65	1.1691	1.004	1.002
24	4.0450	1.192	1.099	70	1.0202	1.002	1.001
25	3.8730	1.181	1.093	75	0.8819	1.0008	1.0004
26	3.7138	1.170	1.087	80	0.7500	1.0002	1.00005
27	3.5661	1.159	1.081	85	0.6198	1.00004	1.00002
28	3.4286	1.149	1.075	100	0.0000	1.00000	1.00000

GUIDE SPECIFICATIONS FOR SECONDARY UNIT SUBSTATIONS

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

- Choice of alternates
- Addition of optional features
- Specific information

SCOPE

These specifications cover a complete (indoor) (outdoor) secondary unit substation from the incoming line terminals to the outgoing feeder terminals.

SECTIONS

The substation will have the following sections:

1. Incoming line section with () incoming primary circuit(s).
2. Transforming section consisting of () transformer(s).
3. Outgoing section which will provide for () outgoing feeders provided with low-voltage power circuit breaker(s).

GENERAL ARRANGEMENT

The accompanying sketch No. _____ indicates orientation of equipment only, not construction details.

RATINGS

The ratings of the substation will be:

- Self-Cooled rating kVA
Fan-Cooled rating kVA
Frequency 60 Hertz
Number of Phases 3
() incoming (3) (4)-wire circuit(s) kV
() outgoing (3) (4)-wire circuit(s) volts

INCOMING LINE SECTION

(2-POSITION, ON-OFF) (3-POSITION, LINE 1-OFF-LINE 2) (FUSED) (UNFUSED) AIR INTERRUPTER SWITCH(ES)

This section shall consist of a floor-mounted, formed welded metal enclosure close-coupled to the transformer section and equipped with:

- ()—3-pole, 2-position, gang-operated, load-interrupter switch, type HPL-C, rated 600 amperes, _____ kV, interrupting capacity 600 amperes.
- ()—3-pole, 2-position selector switch, interlocked and in series with the air interrupter switch.
- ()—Power fuses, current-limiting type CL-14 _____ kV, _____ amperes continuous, to be located between the switch and the transformer. The fuse door to be interlocked with the switch handle to prevent opening while the switch is in the closed position.
- ()—Lightning arresters rated (3) (6) (9) (12) (15) kV.

_____ size cable to enter from (above) (below) and terminate in _____ clamp-type lugs per phase or (1-3/C) (2-3/C) (3-1/C) (6-1/C) pothead(s). Pothead(s) to be provided with _____ fitting for cables with the following specifications: _____ kV size, _____ insulation, _____ O.D. over insulation, _____ O.D. conductor, _____ O.D. overall.

LIQUID (INTERRUPTER) (DISCONNECT) SWITCH(ES)

This section shall consist of non-fused, oil-insulated, load-interrupter switch, mounted on transformer tank. This switch to be 3-pole (2) (3)-position device rated _____ amperes continuous at _____ kV.

This section shall consist of non-fused, askarel-insulated, disconnecting switch, mounted on transformer tank. The switch shall be capable of breaking transformer magnetizing current and the askarel shall be of the type designed for this operation. This switch to be 3-pole (2) (3)-position device rated _____ amperes continuous at _____ kV.

_____ size cable to enter from (above) (below) and terminate in (1-3/C) (2-3/C) (3-1/C) (6-1/C) pothead(s). Pothead(s) to be provided with _____ fitting cables with the following specifications: _____ kV size, _____ insulation, _____ O.D. over insulation, _____ O.D. conductor, _____ O.D. overall.

OIL FUSE CUTOUTS

This section shall consist of 3-gang-operated oil fuse cutouts, mounted in an air-filled terminal chamber directly connected to the transformer tank wall. Cut-outs are to be 2-position and rated _____ amperes continuous at _____ kV.

_____ size cable to enter from (above) (below) and terminate in _____ clamp-type lugs per phase or (1-3/C) (2-3/C) (3-1/C) (6-1/C) pothead(s). Pothead(s) to be provided with _____ fitting for cables with the following specifications: _____ kV size, _____ insulation, _____ O.D. over insulation, _____ O.D. conductor, _____ O.D. overall.

AIR TERMINAL CHAMBER

This section shall consist of a full-height air terminal chamber directly connected to the high-voltage side of the transformer. It shall be rated _____ kV. _____ size cable to enter from (above) (below) and terminate in _____ clamp-type lugs per phase or (1-3/C) (2-3/C) (3-1/C) (6-1/C) pothead(s). Pothead(s) to be provided with _____ fitting for cables with the following specifications: _____ kV size, _____ insulation, _____ O.D. over insulation, _____ O.D. conductor, _____ O.D. overall.

METAL-CLAD SWITCHGEAR

- ()—Metal-clad switchgear unit.
- ()—(4 (6) (7.2) (13.8) kV air circuit breaker, _____ amp, 3-pole, electrically-operated, stored-energy.

State Control Voltage Requirements.

- ()—Set of insulated main bus, _____ amp.
- ()—Current transformers, _____ /5, ratio.
- ()—Overcurrent relays, instantaneous and time.
- ()—Breaker control switch with red and green indicating lights.
- ()—Ammeter, 0- _____ scale.
- ()—Ammeter transfer switch.
- ()—Voltmeter.
- ()—Voltmeter transfer switch.
- ()—Drawout potential transformers, _____ -120 volt ratio.

_____ size cable to enter from (above) (below) and terminate in _____ clamp-type lugs per phase or (1-3/C) (2-3/C) (3-1/C) (6-1/C) pothead(s). Pothead(s) to be provided with _____ fitting for cables with the following specifications: _____ kV size, _____ insulation, _____ O.D. over insulation, _____ O.D. conductor, _____ O.D. overall.

TRANSFORMER SECTION

LIQUID-IMMERSED TYPES (OIL) (ASKAREL)—(OA) (OA/FA)

Transformer shall be (Oil) (Askarel)-insulated, 3-phase, 60 Hertz, (self-cooled) (forced-air cooled) with a temperature rating not to exceed a 65°C rise above 30°C average ambient.

Rated _____ kVA, with delta primary of _____ kV and a secondary of _____ volts (Delta) (Wye). Provide four (4) approximately 2½% full capacity taps in the high-voltage winding, two above and two below normal, brought out to an externally-operated, deenergized tap changer. Tap changer handle to be capable of being locked in any tap position.

Transformer base construction to be of the fabricated type and suitable for using rollers or skidding in any direction.

Transformer to be factory tested as prescribed by ANSI and NEMA Standards. All NEMA standard accessories are to be provided.

VENTILATED-DRY TYPE—(AA) (AA/FA)

Transformer shall be a ventilated-dry type, indoor construction, 3-phase, 60 Hertz, (self-cooled) (forced-air cooled) with a temperature rating not to exceed a 150°C rise above 30°C average ambient.

Rated _____ kVA, with a delta primary of _____ kV and a secondary of _____ volts (Delta) (Wye). Provide four (4) approximately 2½% full capacity taps in the high-voltage winding, two above and two below normal, brought out through studs, complete with bolted flexible links for deenergized tap-changing operation, made accessible through a removable panel on the transformer enclosure.

Transformer base construction to be of the fabricated type and suitable for using rollers or skidding in any direction.

Transformer to be factory tested as prescribed by ANSI and NEMA standards. All NEMA standard accessories are to be provided.

Necessary winding-temperature equipment for control of fans.

Shall have provision for future fan cooling.

SEALED-DRY, GAS-FILLED—TYPE AA

Transformer shall be sealed-dry type, gas-filled, 3-phase, 60 Hertz, self-cooled, with a temperature rating not to exceed a 150°C rise above a 30°C average ambient.

Rated _____ kVA, with a delta primary of _____ kV and a secondary of _____ volts (Delta) (Wye). Provide four (4) approximately 2½% full capacity taps in the high-voltage winding, two above and two below normal, brought out to an externally-operated, deenergized tap changer. Tap changer cover to be capable of being bolted in any tap position.

Transformer base construction to be of the fabricated type and suitable for using rollers or skidding in any direction.

Transformer to be factory tested as prescribed by ANSI and NEMA Standards. All NEMA standard accessories are to be provided.

OUTGOING SECTION

This section shall consist of one metal-enclosed (indoor) (outdoor) switchgear assembly, drawout type, rated 600 V a-c and arranged for _____ volt service on a _____ volt 3-phase (3) (4)-wire (grounded) (ungrounded) system. It shall be designed, factory assembled and tested in accordance with the latest applicable IEEE, NEMA, and ANSI requirements.

SWITCHGEAR (indoor) (outdoor)

Switchgear shall consist of sufficient vertical frames to house the number of circuits specified below, with a minimum number of empty spaces remaining. Each individual frame shall be divided into a front breaker section and a rear bus section isolated by steel panels. In addition, each circuit-breaker compartment shall be completely isolated from adjacent compartment by steel panels. 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 No. 61.

SWITCHGEAR (outdoor only)

Switchgear shall be of the walk-in weatherproof type with gasketing throughout. Sufficient filtered louvers and screened vents shall be provided to afford adequate ventilation. Sufficient strip heaters shall be provided. Interior lighting and convenience outlets shall be furnished in the aisle space. A manually-operated lifting device running the full length of the walk-in aisle shall be provided for easy handling of breakers. Suitable undercoating shall be applied to prevent corrosion. All exterior surfaces shall receive one additional finish coat of oven baked, corrosion-resistant acrylic enamel paint. The color of the finish coat shall be dark gray, ANSI No. 24.

BUS

A single main bus shall extend through all frames of the switchboard, with interconnections to the circuit breakers in each individual frame. All bus shall be silver-plated aluminum. The main bus shall be of the same current rating as the main circuit breaker or the power source. It shall be braced to withstand stresses re-

sulting from the maximum short-circuit current available. Minimum bracing to be 50,000 amperes symmetrical.

DISCONNECTING DEVICES & DRAWOUT MECHANISM

The breakers shall be of the drawout type, provided with self-aligning disconnecting devices, with the disconnecting fingers mounted on the breaker for ease of maintenance. The drawout mechanism shall hold the circuit breaker rigidly in the fully-connected, test and fully-disconnected positions. Interlocks shall be provided that will prevent moving the circuit breaker from the fully-connected, test or fully-disconnected positions, unless the breaker is open. Interlocks shall prevent closing the breaker between any of these positions. Provision shall be made for padlocking the breaker open and in any of the positions noted above.

CIRCUIT BREAKERS

Air circuit breakers shall be three pole, each pole equipped with a (electro-mechanical direct-acting) (solid-state) overcurrent tripping device providing adjustable long-time overcurrent and (short-time) and/or (instantaneous) short-circuit protection (with) (without) ground protection. Solid-state device shall have (load alarm) (target). All (manually) (electrically) operated breakers shall be equipped with (manual) (motor) charged stored-energy closing mechanism to provide quick-make operation.

The drawout mechanism shall be designed so that the breaker can be racked to any position without opening the door, for maximum protection to operating personnel. A hasp on the breaker escutcheon shall be provided that can receive up to three padlocks when the breaker is in the open position, positively preventing unauthorized closing or racking of the breaker. A manual trip button and external breaker position indicator shall be provided.

THE FOLLOWING EQUIPMENT SHALL BE SUPPLIED:

_____ main secondary breaker(s), _____ amp maximum continuous current, _____ amp interrupting capacity at _____ V ac, (manually) (electrically) operated.

_____ tie breaker(s), _____ amp maximum continuous current, _____ amp interrupting capacity at _____ V ac, (manually) (electrically) operated.

_____ feeder breaker(s), _____ amp maximum continuous current, _____ amp interrupting capacity at _____ V ac, (manually) (electrically) operated.

_____ feeder breaker(s), _____ amp maximum continuous current, _____ amp interrupting capacity at _____ V ac, (manually) (electrically) operated.

_____ space(s) for future breaker(s), _____ maximum continuous current, _____ amp interrupting capacity at _____ V ac, (manually) (electrically) operated.

_____ control-power transformer(s) for electrically operated breaker(s).

TRANSFORMER SECONDARY METERING

_____ voltmeter(s), with 3-phase transfer switch.

_____ ammeter with 3-phase transfer switch.

_____ watt-hour meter(s), (two) (three)-element, (with) (without) demand attachment.

_____ current transformer(s), _____ /5 or suitable rating.

_____ potential transformer(s), suitable rating.

FEEDER METERING

_____ ammeter(s), with 3-phase transfer switch.

_____ watt-hour meter(s), (two) (three) element.

_____ current transformer(s), _____ /5 or suitable rating.

BUS DUCT—Switchgear Tie

Bus shall be non-segregated phase, metal-enclosed (indoor) (outdoor), rated 600 Volts _____ amperes, 3-phase, (3) (4)-wire, 60 Hertz and shall consist of silver-plated aluminum conductors, insulated supports and housing.