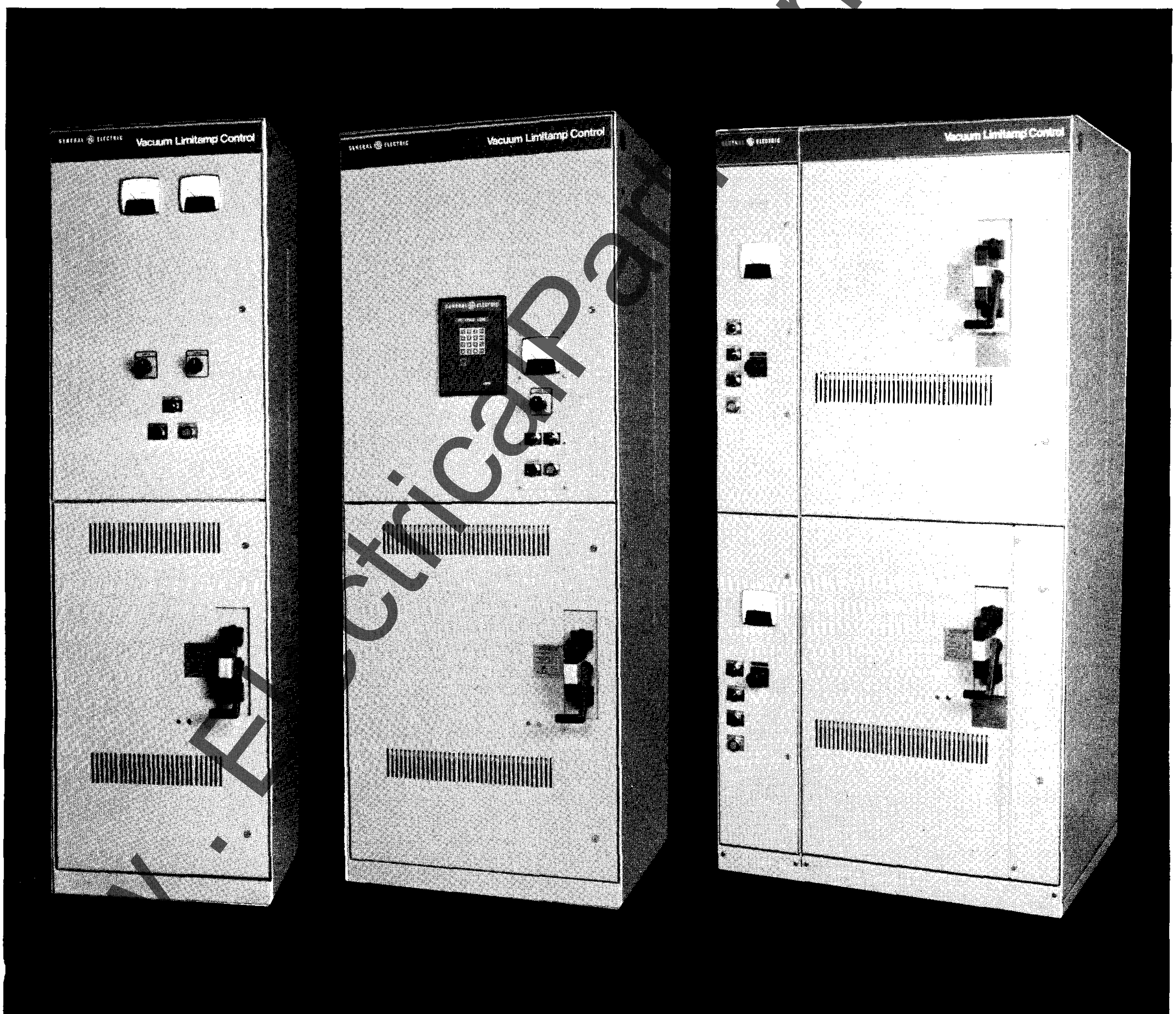
GET-6840

Vacuum Limitamp® Control



GENERAL ELECTRIC

TABLE OF CONTENTS

INTRODUCTION

Vacuum Limitamp® Control is a high-interrupting capacity, high-voltage control used throughout industry to control and protect squirrel-cage, wound-rotor and synchronous motors. It can also be used to feed transformers and other power-utilization circuits.

Typical applications are in paper, steel, cement, rubber, mining, petroleum, chemical and utility-type industries. Limitamp control is also used in water and sewage plants and public buildings for air conditioning, pumps and compressors.

Vacuum Limitamp Control is designed to meet NEMA ICS-2-324 and U/L 347 requirements. It employs fast-acting current-limiting power fuses, a stationary mounted vacuum contactor rated 200, 400 or 800 amperes enclosed, NEMA 1, vented, one-high enclosure, and ambient-compensated overload relays for complete control and protection of motors used on modern power-utilization systems with high available short-circuit currents.

The interrupting ratings of the controllers vary with the value of the utilization voltage. The following table depicts typical NEMA E1 (unfused) interrupting ratings for Class E1 controllers.

TABLE 1

Contactor Type and Rating	Interrupting Rating (mVA)			
	2400 Volts	3600 Volts	5000 Volts	7200 Volts
CR193A 200 Amperes	25	37	--	--
CR193B 400 Amperes	29	43	50	75
CR193C 800 Amperes	37	50	75	--

NEMA Class E2 Limitamp control incorporates the high-interrupting capacity of fast-acting fuses. These current-limiting fuses protect both the connected equipment and control against the high short-circuit current available from modern power systems. (See TABLE 2, page 4.)

In addition to normal motor protective relays, NEMA Class E1 Limitamp control must include instantaneous overcurrent relays to signal the contactor to open on fault current. NEMA Class E1 Limitamp control may be employed on systems having available short-circuit currents up to the interrupting rating of the controller.

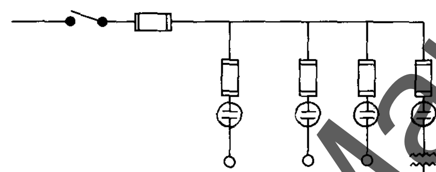
Relaying, metering, ground-fault protection, and lightning arresters are typical of available modifications.

USES

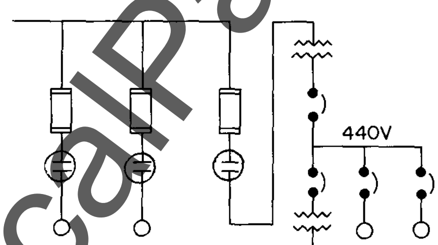
Vacuum Limitamp controllers are primarily designed for the requirements of motor controllers applied to distribution systems rated 2400, 4160 or 4800 volts. 7200-volt starters are available in limited applications. Limitamp motor controllers are available in the following types: full voltage or reduced voltage (reactor and auto-transformer); non-reversing or reversing; dynamic braking; and multi-speed.

Because of its flexibility, other uses for Limitamp equipment have become common. Some of these uses are:

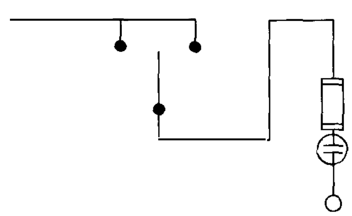
- Limitamp lineup consisting of a fused isolating switch ahead of four NEMA Class E2 Limitamp controllers, the first three being used as motor controllers and the last as a transformer feeder.



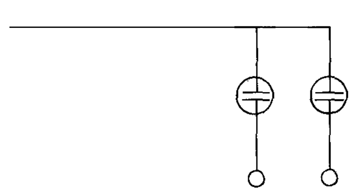
- Limitamp lineup similar to last three units in the preceeding description. The transformer, 440-volt motor controllers, and lighting transformer are included in an integrated Limitamp design.



- Limitamp lineup consisting of a reversing isolating switch ahead of a NEMA Class E2 Limitamp motor controller.



- Limitamp lineup consisting of two NEMA Class E1 Limitamp motor controllers, each having interrupting ratings per TABLE 1.



Possible applications of Limitamp equipment are not limited to the information in this publication. All questions involving the application of Limitamp control should be referred to the General Electric Company.

FEATURES

- **Easily Removable Contactor** – The contactor can be easily removed by loosening several easily accessible bolts. Front access to the coil and tip wear adjustments will substantially reduce the need to remove the contactor in normal circumstances. The absence of stab-in contacts eliminates possibilities for hot spots and misalignments, increasing reliability and also improving resistance measurement capabilities of the motor circuits. The controller must be fully de-energized before making measurements.
- **200, 400 or 800 Ampere Contactor** – Vacuum Limitamp Control meets the varying needs of industry including today's higher horsepower requirements.
- **Choice of 1- or 2-high Configurations** – Vacuum Limitamp Control is available in 1- or 2-high enclosures to meet the space requirements for various applications.
- **NEMA Rated** – Vacuum Limitamp Control is fully rated and designed to meet the requirements of NEMA ICS-2-324, Class E2 controllers.
- **U/L Rated** – Vacuum Limitamp Control is fully rated and designed to meet the requirements of U/L Specifications 347.
- **Self-contained Power Bus** – Vertical power bus is a standard feature of Vacuum Limitamp Control. Horizontal power bus is available within the standard 90-inch height and lines up with that of previous Limitamp designs. The power bus ratings have been increased to 1200/2400 amperes to allow additional capacity for extended line-ups and larger starter requirements.
- **Installation Ease** – Straight cable runs from the top and bottom, easily accessible terminals and small overall size, make installation fast and easy.
- **Fast, Easy Maintenance** – Every component is accessible and removable from the front for simple inspection and maintenance. The contactor is conveniently located and does not need to be removed to replace the operating coil or for vacuum bottle wear checks.

FEATURES (Cont'd)

- **Proven Reliability** – Vacuum Limitamp® Control utilizes the latest vacuum interrupter technology for long, reliable service.
- **Simplified Construction** – The operating mechanisms inside Vacuum Limitamp Control have been simplified for further improvements in reliability and ease of maintenance.
- **Cooler Operation** – The reduced power losses of vacuum interrupters coupled with other design improvements provide a controller that is cooler operating which further enhances service life.
- **Quick-make Quick-break Disconnect** – Disconnection of the starter from the main bus is accomplished by a quick-make quick-break disconnect switch. This switch adds an additional improvement to overall control integrity by eliminating the need to rack out the contactor to isolate the load from the power bus. The switch is equipped with a viewing window for visual assurance that the disconnect contacts are open, and a full barrier for personnel safety.
- **Dependable Performance** – Vacuum Limitamp Control is coordinated to provide the required motor protection functions and offer reliable overcurrent protection against the damaging effects of overloads and short circuits.

RATINGS

Limitamp 200, 400 and 800 control is designed for operation on the following power systems.

TABLE 2

System Distribution Voltage	Approximate Maximum Motor Hp ④ Induction, Wound-rotor, Synchro-nous (0.8 PF)	Synchro-nous (1.0 PF)	Interrupting Rating mVA Symmetrical 3-phase 50 or 60 Hz
LIMITAMP 200			
2400	800①	1000①	200
3600	1200①	1500①	300
LIMITAMP 400			
2400	1600②	2000②	200
3600	2400②	3000②	300
4200	2800②	3500②	350
4800	3200②	4000②	400
7200	4800②	6000②	600
LIMITAMP 800			
2400	3200③	4000③	200
4200	5600③	7000③	350
4800	6400③	8000③	400

① Based on 200 amperes RMS maximum, enclosed, NEMA 1, vented one-high
② Based on 400 amperes RMS maximum, enclosed, NEMA I, vented one-high
③ Based on 800 amperes RMS maximum, enclosed, NEMA 1, vented one-high
④ For non-vented enclosures apply a factor of 0.8 to the maximum horsepower

BASIC CONSTRUCTION

General

Limitamp starters may be stacked two high where horsepower rating and need for metering and relaying is limited to allow stacking. (See TABLE 3 for horsepower and ampere limitations in two-high construction.) Nonstack design (one-high) is used for synchronous-motor starters, wound-rotor starters, and squirrel-cage induction starters, which have associated with the starter a considerable number of extra control functions, protective relays, and/or metering. All enclosures have the same bus location and may be connected together by bus splicing plates.

TABLE 3. Approximate Horsepower Limitations in Multi-high Construction (Two controllers)

Induction	2400 Volts Amperes (Per Starter)	2400 Volts Horsepower (Per Starter)	4200-4800 Volts Amperes (Per Starter)	4200-4800 Volts Horsepower (Per Starter)
Two High (Two controllers)				
Vented	360	1400	360	2500
Non-vented	250	1000	250	1750

NOTE: 200-ampere contactor requires no derating in two-high construction.

Limitamp 200 and 400 control is available in either one- or two-high construction.

Limitamp 800 control is available in one-high construction only.

One-high Construction

LIMITAMP 200 and 400

The one-high packaging (one contactor per enclosure) for Limitamp 200 and 400 has basic dimensions of 90 inches high, 26 inches wide and 30 inches deep (including power bus.) It is constructed to house a single vacuum contactor in the high-voltage compartment located at floor level. The entire upper compartment is available for low-voltage equipment and includes a swing-out panel for ease of component mounting and accessibility.

This enclosure will accommodate cable sizes as shown in TABLE 4. Cable runs may enter from top or bottom without modification. Top or bottom entrance in the enclosure need not be specified.

The Limitamp 200 and 400 one-high design will accommodate the following combination of components:

1. Two potential transformers used for induction motor starters.
2. Up to l0 kVA extra capacity CPT.
3. Up to approximately 10 control relays for induction motor starters.
4. Two Size S1 drawout relay cases.

Power factor correction capacitors can be supplied and will normally be mounted in an auxiliary enclosure.

A 34 inch-wide one-high enclosure is available as an option on the Limitamp 400 where more cable room or multiple cable connections are required.

LIMITAMP 800

The one-high enclosure for Limitamp 800 has basic dimensions of 90 inches high, 30 inches deep and 40 inches wide. This 40-inch enclosure has sufficient space to permit termination of two (2) 750 MCM cables per phase with stress cones for power and motor leads. Protected raceways isolate the motor and power leads from one another. Cable runs may enter from the top or bottom and are straight runs.

Two-high Construction

LIMITAMP 200 and 400

Two-high packaging accommodates two contactors in the enclosure.

The two-high enclosure has basic dimensions of 90 inches wide, 30 inches deep, and 40 inches wide. It is constructed in vertical sections of two space units each. Two FVNR induction starters may be housed in a vertical section.

Cable sizes which may be accommodated in a two-high design are reduced slightly from that which may be connected in the one-high design . (Refer to TABLE 4 for cable size limitations.)

TABLE 4: Cable Size Limits (Approx) in Vacuum Limitamp Control

Limitamp Construction	With Non-shielded Cable Per Phase Incoming	With Non-shielded Cable Per Phase Load	With Shielded Cable and Prefabricated Stress Cones Per Phase Incoming	With Shielded Cable and Prefabricated Stress Cones Per Phase Load	With Shielded Cable and Hand-wrapped Non-cone Stress Relief Per Phase Incoming	With Shielded Cable and Hand-wrapped Non-cone Stress Relief Per Phase Load
200 & 400 Ampere One-high 26-inch wide Case	1-500 MCM	1-500 MCM	1-500 MCM	1-500 MCM	1-500 MCM	1-250 MCM 1-500 MCM possible
34-inch wide Case⑤	2-500 MCM	2-500 MCM	2-500 MCM	2-500 MCM	2-500 MCM	2-500 MCM
200 & 400 Ampere Two-high 40-inch-wide Case	2-500 MCM	1-500 MCM	1-500 MCM	1-250 MCM 1-500 MCM possible	1-500 MCM	1-#3/0 1-250 MCM possible
800-Ampere One-high 40-inch-wide Case	2-750 MCM	2-750 MCM	2-750 MCM	2-750 MCM	2-750 MCM	2-750 MCM

⑤ Can be supplied as an option on 400-ampere Vacuum Limitamp Control when more cable space is required.

The enclosure is designed to safely permit termination of one set of motor leads while the other controller is energized. The two sets of motor leads are isolated from one another. Power lead raceway is also isolated. All sets of leads may be brought into the starter from the top or the bottom.

Control relay space is available in a separate compartment with its own door and barriers. Approximately three extra control relays in addition to a ground-fault relay and TDUV (auto restart) can be mounted in the low-voltage compartment. One ammeter and switch, four pushbuttons, and four lights can be mounted on the low-voltage door. If no extra control relays are used, a special-mounting watthour meter can be mounted on the door.

NOTE: Two-high construction requires horizontal power bus.

FUTURE STARTERS

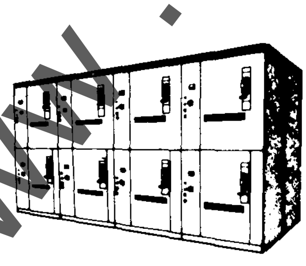
Future squirrel-cage full-voltage nonreversing starters can be installed in two-high construction only when factory-prepared space has been purchased with the original vacuum Limitamp® equipment.

The purchase of factory-prepared space provides a space unit equipped with vertical power bus, complete interlocking and isolating mechanisms, operating handle and high-voltage door. Does not include electrical components.

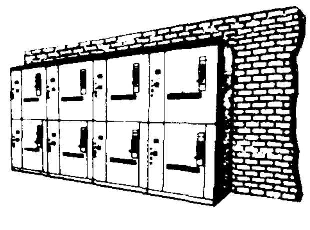
A future starter, purchased as a package, is obtained by the subsequent field installation of a vacuum contactor, power fuses, control power transformer, CPT fuses and fuse supports, current transformers, and low-voltage panel and devices.

CHOICE OF MOUNTING

You may select either back-to-back (60 inches deep) or back-to-wall (30 inches deep) mounting, letting you arrange control lineups to your own floor space and application requirements.



Back-to-back mounting



Back-to-wall mounting

VACUUM CONTACTORS

The vacuum contactors supplied with vacuum Limitamp control are of the magnetically held type. They are fully rated at 200, 400 or 800 amperes in accordance with NEMA and U/L standards. The contactors have the same basic design but differ in size, weight and method of termination. The vacuum interrupters are also different among the various models and are not interchangeable due to their different current ratings.

In one-high Vacuum Limitamp Control, the contactor is mounted on a metal base near the bottom of the high-voltage compartment at floor level. The contactor may be easily removed for service, however, normal maintenance such as vacuum interrupter wear checks and replacement of the operating coil can be done without removing the contactor. The only time the contactor needs to be removed is to replace a vacuum interrupter at the end of its service life or to adjust the vacuum interrupters after 0.016-inch wear on interrupter tips.

Two-high Vacuum Limitamp Control uses the 200- and 400-ampere contactors only. The contactor is mounted in a similar manner to the one-high design except the upper contactor is not mounted at floor level.

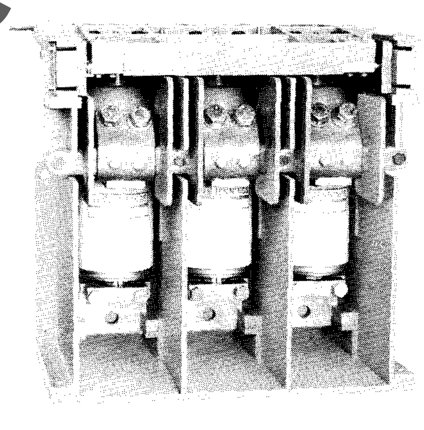


Fig. 1. 400-ampere vacuum contactor

The standard contactors for industrial motor starters are closed by a single magnet and are held closed by the same magnet. This contributes to simplicity of mechancial design and increases the mechanical life of the contactor. Mechanical latch contactors are available as an option and are covered in detail in the following paragraphs.

Standard contactors may not need mechanical repair before 1 to 5 million operations, and this long mechanical life is largely due to mechanical simplicity and sturdiness.

Low-voltage on the contactor operating coil of an electrically held contactor will cause the contactor to open. For most motor applications it is desirable to disconnect the motor from the line when the system voltage is lost or lowered appreciably, therefore, the electrically held contractor is appropriate.

The operating coil of the contactor is rated 120 volts dc only. No other coil voltage is available and no other rating should be required. See page 10 concerning the Contactor Control Module (CCM).

For all NEMA Class E1 controllers, the contactor must be capable of interrupting the available short-circuit current. On these applications, instantaneous overcurrent relays must be used to interrupt the contactor coil circuit.

Latched Contactors

There are some applications where it is not desirable to disconnect the motor from the line during voltage depression.

These applications are generally those associated with a critical drive; where the continued rotation of the drive may be more important than possible damage to the motor from low voltage.

The mechanical latch maintains contactor closure under the most severe under-voltage conditions including complete loss of voltage. Latched contactors may be specified if required by the application. The close and trip coils are rated 120 volts dc. Manual trips are also available.

The Limitamp latched contactors are identical to the unlatched versions except a small latch attachment is mounted to the top front of the contactor. This adds to the depth of the contactor slightly.

Latched contactors are interchangeable mechanically with the standard nonlatched forms. A latched contactor may be replaced in the Limitamp controller with a nonlatched contactor, or a nonlatched contactor may replace a latched contactor. However, in each case it is necessary to change the wiring in the control circuit to the contactor coil or coils.

FUSES

General

To protect the motor branch circuit against the damaging effects of short circuits, current-limiting power fuses are used in Limitamp control. They interrupt all overcurrents of magnitude greater than intended for contactor interruption. On full fault, these fuses start limiting current within the first ¼ cycle and interrupt within the first ½ cycle. Because they are fast acting, these fuses are easily coordinated with system protective relaying to give selectivity in short-circuit protection.

For time-current coordination purposes, refer to GES-5000.

Standard fuses supplied with Vacuum Limitamp® Control are bolt-in type. Clip-in fuses may be supplied in applications where motor full-load current plus service factor does not exceed 320 amperes, but they must be specified by the customer. The blown fuse indicator and the anti-single-phase trip bar is standard with bolt-in fuses only.

Motor-starting fuses used in Limitamp control are current-limiting as indicated in Fig. 2. They melt before the current in the first major loop can reach its peak value when subjected to melting currents within the current-limiting range. Consequently, the total "let-through" energy involved is low because the fuses operate with such great speed. The contactor, current transformers, and overload relays of a Limitamp controller are coordinated with the fuses to give full protection to the system.

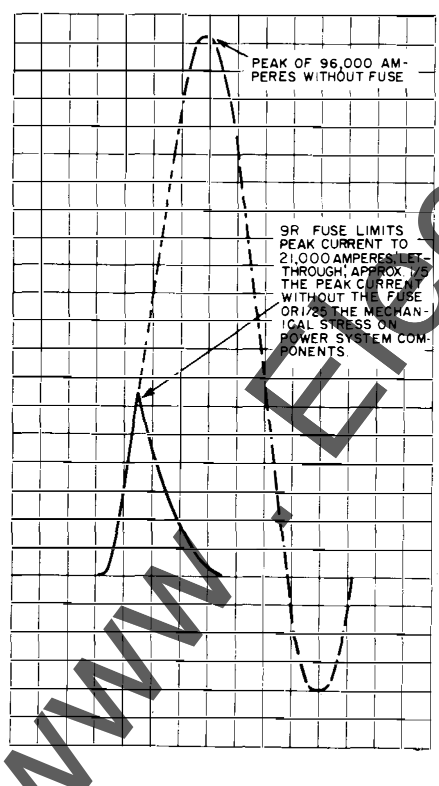


Fig. 2. Current-limiting action of typical fuse.

A design feature of motor-starting fuses inherently limits recovery voltage to safe values. The insulation in the control is thus safe-guarded.

Controller fuses must have sufficient capacity to carry starting and full-load currents on the one hand, and yet must interrupt fault currents at a desirable low value on the other. They are therefore made in a number of ratings or sizes so that maximum protection can be obtained over a range of motor horsepowers.

For a given set of motor characteristics, it is usually possible to use one of several fuses. The smallest fuses will normally be furnished. If the load is a fluctuating one, however, involving swings of current above full-load, the fact should be noted in specifying a controller so that a fuse one size larger than minimum will be furnished.

Transient conditions do not generally affect motor-starting fuses since the sand in the fuse conducts heat away rapidly. If transient currents do not come within 25 percent of the minimum melting curve on a time basis, melting will not occur. For example, if the melting curve for a given size fuse shows melting in 10 seconds at 1000 amperes, transient peaks of 1000 amperes would be withstood repeatedly up to 7.5 seconds duration.

Motor-starting fuses can be applied on 25-Hertz systems but with lower interrupting capacity than for 50- and 60-Hertz systems.

Fuse selection is based on full-load and locked-rotor current.

For a line-up of controllers it may be desirable to use fuses larger than minimum size to reduce the variety of spares required. Such standardization must be specified however.

Blown-fuse Indication (Anti-single-phase Trip Bar)

Bolt-on fuses contain button indicators to show a blown fuse. This button indicator is coupled with a mechanism containing a control contact anti-single-phase trip bar, which, when used in contactor control circuit, can prevent single phasing due to a blown fuse.

The possibility of having one fuse melt, thereby causing a large motor to single phase, has inhibited consideration of fuse-contactor-type starters by some people. Although such a condition is in reality quite unlikely, GE Vacuum Limitamp Control is equipped with a special mechanism which will detect a blown fuse and cause the contactor to open. The blown fuse is visably indicated on the front door.

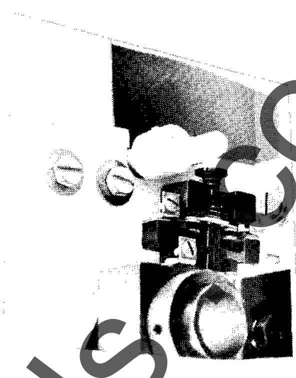


Fig. 3A. Anti-single-phase trip mechanism

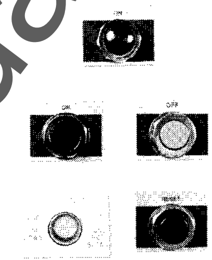


Fig. 3B. Blown-fuse indicator

With this feature, fuses are always bolted in place for correct orientation and alignment. In addition to providing maximum reliability, this feature makes it impossible to mount the fuse in an upside down position which would nullify the trip bar operation.

COORDINATION WITH OTHER PROTECTIVE DEVICES

When Vacuum Limitamp starters are installed on a given power system, it is necessary to coordinate the time-current characteristics of system protective devices with those of the starters. Use the time-current curves included in GES-5000 for this purpose. This publication includes overload-relay tripping curves, fuse-melting curves and fuse-clearing time curves.

STANDARDS AND CODES

Limitamp controllers are designed, built and tested to meet NEMA Standard ICS-2-324 for Class E2 Controllers, and Underwriter's Laboratory Specification 347 for high-voltage industrial control equipment. All of the basic FVNR Limitamp 200, 400 and 800 starters in one- and two-high designs, in NEMA 1 or NEMA 3R enclosures, may be made available with U/L labels on request.

When specified, Limitamp control can be built to comply with the City of Chicago Code and the California Code. For compliance with other city codes, refer code to the Company for review and quotation.

SPECIAL APPLICATIONS

Fire-pump Starter

Limitamp fire-pump controllers are designed to meet GE's interpretation of bulletin NFPA 20 titled "Centrifugal Fire Pumps — 1972" and are acceptable for use in IRI insured properties.

For fire-pump applications, the basic one-high design is modified to include the following:

- 3-phase stall protection relays
- Phase failure relay
- Ammeter
- Ammeter switch
- Extra-capacity CPT
- 115-volt CPT
- Minimum run timer
- Pushbutton relay
- Run relay
- Time-delay relay for sequence starting
- Power-available signal relay
- Power-available indicating lights
- Deluge-valve relay
- Voltmeter
- Pressure switch
- Dripproof enclosure
- Fire-pump-controller nameplate
- External operating handle and latched contactor
- Alarm-circuit supervision relay
- Pump-running alarm contact.

Marine Application

Limitamp® control can be supplied to meet a variety of motor-starting requirements aboard ship. It can be made to comply with ABS, USCG and IEEE 45 specifications.

Capacitor Feeders

Vacuum Limitamp Contactors are ideally suited for capacitor switching applications. See the vacuum contactor ratings in GET-6841 – "Vacuum Limitamp Contactors" for a complete listing of capacitor switching ratings.

Capacitors may be switched with the motor, but maximum rating for this function must be determined by motor design.

When the capacitors are provided in Limitamp control they are normally mounted in an auxiliary enclosure beside the Limitamp controller. Up to 200 kvar can be mounted in the bottom of a two-high enclosure with the controller in the top.

Transformer Feeders

Limitamp controllers are generally considered motor starting equipment, however, they are not strictly limited to motors and can provide very good protection for loads such as transformers.

Transformers that can be controlled by Limitamp controllers must have a primary rated in the 2400-to 7200-volt range. See GET-6841 for complete listings of transformer switching capacities for the Vacuum Limitamp Contactor line.

To adequately protect a transformer it is necessary to define specific protection requirements. The following areas will be considered.

1. Transformer winding fault (primary and secondary)
2. Single-phasing, resulting in a phenomenon known as "ferroresonance"
3. Transformer overload

These functions are basic only and are not intended to be comprehensive. Ground fault, differential, fault pressure, undervoltage, etc., are often required and may also be added to a given control. In addition, a transformer controller must allow for transformer inrush current and not cause a nuisance trip-out from a momentary line-voltage dip.

Transformers must be protected from primary and secondary (winding or downstream) faults. In Limitamp controllers, current-limiting fuses are applied to protect the transformer from a primary winding fault, as well as faults in the conductors from the controller to the transformer. The fuses are selected to clear high-magnitude fault currents at the first fault half-cycle and allow the contactor to energize a transformer without operating on inrush currents. (Inrush currents occur when transformer is energized, typically 8-12 times rated amperes for 0.1 seconds). General Electric Type EJ-2 current-limiting fuses may be applied when used with an overcurrent relay that is chosen to coordinate with the EJ-2 fuse and protect the transformer from damage as a result of a fault in its secondary circuit.

To determine a basis for protection, refer to ANSI transformer short-circuit ratings, in which certain "points" of magnitude and duration of downstream faults that a transformer can withstand without damage are defined. A relay would have to be set to operate before this point is reached. In order to arrive at the exact location of the ANSI point, base ratings, impedance and the connection of the primary and secondary windings of the transformer must be supplied. A 2400-volt, 2000-kVA, 5-percent impedance delta-wye transformer would have its "ANSI point" located at twenty times base current times 0.58 (a factor used to convert line current to winding current), or 5580 amperes and three seconds. Therefore, the relay would have to be set to operate to the left of this point. The relay for this example is a fluid-magnetic dashpot relay, with the fast fluid, and the fuse is a 630-ampere current-limiting type bolted-in fuse. The trip setting of this relay is 150-200 percent transformer base current.

Common practice is to have overload protection applied to the secondary side of the transformer. The relay should not be used to provide transformer overload protection because its trip time is too fast near its ultimate trip point and it retains no hysteresis or "memory" so it would not provide protection from prolonged cyclical overloading of the transformer. The relay curve is far enough to the left of the ANSI point to not only protect the transformer but to keep the 630-ampere current-limiting fuse from being "fatigued" by having fault currents approach too close to its trip characteristic at the ANSI point.

Occasionally, it may be necessary to rely on current relays in the transformer primary to provide overload protection. Where required, a solid-state motor-protective relay can be used to provide overload protection with a setting of about 125 percent of transformer rated load current, while, at the same time, acting quickly enough to protect the transformer against faults on its secondary by passing to the left of the ANSI point.

A common problem with transformers that are single-phased is a phenomenon known as ferroresonance, which can occur when an unloaded or lightly loaded transformer sustains an open conductor in its primary circuit. Ferroresonance causes system overvoltage as a result of the transformer core inductance forming a "tuned" circuit with the system distributed capacitance. To avoid ferroresonance. All three lines must be switched simultaneously as with a medium-voltage contactor. However, if one line fuse blows, then single-phasing will occur. To prevent this, the medium-voltage contactor is supplied with a contactor tripping mechanism that operates from a striker pin located in the fuse. When the fuse element burns in two, the spring-loaded striker pin is released and it projects upward and operates a contact which trips the contactor. This feaure, known as blown fuse trip, would provide positive transformer protection from single-phasing due to blown fuses.

More comprehensive open or single-phase protection can be obtained by applying a solid-state motor-protective relay which will trip the contactor in the event of an open phase. A solid-state relay will trip on open-phase conditions regardless of the cause, even if external to the Vacuum Limitamp® Control.

A possible concern that may arise when applying a medium-voltage contactor to a transformer feeder is what happens to the contactor when a voltage dip occurs. In the past the contactor would drop out removing power from the primary of the transformer when the contactor coil power is reduced to 60 to 80 percent of full voltage. This problem is alieviated somewhat by the Contactor Control Module (CCM). The CCM regulates the contactor coil current at a constant value regardless of the line voltage down to approximately 50 percent of full voltage. This will prevent the contactor from dropping out except in the most severe cases of line voltage dip. To prevent dropout in all cases, latching contactors should be applied. In these cases the contactor is latched by a closing coil and unlatched by a trip coil. A capacitor trip device can be applied to trip the contactor in the event of total loss of control power. (See Latched Contactors, page 5.)

High Resistance Grounding Equipment

High resistance grounding equipment can be mounted in an enclosure which will match and line up with Limitamp dimensions and bus location.

For description of high resistance grounding equipment, refer to GEP-345.

Seismic Capability

Vacuum Limitamp Controllers can be utilized in various applications subject to shock and/or vibration.

For quotations on Limitamp control with seismic capability, or other vibration-type applications, refer your application details to the Company.

Altitude Derating

Vacuum Limitamp Controllers, including power fuses, require the following derating for use at high altitudes:

For current – No derating required up to 6000 feet above sea level.
– Above 6000 feet derate by 0.9 percent for every 1000 feet.

For voltage – No derating required up to 3300 feet above sea level.
– Above 3300 feet derate by 2 percent for every 1000 feet. BIL rating is also derated.

Temperature Derating

Vacuum Limitamp Controllers require the following current derating for ambient temperature. Use only bolt-on fuses.

Up to 40 C – No derating
40-45C – Derate 10 percent
45-50 C – Derate 20 percent
Above 50C – Consult factory

OVERLOAD RELAYS

Several types of overload relays are used in Vacuum Limitamp Control. Limitamp controllers use thermal-overload relays, unless other types are specified.

Thermal-overload Relays

Overload relays provided in Limitamp control have inverse-time characteristics and are ambient compensated. Limitamp control utilizes either the CR324C thermal-type relay or the DS2824-34 inductive-type relay. These relays, operating from current transformers in the control equipment, carry current proportional to the motor-circuit current. When motor overloads occur, the relay operates to open the main power contactor. The time required for operation varies inversely with the magnitude of the overload. The standard CR224C relay should only be used on motors with starting times up to 10 seconds.

The CR324C relay has one operating characteristic. DS2824-34 relays are supplied in three operating types: fast, medium and slow. The particular relay or type furnished on a given installation will depend on the anticipated motor-starting time.

Minimum tripping current for CR324C and DS2824-34 relays with operating tolerance equals 0.9 to 1.0 multiples of relay current rating in a 40 C ambient. Tripping is approached at some time beyond l000 seconds. Relay current settings can be adjusted over a range of 90 to 110 percent of the coil rating for the DS2824-34 relay, and 90 to 110 percent of nominal heater trip rating for the CR324C relay. For detailed information on relay data refer to GES-5000.

Solid-State Overload Relays

Solid-state overcurrent protection is available as an optional feature in place of standard thermal overload relays. The inverse-time characteristics can be adjusted to protect motors of various characteristics, such as long acceleration time or short allowable-stall times. Characteristics are accurate and have a smaller error band compared to bimetal relays. The solid-state overload relay is recommended for hermetically sealed air-conditioning motors, and is well suited as a stall-protection relay.

CONTROL POWER TRANSFORMER

Control power transformers used in Limitamp starters are single-phase, air-cooled, core-and-coil construction with high-voltage windings covered to prevent contamination by dust and dirt. Those furnished in standard panels have a 25-kV Basic Impulse Level (BIL) rating. When specified, 60-kV BIL rated control transformers can be furnished, but will require special space consideration.

OPERATOR'S AND PILOT DEVICES

HAND-OFF-AUTO Selector Switch

A HAND-OFF-AUTO selector switch permits automatic starting and stopping from a pilot device such as thermostat, pressure switch or level control.

For operator control the switch is turned to HAND or OFF, making operation independent of the pilot device

When used in place of the standard momentary-contact START-STOP pushbutton, the selector switch nullifies undervoltage protection but undervoltage release is provided. The starter drops out on low voltage but picks up again when voltage is restored.

To obtain undervoltage protection when a selector switch is used, the switch must be specified in addition to the standard START-STOP pushbutton. In that case the operator controls the motor by means of the START-STOP pushbutton when the selector switch is turned to HAND. Undervoltage protection is provided in this position but not when the selector switch is turned to AUTO.

External-reset Overloads

Some industrial plants do not permit a machine operator to open the doors of control equipment enclosures, this being reserved for electricians. To make possible overload-relay reset by operators, it is therefore necessary to provide some means to do so outside the enclosing case. This is accomplished by providing a mechanical-linkage reset mechanism between the relay and door-mounted reset button.

Where external reset is not absolutely necessary, greater simplification of relay mounting results, and this is of benefit to the user because it simplifies maintenance.

Inasmuch as the tripping of an overload device is indicative of too much strain on the motor, it is preferable that only experienced and reliable personnel be allowed to reset overloads. Such personnel should be capable of realizing whether it was an unintentional overload on the part of the machine operator or whether there is an electrical and/or mechanical defect. The customer should consider this factor, however, before electing to provide externally reset overloads.

METERS AND INSTRUMENTS

Ammeter

An ammeter (panel-type or switchboard-type) is used to indicate either motor line amperes or total incoming amperes. It can either be hard wired to the current transformer of one phase or all three phases can be monitored by the use of a selector switch. One current transformer is required for single-phase reading; two are required for open delta three-phase reading. Three are required in a wye circuit. Three window-type current transformers are provided as standard on Vacuum Limitamp® Controllers.

Voltmeter

The voltmeter (panel-type or switchboard-type) is used to indicate phase-to-phase potential. One potential transformer is required if only one phase-to-phase potential is monitored. Two potential transformers, connected in an open-delta configuration, are required along with a selector switch to monitor any one of the three phases. Three potential transformers mounted in an auxiliary enclosure and a selector switch are required to read both phase-to-phase and phase-to-neutral potentials.

Elapsed-time Meter

An elapsed-time meter is used to indicate hours of operation or shutdown time of a particular motor or drive for purposes of production records, maintenance scheduling, or engineering records. The meter is mounted on the low-voltage compartment door.

Power-factor Meter

A power-factor meter is used to indicate power-factor lead or lag. It is useful in adjusting power factor in synchronous-motor drives and in determining the power factor of a given drive. The addition of a power-factor meter requires the addition also of potential transformers or other potential source of correct phase and accuracy. If a synchronous starter is ordered and the CR192 μSPM is supplied, a digital power-factor meter is built into the device and does not need to be ordered separately.

Varmeter

The varmeter indicates lagging or leading reactive power. It requires the addition of two potential transformers.

In totalizing reactive power on a bus feeding several loads, individual vars for each load can be measured by means of individual varmeters on each motor and added directly.

Wattmeter

A wattmeter is used to indicate loading or useful power being delivered to a drive at any instant. The instrument can be calibrated in kilowatts or can be calibrated directly in horsepower.

For calibration in horsepower efficiencies at zero, 25, 50, 75 and 100 percent, load must be supplied from the motor curve.

Two potential transformers connected in open delta are required for operation of a wattmeter.

Watthour Meter

A watthour meter is used basically to measure work done. Specifically it registers total watthours used by the motor or other load on the controller. It is useful in assigning power charges in plant accounting or for record keeping of power consumed per unit of manufacturing.

It requires the addition of two potential transformers connected in open delta.

Demand Register for Watthour Meter

A demand register indicates maximum demand. It is useful in determining peak loads for particular machines where demand must be controlled to keep power bills down.

Transducers

A variety of transducers can be provided when remote indication, recording or control of amps, volts, watts, etc. are required. Transducers are useful because they can work into much higher impedances than instrument transformers without losing accuracy. Any of the GE transducers may be supplied in Limitamp control. Current transducer requires (1) CT; voltage transducer requires (1) PT. Watts transducer requires (2) CT's and (2) PT's.

Test Blocks

Current and potential test blocks provide a plug-in feature for portable ammeter, voltmeter, wattmeter, watthour meter or recording instrument. The meters can be plugged into the circuit without shutting down the machine to obtain records or readings.

Operation Counter

Counter is electrically operated from a control interlock on line contactors. It totals the number of times the contactor has closed and opened, and thus provides data for the establishment of maintenance schedules or a record of the number of batch processes initiated over a given period, or other purposes where the number of line contactor closures may be significant.

CONTROL CIRCUITS

Timing Relays

Pneumatic-type timing relays close or open a circuit after a definite elapsed time on either energization or de-energization.

Motor-driven timing relays close or open a circuit with time delay on either energization or de-energization. They provide a wide range of time, however, and are not affected by ambient temperatures. Solid-state timing relays with high accuracy and repeatability can be furnished also.

Incomplete-sequence Relay

An incomplete-sequence relay is used to shut down the motor (squirrel-cage induction or synchronous) on reduced-voltage starting if the control fails to transfer to full voltage. It protects the starting reactor or autotransformer from energization longer than rated time. The relay can be furnished for other sequencing functions also.

TDUV – Automatic Restart

In the event of voltage dips of short duration, conventional TDUV circuits provide an automatic restart of Limitamp contactor without operator intervention. (A time delay of approximately 1.5 seconds is usually provided.) However, in motor applications automatic restarting can cause serious damage to windings and mechanical loads connected to the motor due to out-of-phase reclosing. In worst cases this out-of-phase reclosing could apply up to two times the normal voltage to motor windings. TDUV auto-restart scheme is not recommended for synchronous motor, wound-rotor motor and large horsepower high-speed squirrel-cage motor controllers without additional circuitry to delay reclosing on UV condition.

The capacitor-type TDUV automatic restart scheme in Vacuum Limitamp Control permits instantaneous shutdown by connection of the STOP button into the capacitor UV relay circuit. Care should be taken not to connect a maintained-contact device into this circuit because the resistor used to discharge the capacitor is rated for momentary loading only.

Time-delay Undervoltage Protection

NEMA defines undervoltage protection as a device whose principal objective is to prevent automatic restarting of equipment.

Instantaneous undervoltage protection is inherent with the standard 3-wire control circuits since the contactor will drop out and stay out on loss of voltage.

Time delay undervoltage protection for Limitamp controller can be provided to prevent shutdown of a motor on adjustable duration voltage dips below the adjustable dropout voltage.

With either time-delay or the standard instantaneous undervoltage protection, the motor remains disconnected upon return of voltage until such time as the operator may initiate restarting.

CONTROL CIRCUITS (CONT'D)

Control Voltage

The Vacuum Limitamp® Controllers utilizes 120-volt control as standard. 220-volt control power transformers can be supplied to power heaters at 220 volts when specified by customer.

Omission of Control Power Transformer

A line-up of starters can use a common control power transformer or other source of control power. In either case, the power source and control circuit must be provided with interlocking relays so the loss of either will shut down all operating motors. Control bus is required in all controllers if a common source of control power is used.

A single source of control power results in some disadvantages: (1) Unless each panel is provided with a fused control switch, troubleshooting will be with live wires in the panel; (2) a single controller, if relocated independent of the line-up will require modification to add a control transformer and fuses; and (3) the loss of control power will cause shutdown of all machines.

Jogging

Drives requiring "jogging" (or inching) must have the control circuit arranged for repeatedly closing the line contactor at short invervals to effect small movements of the driven machine. The line contactor is held closed only as long as the JOG button is held depressed.

An anti-kiss feature is provided with all Vacuum Limitamp Controllers as a part of the Contactor Control Module (CCM). The CCM insures that the contactor closes and wipes in before dropping the contactor out again. The JOG pushbutton can take advantage of this feature without adding an additional timing relay.

Current Interlocking

Current-operated relays indicate when arc is completely out after line contactor opens. These relays then permit closure of a reversing contactor. A short circuit may occur if a reversing contactor closes after the forward contactor opens but before the arc has been extinguished. This circuit is necessary in controllers with "plug stop" or where pressing one instantaneous contact picks up reversing contactor while running forward. Current interlocking is not normally used on overhauling loads such as mine hoists, since during the lowering cycle enough current may not be drawn to operate the interlocking relays.

This circuit is not supplied on standard Limitamp reversing controllers as the operator is expected to turn the selector switch to reverse only after pressing the STOP button.

Potential Interlocking

Potential interlocking is used for the same reason as in current interlocking. Potential transformers and interlocking relays are added to prevent closure of one primary contactor before complete interruption of the arcs at the tips of the other (reverse) contactor. Operation is based on the principle that by the time the disconnected motor's generated EMF has decayed to the point where the interlocking relays have dropped out, the arc in the disconnected contactor has extinguished, and closing the reversing contactor is permissible.

Potential interlocking is used on hoists and other applications having possible overhauling loads.

OTHER MOTOR PROTECTIVE FUNCTIONS

Contactor Control Module

Provided as a standard feature of Vacuum Limitamp Control is a device known as the Contactor Control Module (CCM). This device provides the following protective functions:

1. Contactor coil current regulation to prevent dropouts due to low line voltage (down to approximately 50-percent full voltage).
2. Elimination of economizing power resistors and transfer contacts in the contactor coil circuits.
3. Controlled point-on-wave contactor tip opening to greatly reduce voltage transients being transmitted to the load due to virtual current chopping caused by restriking as the contactor opens.
4. Built-in anti-kiss protection which insures that the contactor tips fully close and wipe-in under all contactor closing operations, including jogging.
5. Automatic polarity reversing on each controlled tip opening to prevent uneven wear on the vacuum interrupter pole faces.
6. Improved fuse-contactor coordination preventing "gray" areas of overlap between the contactor's interrupting capability and the time-current curve of the fuse without sacrificing fast contactor opening under normal operating conditions.

The controlled point-on-wave contactor tip opening feature is a General Electric exclusive, designed to further enhance system reliability by timing the contactor tip opening to a certain point on the electrical current waveform. The contactor tip opening is timed so that when the current goes through a zero point during a contactor opening operation, the tips will already be far enough apart to prevent restriking of the arc.

Restriking has been shown to be associated with virtual current chopping which is much more severe than "natural" current chop. By providing the CCM as standard equipment, General Electric has taken a step forward to further improve motor protection. This system automatically compensates for contactor aging to maintain the proper point-on-wave operation during the service life of the equipment.

Current Differential Protection

The term differential, as applied to a type of protective relaying, designates the principle on which the scheme operates; that is, a difference in current. The relays used are connected in such a way as to detect a percentage differential in current between ends of a motor winding. Ordinarily, in a machine operating without a winding fault, the current into one end of a phase winding is equal to the current out the other end of the same winding. When a fault occurs, however, the current into one end of the winding is short circuited inside the machine (to another phase or to ground) at the place of fault, so that a differential occurs between current "in" and current "out". This causes the relay to operate. The percentage differential may at times be quite small when the fault is located at a point of high impedance inside the motor winding, and this is the reason why straight overcurrent relays alone do not always give adequate protection.

The cost of this type of relaying is justified by the size of the investment to be protected. Large motors (usually above 1500 hp) that are expensive to repair or replace are often protected by differential relays in addition to fuses and ground-fault relays when the system neutral is grounded.

Specifically, differential relays accomplish the following:

1. Provide for power interruption to a motor in the event of a phase-to-phase insulation failure in the motor winding.

2. Provide for power interruption to a motor in the event of a phase-to-ground fault in the motor winding.

The primary usefulness of differential relays in Vacuum Limitamp Controllers is to give fast, sensitive protection for faults in the end turns outside the stator punchings. Such faults are relatively rare compared with ground faults, but when they do occur, the presence of differential relays would probably mean the difference between minor and extensive damage.

For certain size motors where the power system permits, ground-fault relays, which are much less expensive than differential realys, may be used in lieu of differential protection. This is done on the basis that most phase-to-phase winding faults result in a simultaneous phase-to-ground fault, thereby operating the ground fault relay.

Two methods of differential protection are available. One uses six identical current transformers: three located in the motor leads and three located in the wye points of the motor windings, usually at the motor. In conjunction with these six current transformers, a Type IJD relay is used to detect the difference in current in the current transformer (CTs). The other method, known as self-balancing, uses three donut-type CTs. Both the motor leads and the wye connections are brought back through the holes in the donut CTs. For this system, instantaneous relays of the hand-reset type are used.

Ground-fault Relays

Ground-fault relays are justified economically for all motors rated 2300 to 7200 volts, 150 horsepower and above. The purpose is to provide interruption of power to the motor as rapidly as is practical after positive indication that a ground fault has occurred.

The time of interruption of ground-fault current is dependent on several factors:

1. Sensitivity of the ground-fault relay.
   (a) Instantaneous type
   (b) Time-delay type
2. Magnitude of ground current.
3. Clearing time of the power interrupter.

The importance of clearing ground-fault current rapidly cannot be overstressed. Ground current inside rotating machines causes damage to the laminations which, if not interrupted rapidly, necessitates complete disassembly and repair of the motor.

Although most ground-fault relays are now of the instantaneous type, some few applications do require inverse-time current relays for coordination and selectivity reasons. The use of instantaneous-type relays is made possible through the employment of a zero-sequence "donut" or window-type current transformer installed in the starter in such a way as to permit all three conductors of the three-phase line to be used as the current-transformer primary.

Phase currents add to algebraic zero, regardless of magnitude and no secondary current flows except that induced by primary current going to ground. This system gives positive indication of ground current, eliminates false tripping and permits instantaneous relaying.

If time coordination with other ground-fault relays is necessary, time overcurrent relays may be used in the "donut" current-transformer arrangement.

Another method of detecting ground currents in a three-phase system employs three separate line-current transformers, one in each phase, with the secondaries fed through a single current relay. In this system the secondary currents should add to algebraic zero just as they do in the primary of the "donut" current transformer, and for current ranges below the saturation point of the current transformer and with no ground current flowing, the three secondary currents do add and cancel each other out. Ground current only will cause the relay to operate. For currents of large magnitude, however, such as motor locked-rotor current, current-transformer saturation becomes a problem, causing residual current to flow in the relay coil resulting in false tripping. To prevent false tripping with the residual connection, time-delay relays are necessary to permit riding over the starting period of the motor. This fact makes instantaneous relays impractical in the residual system.

Instantaneous ground-fault relays may be applied to Limitamp® (NEMA Class E2) controllers without limitation on available ground current. The fuse and relay-contactor clearing times are such that ground-fault currents up to and including the fuse rating will be cleared without damage to the controller.

Standard gound-fault relay used in Vacuum Limitamp Control is a solid-state relay which operates on approximately 4 to 12 amperes ground-fault current. If greater sensitivity is required, other solid-state ground-fault relays may be furnished which can be adjusted to trip down to approximately 1 ampere. However, extreme care must be exercised in applying ground-fault relays of such low pick up. They could trip falsely on system-charging current. A magnetic ground-fault relay can be provided on request.

Overtemperature Relays

Some motors have RTD's placed in the stator slots. The purpose is to obtain an indication of winding temperature by measuring the RTD resistance and its change with temperature. Difficulty arises in obtaining a continuously accurate indication of temperatures however, because of the time lag of heat transfer from the stator conductors of the RTD caused by the insulating material surrounding the conductors. Temperature changes in the conductor will not be reflected in RTD resistance change until heat is transferred through the thermal resistance and capacitance of the insulating material.

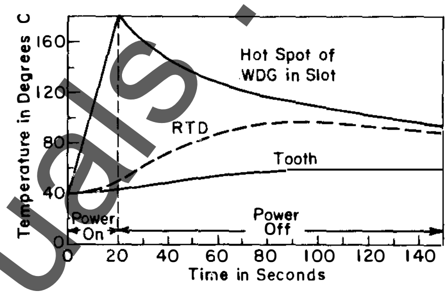


Fig. 4. Approximate temperature of RTD in large motor during locked rotor.

If the copper temperature is changing very rapidly, such as during locked rotor, the RTD will lag far behind the copper temperature as shown in Fig. 4. Consequently, monitoring the RTD temperature is inadequate for thermal protection during rapid-transient conditions. However, for long-time indication of temperature the RTD is very accurate.

A relay which responds to changes in resistance of RTD's, providing long-time indication of motor-winding temperature, used in conjunction with a bimetallic overload relay will provide reasonably precise over-temperature protection for the motor.

Available solid-state relays contain a device which will more accurately compute hot-spot temperature by utilizing RTD and line amperes. This relay accurately tracks motor heating and is recommended in preference to the separate bimetal relay and RTD relay.

Open-phase and Phase-unbalance Protection

A three-phase motor subjected to unbalanced line currents may be damaged, most likely in the rotor from overheating caused by reverse-sequence components of currents not detected by normal overload devices. The open-phase condition is the extreme case of phase unbalance. The rate of motor heating will be a function of the degree of phase unbalance. Therefore, open-phase relays should operate instantaneously and although a motor may be damaged over a period of time with as little as a 10-percent unbalance, the unbalance may be a transient condition which would not justify immediate shutdown and consequently the time to trip should be delayed in proportion to percent of unbalance.

OTHER MOTOR PROTECTIVE FUNCTIONS (CONT'D)

Multifunction Solid-state Relays

Large motors on vital drives need accurate protection against overloads, phase unbalance or ground faults. Multifunction solid-state relays are available from General Electric that offer total motor protection in one compact package. Basic protective functions such as overtemperature, overload, instantaneous overcurrent, open phase, phase reversal, phase unbalance, ground fault, load jam, load loss and bearing overtemperature protection can be provided.

SYNCHRONOUS-MOTOR CONTROL AND EXCITATION

Brush-type Synchronous Control

A solid-state field application and protection module (CR192 μSPM) used in conjunction with a magnetic field contactor is standard on brush-type Limitamp® synchronous controllers. This module contains the logic circuits essential for starting, synchronizing and protecting synchronous motors.

This complete system is described in detail in GEH-5201. This device is fully field programmable and covers a broad range of applications.

Fixed-tap Field Resistor

A fixed-tap field resistor may be used for separate dc source. This resistor, when supplied with the Limitamp panel, is mounted on top and is connected directly in series with the synchronous-motor field as a means of adjusting field current. The resistor is continuously rated with taps to adjust field current 10-percent above and below rated full-load field current for rated power factors in approximately 2 1/2-percent steps.

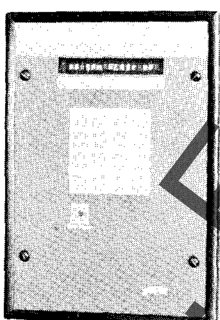


Fig. 5. μSPM Module CR192 with Digital Readout

Exciters

Solid-state packaged exciters are available for integration in Limitamp synchronous-motor starters. Two basic types are available: 1) Field adjustable by fixed-tapped transformer, and 2) silicon-controlled rectifier.

The fixed-tapped transformer single-phase, full-wave bridge may be mounted in a 34-inch-wide, well-vented one-high controller enclosure up to 9 kW. Above 9 kW and up to 19 kW, a 22-inch-wide vented auxiliary enclosure is required. Ratings above 19 kW are available but space requirements are determined on a per-job basis.

Three-phase tapped transformers are available but require extra space in all ratings and are priced on a per-job basis. The cost and space of three-phase exciters cannot ordinarily be justified since the motor field acts as its own filter and ripple effect is not a problem.

All variable SCR-type exciters must be specially ventilated and mounted in the low-voltage compartment. The same space requirements as described for tapped-transformer exciter apply to variable exciter. For NEMA 12 applications, a separate vented enclosure is required for the exciters.

Brushless Synchronous Control

The solid-state CR192 μSPM is also designed for use with brushless synchronous motors. It provides timed field exciter application, pullout protection and stall protection. For further information refer to GEH-5201.

ENCLOSURES

NEMA Type 1–General-purpose

The NEMA Type I is the standard Limitamp enclosure designed primarily to prevent accidental contact with control apparatus. This enclosure is suitable for general-purpose indoor applications with normal atmospheres.

NEMA Type 1–Gasketed

The NEMA Type I rubber-gasketed enclosure is a dust-resistant enclosure (not dust-tight), designed to give protection against dust, and when control devices are properly selected, to give proper operation in a dusty atmosphere. It is recommended for all moderately dusty atmospheres, especially in those industries whose dusts are abrasive, conductive, or form high-resistance contacts. NEMA Type I rubber-gasketed enclosures are not provided with steel bottoms. It is expected that the case will sit on concrete, effectively sealing the bottom against dust.

NEMA Type 2–Driptight

This enclosure is made to protect control apparatus against falling moisture or dirt. All openings are rubber-gasketed and provided with doors or covers. It is intended for use in atmospheres where condensation is heavy or where quantities of water are used in a process or for cleaning. (For applications where a hose is to be directed on the equipment from any direction except above, use NEMA Type 4). Normal instruments, meters and devices are mounted on the door as in NEMA Type 1. Space heaters are used only as the application requires them.

NEMA Type 3R–Weather-resistant

These enclosures must be suitable for outdoor installations and offer protection against driving rain and snow storms as well as dust. Limitamp NEMA 3R enclosures are provided with solid-steel bottoms and tops, an overhanging sloping roof and space heaters.

The following types of NEMA 3R enclosures are available:

NEMA Type 3R, weather-resistant, device-protective doors, non-walk-in (30 inches deep x 101 inches high).

NEMA Type 3R, weather-resistant, full-height cover door, non-walk-in (42 inches deep x 101 inches high). (Use when a number of devices are on the door).

NEMA Type 3R, weather-resistant, walk-in (92 inches deep x 111¼ inches high).

To estimate width use same dimensions as shown for NEMA Type 1 enclosure.

Walk-in enclosures allow ample space for inspection and maintenance of starters within the enclosure.

NEMA Type 4–Watertight

This enclosure must withstand the hose test as described in NEMA standards and must preclude the entry of water under such test. It is intended for use in installations such as dairies or paper mills where cleaning is done with hoses.

Space heaters are furnished.

NEMA Type 12–Dust-tight

These cases are designed to meet the requirements of industrial locations where protection is required against entrance of fibers and flying lint, dust, dirt, light splashings, seep page dripping and external condensation of non-corrosive liquids.

Typical requirements for NEMA 12 are:

1. A gasketed cover which is hinged to swing horizontally, and held in place with screws, bolts or other suitable fasteners.
2. There are no open holes through the enclosure. All openings are sealed with gasketed cover plates.
3. There are no conduit knockouts or knockout openings.
4. Steel bottom.

LINEUPS

Ac Power Bus

Ac power bus is used for conducting power throughout a group of starters joined together in a lineup. Incoming power cable can be terminated at one or more points in the lineup and the power bus employed to distribute power throughout the length of the group.

This bus is available in 1200-, 2400- or 3000-ampere ratings and may be tin-plated copper, silver-plated copper or copper. The location of the horizontal bus compartment is within the standard 90-inch-high enclosure. This location is in the same position in current and previous designs making all compatible.

Vacuum Limitamp® Control horizontal bus is rated 60 kV basic impulse level (1.2 x 40 μ sec wave). (Note that the 200-ampere controller is rated 45 kV BIL). Mechanical strength under short-circuit currents is 80,000 amperes RMS asymmetrical.

Ground Bus

Ground bus in a Limitamp lineup provides a low-resistance path between ground connection points in any group of controllers. This low-resistance path is a bus bar and is for the purpose of decreasing to a low value a possibly hazardous voltage difference between grounding points in the starter group. These voltage differences would occur under ground-fault conditions if a low-resistance ground path were not provided.

The ground bus is normally located near the ac power bus on the inside rear of the enclosure. The bus provides a common termination point for all ground connections within each controller, including the enclosing case, and offers a convenient terminal for incoming ground cables. It should be noted that the customer must make a suitable ground connection to the bus in order to make it effective. When ground bus is not provided, the ground connection may be made to the ground stud provided.

Extensions to the ground bus are located in the incoming line cable compartment and near the load termination points in the high-voltage compartment to make grounding cable shield terminations easy to accomplish.

Control Bus

Control bus is a convenient means of conducting control power throughout a group of controllers joined together in a lineup. Conductors from a single control power source may be terminated in one unit in the lineup and the control bus employed to distribute the power to each unit of the grouped lineup. Control bus may also be used to distribute the power from a single control transformer located in the lineup.

Control bus normally consists of properly sized insulated wire conductors run between terminal boards in a controller.

Maximum voltage for control bus is 600 volts and maximum current rating is determined by application, such as total present and anticipated future load.

Potential Bus

Potential bus is a means of distributing a common source of low voltage throughout the lineup for metering and instrumentation. Potential bus consists of properly sized wire connected between terminal boards mounted on the top inside of enclosure. Maximum voltage is 600 volts.

Dc Excitation Bus

Where a single source of dc power for exciting synchronous motors is provided, dc power can be distributed to each controller by bus bars located on top of the enclosure. Maximum voltage is 600 volts, and maximum current rating of the bus is 600 amperes. Cable connections to the bus may be made from above or below in any controller unit.

Insulated Power Bus

Insulating the ac power bus reduces the possibility of bus faults from causes such as surge voltages, ionized vapors, falling objects (tools, etc.), ground tapes, etc. It also prevents corrosion and oxidation of the bus and its hardware.

The standard power bus consists of bare conductors on insulator supports. Insulation for the conductors can be provided, and it may consist of various types of insulating material such as 130C HV rubber splicing, or polyethylene boots, or other material dictated by availability and individual job requirements.

CABLE-ENTRANCE COMPARTMENT

When incoming cable size exceeds limits shown in TABLE 3, page 4, an optional cable-entrance compartment is required.

The cable-entrance compartment will contain bus bars as required. If potheads are specified, these are mounted on angle supports above or below the bus and connections made by the factory between pothead and bus. Armored cable terminators may be mounted inside the compartment or in the floor for clamping armor.

Cable-entrance compartments are also required for out-going cable potheads of the terminal type.

TRANSITION COMPARTMENT

Vacuum Limitamp Control can be bus connected to transformers and switchgear by a transition compartment to make a continuous lineup. The transition compartment is normally 22 inches wide, however this can vary. Refer to the Company for special applications.

LOAD-BREAK SWITCHES

Fig. 6. 600-ampere drawout load-break switch

IC1074 load-break switches are manually operated triple-pole, single-throw disconnecting switches with an integral interrupter and stored-energy spring that has the capability of interrupting magnetizing and load current within the ratings shown in TABLE 5. They are designed to comply with the performance requirements of ANSI Specification C37.40 and have been so tested.

The IC1074 600-ampere drawout switch is designed for stab connection at line and load terminals. This switch must be fused. Silver-sand current-limiting fuses are available up to a continuous rating of 630 amperes for installation on the switch. The switch is designed to accommodate the bolt-on version of the silver-sand fuse, but clip mounting is available. Construction may be either one- or two-high. Up to two switches can be mounted in a two-high enclosure.

The IC1074 stationary switch (600- or 1200-ampere) is designed for mounting in one-high construction only. It contains line- and load-terminal pads for bolting incoming and outgoing conductors directly to the switch. It may be supplied fused or unfused. If supplied as an unfused switch, an upstream circuit breaker with instantaneous trips must be available to coordinate with switch capabilities or the switch must be supplied with key lock capabilities for all of the Limitamp starters in the lineup. For the 1200-ampere switch, fuses are available up to 960 amperes continuous.

LOAD-BREAK SWITCHES (CONT'D)

These large fuses must be applied as line protectors for short circuit only, relying upon branch circuits or backup overload protection by other means.

Drawout switches must be applied as feeders only. The fixed mounted switches may be used as incoming switches or feeder switches.

These switches are designed specifically for use with Limitamp® control. They are available with 1200- and 2400-ampere ac power bus within enclosure for easy lineup with Limitamp starters.

Other features of these switches are:

- Viewing window to see condition and position of switch blades.
- Blown-fuse indicator that can be seen through view window.
- Bolted fuses available for maximum reliability.
- High reliability interrupter.
- Available with key-type interlocks.
- Maximum of three keys per position.
- Outside door interlocked directly to shaft to prevent opening with switch energized.
- Externally operated handle that activates spring-charge quick-make/quick-break mechanism.
- Easy inspection.
- High mechanical life.

For ratings, dimensions and cable space required see TABLE 5.

TABLE 5. Specifications for IC1074 Load-break Switches (Ratings, Dimensions and Cable Space)

Type	600-ampere Drawout Switch (Fused)	600-ampere Stationary Switch (Fused or Unfused)	1200-ampere Stationary Switch (Fused or Unfused)
RATINGS			
Voltage rating	5000-volt maximum	5000-volt maximum	5000-volt maximum
Unfused rating			
Vented enclosure	N/A	600 amperes	600 amperes
Non-vented enclosure	N/A	540 amperes	540 amperes
Fused rating			
Vented enclosure	600 amperes	600 amperes	600 amperes
Non-vented enclosure	540 amperes	540 amperes	540 amperes
Make/Break rating	600 amperes	600 amperes	600 amperes
Fault-closing rating			
Fused	61,000 amperes	61,000 amperes	61,000 amperes
Unfused	N/A	61,000 amperes	61,000 amperes
Momentary rating			
Unfused	N/A	61,000 amperes	61,000 amperes
Basic Impulse Level (BIL)	60 kV	60 kV	60 kV
Short-circuit Interrupting capacity (Fused)			
2400 volts	200 mVA (Sym)	200 mVA (Sym)	200 mVA (Sym)
4800 volts	400 mVA (Sym)	400 mVA (Sym)	400 mVA (Sym)
DIMENSIONS			
	Dimensions in Inches (H x W x D)	Dimensions in Inches (H x W x D)	Dimensions in Inches (H x W x D)
1-high construction	90 x 34 x 30	90 x 38 x 30	90 x 38 x 30
1-high construction (Option)	90 x 42 x 30	N/A	N/A
2-high construction	90 x 44 x 30	N/A	N/A
CABLE SPACE			
Incoming 38-inch-wide case	N/A	2-500 MCM per phase without stress cones	2-500 MCM per phase without stress cones
Outgoing 38-inch-wide case	N/A	2-500 MCM per phase with or without stress cones	2-500 MCM per phase with or without stress cones
Incoming (For bus only) 34-inch-wide case	2-500 MCM per phase without stress cones 1-500 MCM per phase with stress cones	N/A	N/A
42-inch-wide case	2-750 MCM per phase with or without stress cones	N/A	N/A
44-inch-wide case	1-500 MCM per phase with or without stress cones	N/A	N/A
Outgoing 34-inch-wide case	1-500 MCMper phase with or without stress cones	N/A	N/A
42-inch-wide case	2-750 MCM per phase with or without stress cones	N/A	N/A
44-inch-wide case	1-300 MCM per phase with or without stress cones	N/A	N/A

N/A — Not Applicable.

SURGE PROTECTION

The economics of rotating-machine insulation dictates that the machines be protected from voltage stresses above the operating level insofar as is reasonably possible. Overvoltage damages or reduces the insulation life. There are many causes of accidental over-voltage whose effects may be reduced by protective means. The most prominent causes are:

1. Lightning.
2. Physical contact with higher voltage system.
3. Repetitive restrike (intermittent grounds).
4. Switching surges.
5. Resonance effects in series inductive capacitance circuits

Switching transients occur in every electrical system. A well-known phenomena associated with vacuum interrupters is current chop. General Electric utilizes vacuum interrupters constructed with widely accepted contact tip materials to provide low chopping currents.

Another less widely known, but more severe, switching transient is known as virtual chop. This switching transient occurs primarily due to restriking during contact tip opening during switch-off of the motor. General Electric's Vacuum Limitamp Control provides the solution to this problem by controlling the tip opening point on the current waveform so that as the current passes through zero and the arc extinguishes, the tips have travelled open far enough to prevent restriking. The point on the current waveform where the tips open is precisely controlled by a microprocessor and is consistent from operation to operation. Uncontrolled or random opening of the tips permits the possibility of opening at small arc angles — a condition which is most likely to cause restrikes. For further technical details of the Vacuum Limitamp Control point-on-wave controller and its effect on switching transients, contact the factory.

VACUUM LIMITAMP® CONTACTORS

2.4 kV to 7.2 kV

New Vacuum contactors from General Electric are tailored to equipment OEM's who want minimum size components but also insist on such basic requirements as

- Product Reliability
- Simplicity of operation installation and maintenance
- Broad industry application

General Electric Vacuum Contactors meet these requirements with key design features

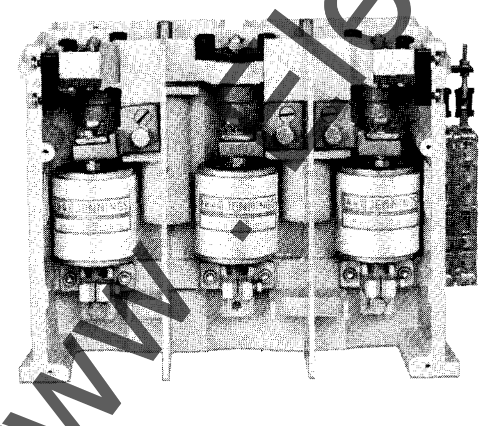
- RELIABILITY - Superior mechanical and electrical life • Up to 5 million mechanical operations at no load • Up to 1.0 million electrical operations at rated load.
- SIMPLICITY - Simple, accurate adjustment of contact tips with unique uniball scheme. Contact wear status can be recorded on convenient labels next to each interrupter. Up to 20 auxillary contacts are housed in a clear lexan case mounted on the contactor easily visable. Lightweight assembly in one piece frame. Smaller control power transformer required due to low power dc magnetic and coils
- BROAD APPLICATION - Expanded product applications in mining, paper, cement and other tough industrial environments due to switching arc containment within the vacuum interrupter and rigid molded frame of glass polyester with excellent tracking resistance, low moisture absorption, and resistance to fungus.

  Flexible use in panels due to compact size and ability to orient the contactors in any mounting plane.

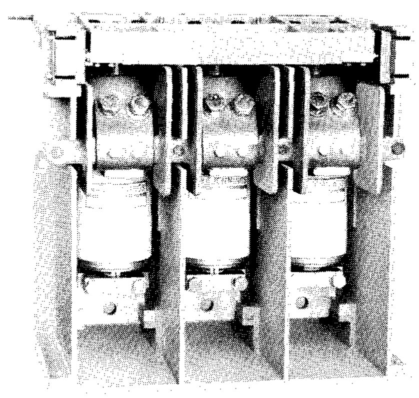
  3 contactor ratings available for optimum packaging.

TABLE 1: CR193 VACUUM CONTACTORS

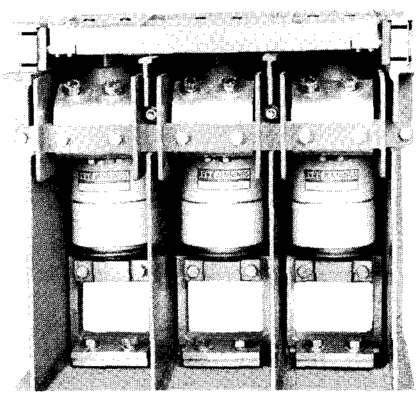
8-hour Open Rating (Amperes)	Catalog Number	System Voltage	Maximum Horsepower Synchronous 1.0	Maximum Horsepower Induction 0.8 Pf	3 Phase Transformers	3 Phase Capacitors
200	CR193A	2400	1000	800	800 kVA	600 kvar
		3600	1500	1200	1200 kVA	900 kvar
400	CR193B	2400	2000	1600	1600 kVA	1200 kvar
		3600	3000	2400	2400 kVA	1800 kvar
		4160	3500	2800	2800 kVA	2100 kvar
		4800	4000	3200	3200 kVA	2400 kvar
		7200	6000	4800	4800 kVA	3600 kvar
800	CR193C	2400	4000	3200	3200 kVA	2400 kvar
		3600	6000	4800	4800 kVA	3600 kvar
		4160	7000	5600	5600 kVA	4200 kvar
		4800	8000	6400	6400 kVA	4800 kvar



Limitamp 200



Limitamp 400

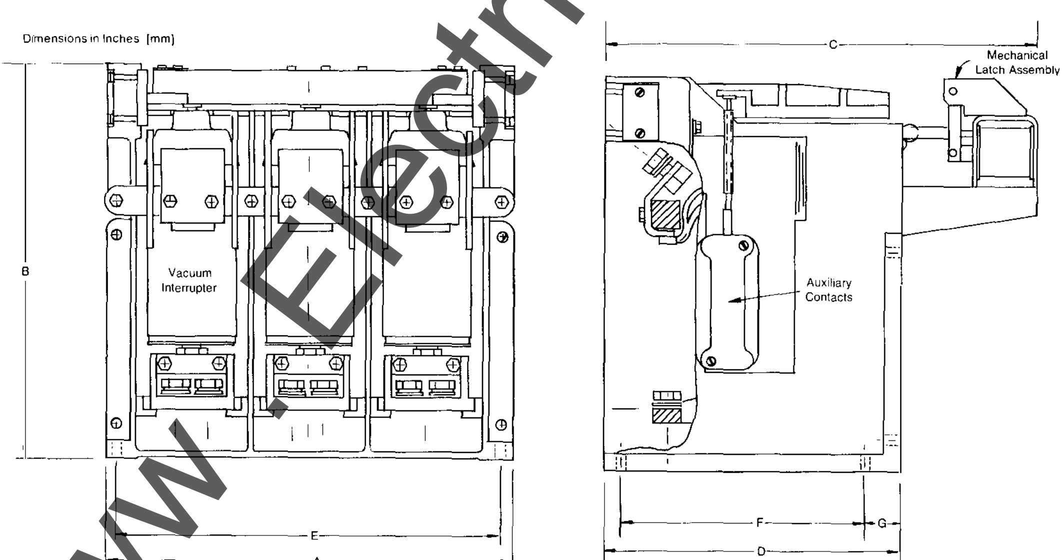


Limitamp 800

SPECIFICATIONS: SEE PAGE 2

CONTACTOR TECHNICAL SPECIFICATIONS

Ratings	CR193A		CR193B		CR193C
Rated voltage (Volts)	2400	3600	5000	7200	5000
Rated current (Amperes)	200		400		800
Short circuit interrupting current (kA)	6.0	6.0	6.0	6.0	9.0
CLASS E1 mVA	25	37	50	75	75
CLASS E2 mVA 2400 volts 3600 volts 4160 volts 4800 volts 7200 volts	200 300 --- --- ---		200 300 350 400 600		200 300 350 400 ---
Short-time current (amperes) 30 seconds 1 second	1200 3000		2400 6000		4800 12000
Impulse withstand (kV)	45		60		60
Dielectric strength 1 minute (kV)	11.0		20.0		13.5
Switching frequency (Operations/minimum)	1200		1200		600
Mechanical life (Operations)	5×10^6		5×10^6		1×10^6
Electrical life (Operations)	1×10^6		1×10^6		0.25×10^6
Closing time (Maximum MS)	120		350		270
Opening time (Maximum MS) Switched on dc side of rectifier	35		50		55
Pick-up voltage (% of rated)	85% max		85% max		85% max
Drop-out voltage (% of rated)	10 - 65%		10 - 65%		10 - 65%
Control voltage (Volts)	110/115 rec. ac		110/115 rec. ac		110/115 rec. ac
Control circuit burden (vA) Closing Hold-in	220 77		165 21		515 67
Auxiliary contacts Quantity	20 maximum (N.O. or N.C.)		20 maximum (N.O. or N.C.)		20 maximum (N.O. or N.C.)
Ratings Current (Amperes) Voltage (Volts) Switching ac dc	10 600 6 amperes at 600 volts 1 amperes at 240 volts		10 600 6 amperes at 600 volts 1 amperes at 240 volts		10 600 6 amperes at 600 volts 1 amperes at 240 volts
Contactor weight (Lb/kg)	27.9 [12.7]		77 [35]		114 [52]
Outline dimensions drawing	Fig. 1.		Fig. 1.		Fig. 1.
Standards applicable	U/L 347 NEMA 2-324		U/L 347 NEMA 2-324		U/L 347 NEMA 2-324



Key	Dimensions in Inches [mm] CR193A	CR193B	CR193C
A	13.50 [343]	14.88 [378]	18.90 [480]
B	9.53 [242]	13.50 [343]	16.93 [450]
C	8.46 [215]	14.65 [372]	17.52 [445]
D	5.8 [147]	10.24 [260]	12.99 [330]
E	11.61① [295]	12.99 [330]	17.00 [432]
F	4.17 [106]	8.46 [215]	11.02 [280]
G	0.63 [16]	1.18 [30]	1.38 [35]

① Mounting dimension on the opposite side is 8.58 [218] centered.

GENERAL ELECTRIC

GENERAL PURPOSE
CONTROL DEPARTMENT
MEBANE, NC 27302, U.S.A.

Fig. 1. CR193

Additional protection against surges for rotating machines may be economically attractive for system voltage installations of 2300 volts and above.

It consists of a surge capacitor and a Thyrite® lightning arrester.

The lightning arrester reduces the amplitude of the voltage impulse wave. The surge capacitor further reduces the amplitude but in addition, it reduces the steepness of the wave front. It is important to reduce the steepness of the surge wave front to keep the turn-to-turn voltage stress in the machine winding to a minimum.

Surge capacitors and arresters should be installed as close to the machine terminals as possible.

To prevent overvoltage in current-transformer secondary circuits during switching, current transformers should be provided with Thyrite protectors when surge capacitors are installed at motor terminals.

Capacitors and arresters require a 22-inch-wide auxiliary enclosure if required at the controller.

TERMINALS

High-voltage terminal lugs are not furnished in Vacuum Limitamp® panels unless specifically requested on the order and cable size is specified. When specified, solderless connectors by Ilsco are furnished. When requested, terminals by other manufacturers can be furnished. In large project installations where the contractor may feel that supplying terminal lugs is not in his contract, the question of who supplies lugs should be settled when the order is issued. Where the Customer is going to connect Limitamp equipment with aluminum conductors, special attention must be given to the selection of terminals.

POTHEADS

Hermetically sealed potheads are required for permanent protection on all paper-insulated cables. Rubber-insulated cables may not require potheads up to 5000 volts, but potheads are often used at lower voltages to afford permanent protection against deterioration.

Potheads serve to: (1) seal cable ends against entrance of moisture which would seriously damage cable insulation, (2) provide a compartment for surrounding the termination with insulating compound thus improving the electrical strength over the surface of cable insulation, and (3) seal cable ends against leakage of cable impregnating oil, loss of which decreases the electrical strength of the insulation.

The three principal types of potheads are as follows:

Through-type — In this type the Purchaser's incoming three-conductor cables are separated by the pothead and run through to terminals on the panel and are sealed with compound. These will accommodate cable to 2 7/8 inches outside diameter, a maximum of Size 00 three-conductor cable.

Terminating Pothead, Entrance from Below — In this type the Purchaser's incoming three-conductor cables terminate in the pothead and the controller cables connect to the terminals. G & W Type NT, Shape C Terminating Potheads are used in Limitamp control, and require an auxiliary compartment.

Terminating Pothead, Entrance from Above — In this type, the Purchaser's cables terminate in the pothead from overhead and the controller cable connects to the terminals of the pothead. G & W Type TRA, Shape C Potheads are used for such termination in Limitamp control, and also require an auxiliary compartment.

COMPARISON OF CONTROLLER TYPES

Full Voltage

The Vacuum Limitamp Control across-the-line (FVNR) controller is the most popular type of controller. In general, high-voltage systems have fewer power restrictions than low-voltage systems, therefore, full-voltage controllers may be applied to a greater number of applications. Full-voltage controllers provide lowest cost, simplicity, minimum maintenance and highest starting torque.

Reduced Voltage

Primary reactor (closed transition) Limitamp controllers are the most popular of the reduced-voltage type starters because they provide a simple, low cost means of obtaining reduced-voltage starts. The starting time and reactor taps are easily adjustable in the field.

Limitamp closed transition auto-transformer controllers provide higher starting torque efficiency and a more favorable power factor during starting than a primary reactor starter. The autotransformer taps and transition time can be easily adjusted in the field. NEMA medium-duty reactors and autotransformers with 50-, 65- and 80-percent taps are provided as standard.

Reduced Inrush

Limitamp wye (star)-delta (closed transition) starters provide a means of reducing the starting inrush where the starting duty is not limited by the controller. This type of controller can be used where extremely long acceleration times are required. Wye-delta starters have a very high torque efficiency. This starter is applicable only to 6 lead motors and no field correction is possible.

INSTALLATION

Installation instructions are furnished with each section of Limitamp control shipped from the factory.

It is recommended that these instructions be followed in detail.

TABLE 6. Comparison of Starting Characteristics

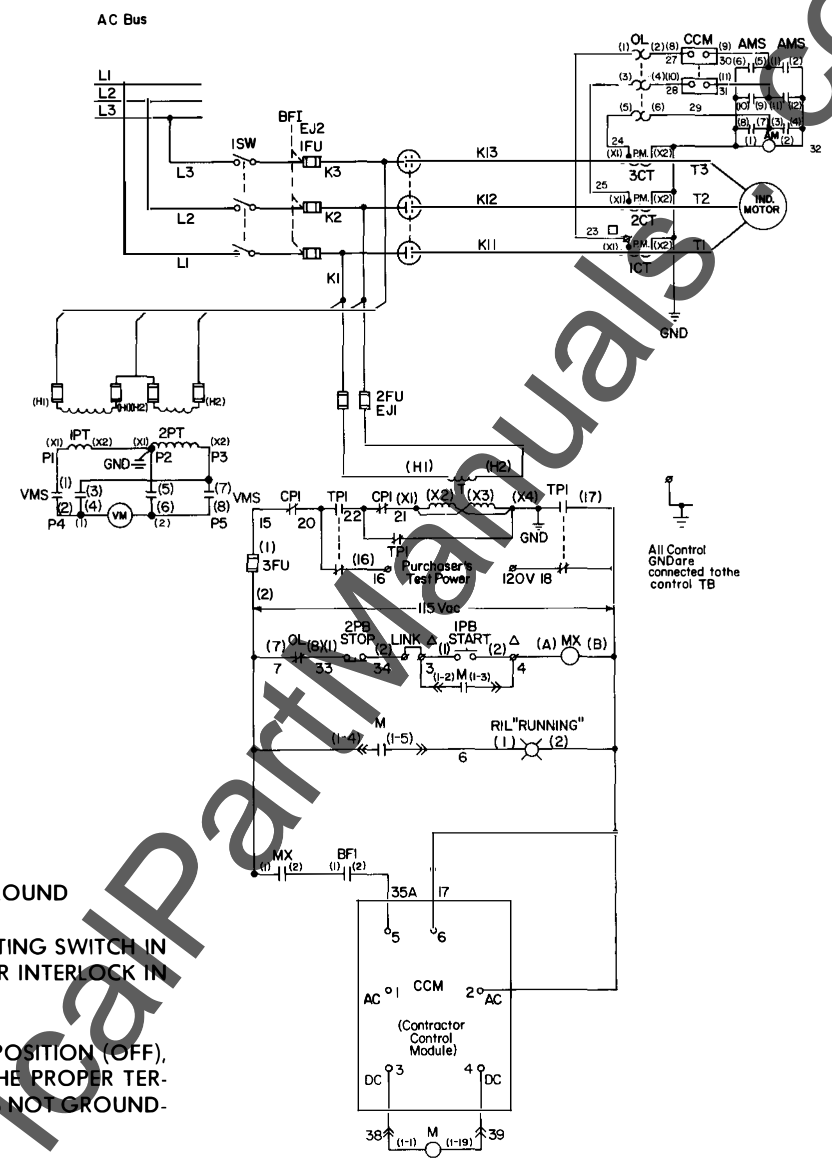
Starter Type	Starting Characteristics Expressed in Percent Rated Values				
	Voltage of Motor	Motor Current	Line Current	Torque	Torque Efficiency
FULL VOLTAGE	100	100	100	100	100
AUTOTRANSFORMER					
80 percent tap	80	80	64*	64	100
65 percent tap	65	65	42*	42	100
50 percent tap	50	50	25*	25	100
PRIMARY-REACTOR					
80 percent tap	80	80	80	64	80
65 percent tap	65	65	65	42	65
50 percent tap	50	50	50	25	50
STAR-DELTA	100	33	33	33	33

*Autotransformer magnetizing current is not included in listed values. Magnetizing current is usually less than 25-percent motor full-load current.

TYPICAL DIAGRAMS

Nomenclature:

AM	Ammeter
AMS	Ammeter Switch
BFI	Blown Fuse Indicator
CT	Current Transformer
CPI	Control Power Interlock
FU	Fuse
GND	Ground
ISW	Main Disconnect Switch
M	Main Contactor (Vacuum)
MX	Aux. Relay to M
OR	Overload Relay
PB	Pushbutton
P.M.	Polarity Mark
PT	Potential Transformer
TIL	Red Indicating Light
T	Transformer
TPI	Test Power Interlock
VM	Voltmeter
VMS	Voltmeter Switch



CONTROLLER GROUND SYSTEM GROUND

THIS DIAGRAM SHOWS STARTER WITH THE ISOLATING SWITCH IN THE DISCONNECT POSITION AND THE TEST POWER INTERLOCK IN THE TEST POSITION.

TO TEST - HANDLE MUST BE IN THE DISCONNECT POSITION (OFF), PURCHASER TO CONNECT HIS TEST POWER TO THE PROPER TERMINALS AND NOTE THAT THE CONTROL CIRCUIT IS NOT GROUNDED WHEN DISCONNECTS ARE OPEN.

CPI - OPENS ONLY WHEN CPI RELEASE ON ISOLATING SWITCH HANDLE IS PUSHED IN. CAN NOT BE OPENED WHEN MAIN LINE CONTACTOR IS CLOSED.

△ - START AND STOP PUSHBUTTON CIRCUITS ARE WIRED THROUGH THE CONTROL TB IN ORDER THAT REMOTE START-STOP BUTTONS CAN BE READILY CONNECTED INTO THE CIRCUIT WHEN REQUIRED.

□ - AT THE CONTROL TB, A LOOP IN THE CT SECONDARY CIRCUIT WIRE PERMITS INSERTION OF A HOOK ON AMMETER FOR MEASURING LINE CURRENT.

Ø - TERMINAL BOARD POINT

NOTE: DEVICE TERM.

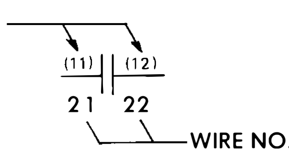
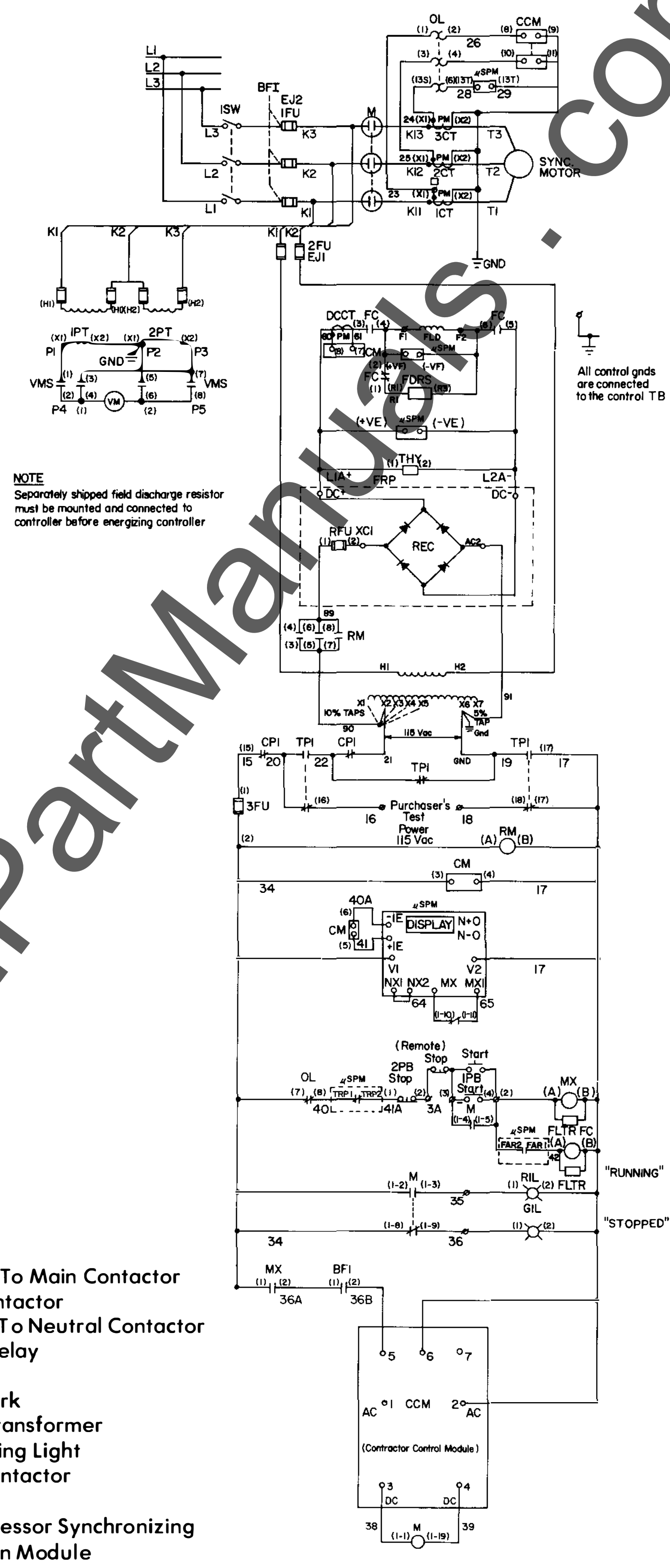


Fig. 7. Typical diagram of induction-motor-control FVNR

TYPICAL DIAGRAMS



CONTROLLER GROUND SYSTEM GROUND

THIS DIAGRAM SHOWS STARTER WITH THE ISOLATING SWITCH IN THE DISCONNECT POSITION AND THE TEST POWER INTERLOCK IN THE TEST POSITION.

TO TEST - HANDLE MUST BE IN THE DISCONNECT POSITION (OFF), PURCHASER TO CONNECT HIS TEST POWER TO THE PROPER TERMINALS AND NOTE THAT THE CONTROL CIRCUIT IS NOT GROUNDED WHEN DISCONNECTS ARE OPEN.

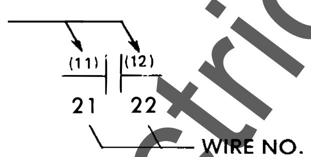
CPI - OPENS ONLY WHEN CPI RELEASE ON ISOLATING SWITCH HANDLE IS PUSHED IN. CAN NOT BE OPENED WHEN MAIN LINE CONTACTOR IS CLOSED.

△- START AND STOP PUSHBUTTON CIRCUITS ARE WIRED THROUGH THE CONTROL TB IN ORDER THAT REMOTE START-STOP BUTTONS CAN BE READILY CONNECTED INTO THE CIRCUIT WHEN REQUIRED.

□- AT THE CONTROL TB, A LOOP IN THE CT SECONDARY CIRCUIT WIRE PERMITS INSERTION OF A HOOK ON AMMETER FOR MEASURING LINE CURRENT.

Ø - TERMINAL BOARD POINT

NOTE: DEVICE TERM.



Nomenclature:

BF1	Blown Fuse Indicator
CCM	Contactor Coil Module
CM	(field-current) Calibration Module
CPI	Control Power Interlock
CT	Current Transformer
DCCT	Dc Current Transformer
FC	Field Contactor
FDRS	Field Discharge Resistor
FLD	Field
FLTR	Filter
FRP	Field Rectifier Panel
FU	Fuse
GND	Ground
GIL	Green Indicating Light
SIW	Main Disconnect Switch
M	Main Contactor
MX	Aux. Relay To Main Contactor
N	Neutral Contactor
NX	Aux. Relay To Neutral Contactor
OL	Overload Relay
PB	Pushbutton
P.M.	Polarity Mark
PT	Potential Transformer
RIL	Red Indicating Light
RM	Rectifier Contactor
REC	Rectifier
µSPM	(micro-processor Synchronizing & Protection Module
THY	Thyrite
VE	Voltage Exciter
VF	Voltage Field
VM	Voltmeter
VMS	Voltmeter Switch

Fig. 8. Typical diagram of synchronous-motor control FVNR, Brush Type with Static Exciter

RATINGS, WEIGHTS AND DIMENSIONS — VACUUM LIMITAMP® 200, 400 AND 800 CONTROLLERS

Limitamp control varies in weight by controller type and construction. The approximate weight for estimating purposes is included in the tables below.

All Limitamp controllers have a common depth of 30 inches and height of 90 inches. Vacuum Limitamp 200 and 400 controllers have a basic width of 26 inches. Two-high Vacuum Limitamp Control has a basic width of 40 inches and Vacuum Limitamp 800 controllers have a basic width of 40 inches.

Overall width of other controllers such as reduced-voltage type controllers vary according to type of controller as shown in TABLE 7 below.

For convenience in handling and installation, Limitamp controllers are equipped with removable lugs or lifting angles.

Power bus for electrically connecting sections of Limitamp control does not add to the standard 90-inch height.

TABLE 7. TECHNICAL DATA - ESTIMATED WEIGHTS AND DIMENSIONS – VENTED NEMA 1 ENCLOSURES

CONTROLLER TYPE	Limitamp Contactor Ampere Rating ①	2400 Volts			4000-4800 Volts ②			7200 Volts		
		Max Hp 3-phase 50/60 Hz	Wt in Lbs	Width in Inches 90 high x 30 deep	Max Hp 3-phase 50/60 Hz	Wt in Lbs	Width in Inches 90 high x 30 deep	Max Hp 3-phase 50/60 Hz	Wt in Lbs	Width in Inches 90 high x 30 deep
	ONE HIGH - ONE STARTER									
SQUIRREL-CAGE INDUCTION FULL-VOLTAGE NONREVERSING	200	800	1200	26	....	....	..	....	....	..
	400	1600	1200	26	2800	1200	26	4800	1200	26
	800	3200	1450	40	5600	1450	40	....	....	..
	TWO HIGH - TWO STARTERS									
	200	800	1900	40	....	....	..	....	....	..
	400	1400	1900	40	2500	1900	40	....	....	..
ONE HIGH STARTERS										
SQUIRREL-CAGE INDUCTION FULL-VOLTAGE REVERSING	200	800	1400	34	....	....	..	....	....	..
	400	1600	1500	40	2800	1500	40	4800	1600	40
	800	3200	1800	60	5600	1800	60	....	....	..
REDUCED-VOLTAGE NONREVERSING PRIMARY REACTOR TYPE	200	800	1900	58	....	....	...			
	400	1000	2800	66	1000	2800	66			
	400	1600	4800	98	2800	4800	98			
	800	3200	5200	108	5600	5200	108			
REDUCED-VOLTAGE NONREVERSING NEUTRAL REACTOR	400							4800	Refer to Company	
REDUCED-VOLTAGE NONREVERSING AUTOTRANSFORMER TYPE (CLOSED TRANSITION)	200	800	2300	72	....	....	...	Refer to Company		
	400	1000	3000	72	1000	3000	72			
	400	1600	5000	104	2800	5000	104			
	800	3200	8600	114	5600	8600	114			
TWO-STEP PART WINDING NONREVERSING	200	800	1400	40	...	....	..			
	400	1600	1400	40	2800	1400	40			
	800	3200	2400	80	5600	2400	80			
TWO-SPEED ONE WINDING FVNR	200	800	1600	62	....	....	..			
	400	1600	1600	62	2800	1600	62			
	800	3200	2700	80	5600	2700	80			
TWO-SPEED TWO WINDING FVNR	200	800	1400	40	....	....	..			
	400	1600	1400	40	2800	1600	40			
	800	3200	2400	80	5600	3200	80			
REVERSING STARTERS TWO-SPEED & REDUCED-VOLTAGE	For single-speed reversing of two-speed starters **add** 32 inches to base starter width. For reversing of RVNR autotransformer type starters **add** 64 inches to base starter width. For reversing on both speeds of two-speed starters **add** 64 inches to base starter width.									

① Derate by 0.8 for non-vented enclosures

② Maximum horsepower at 4160 volts ac in one-high NEMA 1 enclosure

TABLE 7. TECHNICAL DATA - ESTIMATED WEIGHTS AND DIMENSIONS – VENTED NEMA 1 ENCLOSURES

CONTROLLER TYPE	Limitamp Contactor Ampere Rating ①	2400 Volts				4000-4800 Volts ②				7200 Volts			
		Max Hp 3-phase 50/60 Hz		Wt in Lbs	Width in Inches 90 high x 30 deep	Max Hp 3-phase 50/60 Hz		Wt in Lbs	Width in Inches 90 high x 30 deep	Max Hp 3-phase 50/60 Hz		Wt in Lbs	Width in Inches 90 high x 30 deep
		0.8 PF	1.0 PF			0.8 PF	1.0 PF			0.8 PF	1.0 PF		
SYNCHRONOUS-MOTOR FVNR BRUSH TYPE & BRUSHLESS	200	800	1000	1400	34	....	....	....	..	....	....	....	..
	400	1600	2000	1400	34	2800	3500	1400	34	4800	6000	1400	34
	800	3200	4000	2600	40	5600	7000	2600	40	....	....	....	..
SYNCHRONOUS-MOTOR, RVNR PRIMARY REACTOR	200	800		2100	64	....		....	...				
	400	1000		3000	72	1000		3000	72				
	400	1600		5000	104	2800		5000	104				
	800	3200		5400	108	5600		5400	108				
SYNCHRONOUS-MOTOR, RVNR AUTOTRANSFORMER	200	800	1000	2500	78	....	....	....	...				
	400	1000	1250	3200	78	1000	1250	3200	78				
	400	1600	2000	5200	110	2800	3500	5200	110				
	800	3200	4000	8800	114	5600	7000	8800	114				
SYNCHRONOUS-MOTOR, RVNR NEUTRAL REACTOR	200 400 800									Refer to Company			
SYNCHRONOUS-MOTOR REVERSING STARTERS	For single-speed reversing of two-speed starters **add** 32 inches to base starter width. For reversing of reduced-voltage autotransformer type starters **add** 64 inches to base starter width.												
SYNCHRONOUS - MOTOR, DYNAMIC BRAKING	For dynamic braking of Limitamp synchronous starters up to 4800 volts **add** 32 inches to basic panel width. No increase in width is required for reversing starters.												
EXCITER POWER SUPPLIES	For power supplies above 9kW **add** 22 inches to base starter width for an auxiliary compartment.												

① Derate by 0.8 for non-vented enclosures

② Maximum horsepower at 4160 volts ac in one-high NEMA 1 enclosure

CONTROLLER TYPE	Limitamp Contactor Ampere Rating	2400 Volts			4000-4800 Volts			7200 Volts			Number of Enclosures	
		Hp 3-phase 50/60 Hz	Wt in Lbs	Width in Inches 90 high x 30 deep	Hp 3-phase 50/60 Hz	Wt in Lbs	Width in Inches 90 high x 30 deep	Hp 3-phase 50/60 Hz	Wt in Lbs	Width in Inches 90 high x 30 deep	Secondary Contactors	Resistors
WOUND-ROTOR-MOTOR NONREVERSING	200	150	1900	58	....	....	..	Refer to Company			1	0
	200	700	2500	90	....	....	..				1	1
	400	150	1900	58	150	1900	58				1	0
	400	700	2500	90	700	2500	90				1	1
	400	1500	3700	186	1500	3700	186				2	3
	800①/400	1750	5800	230	1750	4100	218				3	3
	800①/ 400	2000	6700	262	2000	4400	250				3	4
	800①/ 400	2250	6700	262	2250	4400	250				3	4
	800①/ 400	2500	6700	262	2500	4900	282				3	4②/5

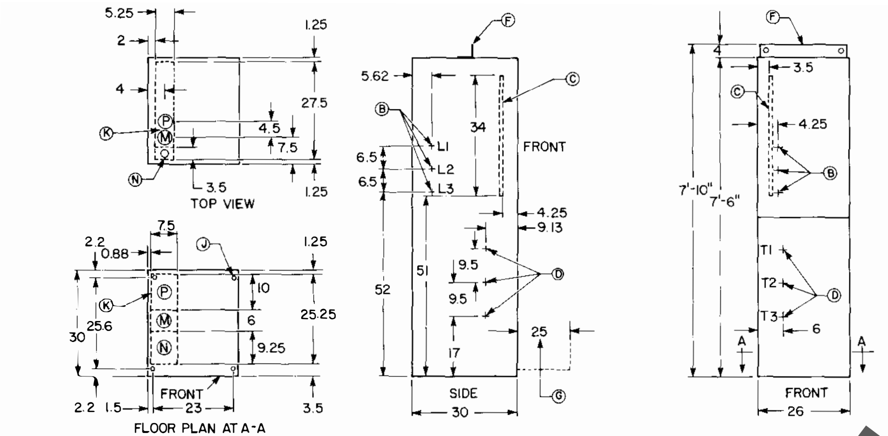
① Limitamp 800 for 2400 volts, Limitamp 400 for 4000-4800 volts.

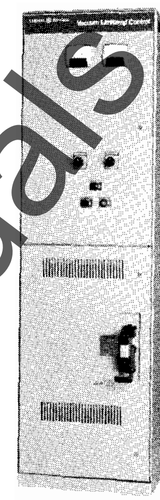
② 4 required at 2400 volts, 5 required at 4000-4800 volts.

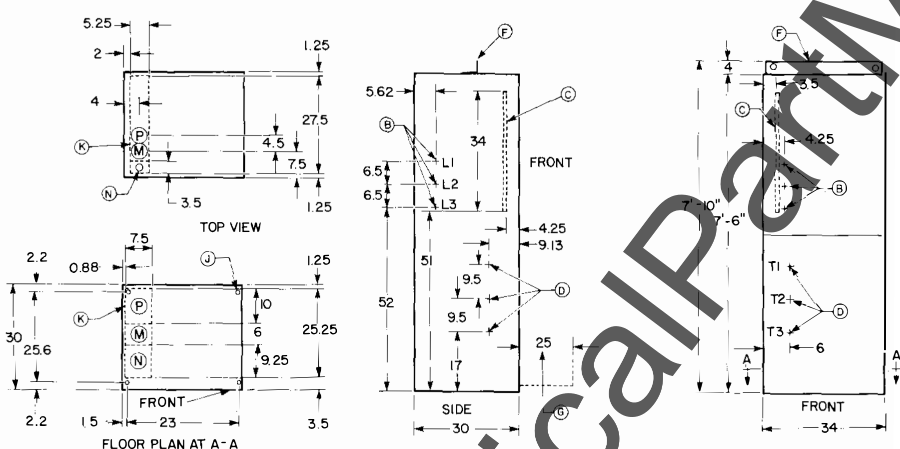
WOUND-ROTOR-MOTOR REVERSING	For reversing of wound-rotor-motor starters **add** 32-inch panel width and 600 pounds.

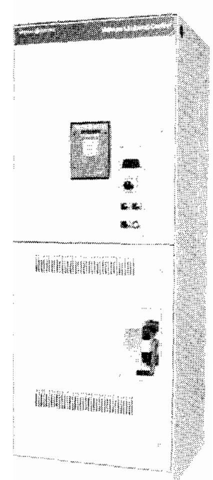
OUTLINE DRAWINGS — VACUUM LIMITAMP® 200, 400 AND 800 CONTROLLERS

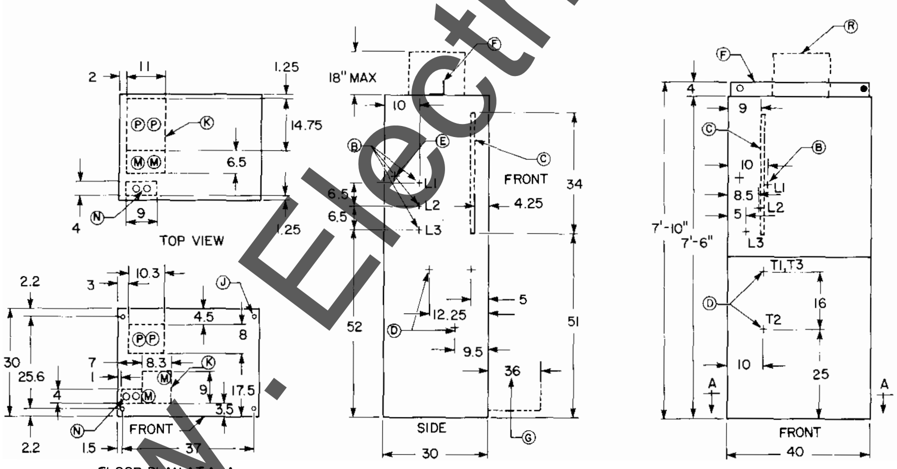
ONE-HIGH OUTLINES (All dimensions under 6 feet are in inches)
(Including 400-ampere at 7.2 kV)



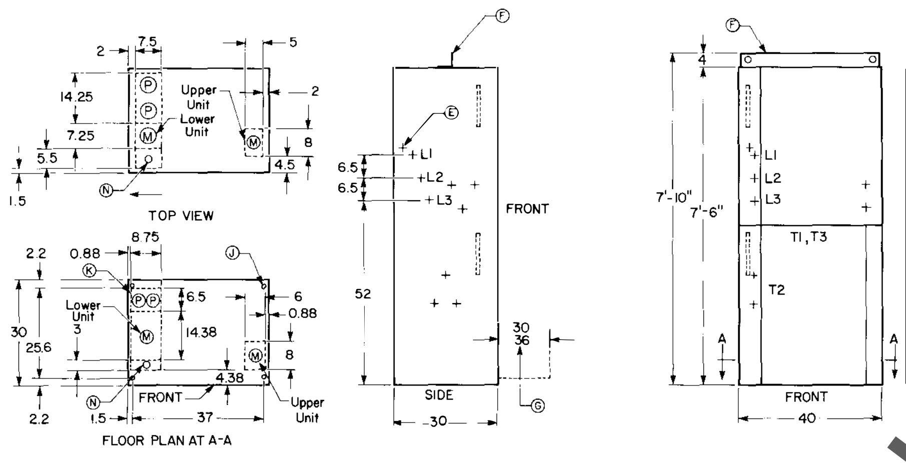








TWO-HIGH OUTLINE (All dimensions under 6 feet are in inches)
(400-ampere, 7.2 kV not offered in two-high construction)



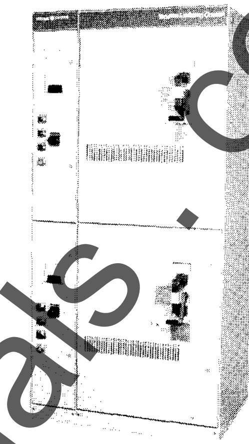
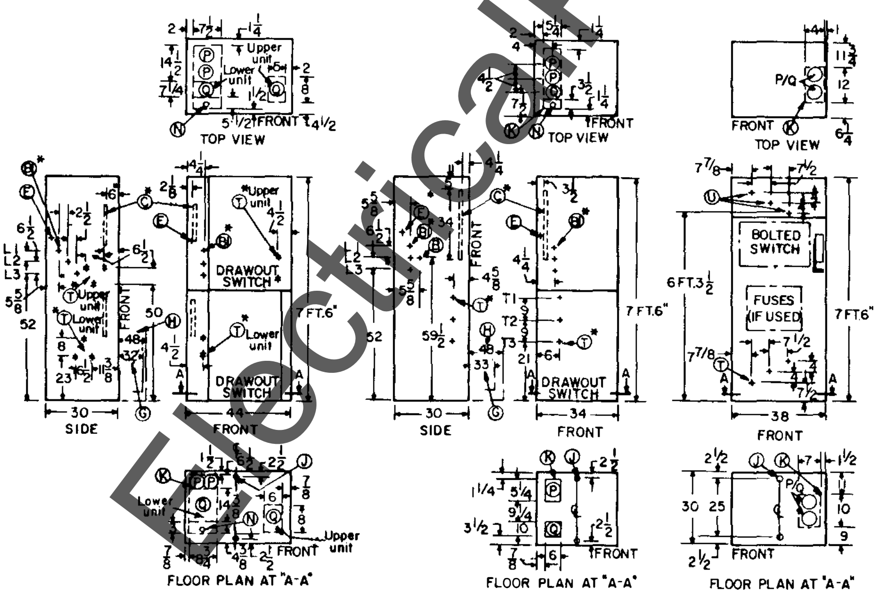


TABLE 8 . RATINGS, WEIGHTS AND DIMENSIONS – LOAD-BREAK SWITCHES

TYPE	2400 Volts						4000 or 4800 Volts					
	Fused Interrupting Capacity kVA Symmetrical	Impulse Level Rating kV	Approx Weight in Lb.	Dimensions in Inches: Height	Width	Depth	Fused Interrupting Capacity kVA Symmetrical	Impulse Level Rating kV	Approx Weight in Lb.	Dimensions in Inches: Height	Width	Depth
	One-high (One Switch)											
600-AMPERE DRAWOUT	200,000	60	1600	90	34	30	400,000	60	1600	90	34	30
600-AMPERE STATIONARY	200,000	60	1600	90	38	30	400,000	60	1600	90	38	30
1200-AMPERE STATIONARY	200,000	60	1600	90	38	30	400,000	60	1600	90	38	30
	Two-high (Two Switches)											
600-AMPERE DRAWOUT	200,000	60	2400	90	44	30	400,000	60	2400	90	44	30

OUTLINE DRAWINGS — LOAD-BREAK SWITCHES (All dimensions under 6 feet are in inches)

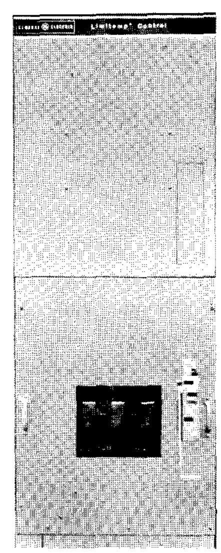


Two-high drawout switch

One-high drawout switch

One-high stationary switch

NEMA Type 1 Enclosures



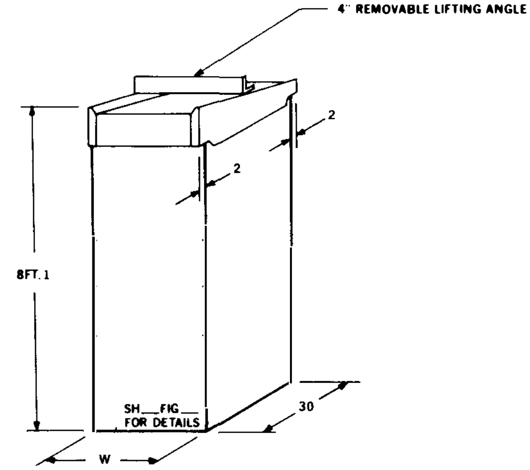
600-ampere drawout load-break switch

OUTLINE DRAWING NOTES

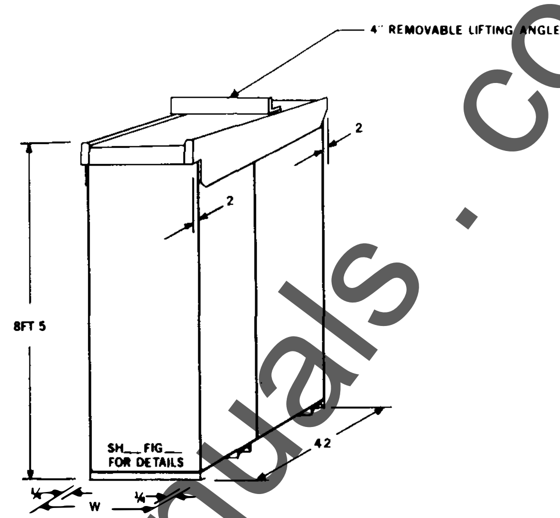
B — INCOMING POWER TERMINAL CONNECTION (IF NO BUS ORDERED)
B1 — AC POWER BUS (IF ORDERED)
C — CONTROL-LEAD TERMINAL BOARD
E — GROUND-BUS TERMINAL CONNECTION (IF ORDERED)
G — SPACE REQUIRED TO OPEN DOORS 90 DEGREES
H — AISLE FOR SWITCH REMOVAL
J — MOUNTING HOLES FOR ½-INCH DIAMETER ANCHOR BOLTS
K — SPACE AVAILABLE FOR INCOMING CONDUIT
M — RECOMMENDED POSITION FOR INCOMING MOTOR CONDUIT
N — RECOMMENDED POSITION FOR INCOMING CONTROL CONDUIT
P RECOMMENDED POSITION FOR INCOMING CONTROL CONDUIT
Q — RECOMMENDED POSITION FOR INCOMING FEEDER CONDUIT
T — SWITCH FEEDER TERMINAL CONNECTION
U — SWITCH INCOMING POWER TERMINAL CONNECTION
* INDICATES TERMINAL LOCATION - APPROXIMATE FOR CABLE LENGTH

OUTLINE DRAWING — NEMA 3R ENCLOSURES

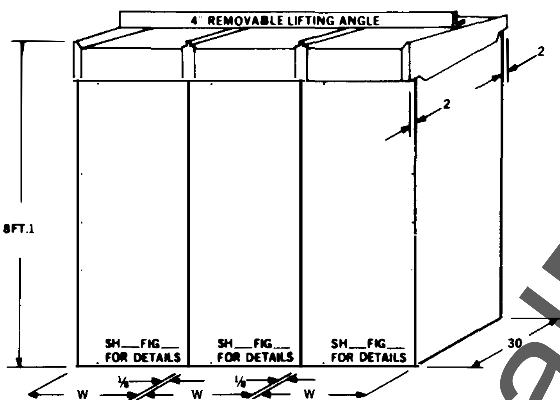
W = width of Vacuum Limitamp® Controller in NEMA 1 enclosure.
Maximum line-up width = 20 feet.



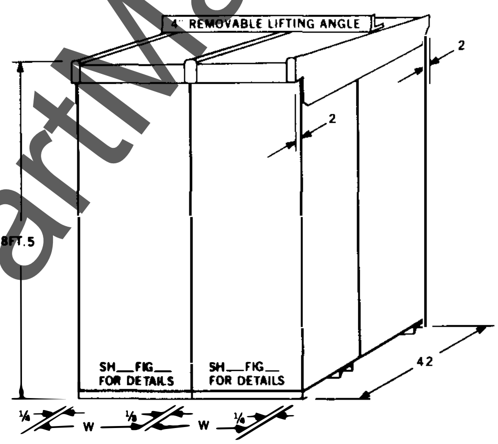
A. NEMA 3R non-walk-in enclosure for single starter 30" deep



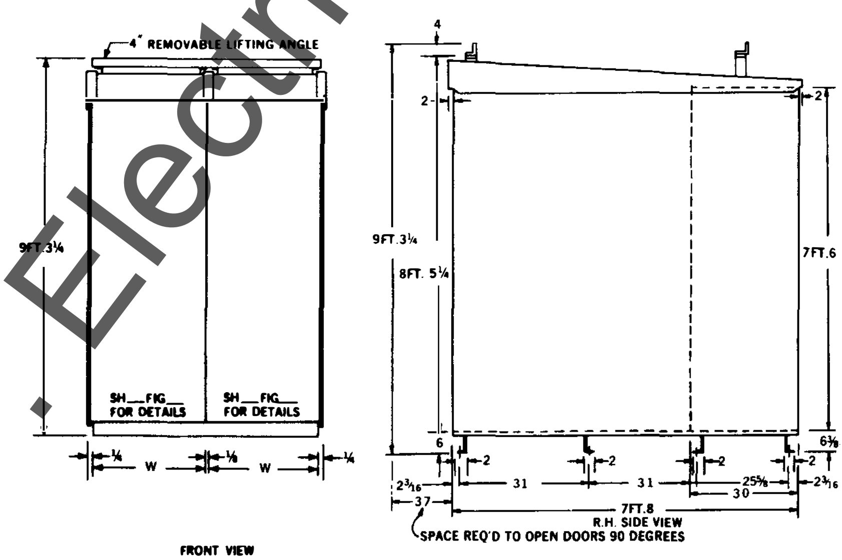
B. NEMA 3R non-walk-in enclosure 42" deep



C. NEMA 3R Non-walk-in enclosure 30" deep.



D. NEMA 3R non-walk-in enclosure 42" deep



E. NEMA 3R Walk-in enclosure

BASIC PANEL SPECIFICATIONS

This table lists the standard features and accessories that are included in basic motor controllers.

ALL STARTERS

Enclosure.............. NEMA Type 1 general-purpose, ventilated.

Connections

Incoming Line .... Entrance top or bottom. Cables separated by barrier from both low-and high-voltage compartments.

Motor Cable .... Entrance top or bottom. Cables separated by barrier from both low-and high-voltage compartments.

SQUIRREL-CAGE-MOTOR STARTERS

COMPONENTS

Full-Voltage Non-Reversing (FVNR)

High-voltage Compartment ....
- 1—Fixed mount vacuum contactor
- 1—Set of bolt-in current-limiting fuses and supports
- 1—Externally operated quick-make quick-break disconnect switch rated 400 or 800 amperes continuous. Mechanism operates in the following sequence — opens CPT secondary, disconnects from vertical bus, releases door interlock.
- 1—Three-pole vacuum contactor with 200-, 400- or 800-ampere rating.
- 1—Set of mechanical interlocks to prevent opening the disconnect when the contactor is on, prevent opening the door when the disconnect is on, to prevent closing the contactor when the disconnect is in an intermediate position and to prevent closing of the disconnect when the high-voltage door is open.
- 1—Control Power Transformer (CPT) with 120-volt secondary.
- 3—Current transformers.
- 3—Terminals for motor cable connections.
- 1—Contactor control module (CCM) to provide point-on-wave tip opening, coil current regulation and anti-kiss function.
- 1—Anti-single-phase trip bar and visable blown-fuse indicator.

Low-voltage Compartment ....
- 1—Three-pole, ambient-compensated thermal overload relay, hand-reset.
- X—Instantaneous undervoltage protection.
- 1—Control-circuit fuse.

On Door ....
- 1—START-STOP pushbutton, oil-tight, flush-mounted.

Full-Voltage Reversing (FVR) — *Same as for full-voltage nonreversing with addition of following:*

High-voltage Compartment ....
- 1—Three-pole vacuum contactor for reversing

On Door ....
- 1—FORWARD-REVERSE-STOP pushbutton, oil-tight, flush-mounted (replacing START-STOP pushbutton).

Reduced-voltage Non-Reversing (RVNR) (Primary Reactor) — *Same as for full-voltage nonreversing with addition of following:*

High-voltage Compartment ....
- 1—Three-pole vacuum contactor used as a RUN contactor

Aux Enclosure (1 High) ....
- 1—Reduced-voltage starting reactor with taps for 50-, 65- and 80-percent line voltage.

Low-voltage Compartment ....
- 1—Definite time transfer relay.

WOUND-ROTOR-MOTOR STARTERS

Non-reversing — *Same as Squirrel-cage FVNR with addition of following:*

Secondary Enclosure ....
- 1—Set of intermediate accelerating contactors.
- 1—Final accelerating contactor
- 1—Set of definite-time accelerating relays.

Resistor Enclosure ....
- 1—Set of starting-duty resistors, NEMA Class 135.

Reversing — *Same as for nonreversing with addition of following:*

High-voltage Compartment .... Three-pole vacuum contactor used for reversing.

On door...................
- 1—FORWARD-REVERSE-STOP pushbutton, oil-tight, flush-mounted (replacing START-STOP pushbutton).

BRUSH-TYPE SYNCHRONOUS-MOTOR STARTERS

COMPONENTS

Full-voltage Non-reversing (FVNR) — *Same as squirrel-cage FVNR with addition of following:*

Low-voltage Compartment .... Field application and discharge contactor.

On door..................
- 1—CR192 μSPM solid-state synchronizing device for precision-angle field application, load-angle field removal and squirrel-cage protection with built-in digital power factor and line ammeter.
- 1—Line amps display-digital readout. Part of CR192 module.
- 1—Field amps display-digital readout. Part of CR192 module.

On Top ....
- 1—Field starting and discharge resistor.

Reduced-voltage Non-reversing (RVNR) — *Same as for full-voltage nonreversing with addition of following:*

High-voltage Compartment ....
- 1—Three-pole vacuum contactor used as a RUN contactor
- 1—Reduced-voltage starting reactor with taps for 50-, 65- and 80-percent line voltage.

Low-voltage Compartment ....
- 1—Definite-time transfer relay.

BRUSHLESS, SYNCHRONOUS-MOTOR STARTERS

Full-voltage Non-reversing (FVNR) — *Same as squirrel-cage FVNR with the addition of following:*

Low-voltage Compartment ....
- 1—Brushless exciter field rheostat

On door..................
- 1—CR192 μSPM solid-state synchronizing device for precision time-delay field application, load-angle field removal and squirrel-cage protection with built-in digital power factor and line ammeter.
- 1—Line amps display-digital readout. Part of CR192 module.
- 1—Field amps display-digital readout. Part of CR192 module.
- 1—Brushless exciter field rheostat.

Reduced-voltage Non-reversing (RVNR) — *Same as for full-voltage nonreversing with addition of following:*

High-voltage Compartment .... Three-pole vacuum contactor used as a RUN contactor.

Auxiliary Enclosure ....
- 1—Reduced-voltage starting reactor with taps for 50-, 65- and 80-percent line voltage.

Low-voltage Compartment ....
- 1—Definite-time transfer relay

Vacuum Limitamp Control
2.4 to 7.2-kV

GENERAL

Fill in	These specifications cover NEMA Class E2 high-voltage control for ________ volts, ________ phase, ________ Hertz motors as follows:
	Controller No. 1
Cross out one in each group	(*Full voltage*) (*reduced voltage*) (*non-reversing*) (*reversing*) controller
Cross out all but one	for (*squirrel-cage induction*) (*wound-rotor induction*) (*synchronous*) (*brush-type synchronous*) (*brushless synchronous*) motor
Fill in	rated ________ horsepower.
	Controller No. 2, etc. (*described as above*)

ALL CONTROLLERS

Select one depending on voltage (*200-, 400- ampere contactor*)	Controller(*s*) shall be fused type employing current-limiting power fuses that give the controller an interrupting rating of (*200 mVA, 3-phase symmetrical at 2400 volts, 50/60 Hz*) (*350 mVA, 3-phase symmetrical at 4200 volts, 50/60 Hz*) (*400 mVA, 3-phase symmetrical at 4800 volts, 50/60 Hz*) (*600 mVA, 3-phase symmetrical at 7200 volts, 50/60 Hz*).
Select one depending on contactor rating (*200-, 400-ampere contactor*)	Starter(*s*) shall employ magnetically held vacuum contactor(*s*) rated (*200 amperes at 3600 volts maximum with an interrupting rating of 37 mVA, 3-phase symmetrical*) (*400 amperes at 7200 volts maximum with an interrupting rating of 75 mVA, 3-phase symmetrical*). Contactor(*s*) shall be equipped with point-on-wave contact tip opening control to reduce the possibility of voltage transients due to restrike.
Select one depending on voltage (*800-ampere contactor*)	Controller(*s*) shall be fused type employing current-limiting power fuses that give the controller an interrupting capacity of (*200 mVA, 3-phase symmetrical at 2400 volts, 50/60 Hz*) (*350 mVA, 3-phase symmetrical at 4200 volts, 50/60 Hz*) (*400 mVA, 3-phase symmetrical at 4800 volts, 50/60 Hz*).
	Starter(*s*) shall employ magnetically held vacuum contactor(*s*) rated 800 amperes, 5000 volts and have an interrupting capacity of 75 mVA, 3-phase symmetrical. Contactor(*s*) shall be equipped with point-on-wave contact tip opening control to reduce the possibility of voltage transients due to restrike.
Select one and fill in type of enclosure	Controller(*s*) shall be (*in a one-high line-up of NEMA ________ enclosures with 3-phase [1200] [2400] ampere horizontal ac power bus*) (*in free-standing one-high individual NEMA ________ enclosure(s) with provisions for terminating incoming cable*) (*in two-high NEMA ________ enclosure(s)* equipped with [1200] [2400] ampere horizontal ac power bus*).

*Vacuum Limitamp 800 control and 400-7200-volt control is only available in one-high construction.

The power bus shall be braced for 80 kA RMS asymmetrical or 50 kA RMS symmetrical.

For safety to personnel, enclosure(s) shall be compartmented into low-voltage control compartment with separate door, high-voltage compartment with separate interlocked door, ac bus compartment with protective barriers and cable entrance compartment.

Each controller shall contain protection against single-phasing due to a blown fuse and shall have a blown fuse indicator on the front panel.

Contactor(s) shall be fixed mounted to eliminate stab-in type connections and the coil shall be removable without removing the contactor from its mounts. The vacuum interrupter wear checks shall not require removal of the contactor.

The controller shall be isolated by a quick-make quick-break isolator switch operated by an externally mounted operating handle. The isolating device shall disconnect the secondary of the control power transformer before opening the main circuit contacts.

Mechanical interlocks shall be provided to prevent:

1. Closing the interrupter with the high-voltage door open.
2. Operating of the isolator while under load.
3. Opening of the high-voltage door when isolator is on.
4. Operation of the contactor when the isolator is in an intermediate position.

NOTE: For overload protection, one three-pole ambient-compensated thermal-overload relay, manual reset, shall be included.

Controllers rated 200 amperes at 3600 volts shall be rated 45 kV Basic Impulse Level (BIL).

Controllers rated 400 and 800 amperes up to 7.2 kV shall be rated 60 kV Basic Impulse Level (BIL).

OPTIONS

Select one if required

(*Solid-state relay protection*) (*latched contactors*).

Control for wound-rotor induction motors

Secondary control shall be fully magnetic. It shall provide automatic acceleration through ___________ starting steps with uniform torque peaks using a NEMA Class ___________ resistor.

Fill in only if regulating duty is required

The control shall provide for continuous speed regulation with ___________ points of speed reduction with a maximum reduction of ___________ percent from full-load speed at ___________ percent full load torque.

Control for synchronous motors

Dc field control for synchronous motors shall consist of one General Electric CR192 starting and protection module equipped with digital displays for power factor, field current and line current, one field starting and discharge resistor and one magnetic field contactor. Operation must be fully automatic.

Select one if required

Static field supplies shall be (*tapped transformer diode*) (*adjustable SCR type*) (*adjustable SCR type with power-factor regulation*).

Additional Functions

Control power at 120 volts shall be provided from a control power transformer in each controller. The transformer shall be protected by current-limiting fuses.

Controller(s) shall provide instantaneous undervoltage protection when momentary contact pushbutton is used, undervoltage release when maintained contact pushbutton is used. (*Pushbutton*) (*switch*) to be (*mounted on door*) (*remotely located*).

Finish

Select finish

Finish shall be (*ASA-61 gray over rust-resistant phosphate undercoat for indoor use*) (*ASA-61 gray over one or more rust-resistant undercoats for outdoor use*).

5-kV Limitamp Load-break Switches

GENERAL

These specifications cover 5-kV load-break switches designed to comply with the performance requirements of ANSI C37.32. They shall be manually operated, triple-pole, single-throw disconnecting type with an integral interrupter and stored-energy spring. The operating handle must be externally operated.

Switches shall be designed to comply with the ratings listed below.

Type	600-ampere Drawout Switch (Fused)	600-ampere Stationary Switch (Fused or Unfused)	1200-ampere Stationary Switch (Fused or Unfused)
Voltage rating	5000-volt maximum	5000-volt maximum	5000-volt maximum
Unfused rating			
Vented enclosure	N/A	600 amperes	1200 amperes
Non-vented enclosure	N/A	540 amperes	1020 amperes
Fused rating			
Vented enclosure	600 amperes	600 amperes	960 amperes
Non-vented enclosure	540 amperes	540 amperes	840 amperes
Make/Break rating	600 amperes	600 amperes	1200 amperes
Fault-closing rating			
Fused	61,000 amperes	61,000 amperes	61,000 amperes
Unfused	N/A	61,000 amperes	61,000 amperes
Momentary rating			
Unfused	N/A	61,000 amperes	61,000 amperes
Basic Impulse Level (BIL)	60 kV	60 kV	60 kV
Short-circuit interrupting capacity (Fused)			
2400 volts	200 mVA (Sym)	200 mVA (Sym)	200 mVA (Sym)
4800 volts	400 mVA (Sym)	400 mVA (Sym)	400 mVA (Sym)

N/A = Not Applicable.

Drawout switches shall be designed for stab connection at the line and load terminals and shall be dead-front construction. They shall be rated 600 amperes and fused with the proper size fuses mounted on the switch. Mechanical interlocks shall be provided to prevent withdrawal or insertion of the switches unless the blades are open. Also provide a shutter assembly which completely isolates the bus when the switch is withdrawn. Construction may be either 1-high or 2-high.

Stationary switches may be rated 600 or 1200 amperes depending upon the application. They shall be mounted in one-high construction only. Provide interlocks to prevent operation of the switch unless the door is closed and to prevent the door from being opened when the switch is closed. The switches may be fused or unfused. If supplied as an unfused switch, an upstream circuit breaker with instantaneous trips must be available to coordinate with switch capabilities or the switch must be supplied with key lock capabilities for all the Limitamp starters in the lineup.

Fuses for switches shall be silver-sand current-limiting, bolt-on type.

Drawout switches shall be applied as feeders only. Stationary switches may be applied as an incoming line or feeder switches.

All switches shall have a viewing window to see the condition and position of the switch blades and to see the blown-fuse indicator.

Ac power bus, if required, shall be supplied and mounted within the 90-inch-high enclosure when switch is in a lineup.

Switches shall comply with the dimensions and cable space listed below.

Type	600-ampere Drawout Switch (Fused)	600-ampere Stationary Switch (Fused or Unfused)	1200-ampere Stationary Switch (Fused or Unfused)
DIMENSIONS			
	Dimensions in Inches (H x W x D)	Dimensions in Inches (H x W x D)	Dimensions in Inches (H x W x D)
1-high construction	90 x 34 x 30	90 x 38 x 30	90 x 38 x 30
1-high construction (Option)	90 x 42 x 30	N/A	N/A
2-high construction	90 x 44 x 30	N/A	N/A
CABLE SPACE			
Incoming 38-inch-wide-case	N/A	2-500 MCM per phase without stress cones	2-500 MCM per phase without stress cones
Outgoing 38-inch-wide case	N/A	2-500 MCM per phase with or without stress cones	2-500 MCM per phase with or without stress cones
Incoming (Far bus only) 34-inch-wide case	2-500 MCM per phase without stress cones 1-500 MCM per phase with stress cones	N/A	N/A
42-inch-wide case	2-750 MCM per phase with or without stress cones	N/A	N/A
44-inch-wide case	1-500 MCM per phase with or without stress cones	N/A	N/A
Outgoing 34-inch-wide case	1-500 MCM per phase with or without stress cones	N/A	N/A
42-inch-wide case	2-750 MCM per phase with or without stress cones	N/A	N/A
44-inch-wide case	1-300 MCM per phase with or without stress cones	N/A	N/A

N/A = Not Applicable.

SWITCH #1

Fill in The load-break switch shall be rated volts, phase, Hertz, amperes.

Select one combination Switch shall be *(fused, drawout), (unfused, stationary), (fused, stationary)* construction .

The fuse rating shall be *(10-), (25-), (100-), (200-), (400-), (630-), (690-)* amperes.

Select one (if fused)① The switch shall be used as *(a feeder), (an incoming line)* switch.

Select one ② The switch shall be provided in *(1-high construction 34 inches wide③), (1-high construction 42 inches wide③), (2-high construction 44 inches wide③), (1-high construction 38 inches wide④).*

Select one

Select one Ac power bus shall be rated *(1000 amperes) (2000 amperes).*

Select one Ac power bus shall be *(tin-plated aluminum), (tin-plated copper), (silver-plated copper), (copper).*

Finish

Select one Finish shall be *(ASA-61 gray over rust-resistant phosphate undercoat for indoor use), (ASA-61 gray over one or more rust-resistant undercoats for outdoor use).*

Comments

① Maximum fuse rating for 600-ampere switch is 630 amperes.
② Drawout switch applied as feeder only. Stationary switch may be applied as feeder or incoming line switch.
③ Drawout switch only.
④ Stationary switch only.

SWITCH #2

(Describe as above)

REFERENCES

Publication	Title
GEA-11527	Vacuum Limitamp® High Voltage Control
GEH-4268	Load-break Switches
GEH-5201	Synchronous Motor Control
GEH-5305	CR194 Vacuum Limitamp Controllers
GEH-5306	CR193 High-voltage Vacuum Contactors
GES-5000	Time-current Characteristic Curves
GET-6840	Vacuum Limitamp Control
GET-6841	Vacuum Limitamp Contactors

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

General Electric Company
General Purpose
Control Department
P.O. Box 489
Mebane, N.C. 27302

Outside the U.S. and Canada write General Electric Company, International Trading Operations, 570 Lexington Avenue, Room 301, New York, N.Y. 10022, U.S.A.

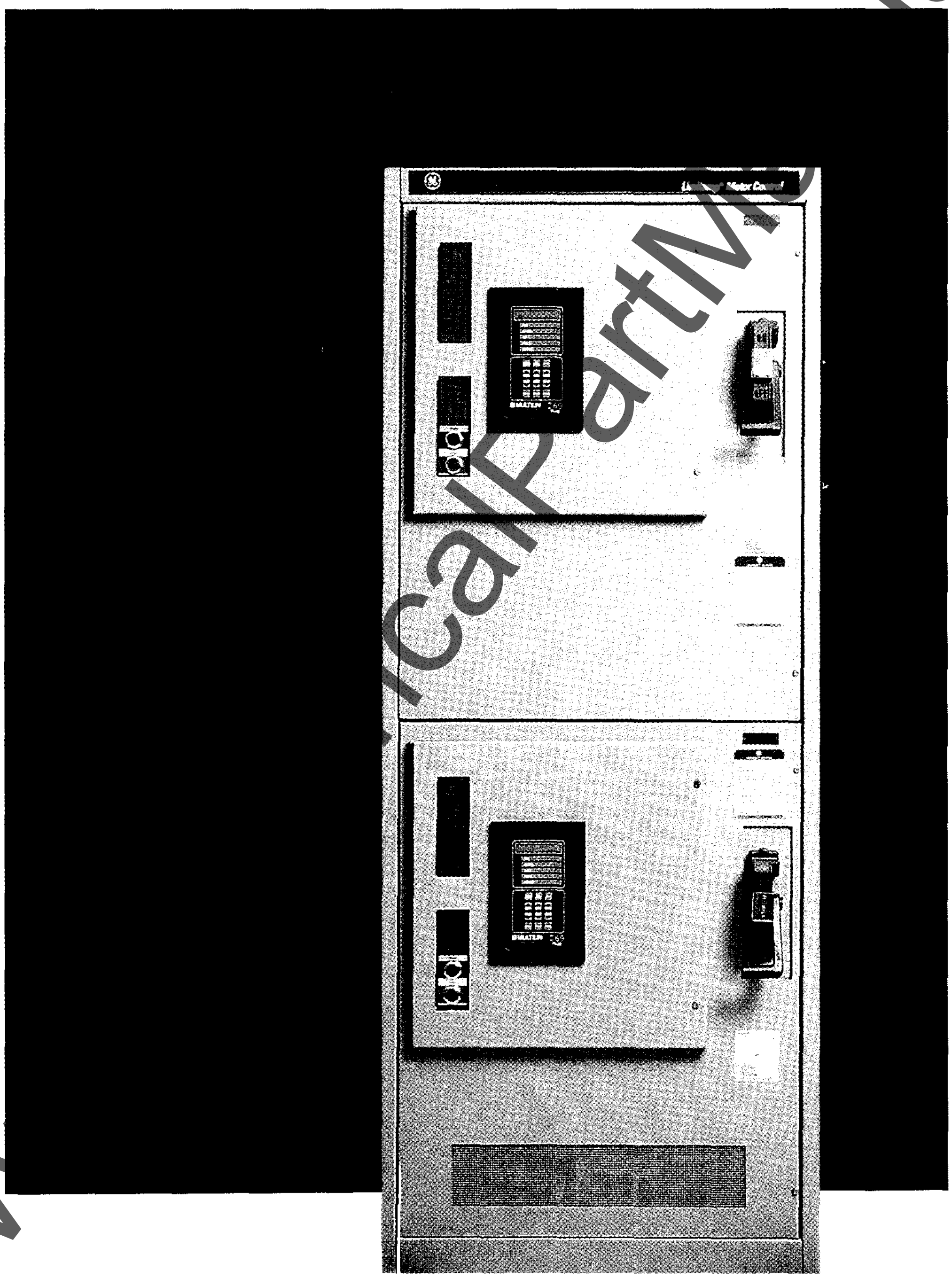
GENERAL ELECTRIC

GET-6840 3/85 (10M)

Limitamp® Medium Voltage Motor Control

2400-7200 Volts

Application and Selection Guide



Contents

The General Electric Limitamp motor control center provides an economical means of centralizing motor starters and related control equipment. It permits motor control starters, feeders, isolator switches, distribution transformers, interlocking relays, programmable control, metering and other miscellaneous devices to be obtained in a single floor-mounted structural assembly fed from a common enclosed main bus.

Limitamp motor control centers are constructed of standardized heavy gauge vertical sections housing vertical and horizontal buses and compartmented starters. Sections are bolted together to form a single line-up assembly. The entire center may be powered by incoming line connection at a single point. When possible, Limitamp motor control centers bear UL section and unit labels.

A

COMPARISON OF CONTROLLER TYPES

FULL VOLTAGE

The Limitamp Control across-the-line (FVNR) controller is the most popular type of controller. In general, high-voltage systems have fewer power restrictions than low-voltage systems; therefore, full-voltage controllers may be applied to a greater number of applications. Full-voltage controllers provide lowest cost, simplicity, minimum maintenance and highest starting torque.

REDUCED VOLTAGE

Primary reactor (closed-transition) Limitamp controllers are the most popular of the reduced-voltage type starters because they provide a simple, low-cost means of obtaining reduced-voltage starts. The starting time is easily adjustable in the field.

Limitamp closed-transition auto-transformer controllers provide higher starting torque efficiency and a more favorable power factor during starting than a primary reactor starter. The transition time can be easily adjusted in the field. NEMA medium-duty reactors and autotransformers with 50-, 65- and 80-percent taps are provided as standard.

REDUCED INRUSH

Limitamp wye (star)-delta (closed-transition) starters provide a means of reducing the starting inrush where the starting duty is not limited by the controller. This type of controller can be used where extremely long acceleration times are required. Wye-delta starters have a very high torque efficiency. This starter is applicable only to six lead motors and no field correction is possible for starting characteristics. See Table A.2.

TRANSFORMER FEEDERS

Limitamp controllers are generally considered motor starting equipment; however, they are not strictly limited to motors and can provide very good protection for loads such as transformers.

Transformers that can be controlled by Limitamp controllers must have a primary rated in the 2400- to 7200-volt range.

To adequately protect a transformer, it is necessary to define specific protection requirements. The following areas will be considered:

1. Transformer winding fault (primary and secondary)
2. Single-phasing, resulting in a phenomenon known as "ferroresonance"
3. Transformer overload

These functions are basic only and are not intended to be comprehensive. Ground fault, differential, fault pressure, undervoltage, etc., are often required and may also be added to a given control. In addition, a transformer controller must allow for transformer inrush current and not cause a nuisance trip-out from a momentary line-voltage dip.

Transformers must be protected from primary and secondary (winding or downstream) faults. In Limitamp controllers, current-limiting fuses are applied to protect the transformer from a primary winding fault, as well as faults in the conductors from the controller to the transformer. The fuses are selected to clear high-magnitude fault currents at the first fault half-cycle and allow the contactor to energize a transformer without operating on inrush currents. (Inrush currents occur when transformer is energized, typically 8-12 times rated amperes for 0.1 seconds). GE Type EJ-2 current-limiting fuses may be applied when used with an overcurrent relay that is chosen to coordinate with the EJ-2 fuse and protect the transformer from damage as a result of a fault in its secondary circuit.

PROTECTION

To determine a basis for protection, refer to ANSI transformer short-circuit ratings, which define the magnitude and duration of downstream faults that a transformer can withstand without damage. A relay would have to be set to operate before the damage point is reached. Base ratings, impedance and the connection of the primary and secondary windings of the transformer must be supplied in order to arrive at the relay setting. The relay for this purpose can be an electronic overload relay.

A common problem with single-phased transformers is a phenomenon known as ferroresonance, which can occur when an unloaded or lightly loaded transformer sustains an open conductor in its primary circuit. Ferroresonance causes system overvoltage as a result of the transformer core inductance forming a "tuned" circuit with the system distributed capacitance. To avoid ferroresonance, all three lines must be switched simultaneously as with a medium-voltage contactor. However, if one line fuse blows, then single-phasing will occur. To prevent this, the medium-voltage contactor may be supplied with a contactor tripping mechanism that operates from a striker pin located in the fuse. When the fuse element burns in two, the spring-loaded striker pin is released. It projects upward and operates a contact that trips the contactor. This feature, known as blown fuse trip, would provide positive transformer protection from single-phasing due to blown fuses.

Transformer feeders typically are applied on critical process applications where it is important to maintain continuity of operation through a system voltage disturbance. Mechanically latched contactors allow the contactor to remain closed during a disturbance. Like circuit breakers, latched contactors are opened either manually or by means of a shunt trip solenoid.

CAPACITOR FEEDERS

Limitamp 400 amp contactors are ideally suited for capacitor switching applications. (Note: 800 Amp is not rated for capacitor switching.)

Capacitors may be switched with the motor, but maximum rating for this function must be determined by motor design.

When the capacitors are provided in Limitamp control, they are normally mounted in an auxiliary enclosure beside the Limitamp controller. A capacitor rated up to 200 KVAR can be mounted in the top of a two-high CR194 enclosure with the controller in the bottom. (See Table B.7 for capacitor switching capacities.)

FUTURE STARTERS

Future squirrel-cage, full-voltage non-reversing starters can be installed in two-high and three-high construction only when factory-prepared space has been purchased with the original Limitamp equipment.

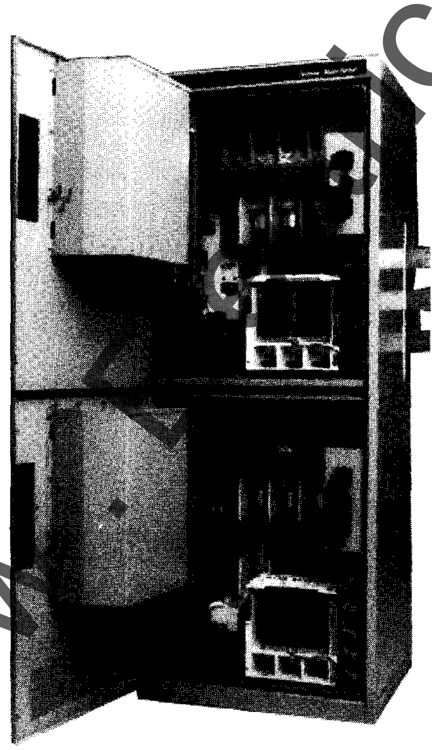


Figure A.1 Medium Voltage Compartments in CR194 two-high design

The purchase of factory-prepared space provides a space unit equipped with vertical power bus, complete interlocking and isolating mechanisms, operating handle and high-voltage door. It does not include electrical components.

When parts are purchased to fill a future starter, these consist of a contactor, power fuses, control power transformer, CPT fuses and fuse supports, current transformers, and low-voltage panel and devices.

Table A.2 Comparison of Starting Characteristics

Starter	Starting Characteristics Expressed in Percent Rated Value				
Type	**Voltage of Motor**	**Motor Current**	**Line Current**	**Torque**	**Torque Efficiency**
Full Voltage	100	100	100	100	100
Autotransformer					
80 percent tap	80	80	64 ①	64	100
65 percent tap	65	65	42 ①	42	100
50 percent tap	50	50	25 ①	25	100
Primary-Reactor					
80 percent tap	80	80	80	64	80
65 percent tap	65	65	65	42	65
50 percent tap	50	50	50	25	50
Wye-Delta	100	33	33	33	100

① Autotransformer magnetizing current is not included in listed values. Magnetizing current is usually less than 25 percent motor full-load current.

CR194 VACUUM STATIONARY & DRAWOUT*

INTRODUCTION

CR194 Vacuum Limitamp Control is a high-interrupting-capacity, high-voltage control used throughout industry to control and protect squirrel-cage, wound-rotor and synchronous motors. It can also be used to feed transformers and other power-utilization circuits.

Typical applications are in paper, steel, cement, rubber, mining, petroleum, chemical and utility-type industries. Limitamp control is also used in water and sewage plants and public buildings for air conditioning, pumps and compressors.

FEATURES

- **Easily removable contactor** — The stationary or drawout contactors can be easily removed by loosening easily accessible bolts. Front access to the coil and tip wear checks will substantially reduce the need to remove the contactor in normal circumstances.
- **400 or 800 Ampere Contactor** — Vacuum Limitamp control meets the varying needs of industry including today's higher horsepower requirements.
- **NEMA rated** — Vacuum Limitamp control is fully rated and designed to meet the requirements of NEMA ICS 3, Part 2 Class E2 controllers.
- **UL rated** — Vacuum Limitamp control is fully rated and designed to meet the requirements of UL 347.
- **Self-contained power bus** — Vertical power bus is a standard feature of Vacuum Limitamp control. Horizontal power bus is available within the standard 90-inch height and lines up with that of previous Limitamp designs. The power bus ratings have capacity for extended lineups and larger starter requirements.
- **Installation ease** — Provision for cable runs from the top and bottom; easily accessible terminals and small overall size make installation fast and easy.
- **Proven reliability** — Vacuum Limitamp control utilizes the latest vacuum interrupter technology for long, reliable service.
- **Simplified construction** — The operating mechanisms inside Vacuum Limitamp control have been simplified for further improvements in reliability and ease of maintenance.
- **Cooler operation** — The reduced power losses of vacuum interrupters, coupled with other design improvements, provide a controller that is cooler operating to further enhance service life.
- **Quick-make quick-break non load-break disconnect** — Disconnection of the starter from the main bus is accompanied by a quick-make quick-break non load-break disconnect switch. This switch improves the overall control integrity by eliminating the need to rack out the contactor to isolate the load from the power bus.
- **Viewing window** — The switch is equipped with a viewing window for visual assurance that the disconnect contacts are open, and a full barrier for personnel safety. When the plunger on the handle is depressed, the CPT secondary is (isolated) disconnected, which drops out the contactor coil. Then, when the handle is thrown to the "off" position, the CPT primary and the high voltage compartment are isolated from line power.
- **Dependable performance** — Vacuum Limitamp control is coordinated to provide the required motor protection functions and offer reliable overcurrent protection against the damaging effects of overloads and short circuits.

INTERRUPTING RATINGS

The interrupting ratings of the controllers vary with the value of the utilization voltage. The following table depicts typical NEMA E1 (unfused) interrupting ratings for Class E1 controllers.

Table B.1 NEMA Class E1 Interrupting Ratings

Contactor Type and Rating	Interrupting Rating rms symmetrical (mVA)			
	2400 Volts	4200 Volts	5000 Volts	7200 Volts
CR193B 400 Amp	25	43	50	75
CR193D 400 Amp	25	43	50	—
CR193C 800 Amp	37	65	75	—

In addition to normal motor protective relays, NEMA Class E1 Limitamp control must include instantaneous overcurrent relays to signal the contactor to open on fault current. NEMA Class E1 Limitamp control may be employed on systems having available short-circuit currents up to the interrupting rating of the contactor.

Relaying, metering, ground fault protection and lightning arresters are typical of available modifications.

NEMA Class E2 Limitamp control incorporates the high-interrupting capacity of fast-acting fuses. These current-limiting fuses protect both the connected equipment and control against the high short-circuit current available from modern power systems. (See Table B.2.)

*Drawout available in two-high construction only

CR194 control is designed for operation on the following power systems.

Table B.2

System Distribution Voltage	Maximum Motor Hp③		Interrupting Rating (mVA) Symmetrical 3-phase 50 or 60 Hz
	Induction, Wound-rotor Synchronous (0.8 PF)	Synchronous (1.0 PF)	
CR194 400 Ampere stationary and drawout			
2400	1600①	2000①	200
4200	2800①	3500①	350
4800	3200①	4000①	400
7200	4800①	6000①	600
CR194 800 Ampere stationary			
2400	3200②	4000②	200
4200	5600②	7000②	350
4800	6400②	8000②	400

① Based on 400 amperes RMS maximum, enclosed, NEMA 1, vented one-high
② Based on 800 amperes RMS maximum, enclosed, NEMA 1, vented one-high
③ For non-vented enclosures, apply a factor of 0.8 to the maximum horsepower

There are three basic constructions available utilizing the vacuum contactor:

- CR194 two-high 400 Amp
- CR194 one-high 400 Amp
- CR194 one-high 800 Amp

CR194 TWO-HIGH 400 AMP

The two-high construction has basic dimensions of 36" wide, 90" high and 30" deep, making it the industry's smallest. An optional 40-inch-wide enclosure is also available when additional cabling space is required. Bolted rigid frame construction provides an accurate and simple building platform, giving greater structural strength and flexibility. Full top and bottom compartment isolation is provided for greater safety, and the two-high construction is UL/CSA approved.

A door-in-door construction provides roomy low-voltage compartments, which offer flexibility, safety and high density. Large low-voltage door mounting surface permits multiple relays and metering packages, including drawout relays. The interior of the low-voltage compartment features a white mounting panel, which is easily accessible and provides ample space for numerous control options.

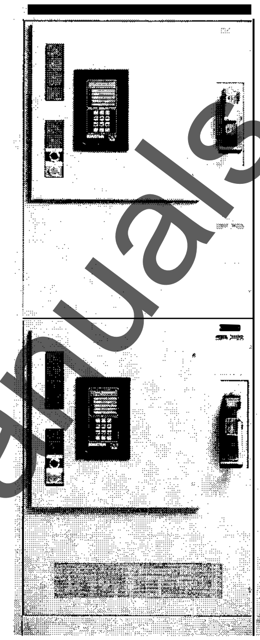


Figure B.1 CR194 two-high construction

The enclosure will accommodate outgoing cable sizes as shown in Table B.4 when both top and bottom compartments house contactors. There is also an option to use the top compartment as an incoming line section with limited cable sizes. Refer to the factory for details. Otherwise, an auxiliary section will be required.

It is not necessary to de-energize one controller to service or install the second controller. The enclosure is designed to safely permit termination of one set of motor leads while the other controller is energized.

Main horizontal power bus is available in 1000/1200 amperes and 2000 amperes. Both the main and vertical bus is epoxy-insulated and accessible from front and rear. The horizontal power bus will match with existing Limitamp lineups, including air-break units.

The current ratings are shown in Table B.3.

Table B.3 Ratings and Horsepower Limitations in CR194 Two-high

Contactor Location	Maximum Current		Horsepower			
			2400 Volts		4000-4800 Volts	
	Vented	Non-Vented	Vented	Non-Vented	Vented	Non-Vented
TOP	360	320	1600	1200	2800	2500
BOTTOM	400	320	1800	1200	3100	2500

B

Table B.4 Cable Size Limits (approximate) in CR194 Vacuum Control

Construction	With Non-shielded Cable		With Shielded Cable and Prefabricated Stress Cones		With Shielded Cable and Hand- wrapped Stress Relief	
	Per phase		Per phase		Per phase	
400-Ampere	Incoming	Load	Incoming	Load	Incoming	Load
One-high 26"-wide Case	1-500 kcmil	1-500 kcmil	1-500 kcmil	1-500 kcmil	1-500 kcmil	1-250 kcmil preferred 1-500 kcmil possible
One-high 34"-wide Case	2-500 kcmil	2-500 kcmil	2-500 kcmil	2-500 kcmil	2-500 kcmil	2-500 kcmil
Two-high 36"-wide Case	Contact Factory	1-500 kcmil	Contact Factory	1-250 kcmil preferred 1-500 kcmil possible	Contact Factory	1-#3/0 preferred 1-#4/0 possible
Two-high 40"-wide Case	Contact Factory	1-500 kcmil	Contact Factory	1-500 kcmil	Contact Factory	1-250 kcmil
800-Ampere						
One-high 48"-wide Case	2-750 kcmil	2-750 kcmil	2-750 kcmil	2-750 kcmil	2-750 kcmil	2-750 kcmil

CR194 ONE-HIGH 400-AMP

The one-high packaging (one contactor per enclosure) for the 400-ampere vacuum contactor has basic dimensions of 26 inches wide, 90 inches high, and 30 inches deep, including power bus. It is constructed from a welded enclosure to house a single vacuum contactor in the high-voltage compartment located at floor level. The entire upper compartment is available for low-voltage equipment and includes a swing-out panel for ease of component mounting and accessibility.

This enclosure will accommodate cable sizes as shown in Table B.4. Cable runs may enter from top or bottom without modification. Top or bottom cable entrance into the enclosure does not need to be specified.

The one-high design will accommodate the following combination of components:

1. One three-phase potential transformer used for metering.
2. Up to 10 kVA extra capacity CPT (34" wide only). 3 KVA max on two-high design.
3. Up to approximately 10 control relays for induction motor starters.
4. Two size S1 drawout relay cases.

A 34-inch-wide, one-high enclosure is available as an option, where more cable room or multiple cable connections are required. Power factor correction capacitors can also be supplied and will be mounted in an auxiliary enclosure.

CR194 ONE-HIGH 800-AMP

The one-high enclosure for the 800-ampere vacuum contactor has basic dimensions of 48" wide, 90" high and 30" deep in a welded frame. Maximum cable sizes are shown in Table B.4. Protected raceways isolate the motor and power leads from one another. Cable runs may enter from the top or bottom and are straight runs.

B

VACUUM CONTACTORS

The vacuum contactors supplied with Vacuum Limitamp are of the magnetically held type. They are fully rated at 400 or 800 amperes in accordance with NEMA and UL standards. The contactors differ in size, weight and method of termination. The vacuum interrupters are also different among the various models and are not interchangeable due to their different current ratings, and variations in interlock and wire harness mounting.

The contactor may be easily removed for service in each of the designs available, providing easy access for normal maintenance, such as vacuum interrupter wear checks and replacement of the operating coil, without removing the contactor. The only time the contactor needs to be removed is to replace a vacuum interrupter at the end of its service life or to adjust the vacuum interrupter for wear on the interrupter tips.

The standard contactors for industrial motor starters are closed by a single magnet and are held closed by the same magnet. This contributes to simplicity of mechanical design and increases the mechanical life of the contactor. Standard contactors may not need adjustment or mechanical repair for many years, primarily due to mechanical simplicity and sturdiness. However, preventive maintenance checks at least once per year are recommended.

Low voltage on the contactor operating coil of an electrically held contactor will cause the contactor to open. For most motor applications, it is desirable to disconnect the motor from the line when the system voltage is lost or lowered appreciably; therefore, the electrically held contactor is appropriate. The DC operating coil of the contactor is designed to be used with a holding circuit to limit coil current. The contactor coil is designed for use on 115 volts rectified AC or 125 volts DC.

For all NEMA Class E1 controllers, the contactor must be capable of interrupting the available short-circuit current. For these applications, instantaneous overcurrent relays must be used to interrupt the contactor coil current. See Table B.5 for additional technical specifications on the vacuum contactor.

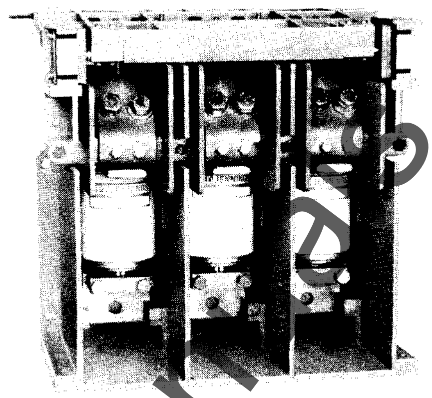


Figure B.2 400-Ampere Vacuum Contactor

LATCHED CONTACTORS

There are some applications where it is not desirable to disconnect the motor from the line during voltage depression. These applications are generally those associated with a critical drive where the continued rotation of the drive may be more important than possible damage to the motor from low voltage.

The mechanical latch maintains contactor closure under the most severe undervoltage conditions, including complete loss of voltage. Latched contactors may be specified if required by the application. The standard close and trip coils are designed for use on 120 volts rectified AC or 125 volts DC. Trip coils are also available in 24V, 48V and 220V. A manual release feature is provided as standard. Capacitor trip devices can also be used for release on the trip coils.

The Limitamp latched contactors are identical to the unlatched versions, with the exception of a small latch attachment mounted on the contactor, which slightly increases the depth of the contactor.

Latched contactors are interchangeable mechanically with the standard non-latched versions, both from latched to non-latched, and vice versa. However, in each case, it is necessary to change the wiring in the control circuit to the contactor coil or coils and to change the enclosure door to accommodate the manual latch release knob.

B

APPLICATION NOTES — VACUUM CONTACTORS

Switching Transients and Vacuum Contactors

Voltage transients when transmitted downstream can be harmful to motor insulation systems. The transients occur in most electrical systems and are usually due to switching surges or lightning strikes. Vacuum contactor switching is only one source of voltage transients. For these reasons GE recommends that customers install surge capacitors and arresters at the motor terminals for vacuum as well as airbreak contactor applications. The surge capacitors reduce the steepness of the voltage transient wavefront, thus reducing the stress on the motor insulation.

Vacuum contactors have proven their suitability as a reliable and safe means of controlling motors, transformers, and capacitor loads. This has been demonstrated by a very good track record over a period of more than 10 years in Vacuum Limitamp equipment and much longer in GE Power-Vac switchgear equipment.

Also, an independent EPRI study, investigating the reliability of vacuum switching devices a number of years ago, concluded "... motors switched by vacuum devices had failure rates which are no higher than those for motors switched by air or air-magnetic devices."

Chopping Transients in Vacuum Limitamp

The vacuum switching device is among the best switching device available because it most frequently interrupts load currents in an "ideal" fashion — that is, when the load current is at a current zero. However, there is a probability that some switching operations may produce voltage transients due to chopping. Chopping is a phenomenon that occasionally occurs as the current through a contactor pole is interrupted during a contactor opening operation.

To understand the nature of chopping, a little understanding of what occurs as a vacuum contactor interrupts current is necessary. When the operating coil of a vacuum contactor is de-energized, kick-out springs in the contactor cause the armature to open and force the vacuum interrupter tips to part. Any current that is flowing through the tips at the instant of parting continues to arc across the open tips. This arcing continues until the sinusoidally varying current approaches zero. As the polarity reverses across the open tips, current ceases to flow because all charge carriers in the arc disappear during the zero-crossing, leaving in its place a very high dielectric vacuum space. Chopping occurs just before the current zero crossing because the arc becomes unstable under the light current conditions and prematurely interrupts the current. The instantaneous level of current when this interruption occurs is called the "chop" current. The magnitude of the resulting voltage transients is the product of the "chop current" and the load surge impedance.

GE employs special metallurgy in its tip design to minimize chopping. The tip material consists of a sintered tungsten-carbide material that is impregnated with silver. The tungsten provides long life in hot arcing conditions, and the silver provides for low chop currents. In chop current tests performed on GE's 400 ampere vacuum contactors, it was found that the load surge impedance had significant effect on the average chop current. For example, tests with a surge impedance of 1000 ohms yielded average chop currents of 1.2 amperes but only 0.28 amperes with 4500 ohms surge impedance. These levels of chop currents cause little concern for motor insulation systems.

If motors are expected to be "jogged" or frequently switched-off while accelerating up to speed, surge suppressing devices discussed earlier should be seriously considered to minimize the effects of long term motor winding insulation degradation due to multiple re-ignition transients that can occur while interrupting motor inrush currents. Multiple re-ignitions are surges of arcing current across an opening vacuum interrupter tip that occur in the first few micro-seconds after the tips part. Multiple re-ignitions are virtually non-existent while interrupting normal motor running currents.

Vacuum Interrupter Integrity

The loss of interrupter integrity due to loss of vacuum is a potential concern because the vacuum interrupter ceases to act as an interrupter if vacuum is lost. Vacuum Limitamp interrupters are tested three times during the manufacturing process for vacuum integrity. Historically, this process has reliably eliminated loss of vacuum during normal product operation. To maintain integrity, annual hipot checks are recommended as part of a user's normal preventative maintenance practice. The recommended hipot test voltage is 20 kV AC RMS for the 400 ampere and 800 ampere contactors. The hipot procedures are described in equipment instructions GEH-5305.

AC vs. DC Hipot

The AC hipot is recommended for vacuum interrupters because DC hipot may indicate problems with a good interrupter. The reason for this is complex, but in essence there may be microscopic gap broaching "anomalies" across the open interrupter tips that the DC hipot cannot distinguish from real problems such as a loss of vacuum. AC hipot systems, on the other hand are able to "burn-off" these anomalies, allowing the good interrupter to recover (Normal contactor load currents will also burn-off these anomalies).

If it is desired to use a DC hipot on a vacuum contactor, it is important to recognize that the results may falsely indicate a bad bottle. Also, DC voltage levels should not be greater than 1.4 times the recommended AC RMS value in order to maintain a safe margin of voltage to X-ray emission. At 35kV small amounts of X-ray radiation may be emitted. The level of emission is well below the allowable levels established in ANSI 37.85-1972. Using DC hipot at 28 kV (1.4 x 20 kV AC RMS) does maintain a safe margin to X-ray emission.

Table B.5 Vacuum Contactor Technical Specifications

Ratings	CR193B CR193D		CR193C
Rated voltage (Volts)	5000	7200 ①	5000
Rated current (Amperes)	400		800
Short circuit interrupting current (kA) symmetrical	6.0	6.0	9.0
Class E1 mVA	50	75	75
E2 mVA 2400 volts	200		200
3600 volts	300		300
4160 volts	350		350
4800 volts	400		400
7200 volts	600 ①		—
Short-time current (amperes) 30 seconds	2400		4800
1 second	6000		12,000
Impulse withstand (kV)	60		60
Dielectric strength 1 minute (kV)	13.25	18.2	13.25
Vacuum integrity test (AC RMS)	20 kV		20 kV
Switching frequency (Operations/hour)	1200		600
Mechanical life (Operations)	2 x 10^6		1 x 10^6
Electrical life (Operations)	1 x 10^6		0.25 x 10^6
Closing time (Maximum MS)	350		270
Opening time (Maximum MS) (Switched on DC side of rectifier)	50		55
Pick-up voltage (% of rated)	85% max		85% max
Drop-out voltage (% of rated)	10 - 65%		10 - 65%
Control voltage (Volts)	115 rect. AC		115 rect. AC
Control circuit burden (VA) Closing	175		550
Hold-in	30		110
Auxiliary contacts	20 ② maximum (N.O. or N.C.)		20 maximum (N.O. or N.C.)
Ratings Current (amperes)	10		10
Voltage (volts)	600		600
Switching AC	6 amperes at 600 volts		6 amperes at 600 volts
DC	1 ampere at 240 volts		1 ampere at 240 volts
Contactor weight lb (kg)	77 (35)		114 (52)
Standards applicable	UL 347 NEMA ICS 3, Part 2		UL 347 NEMA ICS 3, Part 2

① CR193B only.

② Limited to 10 in two-high starter.

Table B.6 Contactor Dimensions in (mm)

Key	CR193B	CR193D	CR193C
A	14.88 (378)	14.88 (378)	18.90 (480)
B	13.50 (343)	13.50 (343)	16.93 (450)
C	14.65 (372)	14.65 (372)	17.52 (445)
D	10.24 (260)	10.24 (260)	12.99 (330)
E	12.99 (330)	12.99 (330)	17.00 (432)
F	8.48 (215)	8.46 (215)	11.02 (280)
G	1.18 (30)	1.18 (30)	1.38 (35)
H		1.93 (49)	

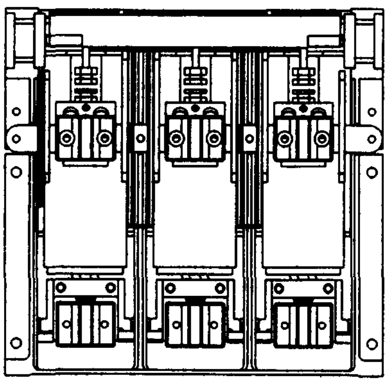


Figure B.3

TRANSFORMER & CAPACITOR FEEDERS

Table B.7 is a listing of switching capacities for both transformer and capacitor loads. A more detailed discussion of these two applications is in the Section A.

Table B.7 CR194 Vacuum Switching Capacities (One-high)

8-hour Open Rating (Amperes)	System Voltage	3-Phase Transformers (kVA)	3-Phase Capacitors (kVAr)
400	2400	1600	1200
	4160	2800	2100
	4800	3200	2400
	7200	4800	3600
800	2400	3200	N/A
	4160	5600	
	4800	6400	

WEIGHTS AND DIMENSIONS

Vacuum Limitamp control varies in weight by controller type and construction. The approximate weight for estimating purposes is included in Table B.8.

All Limitamp controllers have a common depth of 30 inches and height of 90 inches. Overall width of controllers vary according to type of controller as shown in Table B.8.

Main horizontal power bus for electrically connecting sections of Limitamp control does not add to the standard 90-inch height.

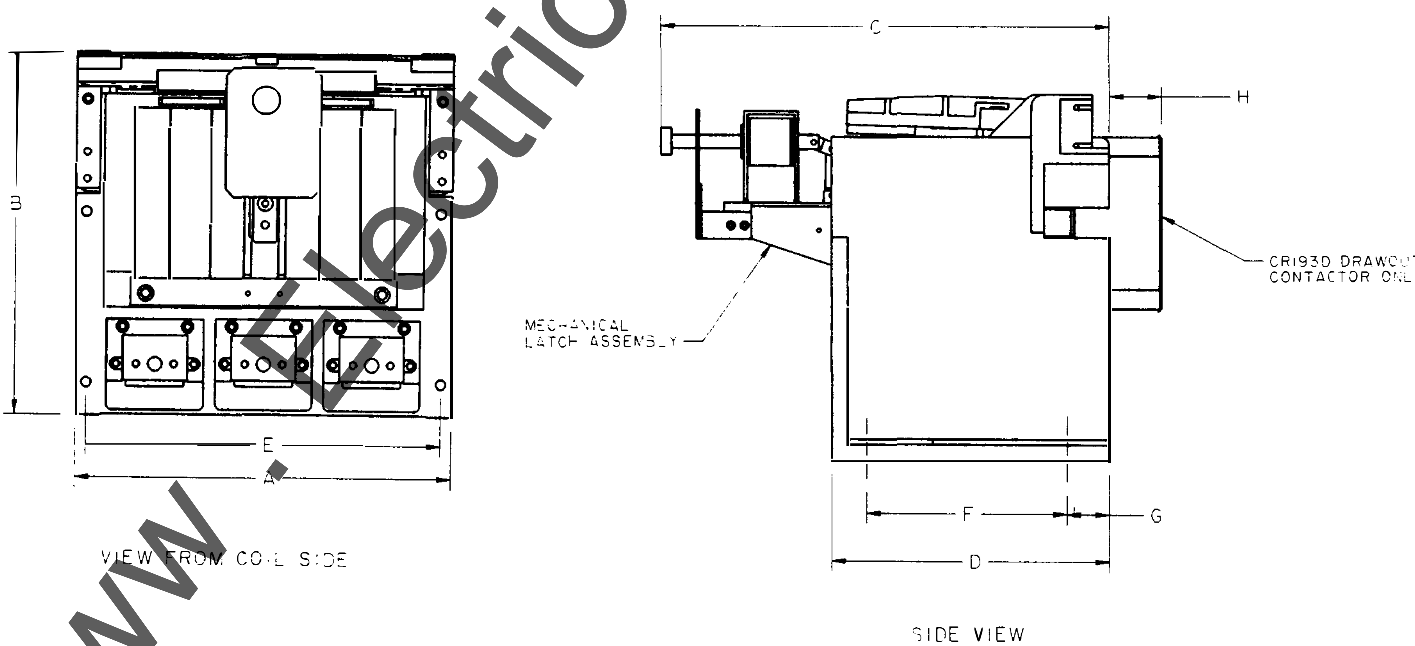


Figure B.4

B

Table B.8 Estimated Weights and Dimensions — CR194 Vacuum Controllers, NEMA 1 Vented Enclosure ①

Controller Type ② One High (One Starter)⑤	Contactor Ampere Rating ③	2400 Volts			4000-4800 Volts ④			7200 Volts		
		Max Hp 3-Phase 50/60	Approx. weight in Lbs	Width in inches ⑤ (90 high x 30 deep)	Max Hp 3-phase 50/60	Approx. weight in Lbs	Width in inches ⑤ (90 high x 30 deep)	Max Hp 3-phase 50/60	Approx. weight in Lbs	Width in inches⑥ (90 high x 30 deep)
Squirrel-Cage Induction Full-Voltage Nonreversing	400	1600	1200	26	2800	1200	26	4800	1200	34
	800	3200	1400	48	5600	1450	48	—	—	—
Squirrel-Cage Induction Full-Voltage Reversing	400	1600	1500	58	2800	1500	58			
Reduced-Voltage Nonreversing Primary Reactor Type	400	1000	2800	58	1000	2800	58			
	400	1600	4800	98	2800	4800	98			
Reduced-Voltage Nonreversing Autotransformer Type (Closed Transition)	400	1000	3000	58	1000	3000	58			
	400	1600	5000	90	2800	5000	90			
	800	3200	5200	112	5600	5200	112			
Two-Step Part-Winding Nonreversing	400	1600	1400	58	2800	1400	58			
Two-Speed One-Winding FVNR	400	1600	1600	68	2800	1600	68			
Two-Speed Two-Winding FVNR	400	1600	1400	58	2800	1600	58			
Induction/Synchronous FVNR		0.8 PF / 1.0 PF			0.8 PF / 1.0 PF			0.8 PF / 1.0 PF		
Synchronous Induction FVNR Brush Type & Brushless	400	1600 / 2000	1400	34	2500 / 3500	1400	34	4800 / 5500	1400	34
	800	3200 / 4000	2600	48	5600 / 7000	2600	48	— / —	—	—
Synchronous Motor, RVNR Primary Reactor	400	1000	3000	68	1000	3000	68			
	400	1600	5000	90	2800	5000	90			
Synchronous Motor, RVNR Autotransformer		0.8 PF / 1.0 PF			0.8 PF / 1.0 PF					
	400	1000 / 1250	3200	76	1000 / 1250	3200	76			
	400	1600 / 2000	5200	108	2800 / 3500	5200	108			
Induction/Synchronous Motor, RVNR								0.8 PF / 1.0 PF		
Neutral Reactor	400							4800 / 5500		68

① See Enclosure & Bus Ratings Section E for NEMA 3R enclosures.
② For wound-rotor motor starter consult factory.
③ Derate by 0.8 for non-vented enclosures.
④ Maximum horsepower at 4160 volts AC in one-high NEMA 1 enclosure.
⑤ Two-high Starters are available in bolted-frame construction, available only for 400 ampere, squirrel-cage FVNR applications. Dimensions are 36" wide x 90" high x 30" deep. Weight is 2000 lbs.
⑥ Dimensions shown are approximate, based on standard motor designs.

B

CR7160 AIR-BREAK DRAWOUT

INTRODUCTION

Air-break Limitamp control is high-interrupting capacity high-voltage control used throughout industry to control and protect squirrel-cage, wound-rotor and synchronous motors. It can also be used to feed transformers and other power-utilization circuits.

Typical applications are in paper, steel, cement, rubber, mining, petroleum, chemical, and utility-type industries. Limitamp control is also typically used in water and sewage plants and public buildings for air conditioning, pumps and compressors.

FEATURES

- **Drawout construction** — Contactor and power fuses form a single drawout assembly. No cables to disconnect.
- **Unique swing-open contactor design** — The contactor is compact and has unique swing-open feature, providing quick inspection and maintenance.
- **400- or 700-ampere contactor** — Limitamp control meets the varying needs of industry including today's higher horsepower requirements.
- **One-, two- or three-high selectivity** — Limitamp control is available in either one-, two- or three-high enclosures to meet the needs of the application.
- **NEMA rated** — Limitamp control is fully rated and designed to meet the requirements of NEMA ICS 3, Part 2, for E2 controllers.
- **UL rated** — Limitamp control is fully rated and designed to meet the requirements of UL 347.
- **Built-in power bus** — Vertical power bus is a standard feature of Limitamp control. Horizontal power bus is available within standard 90-inch height and lines up with that of previous designs.
- **Installation ease** — Drawout construction; straight cable runs from top or bottom. Ample room to enter enclosure makes installation fast and easy
- **Safe, simple operation** — A unique mechanical interlocking system is tied in with the ON-OFF position operating handle to provide sure and simple operation.
- **Dependable performance** — Limitamp control is coordinated to provide the required motor functions and offer reliable overcurrent protection against the damaging effects of overloads and short circuits.
- **Fast, easy maintenance** — Every component is accessible and removable from the front for simple inspection and maintenance. The drawout contactor swings open for rapid contact tip and shunt inspection and maximum access when maintenance is required.

INTERRUPTING RATINGS

Limitamp control is designed to meet NEMA ICS 3, Part 2 and UL 347 requirements with a 60-kV BIL rating. It employs fast-acting current-limiting power fuses, a drawout air-break contactor rated either 400 amperes open (360 amperes, enclosed, NEMA 1, vented, one-high enclosure) or 700 amperes open (630 amperes, enclosed, NEMA 1, vented, one-high enclosure), and ambient-compensated overload relays for complete control and protection of motors used on modern power utilization systems with high available short-circuit currents.

The 400-ampere unfused contactors have an interrupting rating of 50 mVA; the 700-ampere unfused contactor, 75 mVA.

In addition to normal motor protective relays, NEMA Class E1 Limitamp control includes instantaneous overcurrent relays to signal the contactor to open on fault current, NEMA Class E1 Limitamp control may be employed on systems having available short-circuit currents up to the interrupting rating of the contactor.

Relaying, metering, ground fault protection, and lightning arresters are typical of available modifications.

NEMA class E2 Limitamp control incorporates the high-interrupting capacity of fast-acting fuses. These current-limiting fuses protect both the connected equipment and control against the high short-circuit current available from modern power systems.

CR7160 control is designed for operation on the following power systems.

Table B.9

System Distribution Voltage	Maximum Motor HP ① Induction Wound-rotor Synchronous (0.8 PF)	Maximum Motor HP ① Synchronous (1.0 PF)	Interrupting Rating (mVA) Symmetrical 3-phase 50 or 60 Hz
CR7160 400 amp			
2400	1500①	1750①	200
4800	2500●	3000●	400
CR7160 700 amp			
2400	2500②	2750②	260
4800	4500②	5000②	520

① Based on 360 amperes maximum, enclosed, NEMA 1, vented, one-high enclosure.

② Based on 630 amperes maximum, enclosed, NEMA 1, vented, one-high enclosure.

Table B.10 Horsepower Limitations in Multi-high Construction

Induction	2400 Volts		4000-4800 Volts	
	Amperes (per starter)	Hp (per starter)	Amperes (per starter)	Hp (per starter)
Three-high				
Vented	250	1000	250	1750
Non-vented	150	625	150	1000
Two-high				
Vented	310	1250	310	2500
Non-vented	210	875	210	2000

With one common design drawout contactor, CR7160 400 amp control is available in either one-, two- or three-high construction.

CR7160 700 amp control is available in one-high construction only.

BASIC CONSTRUCTION

Limitamp starters may be stacked multi-high (two- or three-high), where horsepower rating and need for metering and relaying is limited to allow stacking. See Table B.10 for horsepower and ampere limitations in multi-high construction. Non-stack design (one-high) is normally used for synchronous-motor starters, wound-rotor starters, and squirrel-cage induction starters, which have a considerable number of extra control functions, protective relays, and/or metering. All enclosures have the same bus location and may be connected together by bus splicing plates.

CR7160 ONE-HIGH 400 AMP

The one-high packaging (one 400 amp contactor per enclosure) has basic dimensions of 34 inches wide, 90 inches high and 30 inches deep, including power bus. It is constructed to house a single drawout contactor in the high-voltage compartment located at floor level. The entire upper compartment is available for low-voltage equipment and includes a swing-out panel for ease of mounting and accessibility.

This enclosure will accommodate cable sizes as shown in Table B.11. Cable may enter from top or bottom without modification. Top or bottom cable entrance in the enclosure need not be specified.

The CR7160 400 ampere one-high design will accommodate the following combination of components:

1. Synchronous static exciter up to 9 kW.
2. Two single-phase or one three-phase potential transformers.
3. Up to 10 kVA extra capacity CPT.
4. Up to approximately 20 control relays for induction starters.
5. Up to six size S1 drawout relay cases.

Power-factor-correction capacitors can be supplied and will be normally mounted in an auxiliary enclosure.

CR7160 TWO-HIGH 400 AMP

Two-high packaging accommodates two contactors in the enclosure, with basic dimensions of 44 inches wide, 90 inches high, and 30 inches deep. It is constructed in vertical sections of two space units each. Two FVNR induction starters may be housed in a vertical section.

Cable sizes which may be accommodated in a two-high design are reduced slightly from that which may be connected in the one-high design. (Refer to Table B.11 for cable size limitations.)

The enclosure is designed to safely permit termination of one set of motor leads while the other controller is energized. The two sets of motor cables are isolated from one another. Incoming power cable raceway is also isolated. All sets of cables may be brought into the starter from the top or the bottom.

Control relay space is available in a separate compartment with its own door and barriers. Approximately three extra control relays in addition to a ground fault relay and time-delay undervoltage protection can be mounted in the low-voltage compartment. One ammeter and switch, four push buttons, and four lights can be mounted on the low-voltage door. If no extra control relays are used, a watt hour meter can be mounted on the door.

CR7160 THREE-HIGH 400 AMP

Three-high packaging (up to three FVNR starters per enclosure) sharply reduces floor space requirements. It is constructed in vertical sections of three space units each. Each space unit is capable of housing one full-voltage, nonreversing squirrel-cage motor starter. You can purchase one or two starters per vertical section and add others later in factory-prepared space units. Although the enclosure is only 44 inches wide x 90 inches high x 30 inches deep (including power bus), an isolated motor-cabling compartment and an isolated incoming power-cabling compartment is included.

All starters must be de-energized to connect motor cable to any one starter.

Cable sizes are limited for motor connection.

Each starter unit has a low-voltage control compartment with separate access door located to the left of the high-voltage compartment.

One extra control relay, time-delay undervoltage protection and the ground fault relay can be mounted in the low-voltage compartment. Two push buttons, two lights, and one ammeter and switch can be mounted on the low-voltage door.

Note: Two-high and three-high constructions require power bus.

CR7160 ONE-HIGH 700 AMP

The one-high enclosure for CR7160 700-ampere control has basic dimensions of 42 inches wide, 90 inches high and 30 inches deep. This 42-inch enclosure has sufficient space to permit termination of two (2) 750 kcmil cables per phase with stress cones for power and motor leads. (See Fig. B.4.) Protected raceways isolate the motor and power leads from one another. Cable runs may enter from the top or bottom and are straight runs.

The 42-inch wide one-high enclosure is available as an option on the CR7160 400-ampere where more cable room or multiple cable connections are required.

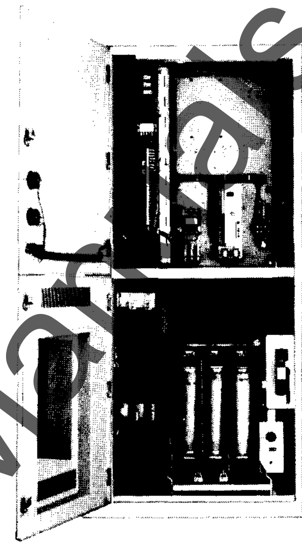


Figure B.5 CR7160 700 amp control with (2) 750 kcmil motor cables per phase, entering from bottom

Table B.11 Cable Size Limits (Approx.) in CR7160 Air-break Control

Construction	With Non-shielded Cable		With Shielded Cable and Prefabricated Stress Cones		With Shielded Cable and Hand-wrapped Stress Relief	
	Per Phase		Per Phase		Per Phase	
400-Ampere	Incoming	Load	Incoming	Load	Incoming	Load
One-high 34" wide Case	2-500 kcmil	1-500 kcmil	1-500 kcmil	1-500 kcmil	1-500 kcmil	1-250 kcmil Preferred 1-500 kcmil Possible
Two-high 44" wide Case	2-500 kcmil	1-500 kcmil	1-500 kcmil	1-250 kcmil Preferred 1-500 kcmil Possible	1-500 kcmil	1-#3/0 Preferred 1-#4/0 Possible
Three-high 44" wide Case	2-500 kcmil	1-500 kcmil	1-500 kcmil	1-#3/0 Preferred 1-250 kcmil Possible	1-500 kcmil	1-#2/0 Preferred 1-#4/0 Possible
700-Ampere						
One-high 42" wide Case ●	2-750 kcmil	2-750 kcmil	2-750 kcmil	2-750 kcmil	2-750 kcmil	2-750 kcmil

① Can be supplied as option on 400-ampere Limitamp control when more cable space is required

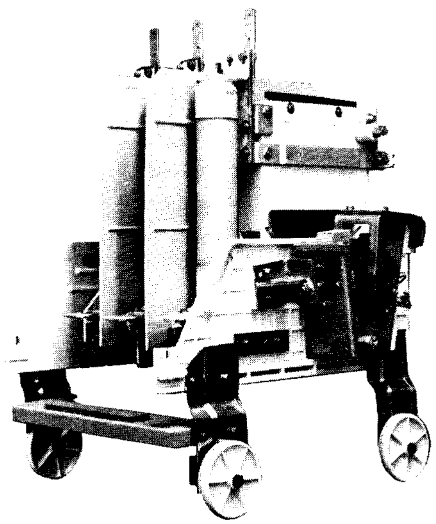


Figure B.6 CR7160 400-ampere air-break contactor is fully rated and completely roll out or drawout

DRAW OUT AIR-BREAK CONTACTORS

The air-break contactor normally furnished on Limitamp control is of the magnetically held-in type. It is drawout and fully rated at 400 or 700 amperes (eight-hour open rating) in accordance with NEMA and UL standards. Both the 400- and 700-ampere contactors have the same basic design but with current-carrying parts of different capacity. This uniquely constructed contactor can actually be swung open, exposing all integral parts for rapid inspection and maintenance. Power fuses are combined with the contactor to form a single assembly which is completely drawout without disconnecting cables.

In one-high Limitamp control, the drawout contactor, which may be rated 400 or 700 amperes, is mounted on wheels and can be easily rolled out of or into the floor-level high-voltage compartment. The contactor can be swung open after simple removal from the enclosure.

The DC operating coil of the contactor is designed to be used with a holding impedance that is inserted after the contactor is fully closed to limit coil current. The contactor coil is designed for use on 120 volts AC (rectified) or 125 volts DC control source.

Two- and three-high Limitamp control uses the 400-ampere contactor only. It is mounted on slide rails for easy removal and can be swung open within the enclosure from its drawout inspection position. Normal inspection and maintenance is done with the contactor in the enclosure. A contactor lifting table is available for contactor removal during installation.

The standard contactors for industrial motor starters are closed by a single magnet and are held closed by the same magnet. This contributes to simplicity of mechanical design and increases the mechanical life of the contactor. Mechanical latch contactors are available as an option and are explained on page B4.

See Table B.14 for additional technical specifications on the air magnetic contactors.

WEIGHTS AND DIMENSIONS

Limitamp control varies in weight by starter type and construction. The approximate weight for estimating purposes is included in the Table B.12.

All Limitamp control has a common height of 90 inches and a common depth of 30 inches. However, the overall width varies with type of Limitamp and is included in Table B.12.

For convenience in handling and installation, Limitamp control is equipped with removable lifting angles or lugs.

Power bus for electrically connecting sections of Limitamp control does not add to the standard 90-inch height.

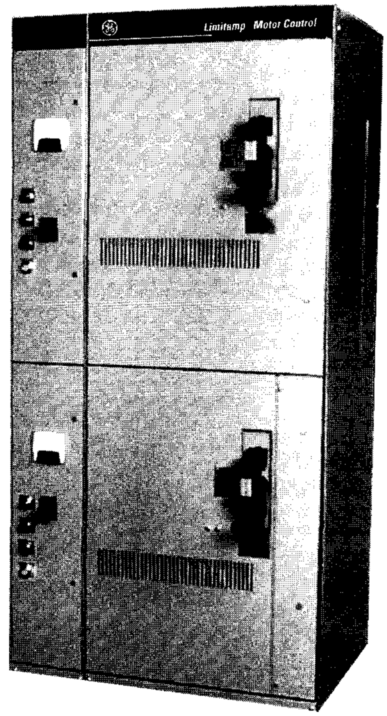


Figure B.7 CR7160 two-high construction

B

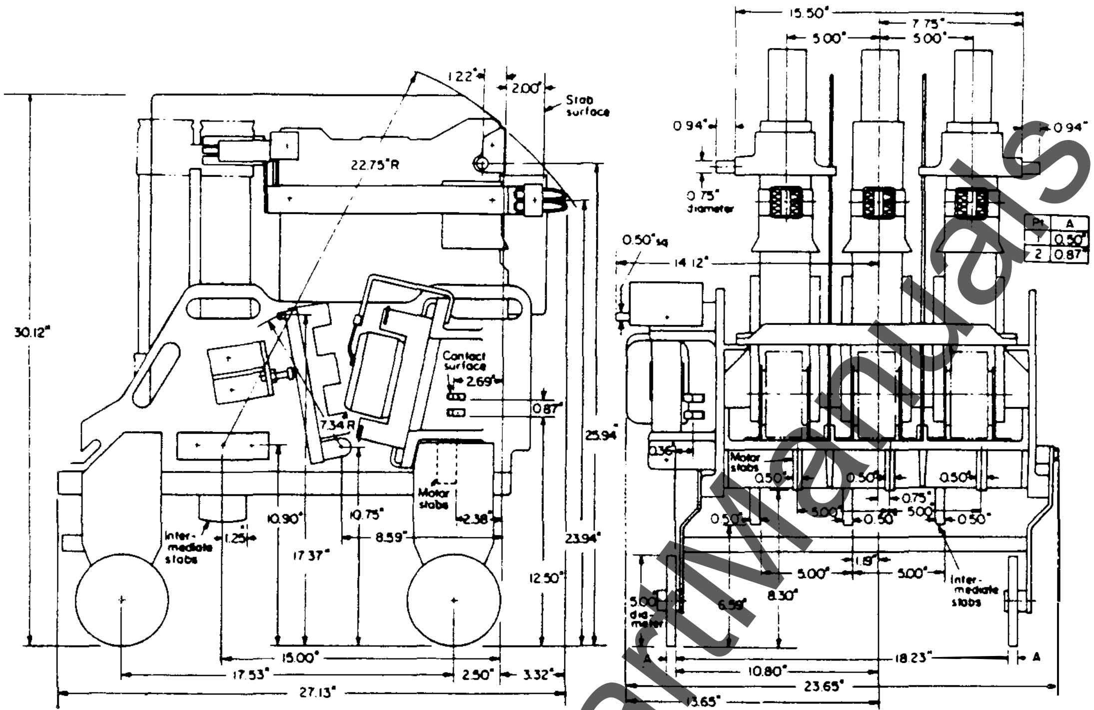


Figure B.8 Standard contactor 400 amperes, with wheels, fuse clips, and stab connections. (No fuses included). Weight 275 pounds applicable to one-high controllers

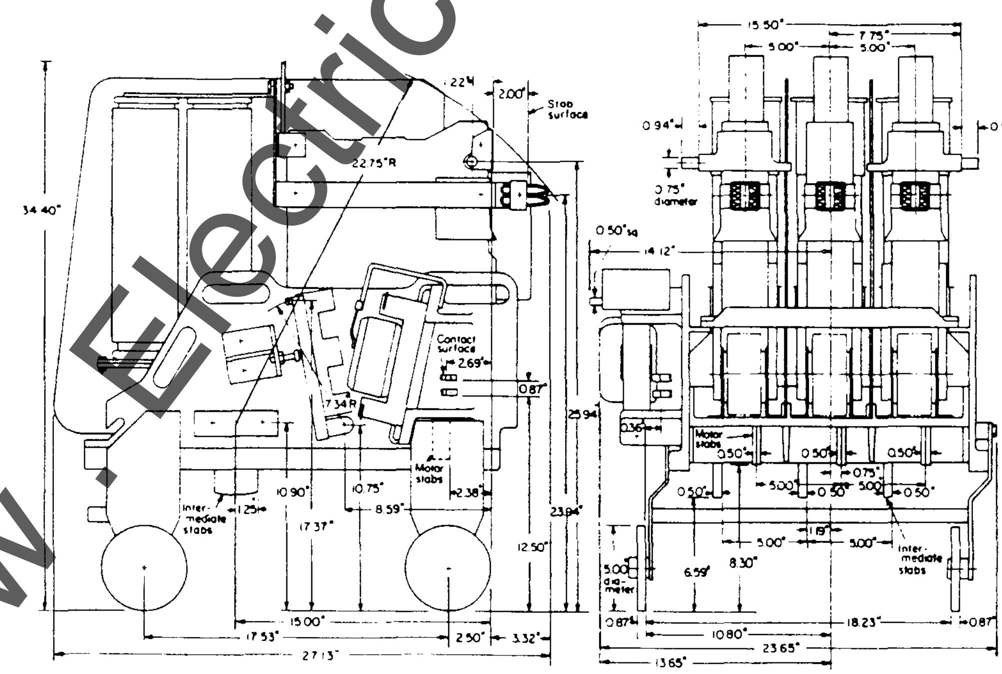


Figure B.9 700-amperes contactor with bolted fuses, stab connections and wheels. Weight 300 pounds

INTRODUCTION

IC1074 load-break switches are manually operated triple-pole, single-throw disconnecting switches with an integral interrupter and stored-energy spring that has the capability of interrupting magnetizing and load current within the ratings shown in Table C.1. They are designed and tested to comply with the performance requirements of ANSI Specification C37.57 and C37.58.

The IC1074 600-ampere drawout switch is designed for stab connection at line and load terminals. This switch must be fused. Current-limiting fuses are available up to a continuous rating of 630 amperes for installation in the switch.

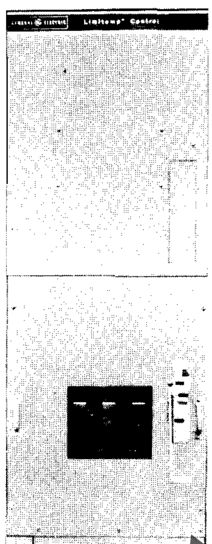


Figure C.1 600-ampere drawout load-break switch

The switch is designed to accommodate the bolt-on version of the current-limiting fuse, but clip mounting is available. Construction may be either one- or two-high, with one-high in a rollout design instead of drawout. Either two switches or a combination switch and 5kV air-break starter can be mounted in a two-high enclosure.

The IC1074 stationary switch (600- or 1200-ampere) is designed for mounting in one-high construction only. It contains line- and load-terminal pads for bolting incoming and outgoing conductors directly to the switch. It may be supplied fused or unfused. If supplied as an unfused switch, an upstream circuit breaker with instantaneous trips must be available to coordinate with switch capabilities — or the switch must be supplied with key lock capabilities — for all of the Limitamp starters in the lineup. For the 1200-ampere switch, fuses are available up to 960 amperes continuous. These large fuses must be applied as line protectors for short circuit only, relying upon branch circuits or backup overload protection by other means.

Drawout switches must be applied as feeders only. The fixed mounted switches may be used as incoming switches or feeder switches.

These switches are designed specifically for use with Limitamp control. They are available with 1000- or 2000-ampere AC main power bus within the enclosure for easy lineup with Limitamp starters.

Other features of these switches are:

- Viewing window to see condition and position of switch blades.
- Blown-fuse indicator that can be seen through view window.
- Bolted fuses available for maximum reliability.
- High reliability interruption.
- Available with key-type interlocks. Maximum of three keys per position (lock open or lock closed).
- Outside door interlocked directly to shaft to prevent opening with switch energized.
- Externally operated handle that activates spring-charged quick-make/quick-break mechanism.
- Easy inspection.
- High mechanical life.

C

Table C.1 IC1074 Load-break Switch Technical Specifications

Type	600-Ampere Drawout Switch (Fuse)	600-Ampere Stationary Switch (Fused or Unfused)	1200-Ampere Stationary Switch (Fused or Unfused)
Ratings			
Maximum nominal rating	4760 volts	4760 volts	4760 volts
Unfused rating			
Vented enclosure	N/A	600 amperes	1200 amperes
Non-vented enclosure	N/A	540 amperes	1020 amperes
Fused rating			
Vented enclosure	600 amperes	600 amperes	960 amperes
Non-vented enclosure	540 amperes	540 amperes	840 amperes
Make/Break rating	600 amperes	600 amperes	1200 amperes
Fault-closing rating (asym)			
Fused	61,000 amperes	61,000 amperes	61,000 amperes
Unfused	N/A	61,000 amperes	61,000 amperes
Momentary rating (asym)			
Unfused	N/A	61,000 amperes	61,000 amperes
Basic impulse level (BIL)	60 kV	60 kV	60 kV
Short-circuit interrupting capacity (fused)			
2400 volts	200 mVA (sym)	200 mVA (sym)	200 mVA (sym)
4800 volts	400 mVA (sym)	400 mVA (sym)	400 mVA (sym)
Dimensions			
	Dimensions in inches (W x H x D)	Dimensions in inches (W x H x D)	Dimensions in inches (W x H x D)
One-high construction	34 x 90 x 30	38 x 90 x 30	38 x 90 x 30
One-high construction (option)	42 x 90 x 30	N/A	N/A
Two-high construction	44 x 90 x 30	N/A	N/A
Cable space			
Incoming 38"-wide case	N/A	2-500 kcmil per phase with or without stress cones	2-500 kcmil per phase with or without stress cones
Outgoing 38"-wide case	N/A	2-500 kcmil per phase with or without stress cones	2-500 kcmil per phase with or without stress cones
Incoming (for bus only)			
34"-wide case	2-500 kcmil per phase without stress cones 1-500 kcmil per phase with stress cones	N/A	N/A
42"-wide case	2-750 kcmil per phase with or without stress cones	N/A	N/A
44"-wide case	1-500 kcmil per phase with or without stress cones	N/A	N/A
Outgoing			
34"-wide case	1-500 kcmil per phase with or without stress cones	N/A	N/A
42"-wide case	2-750 kcmil per phase with or without stress cones	N/A	N/A
44"-wide case	1-300 kcmil per phase with or without stress cones	N/A	N/A

CABLE-ENTRANCE COMPARTMENT

When incoming cable exceeds limits shown in the cable size limits tables, an optional cable-entrance compartment is required.

TRANSITION COMPARTMENT

Limitamp control can be close-coupled to transformers and switchgear by a transition compartment to make a continuous lineup. The transition compartment is normally 22 inches wide; however, this can vary. See Table D.1.

BUS ENTRANCE COMPARTMENT

Bus entrance compartments are required in all cases where power is fed to the controller lineup by means of bus. See Table D.1.

CABLE TERMINALS

Terminal lugs for both line and load cables are not supplied unless specified.

Clamp-type lugs or NEMA 2-hole compression-type lugs can be supplied as options.

The customer must specify the number and size cable when lugs are to be supplied by GE.

Where aluminum cable is to be used, special attention must be given to terminal selection.

HIGH-RESISTANCE GROUNDING EQUIPMENT

IC9181 high-resistance grounding equipment can be mounted in an enclosure which will match and line up with Limitamp dimensions and bus location.

For description of high-resistance grounding equipment, refer to GE publication GEP-345.

Note: Order GEP-345 from:

General Electric Company
Drive Systems Department
1501 Roanoke Blvd.
Salem, VA 24153

Table E.1 Enclosure dimensions

Type	Description	Page
NEMA 1 motor starters	**CR194 Vacuum Stationary and Drawout, Bolted Construction**	
	400A, 2-high, 36" wide	E4
	400A, 2-high, 40" wide	E5
	CR194 Vacuum Stationary, Welded Construction	
	400A, 1-high, 26" wide	E6
	400A, 1-high, 34" wide	E7
	800A, 1-high, 48" wide	E8
	CR7160 Air-break Drawout, Welded Construction	
	400A, 1-high, 34" wide	E9
	400A, 2-high, 44" wide	E10
	400A, 3-high, 44" wide	E11
	700A, 1-high, 42" wide	E12
NEMA 3R motor starters	CR194 400A and 800A, 1-high, non-walk-in	E13
	CR194 400A, 1-high, walk-in	E14
	CR194 800A, 1-high, walk-in	E15
	CR7160 400 1-and 2-high, non-walk-in	E16
	CR7160 400A 1- and 2-high, walk- in	E17
	CR7160 700A, 1 high, walk-in	E18
	Estimated widths	E19
IC1074 load break switches	NEMA 1, 38" wide	E20
	NEMA 3R, 42" deep, non-walk-in	E21
	NEMA 3R, 92" deep, walk-in	E22

NAMEPLATES

Enclosure nameplates are provided for identification on front panels and internally for identifying units and devices.

Standard unit nameplates are 1" x 3" 2-ply thermoplastic, black letters on white background or white letters on black background.

Front panel device nameplates are ½" x 1½" thermoplastic.

Internal device nameplates are fabric type with adhesive backing.

Thermoplastic nameplates are fastened with corrosion-resistant steel screws.

Table E.2 Enclosure features

Description	NEMA 3R Non-walk-in 42" deep	NEMA 3R Walk-in 92" deep
Strip heater	Standard ①	Standard ②
Thermostat	Option	Standard
Receptacle	Option	Standard
Incandescent light	Standard	Standard
Undercoat	Standard	Standard
Door stops	Standard	Option
Floor sills	Standard	Standard

① In starter only
② One in starter, one in aisle

LIMITAMP BUS SYSTEMS

AC power bus is used for conducting power throughout a group of starters joined together in a lineup. Incoming power cable can be terminated at one or more points in the lineup and the power bus employed to distribute power throughout the length of the group.

This bus is available in ratings of 1000 and 2000 amperes and may be tin-plated copper, silver-plated copper or bare copper. For higher ratings refer to factory. Derating is necessary in certain applications. The horizontal bus compartment is located within the standard 90-inch-high enclosure in the same position as in current and previous air-break designs, dating back to 1960, making all compatible. Limitamp horizontal bus is rated 60kV basic impulse level (1.2 x 50 μ sec wave). Mechanical strength under short-circuit currents is 50 kA RMS symmetrical.

GROUND BUS

Ground bus in a Limitamp lineup provides a low-resistance path between ground connection points in any group of controllers. This low-resistance path is a bus bar and is for the purpose of decreasing to a low value a possibly hazardous voltage difference between grounding points in the starter group. These voltage differences would occur under ground fault conditions if a low-resistance ground path were not provided.

The ground bus is normally located near the AC power bus on the inside rear of the enclosure. The bus provides a common termination point for all ground connections within each controller, including the enclosing case, and offers a convenient terminal for incoming ground cables. It should be noted that the customer must make a suit-

suitable ground connection to the bus in order to make it effective. When ground bus is not provided, the ground connection may be made to the ground stud provided.

Extensions to the ground bus are located in the incoming line cable compartment and near the load termination points in the high-voltage compartment to make grounding cable shield terminations easy to accomplish.

CONTROL BUS

Control bus is a convenient means of conducting control power throughout a group of controllers joined together in a lineup. Conductors from a single control power source may be terminated in one unit in the lineup and the control bus employed to distribute the power to each unit of the grouped lineup. Control bus may also be used to distribute the power from a single control transformer located in the lineup.

Control bus normally consists of properly sized insulated wire conductors run between terminal boards.

Standard voltage for control bus is 120 or 240 volts AC and maximum current rating is determined by application, such as total present and anticipated future load.

POTENTIAL BUS

Potential bus is a means of distributing a common source of low voltage throughout the lineup for metering and instrumentation. Potential bus consists of properly sized wire connected between terminal boards typically mounted on the top inside of enclosure. Maximum voltage is 600 volts.

INSULATED POWER BUS

Insulating the AC power bus reduces the possibility of bus faults from causes such as surge voltages, ionized vapors, falling objects (tools, etc.), ground tapes, etc. It also prevents corrosion and oxidation of the bus and its hardware.

The standard power bus consists of bar conductors on insulator supports. Insulation for the conductors can be provided, and it may consist of various types of insulating material, such as 130°C HV rubber splicing tape or other material dictated by availability and individual job requirements.

The CR194 two-high Vacuum Equipment design uses epoxy-insulated main and vertical bus as standard.

Table E.3 Bus cross section

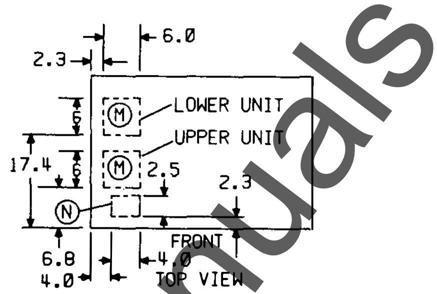
Bus type	Rating	Cross section
Main bus	1000A①	¼" x 3" copper
	2000A	(2) ¼" x 3" copper
Vertical bus	400A	¼" x 1" copper
	700A	½" x 1" copper
	800A	¼" x 3" copper
Ground bus	400A	⅛" x 2" copper
	600A	¼" x 2" copper

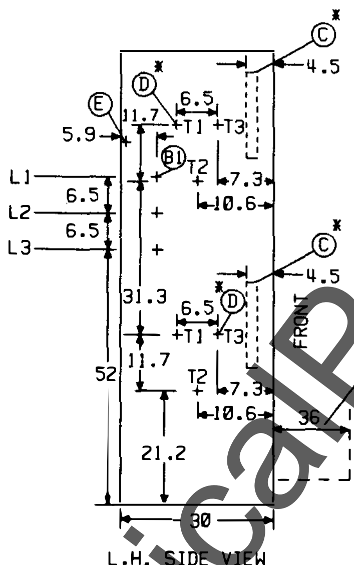
① Refer to factory for 1200A applications.

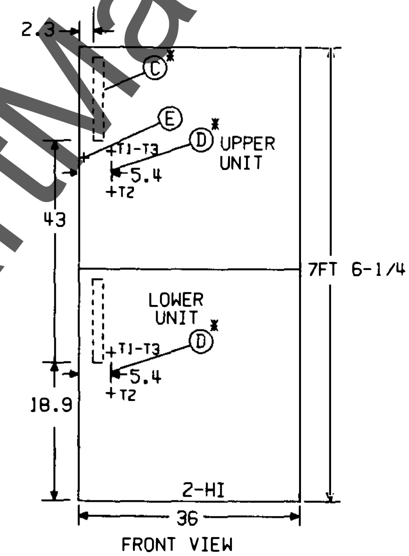
E

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

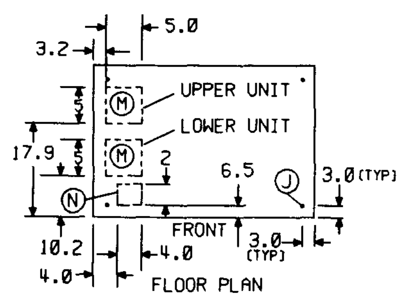
CR194 400-ampere Vacuum Stationary or Drawout (Two-high)
Standard 36" Wide







Δ - 2000 *



Notes:

B1 — AC Power Bus

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

G — Space Required to Open Doors 90°

H — Four-foot Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

M — Recommended Position for Incoming Motor Conduit

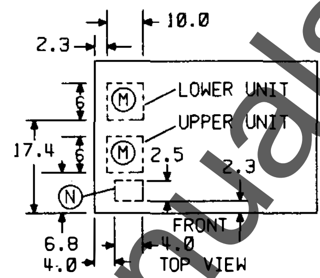
N — Recommended Position for Incoming Control Conduit

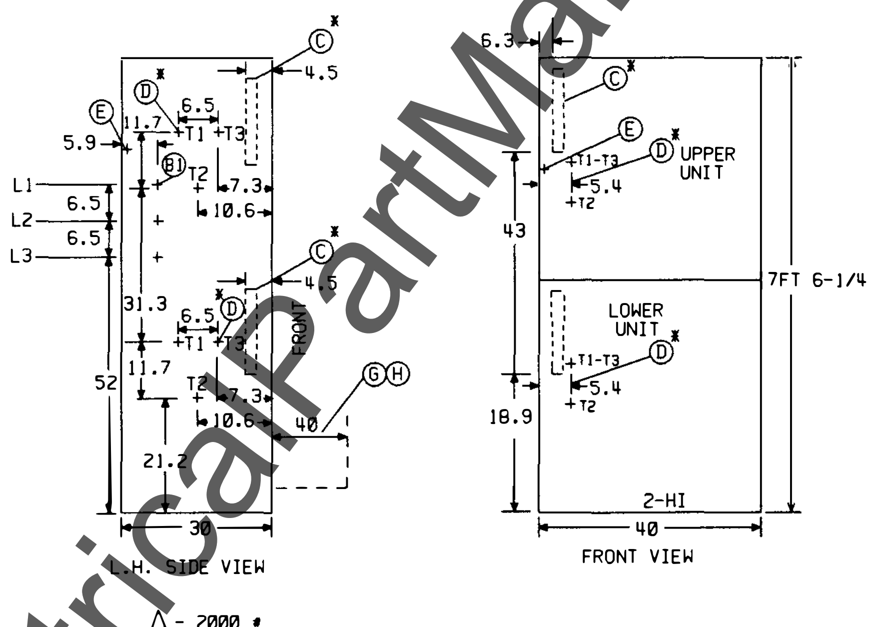
* — Indicates Terminal Location — Approximate for Cable Length

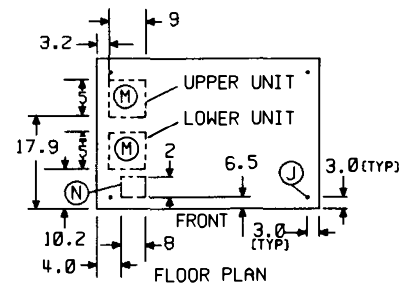
△ — Approximate Weight

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

CR194 400-ampere Vacuum Stationary or Drawout (Two-high)
Optional 40" Wide







Notes:

B1 — AC Power Bus

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

G — Space Required to Open Doors 90°

H — Four-foot Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

M — Recommended Position for Incoming Motor Conduit

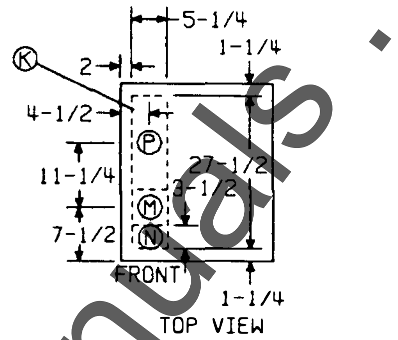
N — Recommended Position for Incoming Control Conduit

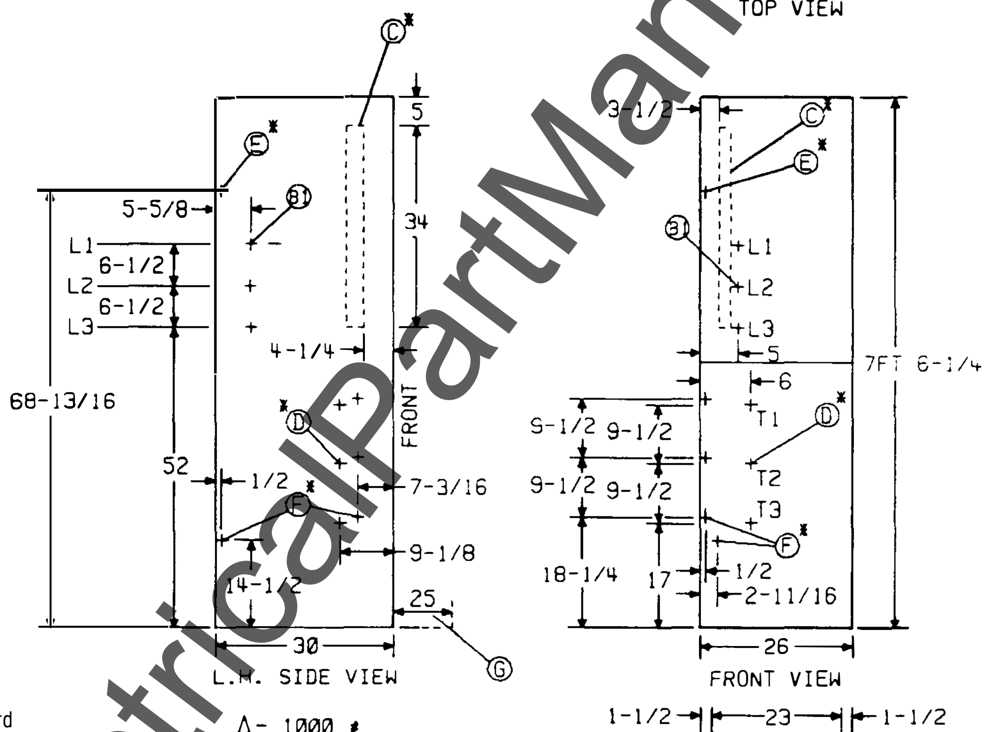
* — Indicates Terminal Location — Approximate for Cable Length

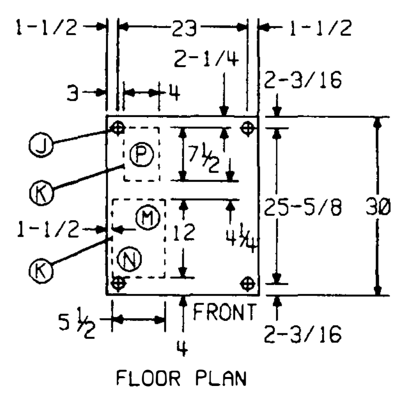
△ — Approximate Weight

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

CR194 400-ampere Vacuum Stationary (One-high)
Standard 26" Wide







Notes:

B1 — AC Power Bus (if ordered)

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

G — Space Required to Open Doors 90°

H — Four-foot Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

M — Recommended Position for Incoming Motor Conduit

N — Recommended Position for Incoming Control Conduit

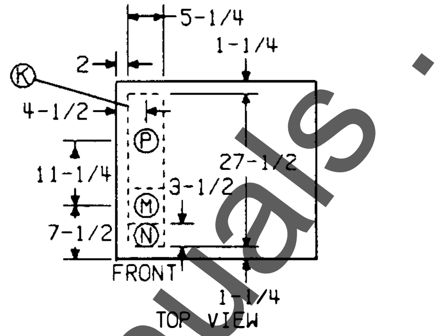
P — Recommended Position for Incoming Power Conduit

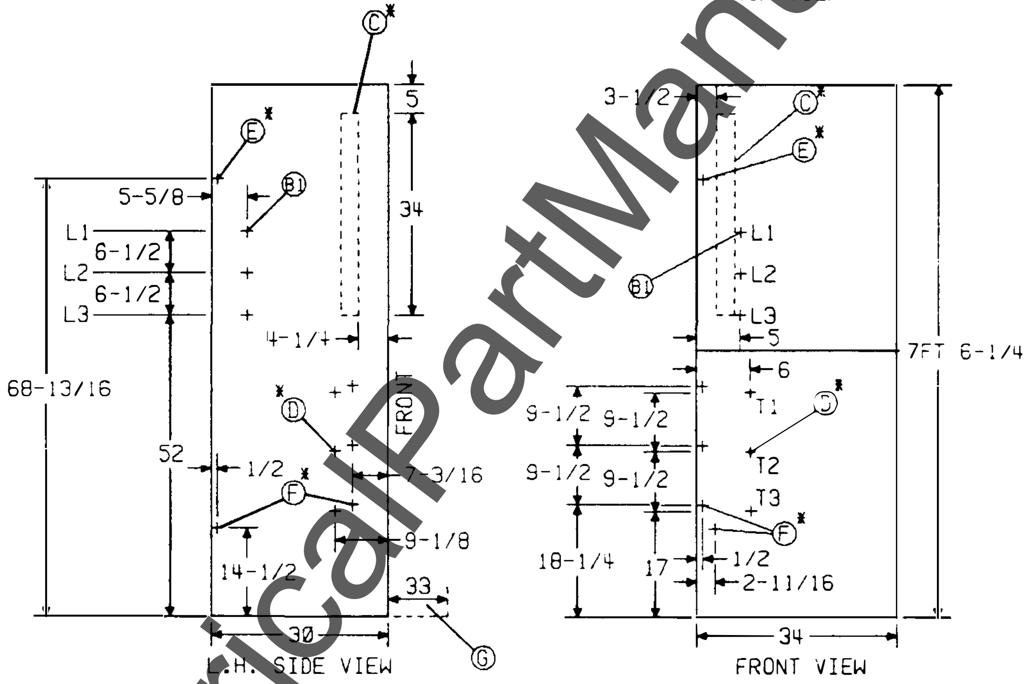
* — Indicates Terminal Location — Approximate for Cable Length

△ — Approximate Weight

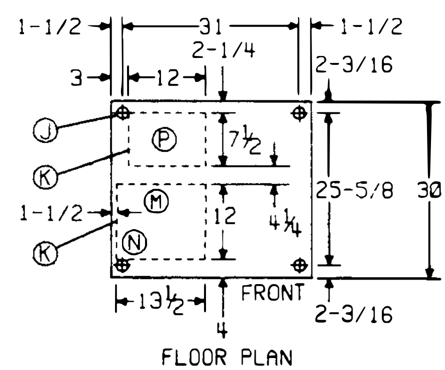
ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

CR194 400-ampere Vacuum Stationary (One-high)
Optional 34" Wide





Δ- 1300 *



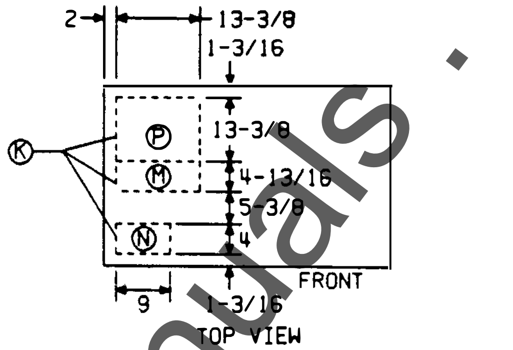
Notes:

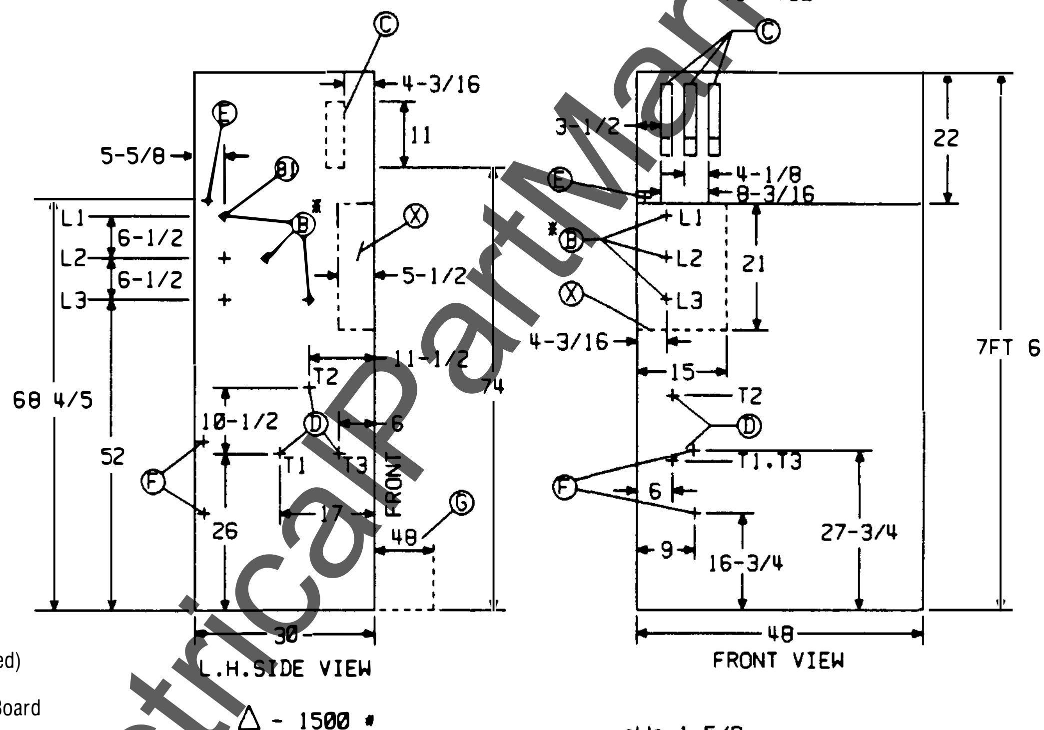
B1 — AC Power Bus
C — Control Lead Terminal Board
D — Motor Lead Terminal Connection
E — Ground Bus Terminal Connection
F — Ground Terminal Connection (if ordered)
G — Space Required to Open Doors 90°
H — Four-foot Aisle for Contactor Removal
J — Mounting Holes for ½" Diameter Anchor Bolts
K — Space Available for Incoming Conduit
M — Recommended Position for Incoming Motor Conduit
N — Recommended Position for Incoming Control Conduit
P — Recommended Position for Incoming Power Conduit
* — Indicates Terminal Location — Approximate for Cable Length
△ — Approximate Weight

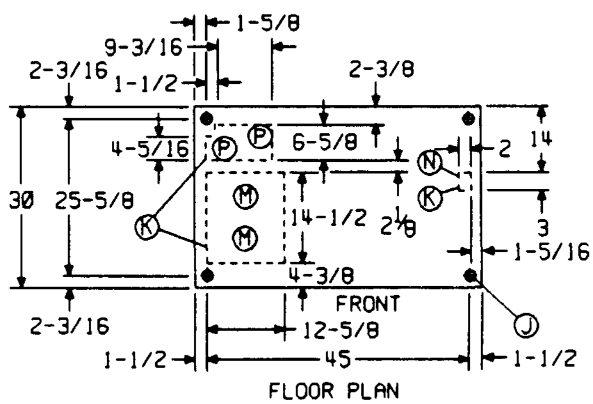
E

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

CR194 800-ampere Vacuum Stationary (One-high)
Standard 48" Wide







Notes:

B1 — AC Power Bus (if ordered)

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

G — Space Required to Open Doors 90°

H — Four-foot Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

M — Recommended Position for Incoming Motor Conduit

N — Recommended Position for Incoming Control Conduit

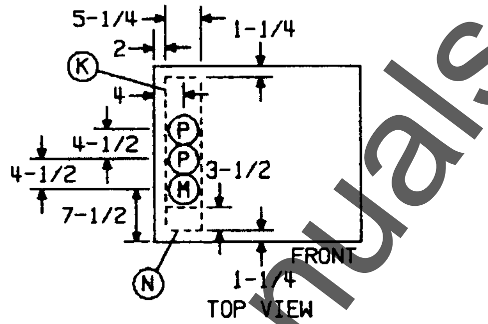
P — Recommended Position for Incoming Power Conduit

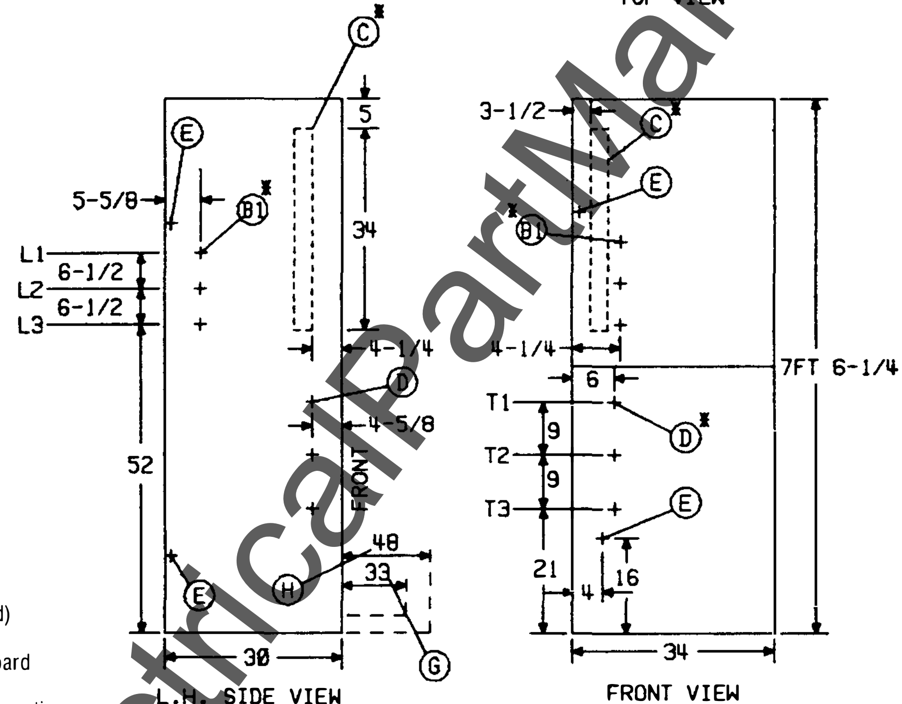
* — Indicates Terminal Location — Approximate for Cable Length

Δ — Approximate Weight

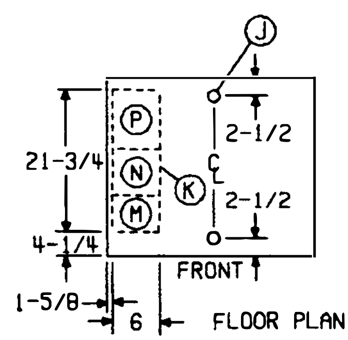
ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

CR7160 400-ampere Air-break Drawout (One-high)
Standard 34" Wide





Δ - 1300 #



Notes:

B1 — AC Power Bus (if ordered)

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

G — Space Required to Open Doors 90°

H — Four-foot Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

M — Recommended Position for Incoming Motor Conduit

N — Recommended Position for Incoming Control Conduit

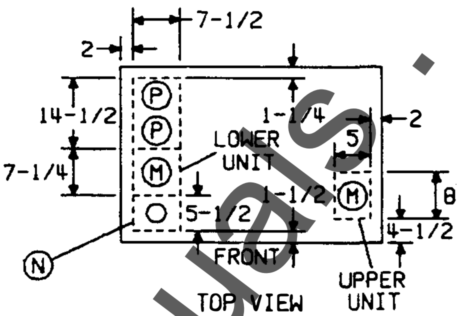
P — Recommended Position for Incoming Power Conduit

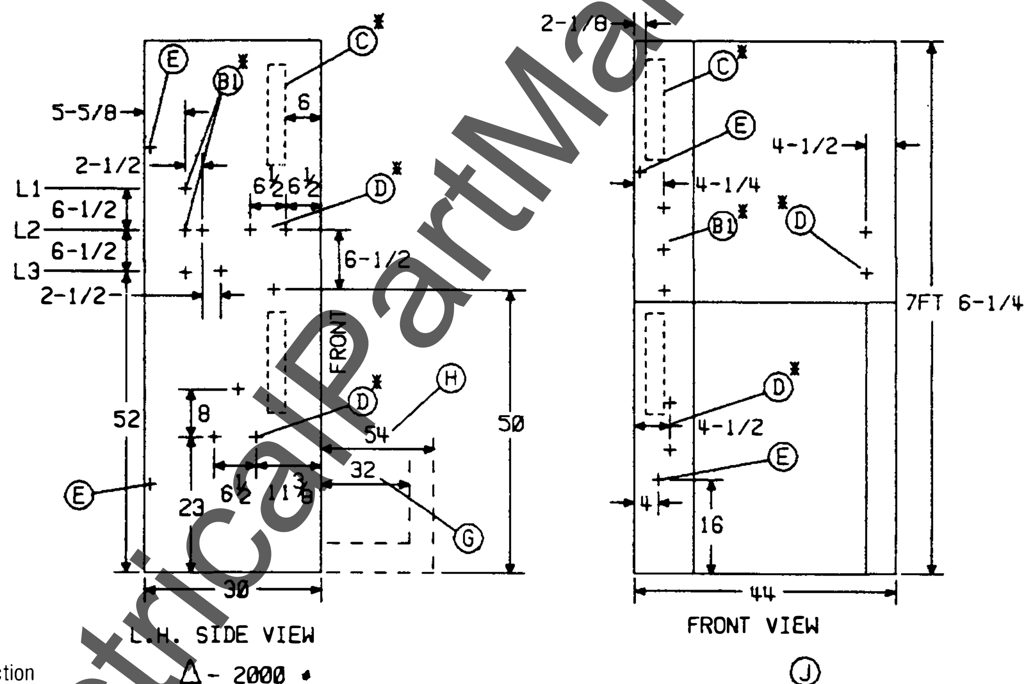
* — Indicates Terminal Location — Approximate for Cable Length

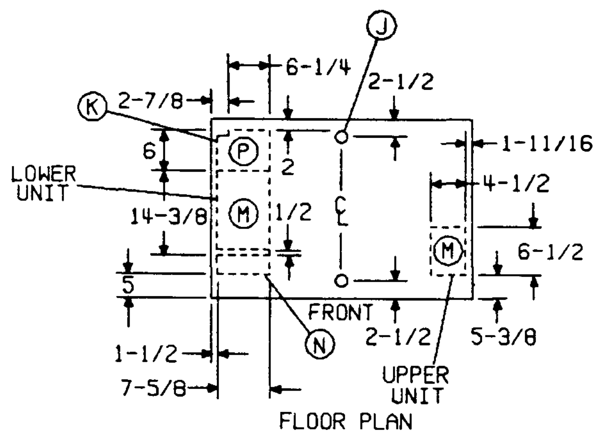
△ — Approximate Weight

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

CR7160 400-ampere Air-break Drawout (Two-high)
Standard 44" Wide







Notes:

B1 — AC Power Bus

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

G — Space Required to Open Doors 90°

H — Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

M — Recommended Position for Incoming Motor Conduit

N — Recommended Position for Incoming Control Conduit

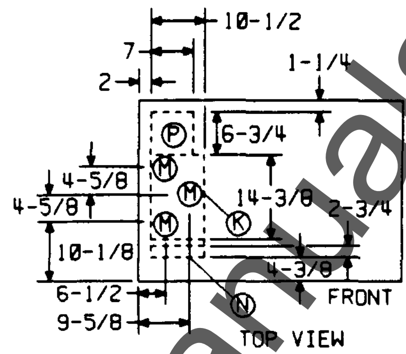
P — Recommended Position for Incoming Power Conduit

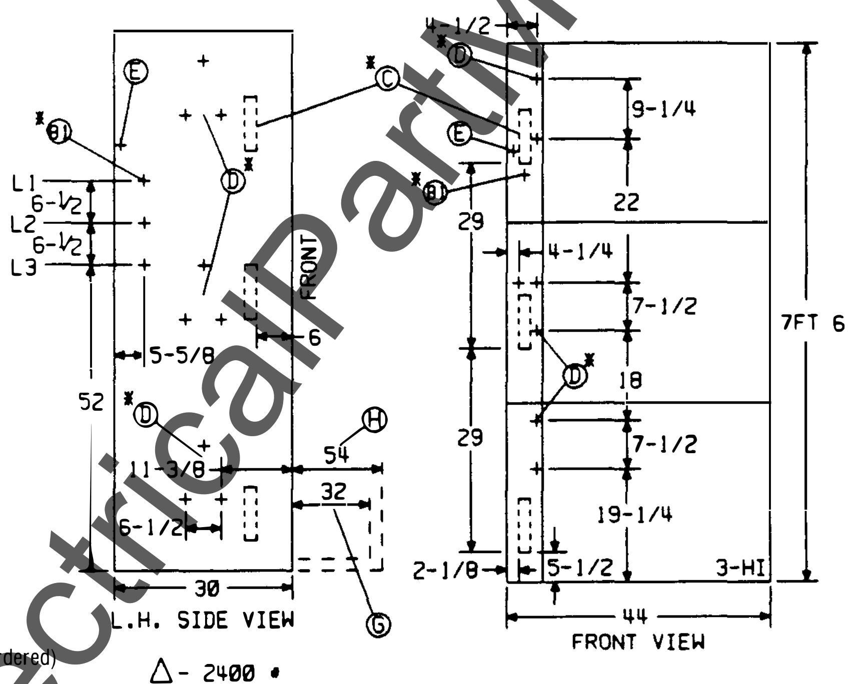
* — Indicates Terminal Location — Approximate for Cable Length

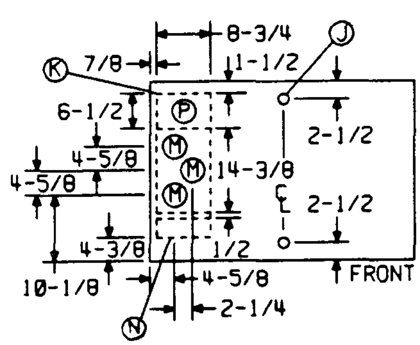
△ — Approximate Weight

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

CR7160 400-ampere Air-break Drawout (Three-high)
Standard 44" Wide







Notes:

B1 — AC Power Bus

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

G — Space Required to Open Doors 90°

H — Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

M — Recommended Position for Incoming Motor Conduit

N — Recommended Position for Incoming Control Conduit

P — Recommended Position for Incoming Power Conduit

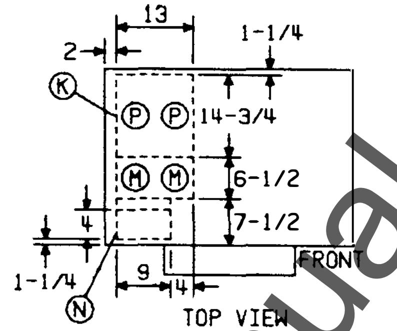
* — Indicates Terminal Location— Approximate for Cable Length

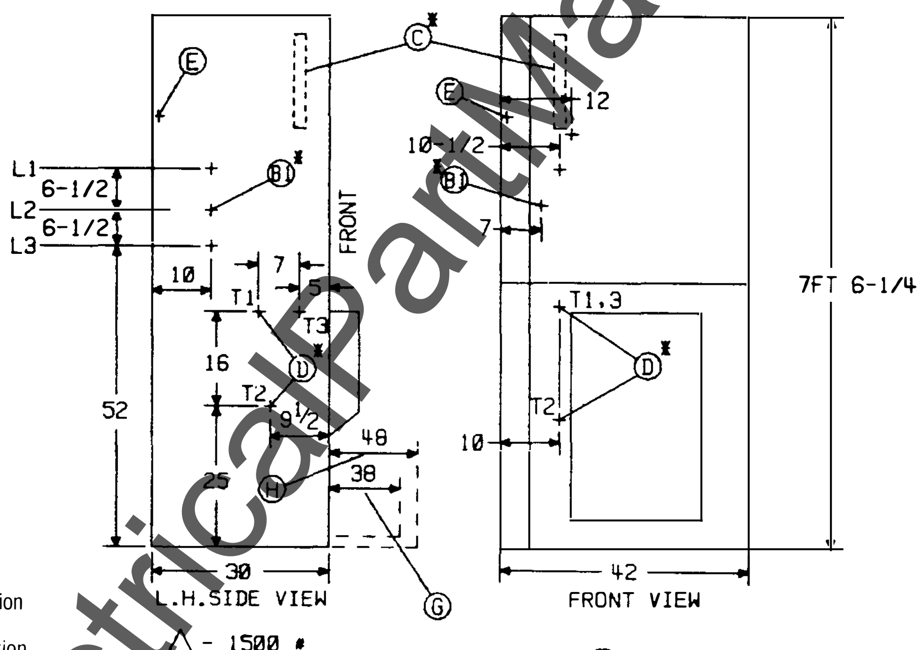
△ — Approximate Weight

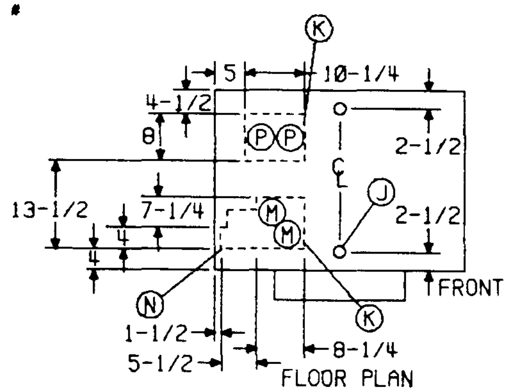
E

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

CR7160 700-ampere Air-break Drawout (One-high)
Standard 42" Wide







Notes:

B1 — AC Power Bus (if ordered)

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

G — Space Required to Open Doors 90°

H — Four-foot Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

M — Recommended Position for Incoming Motor Conduit

N — Recommended Position for Incoming Control Conduit

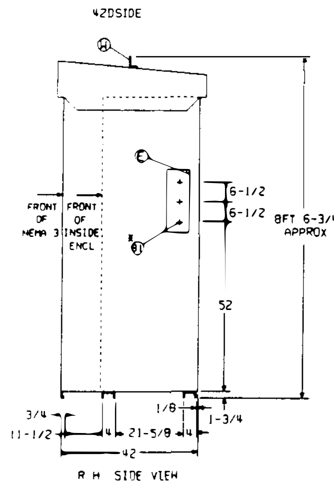
P — Recommended Position for Incoming Power Conduit

* — Indicates Terminal Location— Approximate for Cable Length

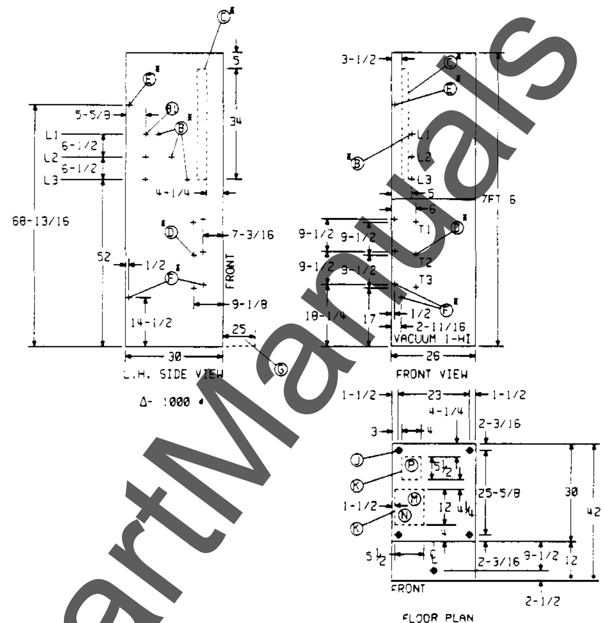
△ — Approximate Weight

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

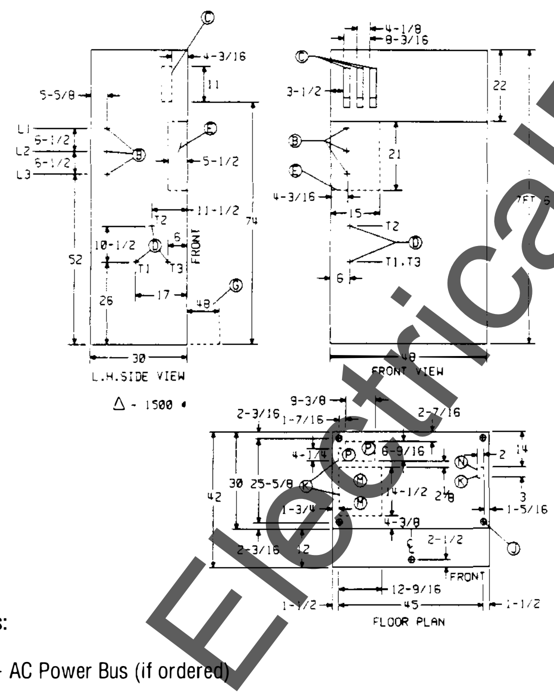
**CR194 Vacuum 400-ampere and 800-ampere Vacuum Stationary (One-high)
NEMA 3R 42" Deep**



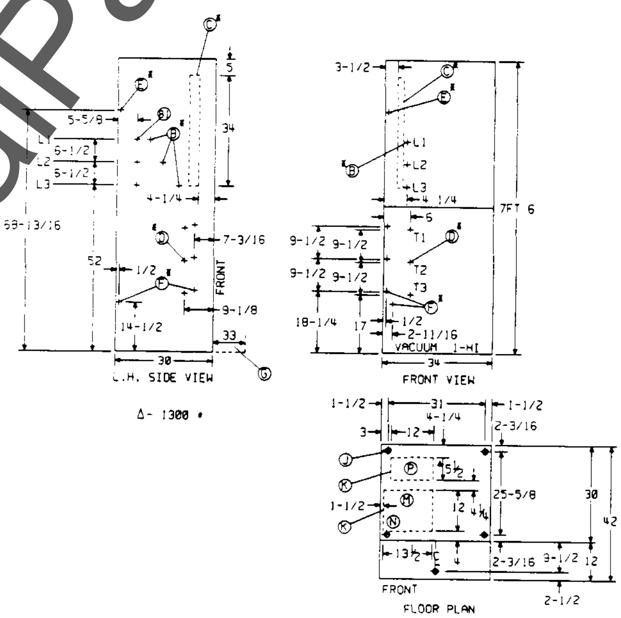
1 H1-400A-26W



1 H1GH-800A-48W



1 H1GH-400A-34W



Notes:

B1 — AC Power Bus (if ordered)

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

G — Space Required to Open Doors 90°

H — Four-foot Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

M — Recommended Position for Incoming Motor Conduit

N — Recommended Position for Incoming Control Conduit

P — Recommended Position for Incoming Power Conduit

W — Lifting Angle

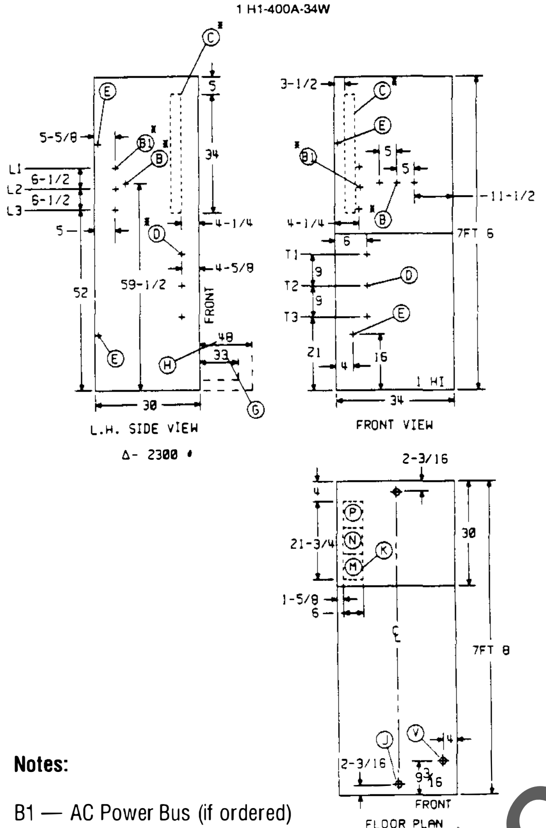
* — Indicates Terminal Location — Approximate for Cable Length

△ — Approximate Weight

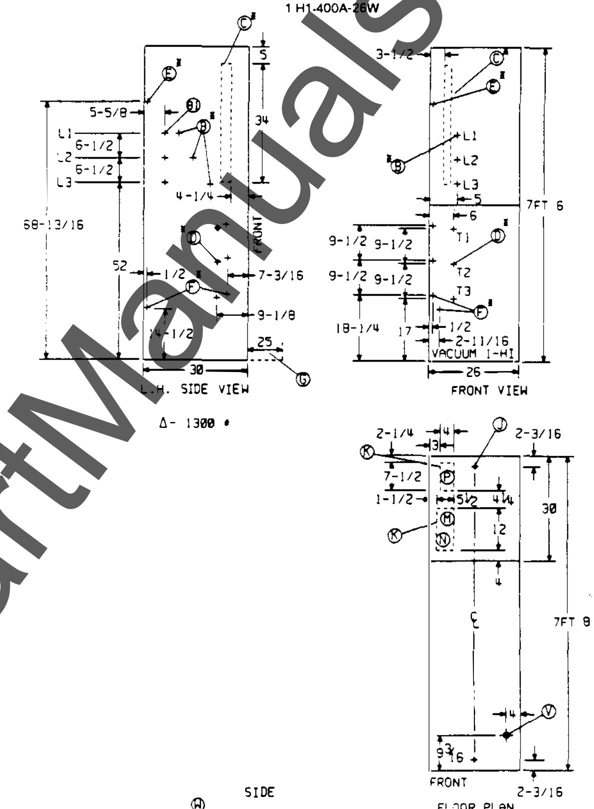
ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

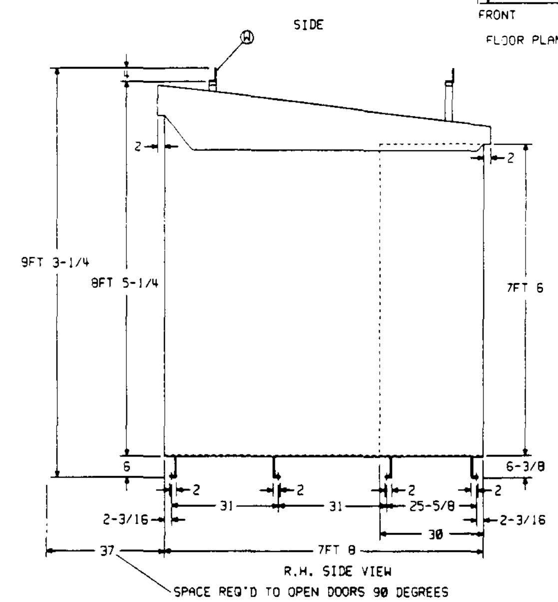
CR194 400-ampere Vacuum Stationary (One-high)
NEMA 3R 92" Deep Walk-in

1 H1-400A-34W



1 H1-400A-26W





Notes:

B1 — AC Power Bus (if ordered)

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

G — Space Required to Open Doors 90°

H — Four-foot Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

M — Recommended Position for Incoming Motor Conduit

N — Recommended Position for Incoming Control Conduit

P — Recommended Position for Incoming Power Conduit

Q — Recommended Position for Incoming Feeder Conduit

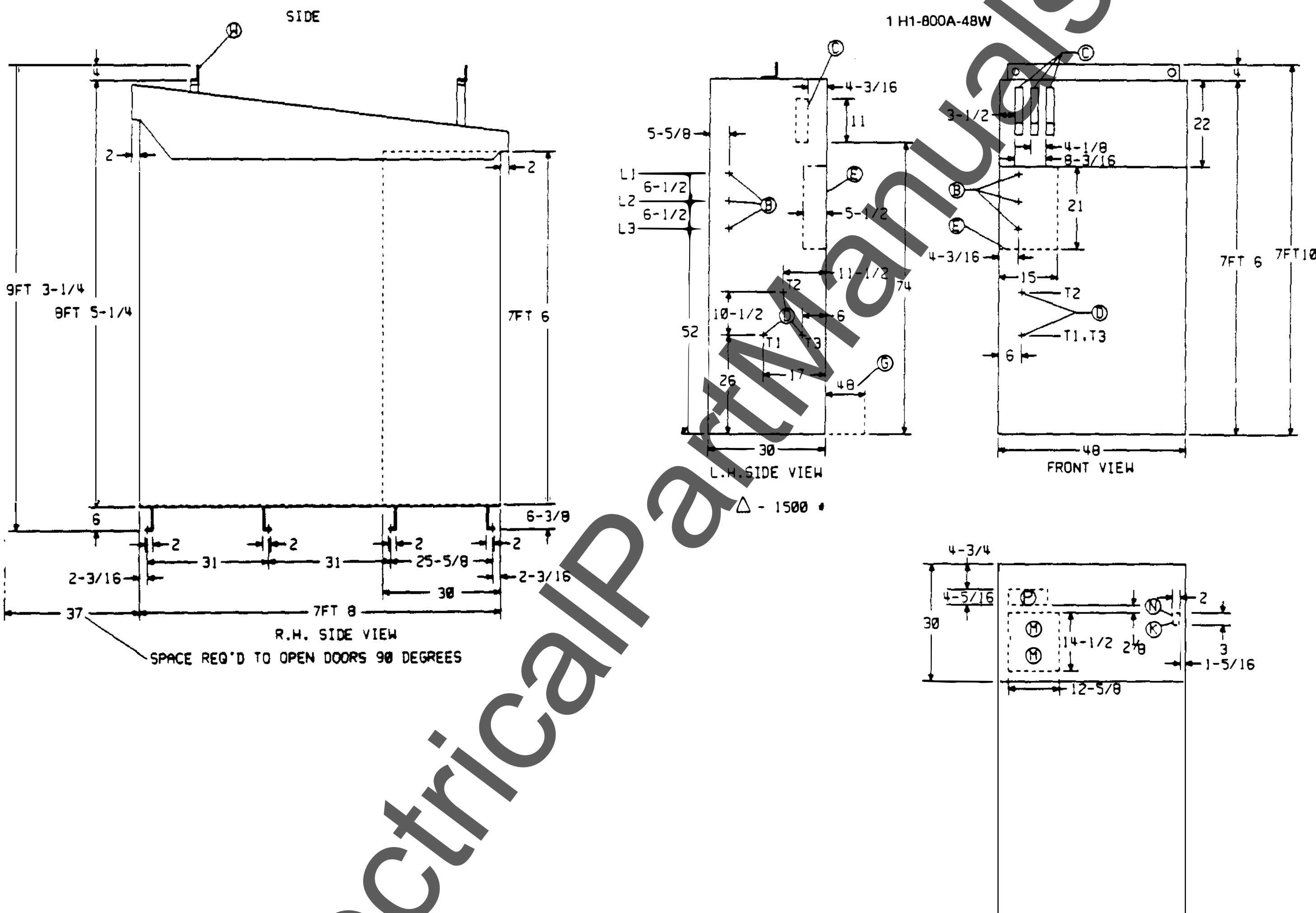
W — Lifting Angle

* — Indicates Terminal Location — Approximate for Cable Length

△ — Approximate Weight

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

CR194 800-ampere Vacuum Stationary (One-high),
NEMA 3R 92" Deep Walk-in



Notes:

B1 — AC Power Bus (if ordered)

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

G — Space Required to Open Doors 90°

H — Four-foot Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

M — Recommended Position for Incoming Motor Conduit

N — Recommended Position for Incoming Control Conduit

P — Recommended Position for Incoming Power Conduit

W — Lifting Angle

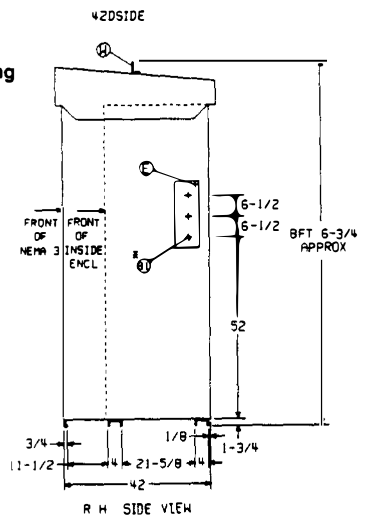
* — Indicates Terminal Location — Approximate for Cable Length

△— Approximate Weight

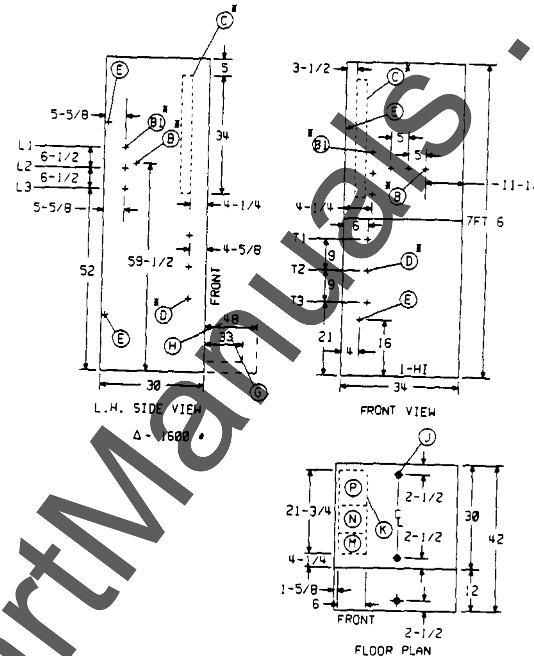
ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

CR7160 400-ampere Air-break Drawout (One- & Two-high)
NEMA 3R 42" Deep

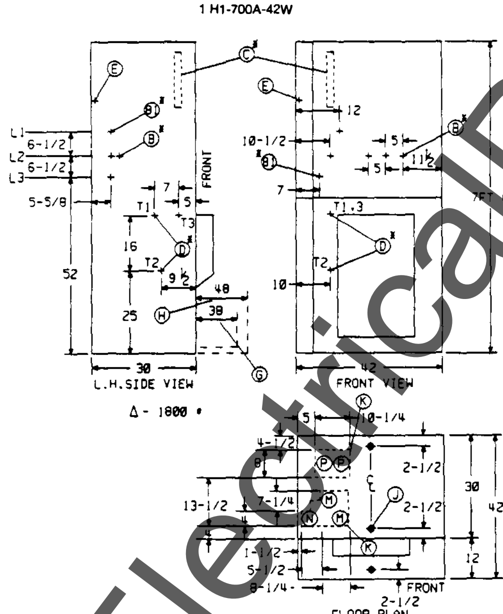
Outline Drawing



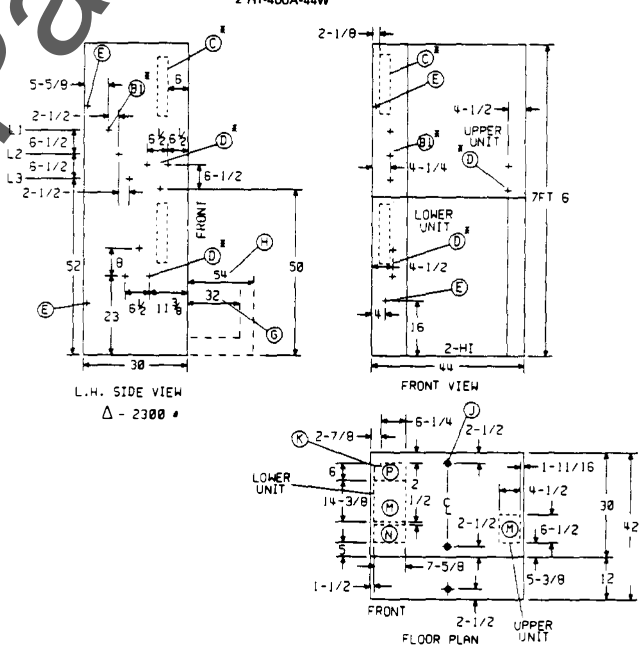
1 H1-400A-34W



1 H1-700A-42W



2 H1-400A-44W



Notes:

B1 — AC Power Bus (if ordered)

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

G — Space Required to Open Doors 90°

H — Four-foot Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

M — Recommended Position for Incoming Motor Conduit

N — Recommended Position for Incoming Control Conduit

P — Recommended Position for Incoming Power Conduit

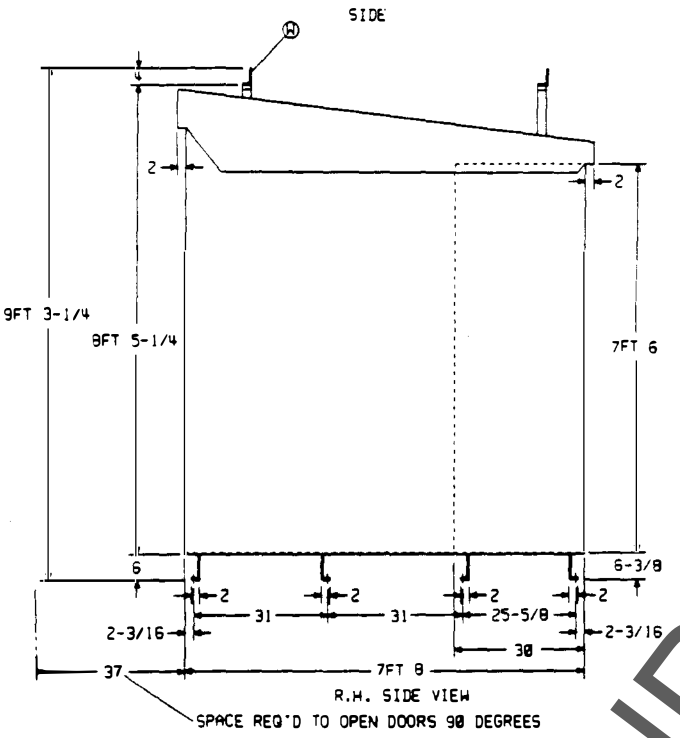
W — Lifting Angle

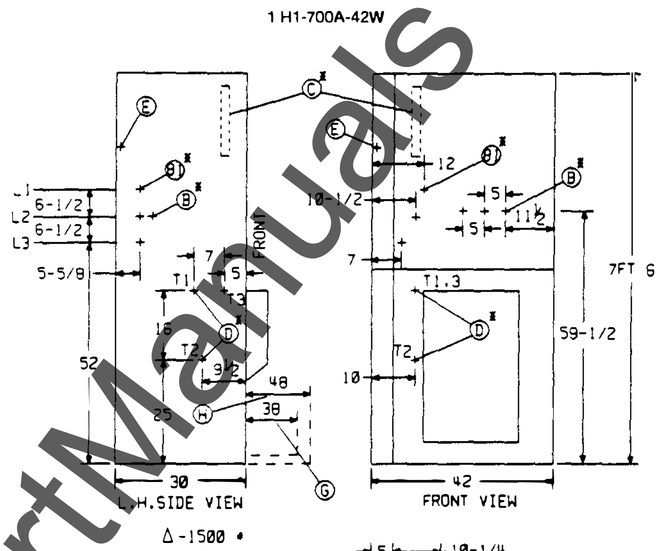
* — Indicates Terminal Location — Approximate for Cable Length

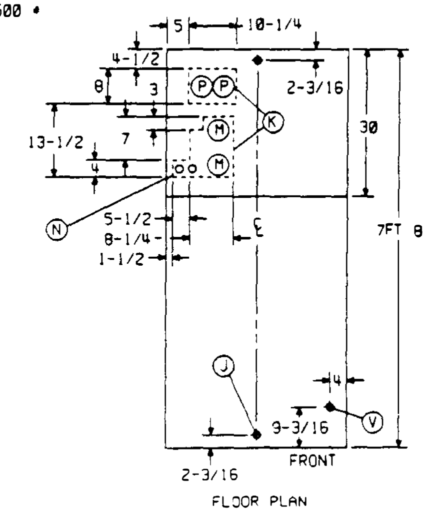
△ — Approximate Weight

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

CR7160 700-ampere Air-break Drawout (One-high)
NEMA 3R 92" Deep Walk-in







Notes:

B1 — AC Power Bus (if ordered)

C — Control Lead Terminal Board

D — Motor Lead Terminal Connection

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

G — Space Required to Open Doors 90°

H — Four-foot Aisle for Contactor Removal

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

M — Recommended Position for Incoming Motor Conduit

N — Recommended Position for Incoming Control Conduit

P — Recommended Position for Incoming Power Conduit

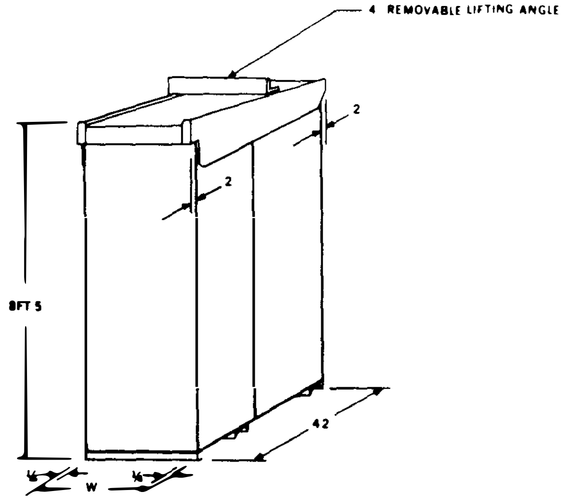
W — Lifting Angle

* — Indicates Terminal Location— Approximate for Cable Length

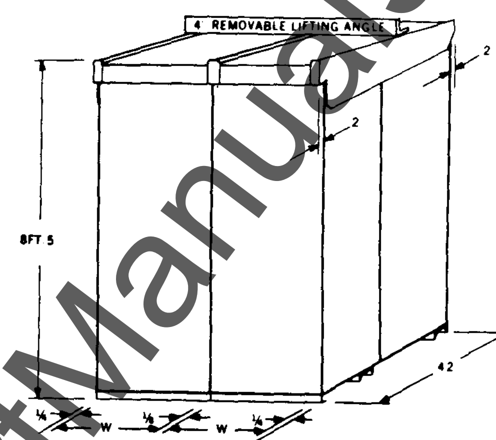
△ — Approximate Weight

ENCLOSURE OUTLINE DIMENSIONS

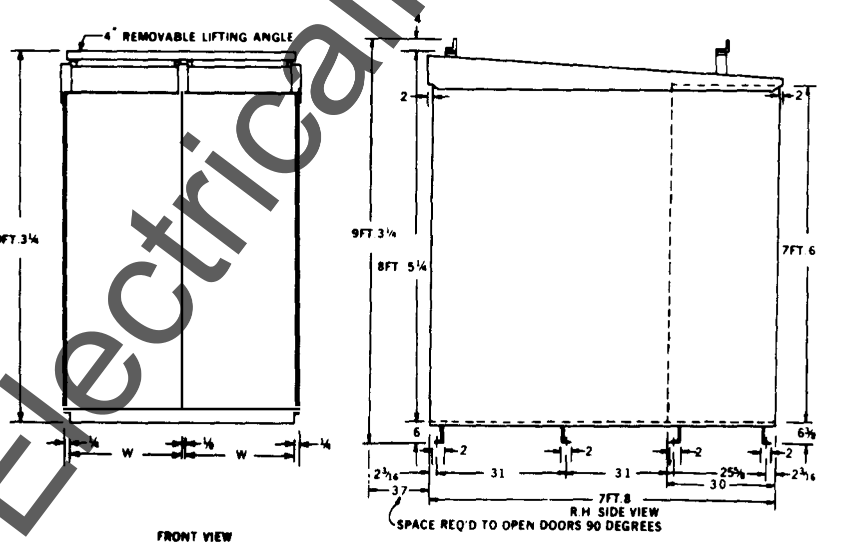
Limitamp Non-walk-in & Walk-in
NEMA 3R



NEMA 3R non-walk-in enclosure 42" deep



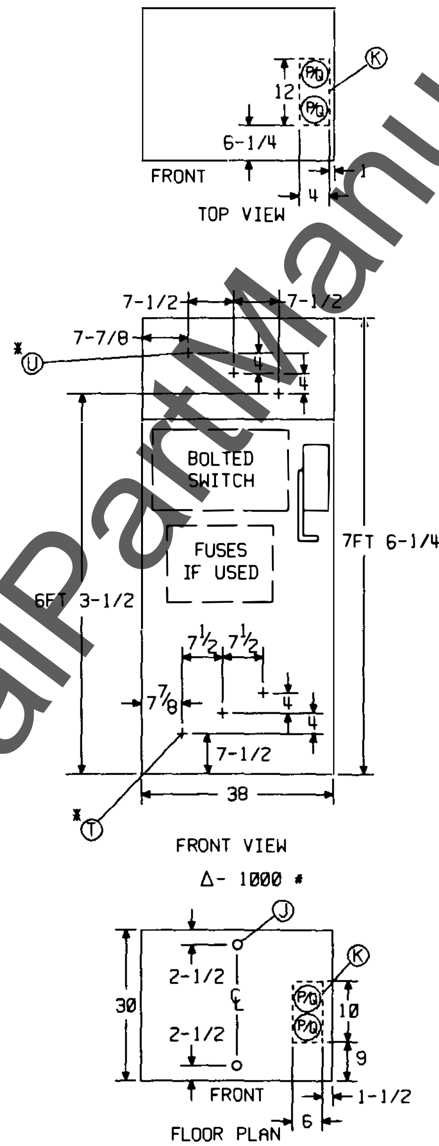
NEMA 3R non-walk-in enclosure 42" deep



NEMA 3R non-walk-in enclosure 92" deep

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

IC1074 Bolted Load Break Switch
NEMA 1 Standard 38" Wide



Notes:

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

P — Recommended Position for Incoming Power Conduit

Q — Recommended Position for Incoming Feeder Conduit

T — Switch Feeder Terminal Connection

U — Switch Incoming Power Terminal Connection

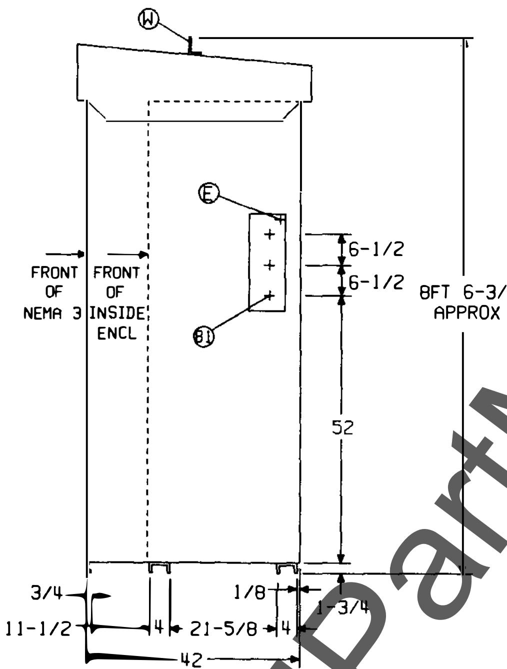
* — Indicates Terminal Location — Approximate for Cable Length

△ — Approximate Weight

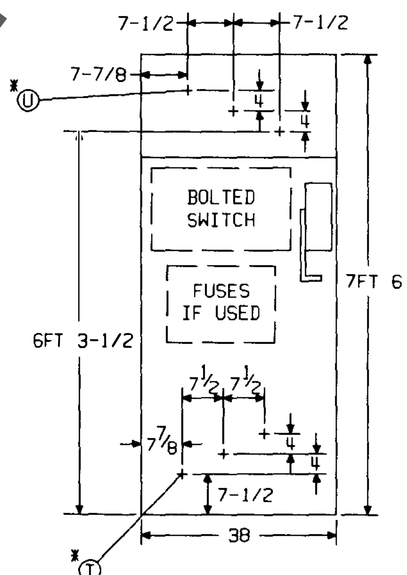
E

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

IC1074 Bolted Load Break Switch
NEMA 3R Standard 38" Wide, 42" Deep

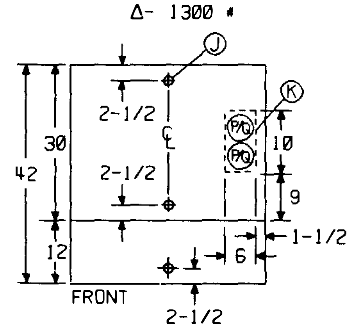


R.H. SIDE VIEW



FRONT VIEW

Δ- 1300 #



FLOOR PLAN

Notes:

B1 — AC Power Bus (if ordered)

E — Ground Bus Terminal Connection

F — Ground Terminal Connection (if ordered)

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

P — Recommended Position for Incoming Power Conduit

Q — Recommended Position for Incoming Feeder Conduit

T — Switch Feeder Terminal Connection

U — Switch Incoming Power Terminal Connection

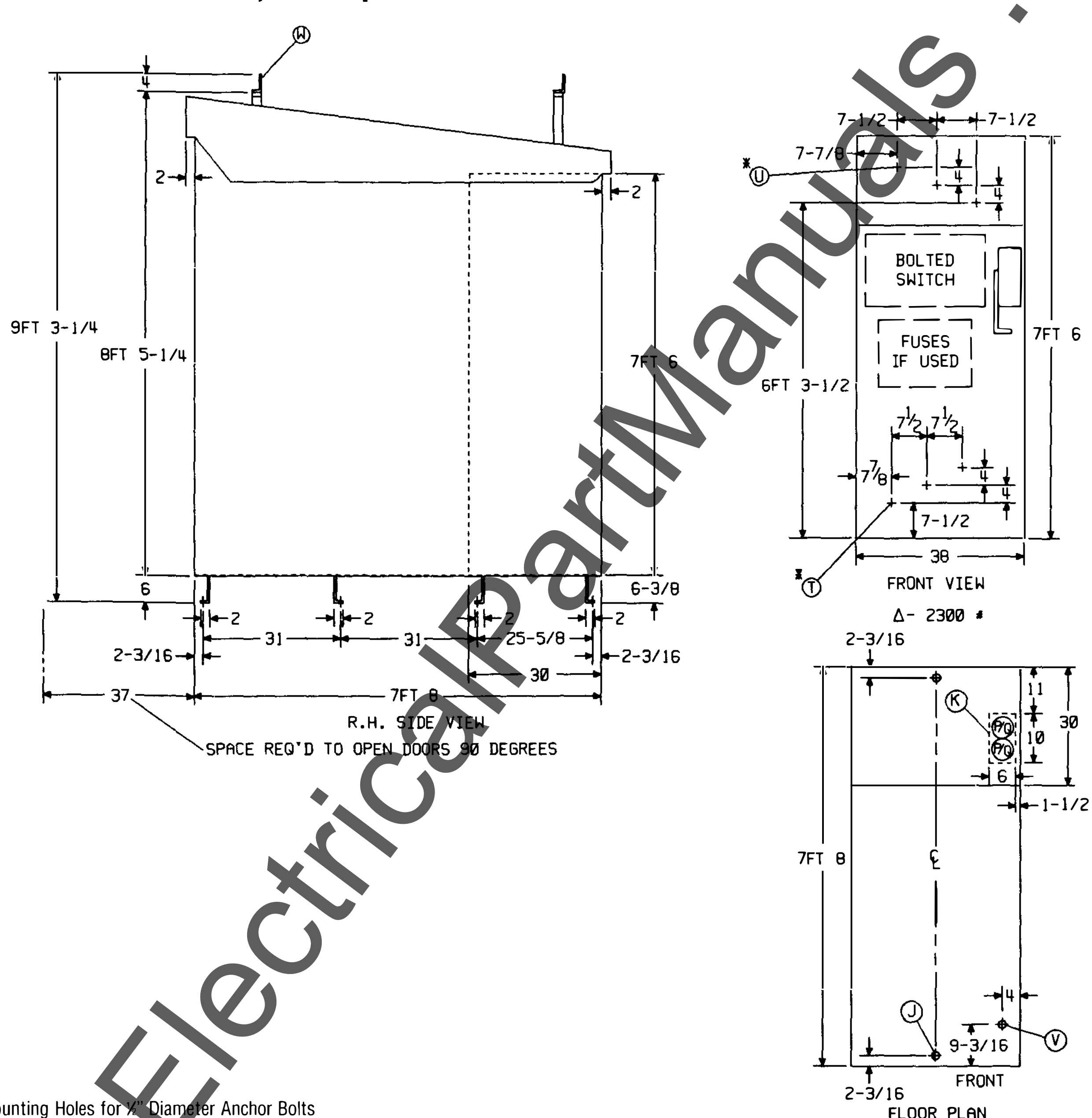
W — 4 Inch Removable Lifting Angle

* — Indicates Terminal Location — Approximate for Cable Length

△ — Approximate Weight

ENCLOSURE OUTLINE DIMENSIONS 2400-4160 VOLTS

IC1074 Bolted Load Break Switch
NEMA 3R Standard 38" Wide, 92" Deep Walk-in



Notes:

J — Mounting Holes for ½" Diameter Anchor Bolts

K — Space Available for Incoming Conduit

P — Recommended Position for Incoming Power Conduit

Q — Recommended Position for Incoming Feeder Conduit

T — Switch Feeder Terminal Connection

U — Switch Incoming Power Terminal Connection

* — Indicates Terminal Location — Approximate for Cable Length

△ — Approximate Weight

E

FUSES

INTRODUCTION

To protect the motor branch circuit against the damaging effects of short circuits, current-limiting power fuses are used in Limitamp control. They interrupt all overcurrents of magnitude greater than intended for contactor interruption. On full fault, these fuses start limiting current within the first ¼ cycle and interrupt within the first ½ cycle. Because they are fast acting, these fuses are easily coordinated with system protective relaying to give selectivity in short-circuit protection.

Standard fuses supplied with Limitamp CR194 Control are bolt-in type. Clip-in fuses may be supplied in applications where motor full-load current plus service factor does not exceed 320 amperes, but they must be specified by the customer. The blown fuse indicator and the anti-single-phase trip are available with bolt-in fuses only.

Motor-starting fuses are current-limiting as indicated in Figure F.1. They melt before the current in the first major loop can reach its peak value when subjected to melting currents within the current-limiting range. Consequently, the total "let-through" energy involved is low because the fuses operate with such great speed. The contactor, current transformers, and overload relays of a Limitamp controller are coordinated with the fuses to give full protection to the system.

A design feature of motor-starting fuses inherently limits recovery voltage to safe values, thus protecting control insulation.

Controller fuses must have sufficient capacity to carry starting and full-load currents, and yet must interrupt fault currents at a desirable low value. They are therefore made in a number of ratings or sizes so that maximum protection can be obtained over a range of motor horsepowers.

For a given set of motor characteristics, it is usually possible to use one of several fuses. The smallest fuses will normally be furnished. If the load is a fluctuating one, involving swings of current above full-load, the fact should be noted in specifying a controller so that a fuse one size larger than minimum will be furnished.

Transient conditions do not generally affect motor-starting fuses since the sand in the fuse conducts heat away rapidly. If transient currents do not come within 25 percent of the minimum melting curve on a time basis, melting will not occur. For example, if the melting curve for a given size fuse shows melting in 10 seconds at 1000 amperes, transient peaks of 1000 amperes would be withstood repeatedly up to 7.5 seconds duration.

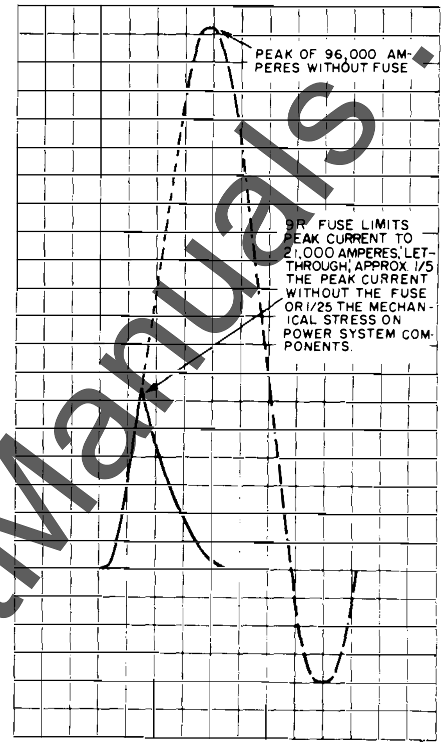


Figure F.1 Current-limiting action of typical fuse.

Motor-starting fuses can be applied on 25-Hertz systems but with lower interrupting capacity than for 50- and 60-Hertz systems. Fuse selection is based on full-load and locked-rotor current.

For a lineup of controllers it may be desirable to use fuses larger than minimum size to reduce the variety of spares required. Such standardization must be specified, however.

BLOWN FUSE TRIP AND BLOWN FUSE INDICATION

The possibility of having one fuse melt, thereby causing a large motor to single phase, has inhibited consideration of fuse-contactor-type starters. Although such a condition is in reality quite unlikely, GE Limitamp Control can be equipped with an optional special mechanism which will detect a blown fuse and cause the contactor to open. Bolt-on fuses contain button indicators to show a blown fuse. This button indicator can be coupled with an anti-single-phase trip mechanism containing a control contact, which, when used in contactor control circuit, can open the contactor to prevent single phasing and/or provide a blown fuse indication on the front door. Blown fuse indication on the front door is available for CR194 equipment only.

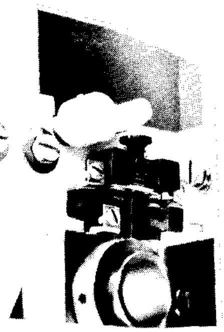


Figure F.2 Anti-single-phase trip mechanism

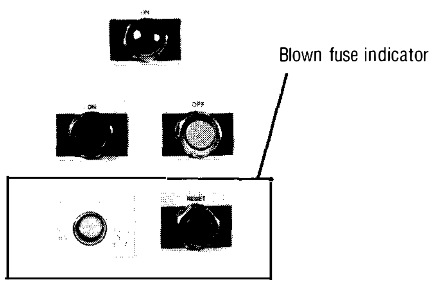


Figure F.3 Blown fuse indicator on door

With this feature, fuses are always bolted in place for correct orientation and alignment. In addition to providing maximum reliability, this feature makes it impossible to mount the fuse in an upside down position which would nullify the trip bar operation.

COORDINATION WITH OTHER PROTECTIVE DEVICES

When Limitamp starters are installed on a given power system, it is necessary to coordinate the time-current characteristics of system protective devices with those of the starters. Use the time-current curves included in GE Time Current Curve No. GES-5000 for this purpose. It includes overload-relay tripping curves, fuse-melting curves and fuse-clearing time curves.

SURGE PROTECTION

The economics of rotating-machine insulation dictates that the machines be protected from voltage stresses above the operating level insofar as is reasonably possible. Overvoltage damages reduce the insulation life. There are many causes of accidental over-voltage whose effects may be reduced by protective means. The most prominent causes are:

1. Lightning.
2. Physical contact with higher voltage system.
3. Repetitive restrike (intermittent grounds).
4. Switching surges.
5. Resonance effects in series inductive capacitance circuits.

Switching transients occur in every electrical system. A well-known phenomenon associated with vacuum interrupters is current chop. GE utilizes vacuum interrupters constructed with widely accepted contact tip materials to provide low chopping currents.

Additional protection against surges for rotating machines may be economically attractive for system voltage installations of 2300 volts and above. This consists of a surge capacitor and lightning arresters.

Lightning arresters reduce the amplitude of the voltage impulse wave. The surge capacitor further reduces the amplitude — but in addition, reduces the steepness of the wave front. It is important to reduce the steepness of the surge wave front to keep the turn-to-turn voltage stress in the machine winding to a minimum.

To prevent overvoltage in current transformer secondary circuits during switching, CTs should be provided with Thyrite protectors when surge capacitors are installed at motor terminals.

Surge capacitors and arresters should be installed as close to the machine terminals as possible. Capacitors and arresters require a 22-inch wide auxiliary enclosure if installed in the controller.

OVERLOAD RELAYS

Several types of overload relays are used in Limitamp Control. Limitamp controllers use thermal-overload relays, unless other types are specified.

THERMAL-OVERLOAD RELAYS

Overload relays provided in Limitamp control have inverse-time characteristics and are ambient compensated. Limitamp control utilizes either a thermal-type relay or the solid-state protective relay. These relays, operating from current transformers in the control equipment, carry current proportional to the motor-circuit current. When motor overloads occur, the relay operates to open the main power contactor. The time required for operation varies inversely with the magnitude of the overload. The standard thermal relay should only be used on motors with starting times up to 10 seconds.

F

EXTERNAL-RESET OVERLOADS

Some industrial plants do not permit a machine operator to open the doors of control equipment enclosures, this being reserved for electricians. To make possible overload-relay reset by operators, it is therefore necessary to provide some means to do so outside the enclosing case. This is accomplished by providing a mechanical-linkage reset mechanism between the relay and door-mounted reset button.

Where external reset is not absolutely necessary, greater simplification of relay mounting results, and this is of benefit to the user because it simplifies maintenance.

Inasmuch as the tripping of an overload device is indicative of too much strain on the motor, it is preferable that only experienced and reliable personnel be allowed to reset overloads. Such personnel should be capable of realizing whether it was an unintentional overload on the part of the machine operator or whether there is an electrical and/or mechanical defect. The customer should consider this factor, however, before electing to provide externally reset overloads.

SOLID-STATE OVERLOAD RELAYS

Solid-state overcurrent protection is available as an optional feature in place of standard thermal overload relays. The inverse-time characteristics can be adjusted to protect motors of various characteristics, such as long acceleration time or short allowable-stall times. Characteristics are accurate and have a smaller error band compared to bimetal relays. The solid-state overload relay is recommended for hermetically sealed air-conditioning motors, and is well suited as a stall-protection relay.

MULTIFUNCTION SOLID-STATE RELAYS

Large motors on vital drives need accurate protection against overloads, phase unbalance or ground faults. Multifunction solid-state relays are available from GE that offer total motor protection in one compact package. Basic protective functions such as overtemperature, overload, instantaneous overcurrent, open-phase, phase reversal, phase unbalance, ground-fault, load jam, load loss and bearing overtemperature protection can be provided.

OVERTEMPERATURE RELAYS

Some motors have RTDs placed in the stator slots. The purpose is to obtain an indication of winding temperature by measuring the RTD resistance and its change with temperature. Difficulty arises in obtaining a continuously accurate indication of temperatures, however, because of the time lag of heat transfer from the stator conductors to the RTD caused by the insulating material surrounding the conductors. Temperature changes in the conductor will not be reflected in RTD resistance change until heat is transferred through the thermal resistance and capacitance of the insulating material.

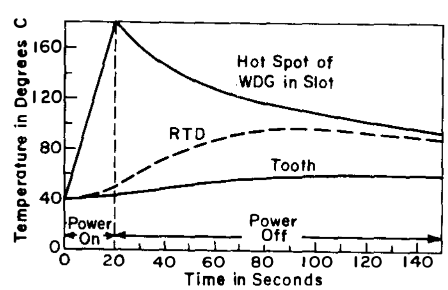


Figure F.4 Approximate temperature of RTD in large motor during locked rotor.

If the copper temperature is changing very rapidly, such as during locked rotor, the RTD will lag far behind the copper temperature as shown in Figure F.4. Consequently, monitoring the RTD temperature is inadequate for thermal protection during rapid-transient conditions. However, for steady-state indication of temperature, the RTD is very accurate.

A relay which responds to changes in resistance of RTDs, providing steady-state indication of motor-winding temperature, used in conjunction with a bimetallic overload relay will provide reasonably precise over-temperature protection for the motor.

Available solid-state relays contain a device which will more accurately compute hot-spot temperature by utilizing RTD amperes and line amperes. This relay accurately tracks motor heating and is recommended in preference to the separate bimetal relay and RTD relay.

OPEN-PHASE AND PHASE-UNBALANCE PROTECTION

A three-phase motor may be damaged when subjected to unbalanced line currents. Usually, the damage occurs in the rotor from overheating, caused by reverse sequence components of currents not detected by normal overload devices. The rate of motor heating will be a function of the degree of phase unbalance, the most extreme of which is the open-phase condition. For that reason, open-phase relays should operate instantaneously to avoid serious motor damage. Likewise, a motor may be damaged over a period of time with as little as 10% unbalance, where unbalance is a transient condition which would not justify instantaneous shutdown. Consequently, the time to trip should be delayed in proportion to the percentage of unbalance.

More comprehensive open-phase or single-phase protection can be obtained by applying a solid-state motor-protective relay, which will trip the contactor in the event of an open phase, regardless of the cause, even if external to the vacuum Limitamp control.

A possible concern that may arise when applying a medium-volt contactor to a transformer feeder is what happens to the contactor when a voltage dip occurs. In the past, the contactor would drop out — removing power from the primary of the transformer when the contactor coil power is reduced to 60 to 80 percent of full voltage. To prevent dropout during loss of control voltage, latching contactors should be applied. In these cases, the contactor is latched by a closing coil and unlatched by a trip coil. A capacitor trip device can be applied to trip the contactor in the event of total loss of control power. (See Latched Contactors, page B4.)

CURRENT DIFFERENTIAL PROTECTION

The term differential, as applied to a type of protective relaying, designates the principle on which the scheme operates — that is, a difference in current. The relays used are connected in such a way as to detect a percentage differential in current between ends of a motor winding. Ordinarily, in a machine operating without a winding fault, the current into one end of a phase winding is equal to the current out the other end of the same winding. When a fault occurs, however, the current into one end of the winding is short circuited inside the machine (to another phase or to ground) at the place of fault, so that a differential occurs between current "in" and current "out." This causes the relay to operate. The percentage differential may at times be quite small when the fault is located at a point of high impedance inside the motor winding, and this is the reason why straight overcurrent relays alone do not always give adequate protection.

The cost of this type of relaying is justified by the size of the investment to be protected. Large motors (usually above 1500 hp) that are expensive to repair or replace often employ differential relays.

Specifically, differential relays accomplish the following:

1. Provide for power interruption to a motor in the event of a phase-to-phase insulation failure in the motor windings.
2. Provide for power interruption to a motor in the event of a phase-to-ground fault in the motor winding.

The primary use of differential relays in Limitamp Controllers is to give fast, sensitive protection for faults in the end turn outside the stator punchings. Such faults are relatively rare compared with ground faults. However, when they do occur, the presence of differential relays would probably mean the difference between minor and extensive damage.

Two methods of differential protection are available. One uses six identical current transformers: three located in the motor leads and three located in the wye points of the motor windings, usually at the motor. In conjunction with these six current transformers, a Type IJD or CFD relay is used to detect the difference in current in the current transformer (CTs). The other method, known as self-balancing, uses three donut-type CTs. Both the motor leads and the wye connections are brought back through the holes in the donut CTs. For this system, an instantaneous relay of the hand-reset type is used.

GROUND-FAULT RELAYS

Ground fault relays are justified economically for all motors rated 2300 to 7200 volts, 150 horsepower and above. The purpose is to provide interruption of power to the motor as rapidly as is practical after positive indication that a ground fault has occurred.

The time of interruption of ground-fault current is dependent on several factors:

1. Sensitivity of the ground-fault relay.
   (a) Instantaneous type
   (b) Time-delay type
2. Magnitude of ground current.
3. Clearing time of the power interrupter.

The importance of clearing ground-fault current rapidly cannot be overstressed. Ground current inside rotating

F

machines causes damage to the lamination which, if not interrupted rapidly, necessitates complete disassembly and repair of the motor.

Although most ground-fault relays are now of the instantaneous type, few applications do require inverse-time current relays for coordination and selectivity reasons. The use of instantaneous-type relays is made possible through the employment of a zero-sequence "donut" or window-type current transformer installed in the starter in such a way as to permit all three conductors of the three-phase line to be used as the current-transformer primary.

Phase currents add to algebraic zero, regardless of magnitude, and no secondary current flows except that induced by the primary current going to ground. This system gives positive indication of ground current, eliminates false tripping and permits instantaneous relaying.

If time coordination with other ground-fault relays is necessary, time overcurrent relays may be used in the current-transformer arrangement.

For certain sized motors where the power system permits, ground-fault relays may be used as a less expensive alternative to differential relays. Most phase-to-phase winding faults detected by differential relays result in a simultaneous phase-to-ground fault, thereby operating the ground fault relay. For that reason, ground fault relays may be used as a less expensive alternative to differential relays.

Another method of detecting ground currents in a three-phase system employs three separate line-current transformers, one in each phase, with the secondaries fed through a single current relay. In this system, the secondary currents should sum to zero just as they do in the primary of the "donut" current transformer. And, with no ground current flowing, the three secondary currents do add and cancel each other out. Ground current only will cause the relay to operate. For currents of large magnitude, however, such as motor locked-rotor current, current-transformer saturation becomes a problem, causing residual current to flow in the relay coil...resulting in false tripping. To prevent false tripping with the residual connection, time-delay relays are necessary to permit riding over the starting period of the motor. This fact makes instantaneous relays impractical in the residual system.

Instantaneous ground-fault relays may be applied to Limitamp (NEMA Class E2) controllers without limitation on available ground current. The fuse and relay-contactor clearing times are such that ground-fault currents up to and including the fuse rating will be cleared without damage to the controller.

Standard ground-fault relay used in Vacuum Limitamp Control is a solid-state relay which operates on approximately 4 to 12 amperes ground-fault current. If greater sensitivity is required, other solid-state ground-fault relays may be furnished which can be adjusted to trip as low as 1 ampere. However, extreme care must be exercised in applying ground-fault relays of such low pick up. They could trip falsely on system-charging current. A magnetic ground-fault relay can be provided on request.

UNDERVOLTAGE PROTECTION

NEMA defines undervoltage protection as a device whose principal objective is to prevent automatic restarting of equipment.

Instantaneous undervoltage protection is inherent to the standard 3-wire control circuits, since the contactor will drop out and stay out on loss of voltage.

TIME-DELAY

Time delay undervoltage protection (TDUV) for a Limitamp controller can be provided to prevent shutdown of a motor on adjustable duration voltage dips below the adjustable dropout voltage. With either time-delay or the standard instantaneous undervoltage protection, the motor remains disconnected until the operator restarts the motor.

TDUV — AUTOMATIC RESTART

In the event of voltage dips of short duration, conventional TDUV circuits provide an automatic restart of Limitamp contactor without operator intervention. (A time delay of approximately 1.5 seconds is usually provided.) However, in motor applications, automatic restarting can cause serious damage to windings and mechanical loads connected to the motor due to out-of-phase reclosing. In worst cases this out-of-phase reclosing could apply up to two times the normal voltage to motor windings. TDUV auto-restart scheme is not recommended for synchronous, wound-rotor or large horsepower high-speed squirrel-cage motor controllers without additional circuitry to delay reclosing after a UV condition.

The TDUV automatic restart scheme in Limitamp Control permits instantaneous shutdown by connection of the STOP button into the UV relay circuit. Care should be taken not to connect a maintained-contact device into this circuit.

SYNCHRONOUS-MOTOR CONTROL AND EXCITATION

SYNCHRONOUS MOTOR CONTROL

GE Limitamp synchronous-motor controllers are offered for both brush-type and brushless synchronous motors. As a standard, both brush-type and brushless synchrnous motor controllers are equipped with the CR192 µSPM solid-state field application and protection module. This microprocessor-based module provides basic synchronous motor control and protection functions including squirrel-cage starting protection, power factor and pull-out running protection, and field application control to maximize pull-in torque (for brush-type machines only). Digital displays of motor running line current and power factor are featured along with a keypad for entering set-point parameters. Available options are field loss protection, exciter voltage check protection, field amps display, exciter volts display, incomplete sequence protection, and power factor regulation (when used with compatible SCR type variable field exciters).

EXCITERS FOR BRUSH TYPE MOTORS

For synchronous motors equipped with slip-rings and brushes, Limitamp is offered with a variety of excitation options. Single-phase solid-state exciters can be integrated in the controller NEMA 1 ventilated enclosure up to 9 kW (exciters must be derated for non-ventilated enclosures). Larger exciters require auxiliary enclosures that can be placed in the common bussed line-up with the Limitamp controllers. Two basic types of exciters are available:

- SFC (fixed excitation with adjustable tapped transformer)
- VFC (on-line adjustable excitation by manual or automatic means)

FIXED EXCITATION

The basic exciter offering is a single-phase, tapped-transformer, static field contactor (SFC). The SFC is a solid-state switching device consisting of silicon controlled rectifiers (SCRs) in a bridge circuit for rectification of AC power to DC. Additional SCRs are provided to switch the field discharge resistor. During starting, the SFC switches the field discharge resistor on so that the induced field current from the motor field is passed through the discharge resistor. The field discharge resistor is also switched on to discharge the field current when DC is removed at motor shutdown and if, during normal motor operation, the motor field generates a high voltage surge above approximately 600 volts, such as would occur if the motor "slips" a pole. When the motor has accelerated to near synchronous speed, the CR192µSPM module signals the SFC to apply DC to the motor field, the SFC switches the field discharge resistor off and causes the SCRs in the rectifier bridge to turn on, resulting in DC being applied to the motor field. The bridge SCRs are gated "full on" so that they emulate a diode rectifier bridge. The voltage of this DC field supply is determined by the tap connection of the customized transformer that feeds AC power to the rectifier bridge. This transformer has secondary taps arranged so that the DC voltage can be adjusted in 5% increments from 70% to 130% of the transformer nominal secondary voltage by changing connections at the transformer tap.

VARIABLE EXCITATION

Another exciter offering is the electronic variable field contactor (VFC). The VFC is available in single- or three-phase versions. Three phase VFC exciters are recommended for sizes 20 kW and above (125 VDC fields), and 25 kW and above (250 VDC fields). Like the SFC (above), the VFC controls the switching of the field discharge resistor and DC to the field depending on inputs from the CR192 µSPM. The difference is that the gating of the rectifier bridge SCRs can be controlled by varying an analog voltage at its control input. This allows on-line control of the DC exciter voltage by any of several means:

1) Manual control via a door-mounted potentiometer.
2) Automatic control via the field current regulation module.
3) Automatic control via the CR192 µSPM equipped with power factor regulation.

ON-LINE FIELD ADJUSTMENT

The manual potentiometer is normally mounted on the door and allows an operator to adjust the motor field current while the motor is running. This provides the convenience over the SFC type exciter of not having to shut down the motor and physically move cables between several taps on the exciter transformer.

FIELD CURRENT REGULATION

The field current regulator module also employs a manual potentiometer for adjustment of the field current. However, the regulator provides a closed loop control so that the VFC DC output is automatically adjusted to maintain the set-point field current as set by the manual potentiometer. This feature allows the operator to set the field one time at a desired field current. The field current will then be regulated to compensate for field resistance changes due to field winding heating or system voltage fluctuations. The leading reactive power contribution of a synchronous motor is related to the level of field current. If it is desired to maximize the contribution of leading reactive power from the synchronous motor at all shaft loading conditions, set the field current as high as possible without exceeding its nameplate rating. Field current regulation is the ideal choice for maximizing the leading reactive power because it allows the operator to set the field current very close to rated and not worry about the current "creeping" higher or lower from the potentiometer setting.

POWER FACTOR REGULATION

Power factor regulation is an excellent choice for applications requiring field forcing, which is applying DC excitation above its rating for a short time. Many drives, such as chippers, are subject to transient impact overloads many times the motor rating for short time intervals. By forcing the field, the synchronous motor can be enabled to deliver shaft torques above the rating without "pulling-out" of synchronism and shutting down. GE tests on chipper drives have demonstrated that the power factor regulation option can provide the rapid field forcing feature to prevent disruptive motor "pull-out." Power factor regulation operates on the principle that the motor running power factor is a good predictor of motor pull out. Before a motor pulls out of step (as a result of high shaft loading from a hard or oversized log entering a chipper), the power factor dips in the lagging direction drastically. By setting the regulator such that it boosts excitation as the power factor dips more lagging than the regulator set point, the motor running power factor is held to a "healthy" level and motor "pull-out" is avoided. Power factor regulation also allows the field excitation power to be conserved when the motor is running lightly loaded or unloaded. This not only allows energy conservation but also deeper no-load cooling of the motor windings, so the motor runs cooler for a given level of RMS loading. Power factor regulation can help regulate the power system voltage by minimizing reactive power swings over a wide range of motor loads.

BRUSHLESS SYNCHRONOUS CONTROL

The CR192 μSPM is also designed for use with brushless synchronous motors. It provides timed field exciter application, power factor and pull-out protection and starting/stall protection. Included with the standard brushless synchronous motor Limitamp controller is a variable exciter field supply consisting of a door mounted variable autotransformer and rectifier for on-line exciter voltage control.

FIXED-TAP FIELD RESISTOR

A fixed-tap field resistor may be used for separate DC source. This resistor, when supplied with the Limitamp panel, is mounted on top and is connected directly in series with the synchronous-motor field as a means of adjusting field current. The resistor is continuously rated with taps to adjust field current 10-percent above and below rated full-load field current for rated power factors in approximately 2½-percent steps.

F

CONTROL CIRCUITS

CONTROL POWER TRANSFORMER

Control power transformers used in Limitamp starters are single-phase, air-cooled, core-and-coil construction with high-voltage windings covered to prevent contamination by dust and dirt. Those furnished in standard panels have a 25-kV Basic Impulse Level (BIL) rating. When specified, 60-kV BIL rated control transformers can be furnished, but will require special space consideration. Two kVA is standard in a basic controller. Transformers above 2 kVA are optional, and above 3 kVA may require an auxiliary enclosure for mounting.

OMISSION OF CONTROL POWER TRANSFORMER

A lineup of starters can use a common control power transformer or other source of control power. In either case, the power source and control circuit must be provided with interlocking relays so the loss of either will shut down all operating motors. Control bus is required in all controllers if a common source of control power is used.

A single source of control power results in some disadvantages: (1) Unless each panel is provided with a fused control switch, troubleshooting must be done with live wires in the panel; (2) a single controller, if relocated independent of the lineup, will require modification to add a control transformer and fuses; and (3) the loss of control power will cause shutdown of all machines.

TIMING RELAYS

Pneumatic-type timing relays close or open a circuit after a definite elapsed time on either energization or de-energization.

Motor-driven timing relays close or open a circuit with time delay on either energization or de-energization. They provide a wide range of time, however, and are not affected by ambient temperatures. Solid-state timing relays with high accuracy and repeatability can be furnished.

INCOMPLETE-SEQUENCE RELAY

An incomplete-sequence relay is used to shut down the motor (squirrel-cage induction or synchronous) on reduced-voltage starting if the control fails to transfer to full voltage. It protects the starting reactor or autotransformer from energization longer than rated time. The relay can be furnished for other sequencing functions also.

JOGGING

Drives requiring "jogging" (or inching) must have the control circuit arranged for repeatedly closing the line contactor at short intervals to effect small movements of the driven machine. The line contactor is held closed only as long as the JOG button is held depressed.

An anti-kiss circuit is provided with the JOG push button, including a jog relay. The jog relay closes when the JOG button is depressed, energizes the line contactor coil, seals itself in around the JOG button and is dropped out only after the line contactor has closed and wiped in. This makes possible repeated opening and closing of the line contactor, but also assures that the tips wipe closed each time.

CURRENT INTERLOCKING

Current-operated relays indicate when the arc is completely extinguished after the line contactor opens. These relays then permit closure of a reversing contactor. A short circuit may occur if a reversing contactor closes after the forward contactor opens but before the arc has been extinguished. This circuit is necessary in controllers with "plug stop" or where pressing one instantaneous contact picks up reversing contactor while running forward. Current interlocking is not normally used on overhauling loads such as mine hoists, since during the lowering cycle enough current may not be drawn to operate the interlocking relays.

This circuit is not supplied on standard Limitamp reversing controllers, as the operator is expected to turn the selector switch to reverse only after pressing the STOP button.

POTENTIAL INTERLOCKING

Potential interlocking is used for the same reason as in current interlocking. Potential transformers and interlocking relays are added to prevent closure of one primary contactor before complete interruption of the arcs at the tips of the other (reverse) contactor. Operation is based on the principle that by the time the disconnected motor's generated EMF has decayed to the point where the interlocking relays have dropped out, the arc in the disconnected contactor has extinguished, and closing the reversing contactor is permissible.

Potential interlocking is used on hoists and other applications having possible overhauling loads.

INSTRUMENTATION

AMMETER

An ammeter (panel-type or switchboard-type) is used to indicate either motor amperes or total incoming amperes. It can either be hardwired to the current transformer of one phase or all three phases can be monitored by the use of a selector switch. One current transformer is required for single-phase reading; two are required for open delta three-phase reading; three are required in a wye circuit. Three window-type current transformers are provided as standard on Limitamp Controllers.

VOLTMETER

The voltmeter (panel-type or switchboard-type) is used to indicate phase-to-phase potential. One potential transformer is required if only one phase-to-phase potential is monitored. Two potential transformers, connected in an open-delta configuration, are required along with a selector switch to monitor any one of the three phases. Three potential transformers mounted in an auxiliary enclosure and a selector switch are required to read both phase-to-phase and phase-to-neutral potentials.

POWER FACTOR METER

A power factor meter is used to indicate power factor lead or lag. It is useful in adjusting power factor in synchronous motor drives and in determining the power factor of a given drive. The addition of a power factor meter requires the addition of potential transformers, or of some other potential source with correct phase and accuracy. When a synchronous starter is supplied, the CR192 μSPM has a digital power factor meter built into the device.

WATTMETER

A wattmeter is used to indicate loading or useful power being delivered to a drive at any instant. The instrument is typically calibrated in kilowatts. Two potential transformers connected in open delta are required for operation.

OPERATION COUNTER

The operation counter is electrically operated from a control interlock on the line contactor. It totals the number of times the contactor has closed and opened, and thus provides data for the establishment of maintenance schedules, a record of the number of batch processes initiated over a given period of time, or any other purpose where the number of line contactor closures may be significant.

VARMETER

The varmeter indicates lagging or leading reactive power. It requires the addition of two potential transformers. In totaling reactive power on a bus feeding several loads, individual vars for each load can be measured by means of individual varmeters on each motor and added directly.

ELAPSED TIME METER

An elapsed time meter is used to indicate hours of operation or shutdown time of a particular motor or drive for the purpose of production records, maintenance scheduling, or engineering records.

TRANSDUCERS

Transducers are used to transmit electrical properties to remote devices, while maintaining a high accuracy when the cabling distance or resistance may be high. The standard output is 4 - 20 mA DC. Current transducers require (1) CT; voltage transducers require (1) PT; watts transducers require (2) CTs and (2) PTs.

TEST BLOCKS

Current and potential test blocks provide a plug-in feature for portable meters, to obtain readings or records without shutting down the machine.

WATT-HOUR METER

A watt-hour meter is used basically to measure work done. Specifically, it registers total watt-hours used by the motor or other load on the controller. It is useful in assigning power charges in plant accounting or for record keeping of power consumed per unit of manufacturing. It requires the addition of two potential transformers connected in open delta.

A demand register indicates maximum demand. It is useful in determining peak loads for particular machines where demand must be controlled to keep power costs at a minimum.

Below are typical push buttons, selector switches and control wiring used in standard Limitamp. The following pages depict cut-sheets showing details of typical components. For more detail, refer to Table A.4,which shows publication reference.

Table G.1 Typical push buttons

Function	Device used	Application
Start-Stop	CR104P momentary type	FVNR starters with 3-wire control
Stop	CR104P momentary type CR104P maintained type **Options:** Mushroom head Provisions for locking open	Starters with 3-wire control Starters with 2-, 3-wire control
Forward-Reverse-Stop	CR104P momentary type	FVR starters
Fast-Slow-Stop	CR104P momentary type	2-speed starters

Table G.2 Typical selector switches

Function	Device used	Application
On-Off	CR104P maintained type	Permissive start with 2-, 3-wire control
Hand-Off-Auto	CR104P maintained type	Auto or manual start with 2-wire control
Fast-Slow-Off-Auto	CR104P momentary type	2-speed starters

Table G.3 Control wiring details

Item	Standard	Option
Control wiring type	MTW, thermoplastic 600V, 90° C	SIS (vulkene)
Control wire size	AWG #14	AWG #12
Control wire terminals	Uninsulated spade type	Insulated ring type
Wiremarkers	Plastic sleeve type	Heat-shrinkable labels
Wire color code	Power-Black Control-Red Neutral-White Ground-Green	
Terminal blocks	CR151B, 30A, 600V	EB-25, 50A, 600V Connectron Type KUX

CR120B MACHINE TOOL AND INDUSTRIAL RELAYS

The CR120B and CR120BL Series A, multi-circuit industrial relays are designed to meet most panel application requirements. They are available as standard, latched or time-delay relays.

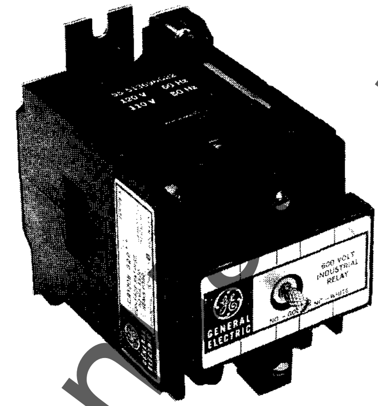
All forms of the relay mount on the same base and in the same small panel-mounting area. Relays may be arranged in any configuration or modified on a panel without altering the mounting area.

FEATURES

- **Bifurcated contacts assure positive make** — unique bifurcated contacts assure positive make at all voltages and give excellent fidelity, even in harsh environments.
- **Transparent Lexan® contact cartridges** — allow inspection of contacts.
- **Convertible contacts** — allow conversion from normally open to normally closed, or vice versa. Just change the terminal screws and invert the contact module.
- **Quick-change coil** — can be changed without removing any screws.

LATCH ATTACHMENT

The latch attachment mounts on any standard CR120B relay in the same manner as a deck adder.



CR120B standard AC relay

G

Table G.4 Coil data

	Inrush VA	Sealed VA	Sealed watts
AC relay coil	120	15	7
AC unlatch coil	31	15	9.2
DC relay coil	235	2.8	2.8

Table G.5 Coil data

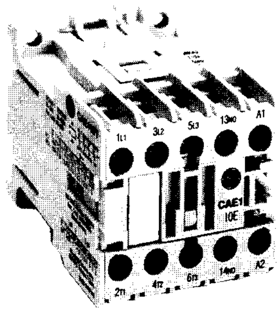
	Volts
60 Hz	115-120, 230, 460
DC	24, 48, 125

Table G.6 Contact ratings

Type of contacts	Max. AC voltage	Max. Continuous rating amperes	Maximum AC volt-ampere rating		Maximum AC rating amperes		Maximum DC rating amperes		Maximum DC volt-ampere rating
			Make	Break	Make	Break	125V	250V	300V or less
Inst.①	600	10	7200	720	60	6	1.1	0.55	138
Delay	600	5	3600	360	30	3	0.5	—	—

① Use for CR120B contact rating.

C-2000 MINI-CONTACTORS (MCR4)



FEATURES AND BENEFITS

- **Modular design** — Various configurations can be created with the wide selection of available accessories.
- **Compact size** — The contactor/relay mounting profile is approximately 1¾” x 1⅞”.
- **Long life** — This family of relays offers superior performance. Mechanical life is rated at 10 million operations.
- **Reliable operation** — These products are manufactured with the latest advancements in materials technology and designed to ensure long, dependable operation. (Coils are designed for protection against burnout during demanding brownout conditions.)
- **Flexible mounting** — Mounting is not restricted for contactor and relay applications; contactors may be horizontal-, tabletop- or ceiling-mounted.
- **International acceptance** — Devices are listed and certified to IEC 947.4, VDE0660 and North American standards, and they provide dual markings.

ACCESSORIES

Surge Suppressor
Used to protect control circuits from voltage transients. Plugs into front of contactor, no external wiring required.

While the standard line of DC-operated relays requires only three-watt coil holding current, some PLC applications require lower wattage coils to efficiently interface with the PLC. Special relays are available with 24-volts DC coils, which only require 1.2 or 2 watts for pull-in and holding. These relays are available in three different terminal configurations — 4NO, 3NO-1NC and 2NO-2NC.

Table G.7 Main contacts data

	Control relays
Rated insulation voltage (IEC 947.1)	660 volts
Rated thermal current (UL 508)	10 amperes
Contact rating	A600, Q600
Frequency limits	25-400 Hz
Impedance per pole	2.4 mΩ
No overlap between NO and NC contacts	
Space	1.1 mm
Time	>2 msec

Table G.8 Main contacts data

Time	Rating amperes	Carry continuous amperes	Make momentary amperes	Break amperes
A600	AC	10	60	6
Q600	DC	2.5	0.55	0.55

Table G.9 Pickup/Dropout percentage coil voltage

Type coil	Pickup	Dropout
AC controlled	80%-110%	35%-55%
DC controlled	80%-110%	20%-40%
PLC interface (1.2W)	80%-125%	20%-30%
PLC interface (2W)	70%-125%	20%-35%

G

CR104P PILOT DEVICES

DESCRIPTION

Newly designed nameplates with chrome-plated octagonal rings project an attractive, quality appearance. Positive-feel selector switches give a quality touch in all illuminated, solid-color, spring-return and maintained units.

Standard and illuminated push buttons and selector switches are available with key or conventional operation. The CR104P push button line also includes press-to-test and standard indicating lights, mushroom-head, joystick, push-pull and push-push operators.

APPLICATION

These pilot devices are specially adapted to machine-tool service or any application where oil or coolant is present. The convenient one-hole mounting makes this line suitable for general purpose use in equipment of all kinds where panel mounting is possible. This line is ideal for applications where oil tightness, watertightness and long life are essential.

All units are suitable for use in Type 1, 3, 3R, 4, 12 and 13 environments when mounted in enclosures rated for those same applications. (See ① under Table G.10.)

FEATURES

- **Ease of assembly** — One-screw contact block mounting. Octagonal ring provides ease in front panel mounting and enclosure applications.
- **Greater torque** — Due to the eight-sided ring design, greater torque can be developed during assembly and installation to provide oil tightness.
- **Stocking inventories reduced** — Forms may be furnished as complete units or as components, allowing building-block construction from a minimum of stock.
- **Color convertible** — Colored knobs and caps are available in kit form for easy field conversion.

Type	Standard	Push-to-test	Bulb	Color
Full voltage (120 Volts AC)	X	X	#120PSB	Red, Green, Amber, Blue, White, Clear
Transformer (6 Volts AC Secondary)	X	X	#755	
Neon	X	N/A	Neon	Red, White, Amber, Clear
LED (Transformer type only)	X	X	LED (6 volt)	Red, Green, Blue, Amber

CONTACT RATINGS

Table G.10 AC ratings, NEMA A600 heavy pilot duty

Maximum AC	Continuous current amperes	AC voltamperes 50/60 Hz②	
		Make	Break
600	10	7200	720

① CR104PTP units are suitable for Type 1, 12 and 13 applications only.

② Maximum make and break currents are 60 and 6 amperes, respectively, for voltages of 120 and below.

Table G.11 DC ratings, NEMA P600

Maximum make or break amperes		
125 volts	250 volts	600 volts
1.1	0.55	0.2

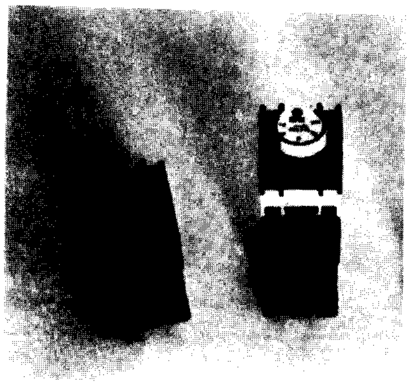
CR104P PILOT LIGHTS

Pilot lights match appearance of switches above. Standard applications use full-voltage or transformer-type lights. Optional nameplates match those used with switches; neon lights are available (with limited lens colors).

Table G.12 Typical pilot lights

Function	Device used	
Full voltage	CR104P with 120-volt, 10,000-hour lamp	
Transformer	CR104P with 6-volt, 20,000-hour lamp	
Push-to-test	CR104P, full-voltage or transformer-type	
Colors available	Red	On, Fast, Forward, Up
	Amber	Down, Reverse, Slow
	Green	Stopped, Ready

CR7R INDUSTRIAL TIMING CONTROL RELAY



The CR7R industrial control timing relay is a compact relay designed for heavy-duty industrial control applications where reliability and versatility are required.

- Compact mounting dimensions
- Mounted on vertical plane
- Straight-through wiring
- Easy coil replacement
- Long contact life
- High operating speed
- Silver alloy contacts
- Captive terminals
- Rated 600 volts
- UL listed

Auxiliary components convert basic four-pole relay to a four-pole relay with two pneumatic time delay contacts.

Table G.13 Instantaneous relay contacts

Contact arrangement AC controlled	Contact arrangement DC controlled
4 NO 3 NO, 1 NC 2 NO, 2 NC	4 NO 3 NO, 1 NC 2 NO, 2 NC

• Pull-in volts	Min. 85% rated voltage
• Drop-out volts	50T or less rated voltage
• Mechanical life	In excess of 10 million operations
• Contact life	In excess of 1 million operations

Table G.14 AC coil ratings

AC coil rating			
24V/60 Hz 48V/60 Hz 120V/60 Hz 208V/60 Hz 240V/60 Hz	24V/50 Hz 48V/50 Hz 110V/50 Hz 190V/50 Hz 220V/50 Hz	277V/60 Hz — — 480V/60 Hz 600V/60 Hz	240V/50 Hz 380V/50 Hz 415V/50 Hz 440V/50 Hz 550V/50 Hz
AC inrush	**Holding**	**DC inrush**	**Holding**
VA	VA	W	W
55	9	8.5	8.5

Table G.15 DC coil ratings

DC coil rating	
24 volts DC	125 volts DC
48 volts DC	250 volts DC

Table G.16 Pneumatic time-delay attachments — 1 NO, 1 NC time delay contacts ①

Time-delay (convertible)	Time range (seconds)
TDAE	0.3-30
TDAE	10.0-180
TDAD	0.3-30
TDAD	10.0-180

① Contacts are in addition to base relay contacts.

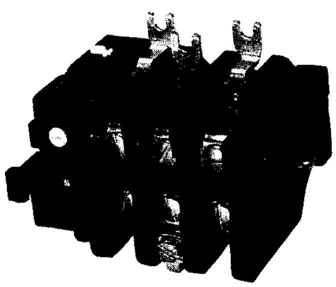
Table G.17 Contact ratings — for relay contacts and timer contacts

Max. AC voltage	Max. continuous amperes	Maximum AC Volt-amperes		Maximum AC amperes		Maximum DC amperes — break or make					
						Relay			Timer		
		Make	Break	Make	Break	24V	125V	250V	24V	125V	250V
600	10	7200	720	60	6	5.0	1.1	0.55	2.5	.55	.27

G

CR324 BLOCK OVERLOAD RELAYS FOR PANEL MOUNTING

3-POLE 600 VOLTS AC/250 VOLTS DC, 135 MAXIMUM AMPERES CONTINUOUS, UL FILE 2403



APPLICATION

The panel-mount block overload relay with ambient compensation provides overload protection for motors having full-load currents up to 135 amperes. The relays are furnished complete for use on control panels. When an overload condition occurs in any of the three legs in which heaters are inserted, it will cause the relay to trip, opening a normally closed contact, and closing a normally open contact.

A normally open circuit may be connected to a signal light, an alarm bell or input circuit of a programmable controller, e.g., to provide indication of an overload relay trip.

FEATURES

- +10/-10% adjustment of trip current to allow fine tuning and eliminate nuisance tripping
- Bright yellow visual trip indicator tells you at a glance if the relay has tripped
- Manual weld check — Check for welded contacts by depressing the arm to trip the relay and doing a simple continuity check across the terminals
- Dual bimetal current monitoring — Additional bimetal strip "anticipates" the rate of temperature rise in the motor winding, effectively reducing trip time in locked rotor conditions. It prevents dangerous temperature overshoot in the motor windings.
- Flexibility of operation — The trip rating can be easily changed by replacing the front-accessible heaters
- Isolated NO contact — Can be used for input to a programmable controller, an alarm bell, or a signal light
- Safe reset — Operates on upstroke only

Table G.18 Manual reset only

Maximum full-load current in amperes	Size	Control circuit arrangement	Catalog Number
27	1	1 NO, 1 NC	CR324C660A

Table G.19 Contact ratings

Continuous rating amperes	Make amperes	Recommended maximum interrupting capacity, amperes					
		DC circuits		AC circuits			
AC or DC		125V	250V	115V	230V	460V	575V
10	30	0.35	0.17	3	1.5	0.75	0.6

Multilin 269 Plus Motor Management Relay®

PRODUCT DESCRIPTION

The Multilin 269 Plus Motor Management Relay is designed to allow the user to safely maintain maximum-rated motor output without risk of downtime. To achieve this, the 269 Plus system has the following portfolio of Motor Management tools:

- A complete protection package including the unique Multilin features **FlexCurve**™ and **MotorMatch**™.
- **StatTrac**™ operation monitoring for effective maintenance.
- RelayCom™ option for motor monitoring by computer.
- Flexibility of control with prior alarms to alert the need for action to maintain operation.
- Diagnostic data gathering and retrieval to determine the exact cause of shutdown.
- Exponential running cooldown.
- Optional metering module with 4 isolated analog outputs.

The 269 Plus relay is housed in a compact, rugged enclosure compatible with all types of motor starters.

FEATURES

- Rugged, corrosion and flame retardant case.
- Durable polycarbonate front panel.
- 48 character backlit alphanumeric display.
- Red LED on steady when output relay activated.
- Indicator and remote alarm output when self-check detects internal hardware failure.
- Press to display actual motor values of current, temperature, thermal capacity and learned parameters.
- Provides user with application information and programming assistance.
- Allows user to set, alter and examine all alarm, trip and other setpoints.
- Allows user to increment or decrement currently entered setpoint.
- Allows user to scan the next or previous line on the currently selected page.
- Allows user to scan the next or previous page of actual values or setpoints.
- Press to store displayed setpoint in memory when in access mode.
- Use to return from altered setpoint or help message to previous display.
- Permits user to reset latched output relays.

OPTIONS

- Remote Mounted MTM Meter and Transducer Module communicates volts, KW, KVAR, PF and Hz to 269 Plus screen.

EASE OF USE

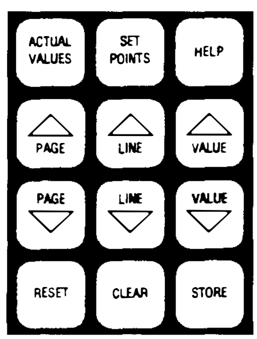
Simple operation

The 269 Plus relay will normally be shipped programmed for most application, and only minor field program changes will be necessary to suit the particular motor.

Use HELP key at any time
for operational assistance.

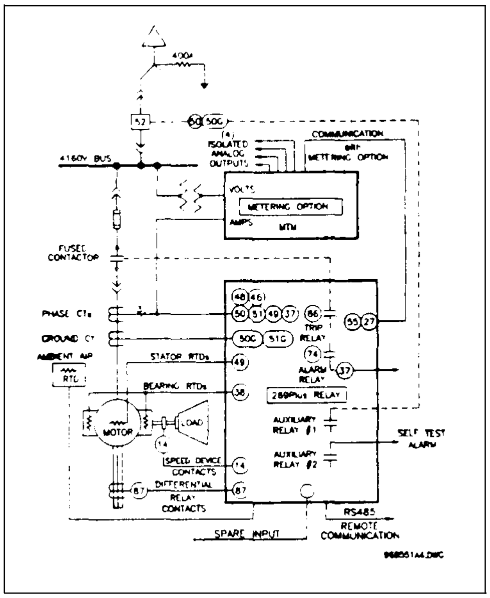
To facilitate this, the model 269 Plus has the following features:

- Keypad programming
- Tamperproof setpoints
- Backlit, 48-character alphanumeric display
- Question and answer messages
- Request for HELP messages
- Recall of setpoints
- Actual values upon demand
- Output relay status indication



The microcomputer design communicates information to the user through the 48 character alphanumeric display. Just like reading a book, the keypad page and line selection system guides the user through the required setpoint values for optimum motor protection and performance. To aid the user, the HELP key can be pressed at any time to provide additional information and programming assistance. Access for programming is gained by placing a jumper across the access terminals. When programming is complete, the jumper is removed, thus making the program secure and tamperproof. Alternatively, these terminals can be wired to a separate key-operated shorting switch available as an accessory.

A software access code can also be programmed for added security.



Legend

Device No.	Function
14	Speed Device
37	Undercurrent/Minimum Load
38	Motor/Load Bearing Overtemperature
46	Unbalance — Negative Sequence
47	Phase Reversal
48	Multiple Start/Locked Rotor
49	Stator Winding Overtemperature
49/51	Overload Curves/FlexCurve
50	Short Circuit
	Mechanical Jam/Rapid Trip
50G/51G	Zero Sequence Ground Fault
52	Breaker
74	Alarm Relay
86	Main Trip Latched Relay
	Auxiliary Relay No. 1
	Auxiliary Relay No. 2
	Differential Relay Contact Output
66	Starts Per Hour
27	Undervoltage (Meter Option)
	Frequency (Meter Option)
55	Power Factor (Meter Option)

Functional specifications

Motor Management and protection shall be provided by the 269 Plus Protection Relay.

Protective functions must include: Phase overload standard curves (51), overload by custom programmable curve (51), I^2t modeling (49), Stator Overtemperature/Bearing Overtemperature with 10 independent RTD inputs (49), negative sequence unbalance/single phase (46), phase reversal (47), starts per hour and time between starts (48), short circuit (50), ground fault (50G, 50N, 51G, 51N), undercurrent (37) and mechanical jam/stall.

Management functions include:

- Statistical data
- Pre-trip data
- Ability to learn, display and integrate critical parameters to maximize motor protection
- Communication with external devices

The relay shall be capable of displaying important metering functions. As a minimum phase voltages, kilowatt, kilovar, power factor, frequency and MWHr shall be available. In addition, undervoltage (27) and low power factor alarm and trip levels shall be field programmable. It is required that the metering option be a separate box that communicates with the 269 Plus relay and may be field installed without modification to the 269 Plus relay. The metering option can be used with any 269 Plus relay where diagnosis or load measurements are required and shall also provide isolated analog outputs for average RMS amps, kilowatts, kilovars and power factor.

G

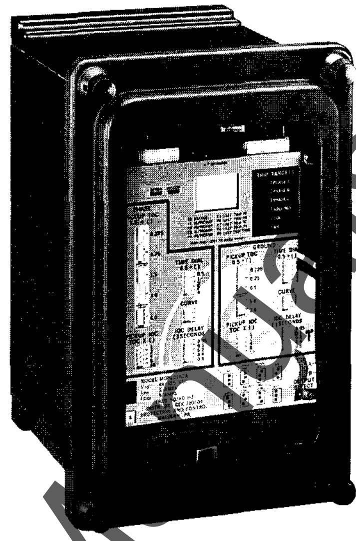
MDP 3-PHASE OVERCURRENT RELAY

DESCRIPTION

The MDP relay is a digital, microprocessor-based non-directional time overcurrent relay that protects against phase-to-phase and phase-to-ground faults. The MDP series relay includes four measuring units, including one for each of the three phases in addition to ground. Each measuring unit contains a time overcurrent unit and an instantaneous unit.

FEATURES

- Information
  - — Last trip current
  - — Last trip time
  - — Trip indication
  - — Pickup indication
  - — Breaker status
- Eight selectable curves
  - — Inverse (51)
  - — Very inverse (53)
  - — Extremely inverse (77)
  - — Long-time inverse (66)
  - — Four definite times
- Enhanced selectivity
  - — Block instantaneous
  - — Block ground
  - — Instantaneous delay
  - — Breaker status
- Configurable outputs
  - — 5 output relay contacts
- Communications
  - — Field upgradeable communications
  - — Interfaces with POWER LEADER distribution software
- Other
  - — Meets ANSI C37.90, BS142 and IEC 255
  - — Drawout construction (S2 case)
  - — External reset lever



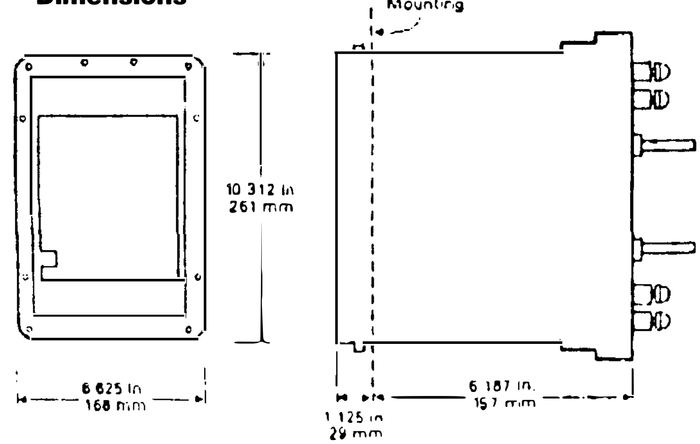
MDP Relay

MDP * * * 0000A

0	No communications or digital inputs
1	Digital inputs* and communication socket
2	Commnet communications card installed
A	RS232 communications option**
1	5A, 1.5 to 13.125A phase, 0.5 to 4.375 ground
2	5A, 1.5 to 13.125A phase, 1.5 to 13.125 ground
3	5A, 1.5 to 13.125A phase, 0.1 to 0.875 ground
4	1A, 0.3 to 2.625A phase, 0.1 to 0.875 ground
5	1A, 0.3 to 2.625A phase, 0.3 to 2.625 ground
6	1A, 0.3 to 2.625A phase, 0.05 to 0.4375 ground
1	24-48 volts DC
2	48-125 volts DC
3	125-250 volts DC

* Digital inputs include block ground, block IOC and breaker status
** RS232 communications is not field upgradeable; breaker status not available
*** MDPCMN upgrade communications card

Dimensions



HFC INSTANTANEOUS OVERCURRENT

The HFC relay is a hinged armature instantaneous device with two electrically separate contacts, assembled in a C1 single end drawout case. Each unit contains a target, which is raised into view and latched when the relay is picked up. The targets are manually reset by a button on the front of the relay cover.

The HFC is generally applied where a direct trip instantaneous overcurrent function is required.

The relay can be used to provide differential protection of a motor usually by means of self balanced primary current scheme with the current transformers mounted at the machine terminals.

Table G.20 Selection guide

Current range		Number of units	Model number	Case size	Weight lbs (kg) NET
Minimum	Maximum				
0.5 2.0	4.0 50	3	12HFC23C1A 12HFC23C2A	C1	8 (3.6)

Table G.21 Tapped coil ratings

Instantaneous unit (amps)	Range Link position	Rating (amps)	Continuous 1-second (amps)	Rating	K
0.5-4	L H	0.5-2 2-4	0.75 1.5	94	8,836
2-50	L H	2-10 10-50	3.7 7.5	130	16,900

Table G.22 Burden 60 Hz unit

Instantaneous unit (amps)	Link position	Burden at minimum pickup (ohms)			Burden times pickup (ohms)		
		R	X	Z	3	10	20
0.5-4	L H	10.63 5.13	9.77 3.49	14.44 6.21	9.81 4.66	8.56 4.26	7.8 4.18
2-50	L H	0.750 0.070	0.650 0.024	0.992 0.074	0.634 0.072	0.480 0.071	0.457 0.070

IJD PERCENTAGE-DIFFERENTIAL

DESCRIPTION

The type IJD relays are induction disk units used to protect AC rotating machines, two winding transformers, and wye winding of power transformers. IJD relays protect against phase-to-phase faults within the AC machine and the lead in the differential zone, provided the fault current is above the minimum pickup value.

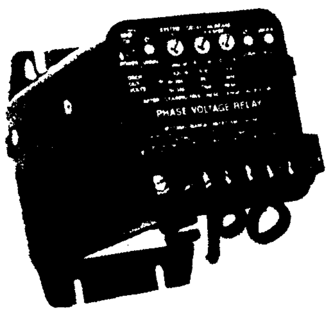
Model number	Frequency	Continuous rating (amperes)	Min. operating Current (amperes)	Min. operating Slope (percent)
Type IJD52A — 2 NO contacts, S1 case construction				
12IJD52A12A	60	5	0.5	25

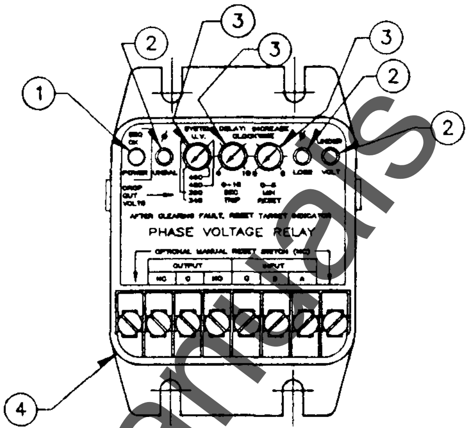
G

THREE-PHASE VOLTAGE MONITORS

MODEL LPVR

UL-listed File number E103039





GENERAL

The model LPVR is a three-phase voltage monitor that uses negative phase sequence monitoring to protect against phase loss, phase reversal and undervoltage on the power system. Electromechanical diagnostic indicators (manually reset) show trip conditions due to phase unbalance, phase loss and undervoltage. A green LED indicates that the power system has no faults present and that the phases are in sequence.

Model LPVR specifications:

- Provides prestart and running protection
- Fully rated 600 volt contacts
- Diagnostic indicators continue to show cause of operation after voltage is removed
- Adjustable undervoltage trip point settable to 75% of nominal
- Adjustable trip delay from 50 milliseconds to 10 seconds
- Adjustable reset delay from 1 second to 5 minutes
- Operates at 6% phase unbalance
- Maintains operation with a 12.5% phase voltage loss
- Automatic or manual reset, local or remote
- Operational green LED indicator
- Fail-safe — will not operate if fault is present
- Isolated Form "C" output contacts
- Terminal screws are #6-32 nickel-plated brass

① **GREEN LED INDICATOR:**
- Power system condition

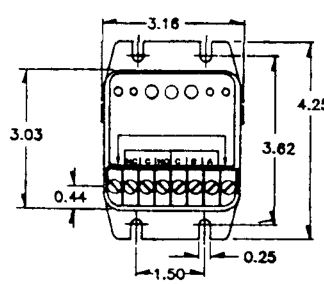
② **ELECTROMECHANICAL DIAGNOSTIC INDICATORS:**
- Phase unbalance
- Phase loss
- Undervoltage

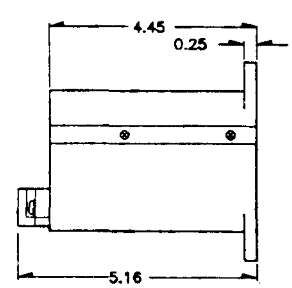
③ **ADJUSTABLE SYSTEM DELAYS:**
- Undervoltage trip point
- .05-10 second trip delay
- 0-5 minute reset delay

④ **TERMINAL BLOCK:**
- Automatic or manual reset
- Input voltage — 120-575 volts
- Output contacts — Form "C," 1 NO & 1 NC

Table G.23 Three-phase voltages available with Model LPVR

Catalog Number	Nominal rating	Voltage range
LPVR 120	120	90-125
LPVR 240	240	180-250
LPVR 480	480	360-500
LPVR 575	575	430-600

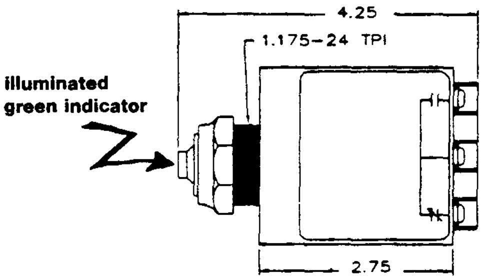




G

MODEL APVR

UL-listed File number E103039



GENERAL

The model APVR phase-sensing relay performs similarly to the model LPVR, except that the relay requires no adjustments. It will fit in the push button bracket, and thus does not increase the required unit spacing.

Model APVR specifications:

- Fail-safe — will not operate if a fault is present
- Manual or automatic reset
- Fixed undervoltage trip point: Approximately 90% pickup, 80% dropout
- Operates at 6% phase unbalance
- Maintains operation with a 6% phase voltage loss
- 3-second dropout delay to avoid nuisance tripping
- Operational green LED indicator
- Isolated Form "C" output contacts
- Output contact rating: 250 volts AC, 5 amperes (general use); 30 volts AC, 5 amperes (resistive)

Table G.24 Three-phase voltages available with Model APVR

Catalog number	Nominal rating	Voltage range	Frequency
APVR 120	120	95-135	60 Hz
APVR 240	240	190-270	60 Hz
APVR 480	480	380-530	60 Hz
APVR 575	575	455-600	60 Hz
APVR380	380	300-425	50 Hz

G

POWER LEADER™ EPM

GENERAL

The POWER LEADER EPM is a microprocessor-based device that displays a full range of over 50 metered values with revenue class accuracy of 0.5%. The PL-EPM is available with a communication option that is factory- or field-installable so that all data can be transmitted to a remote host computer.

FEATURES

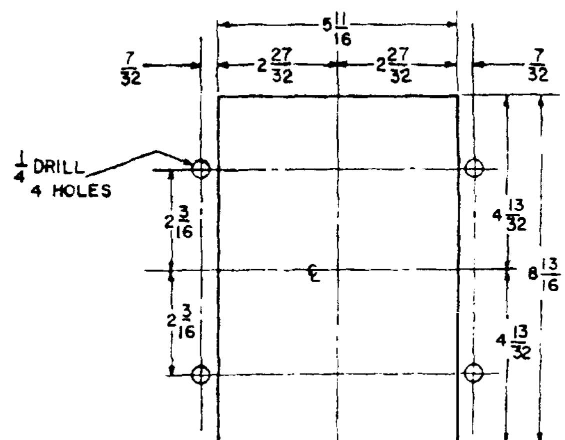
The PL-EPM comes in the standard S1 case as the present DS-63 and DS-65 electromechanical watt-hour meters. This provides the user the ability to retrofit the electromechanical meters with the PL-EPM. Metered values cover a full range of parameters:

- Revenue Class accuracy of 0.5%
- Optional communications provide connectivity to POWER LEADER network (Commnet)
- Pulse initiation option with programmable outputs

	(kWh, kVArh, kVAh, kQh)
Amperes	3-phase and neutral (0.25% accuracy)
Volts	L-L and L-N (0.25% accuracy)
Watts	per phase, 3-phase total, peak watts, watt demand, and watts at maximum kVA
Energy	kwh, kVAh, kVArh lag and lead, and kQh
Volt-amperes	per phase, 3-phase total, peak kVA and kVA demand
KVARs	per phase, 3-phase total, peak kVAr, peak kVAr lead, kVAr demand, kVAr demand lead
Power factor	per phase, 3-phase total, average, power factor at previous interval, power factor at maximum kVA
Frequency	60 Hz check factory for 50 Hz availabiltiy

INPUTS

The PL-EPM requires CT inputs with a 5-ampere secondary current. The meter can accept direct input voltages up to 600 volts and is self-powered from the voltage inputs. Three CTs are required for four wire wye-systems and two CTs are required for three wire delta-system.



PANEL DRILLING FOR SEMI-FLUSH MOUNTING
(FRONT VIEW)

G

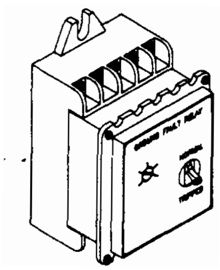
GROUND FAULT SYSTEM

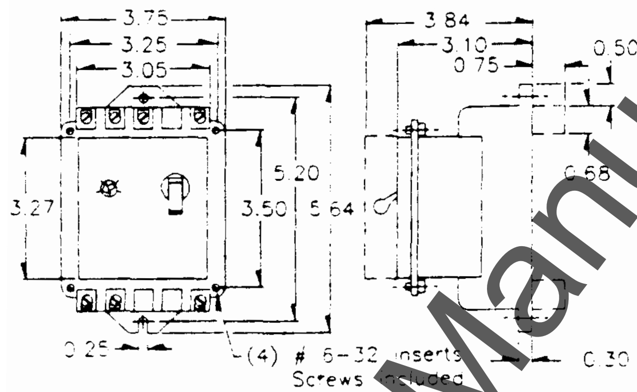
MODEL GFM

UL-listed File number E110395

SENSORS

Model number	Trip current	Window size
GFM 250	3.5 to 11	2.5"
GFM 462	4 to 12	4.62"

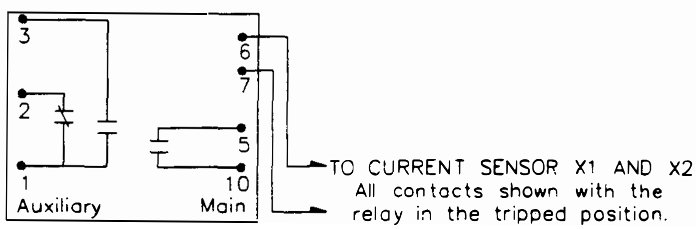




- Self powered.
- Temperature range: -30° C to 75° C.
- Positive "ON" (green) and "OFF" (red) condition indication, manual reset.
- Instantaneous only (GFM-353) standard.
- Optional time delay from instantaneous to 36 cycles (GFM-363).

GENERAL

These Class 1 model GFM ground fault protection systems are designed to minimize damage or loss to equipment caused by destructive arcing ground faults. This GFM system is designed for all polyphase applications and is ideally suited for motor control, motor control centers and high-voltage starters. Systems can be wye or delta, grounded or resistance grounded. When the ground fault current exceeds a preselected condition (current only, or current and time settings), the relay trips. The relay contacts can be connected in the control circuit of a motor starter, to the shunt trip of a circuit breaker or similar disconnecting or alarm devices. The system has an inverse time characteristic to prevent nuisance tripping. The relay tripping current value is field adjustable over the trip current range of the sensor. The adjustable trip time delay relay, when specified, is field settable up to 36 cycles.



MODEL GFM 353

Main contact rated 30 amperes, 277 volts AC.

Auxiliary contacts rated 10 amperes continuous, 23 amperes inrush, 120 volts AC.

G

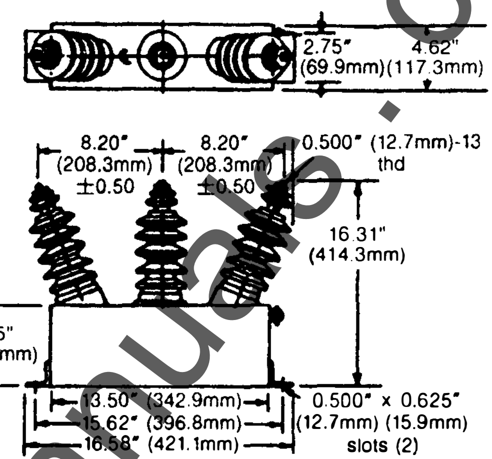
AC ROTATING-MACHINE PROTECTION

DIELEKTROL® PROTECTIVE CAPACITORS

0-18,000-ft. altitude

DIELEKTROL is the GE non-PCB power capacitor dielectric system, developed to provide an environmentally acceptable product with superior performance and reliability. The DIELEKTROL insulating liquid is a Class IIIB combustible fluid.

Protective capacitors contain a film dielectric and hermetically sealed bushings, which permit mounting of capacitors in an upright position or on the side.



Three-pole capacitor, 4160 volts

Table G.25 DIELEKTROL non-PCB dielectric protective capacitors with internal discharge resistors — indoor and outdoor mounting

Voltage rating RMS volts L-L	Maximum voltage RMS volts L-L	Catalog number	Poles per unit	Microfarads per pole	Approximate net weight	
					Lb	Kg
2400 or 4160	4576	18L15UJ	3	1.5	35	15.8

TRANQUELL® XEP™— STATION ARRESTERS

POLYMER HIGH-VOLTAGE

DESCRIPTION

Tranquell XEP polymer station arresters provide both excellent protective characteristics and temporary over-voltage capability. Gapless construction results in a design that is simple, reliable and economical while offering excellent pressure relief capability to meet the most demanding service conditions. The GE arrester is based on the field-proven Zenox™ — metal oxide disks known for maintaining stable characteristics. Tranquell station arresters are designed and manufactured in accordance with ANSI/IEEE C62.11.

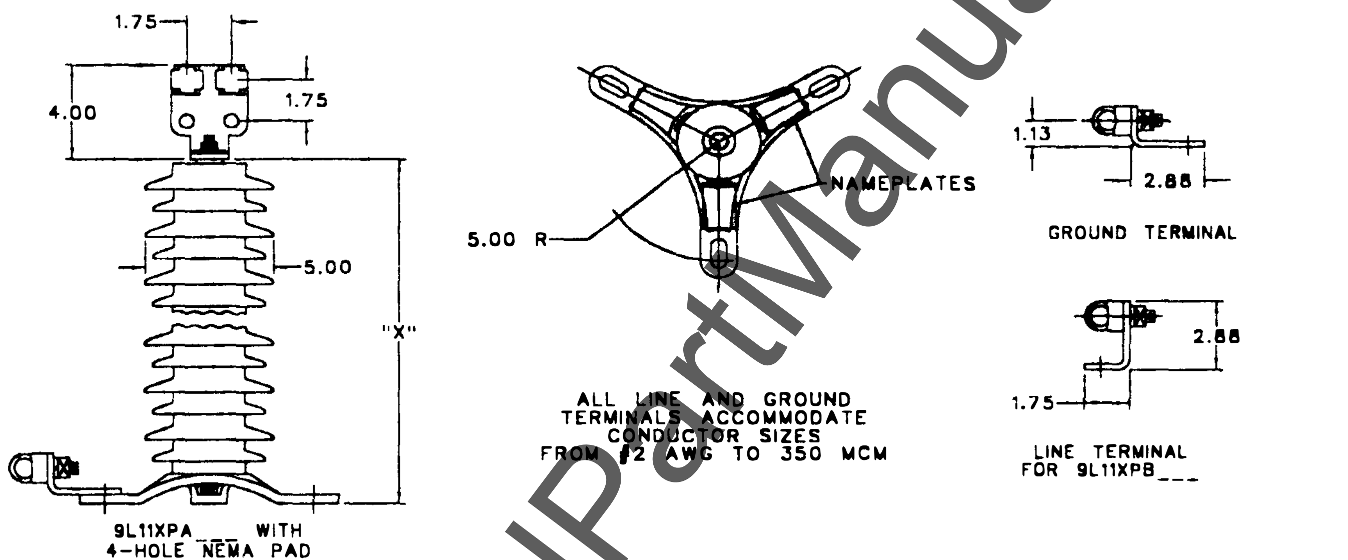


Table G.26 Polymer arrester (station-class) ratings

Arrester rating ① (kV RMS)	Maximum continuous operating voltage capability① (L-N) (kV RMS)	Normally used on system voltage class (L-L)		Single-pole arrester Catalog number Gray polymer housing with eyebolt (small diameter)
		Delta or impedance grnd. neutral sys. (kV RMS)	Solidly grnd. neutral sys. (kV RMS)	
3	2.55	2.4	4.16	9L11XPB003
6	5.10	4.8	—	9L11XPB006

① TRANQUELL arresters are designed to be operated at voltages equal to or less than their continuous capability. **Note:** For ratings above 360kV, contact factory

② Application of specified rating is permissible for ungrounded or resistance grounded system where a single phase ground may be tolerated for a substantial period of time not to exceed the TRANQUELL arrester's overvoltage capability as described in GET-6951.

Note: Contact factory o r G E Sales Office for Design Test data.

Table G.27 Polymer station arrester weights and dimensions

Catalog Number		Height (X)		Creep		Weight		Min. Clearance		Min. Mounting Spacing on Center Phase to Phase		Min. Mounting Spacing on Center Phase to Ground	
	Arrester Rating (kV rms)	In	mm	In	mm	lb	kg	In	mm	In	mm	In	mm
9L11XPB003	3	7.9	200.7	17.2	436.9	7.9	3.6	2.0	50.8	12.3	312.4	7.7	195.6
9L11XPB006	6	7.9	200.7	17.2	436 9	8.1	3.7	3.0	76.2	12.3	312.4	7.7	195.6

STANDARD SERVICE CONDITIONS

Limitamp equipment is designed for the following standard conditions: Operating ambient temperature -20° C to 40° C. Storage ambient temperatures -40° C to 70° C; strip heaters with thermostat control are recommended at 0° C. One heater per enclosure. Thermostats may control up to 14 heaters.

— Altitude to 3,300 feet above sea level

— Humidity 0 to 90 percent (non-condensing)

SEISMIC CAPABILITY

Vacuum Limitamp Controllers can be used in various applications subject to shock and/or vibration. Certain controllers will withstand forces generated by a Zone 4 earthquake as defined in 1985 uniform building code for non-essential equipment when properly anchored at ground level.

For Limitamp control with seismic capability, or other vibration-type applications, refer your application details to the factory.

ALTITUDE DERATING

Vacuum Limitamp Controllers, including power fuses, require the following derating for use at high altitudes:

For current — No derating required up to 6,000 feet above sea level.

— Above 6,000 feet, derate by 0.9 percent for every 1,000 feet above sea level.

For voltage — No derating required up to 3,300 feet above sea level.

— Above 3,300 feet, derate by 2 percent for every 1,000 feet above sea level. BIL rating is also derated by the same percentage.

TEMPERATURE DERATING

Vacuum Limitamp Controllers require the following current derating for ambient temperature. Use only bolt-on fuses.

— Up to 40° C — No derating

— 40-45° C ◆— Derate 10 percent

— 45-50° C — Derate 20 percent

— Above 50° C — Consult factory on the application

ESTIMATED HEAT LOSS

The following data can be used for estimating heat loss of Limitamp controllers at rated load amps. The estimates are based upon a single full-voltage non-reversing 400 ampere induction motor controller with basic panel options.

— CR194 Vacuum - 370 watts per contactor

— CR7160 Air break - 670 watts per contactor

STANDARDS AND CODES

Limitamp controllers are designed to meet NEMA Standard ICS 3, Part 2 for Class E2 Controllers, and UL Standard 347 for high-voltage industrial control equipment under UL File E57411.

When specified, Limitamp control may be built to comply with the City of Chicago Code and the California Code.

Each UL-listed section includes a UL section nameplate and each UL-listed motor controller includes a UL controller label.

Additional information can be found in Table A.3.

GE UL-LISTED VACUUM CONTROLLERS

A. Full-voltage non-reversing induction motor starters, 2400-4800 volts, up to 400 amperes rating.

B. CR194 one-high NEMA 1 enclosure, 26W or 34W x 90H x 30D, with stationary mounted vacuum contactor and DC operating coil.

CR194 two-high NEMA 1 enclosure, 36W or 40W x 90H x 30D, with stationary or drawout mounted vacuum contactor and DC operating coil.

C. GE Type RA or RB current limiting power fuses.

D. Ambient compensated thermal overload relays (CR324C).

E. Solid state overload (CR324CX).

F 1000 or 2000 amp copper main bus. (Refer to factory for 1200 amp main bus application)

G. Phase and ground current transformers.

H. Control power transformer with primary and secondary fuse protection.

GE UL-LISTED AIR MAGNETIC CONTROLLERS

A. Full-voltage non-reversing induction motor starters, 2400-4800 volts, up to 400 ampere rating.

B. CR7160 one- high construction in 34W x 90H x 30D or two- and three- high construction in 44W x 90H x 30D, in NEMA 1 enclosures.

C. Same as listed above for C, D, F, G.

D. 1000 or 2000 amp copper main bus, silverplated.

H

APPROVED COMPONENTS FOR GE CONTROLLERS

A. Any UL-listed low-voltage component

B. Current transformers

C. Control wire, Type MTW, THW, SIS, XHHN

D. Power wire — MV-90 Dry

E. Control power transformers

See Table A.3 for details.

STANDARD PAINT SYSTEM — INDOOR & OUTDOOR EQUIPMENT

The standard Limitamp paint system consists of the following two processes:

Phase I — Cleaning

In a seven-stage spray washer, steel parts are cleaned and sprayed in controlled cleaning solutions.

Cleaned steel parts enter a drying oven at 300-350° F. The preceding operating parameters have been deter-

Stage	Temperature	Chemical Solution(s)
1 — Cleaning	115-120°	Ridoline
2 — Rinse	105-118°	Bonderite
3 — Iron Phosphate	90-105°	Bonderite, Soda Ash
4 — Rinse	Ambient	None
5 — Acidated Rinse	Ambient	Parcolene
6 — Rinse	Ambient	None
7 — Deionized Rinse	Ambient	None

mined to produce an Iron Phosphate coating of a minimum of 150 milligrams per square foot to meet MIL Spec. TT-C-490.

Phase II — Painting by electro-static powder process

670-011 ANSI-61 Polyester Finish Paint (Light Gray)
Metal parts will enter a drying oven at 375-400° F and remain for 20 minutes. The standard color finish is ANSI-61 light gray with a gloss of 60 plus or minus five and a thickness of 2.5 mils. This system will withstand a minimum of 1000 hours salt spray test.

H

STANDARD COMMERCIAL TESTS AND INSPECTIONS

GENERAL

The following summary description defines the standard factory tests and inspections performed during manufacture of Limitamp Control. All Limitamp equipment is tested and inspected for conformance with NEMA ICS 3 part 2 and UL347.

Production tests and inspections encompass the verification of physical configuration of assembly and workmanship, the mechanical adjustments of parts and components, and the sequencing and functional operations of the control systems. These tests and inspections are performed on manufactured products to verify conformance of the equipment to a previously qualified design. The tests do not include type testing or other destructive tests on equipment to be shipped to a customer.

Any additional factory tests beyond those listed in the following paragraphs must be referred to the factory to verify availability of test facilities and qualified manpower. Additional testing beyond the scope of the following standard commercial tests will affect normal shipment schedules.

H

PRODUCTION TESTS

The following list of inspection activities shall be performed to assure proper and correct materials, workmanship and for any damage conditions in accordance with the manufacturing documentation and drawings:

- Components, parts and material
- Physical condition of components, parts, wire insulation
- Location and orientation of components and parts
- Finish — plating — painting
- Wire/cable type, size, insulating and clamping support
- Wire terminations, insulation removal and crimping of terminals
- Tightness of electrical connections and torque of bus bar bolts
- Wire markers and terminal markers (where specified)
- Labeling of components, parts, etc.
- Tightness torque of assembly bolts and hardware
- Welds (spot only)
- Mechanical clearance
- Electrical clearance (potential hazards)

MECHANICAL OPERATION TESTS

Mechanical operating tests shall be performed to ensure proper functioning of operating mechanisms and interlocks. The operation of shutters, mechanical interlocks, circuit-breaker-door interlocks, operating handles, trip mechanisms, solenoid armature travels, contact wipes, electro-mechanical interlocks, physical clearances for mechanical and electrical isolation including any additional mechanically related operating functions shall be verified.

CONTINUITY TESTS — CONTROL WIRING AND POWER CABLES

The correctness of the individual circuit wiring contained in each assembly and the assembly wiring interfaces shall be verified as in accordance with the connection diagram, wiring table, or elementary drawing. The continuity of each circuit shall be checked.

OPERATIONS TEST

All equipment shall be subjected to an operational test. The test shall verify the functional operation of the control and power circuits and related components, devices and subassembly-modules under simulated operating conditions (excluding loading of the power circuits).

a. Devices

All devices, including subassembly-modules, shall be operated, set and checked for their functional characteristics in accordance with the instructions for each and any additional characteristic peculiar to the device:

- Pick-up
- Drop-out
- Contact wipe
- Amperes
- In-rush current
- Time-delay

Contactors must pick-up and hold-in at or below the following percentage of rated coil voltage:

Device Type	Voltage Source	Pick-up (Percentage)
DC	DC	65
AC	AC	85①
DC	AC with rectifier	70 with holding resistor
DC	AC with rectifier	70 with holding and pick-up resistor

① If a CPT is used, apply 90% voltage to transformer primary.

b. Sequence and timing circuits

Assemblies and systems involving sequential operation of devices and time delays shall be tested to assure that the devices in the sequence function properly and in the order intended.

c. Polarity — phase-sensitive circuits

The polarity of direct-current circuits and phase connections of alternating-current circuits shall be verified by application of power and measurement of the relative polarities and phase sequence.

d. Grounding

The grounding circuits and buses shall be certified.

HIGH POTENTIAL — INSULATION TESTS

a. Control wiring insulation tests

A dielectric test (hi-pot) shall be performed on circuit wiring to confirm the insulation resistance to withstand breakdown to a selected test voltage. The test voltage — amplitude and waveshape, method of application and duration of time applied — shall be specified in UL347.

b. Power cable insulation and isolation test

Power cables and buses shall be tested, phase-to-phase and phase-to-ground for insulation breakdown resistance and circuit isolation as specified in UL347.

Note: These test conditions are as specified for newly constructed equipment and performed in a clean, temperature and humidity controlled factory environment.

Rated Circuit Voltage AC or DC	High Potential Test Voltage	Duration of Test
120	1500	1 second
140	1800	1 second
480/600	2700	1 second
2300	7200	60 seconds
5000	13,250	60 seconds
7200	18200	60 seconds

These test voltages include the standard test voltages:

a. For equipment rated under 600 volts RMS or DC:

Two times rated plus 1000, times 120 percent (for one-second application).

b. For equipment rated over 600 volts RMS or DC:

Two-and-a-fourth times rated plus 2000 (60 seconds only).

The frequency of the test voltage shall not be less than the rated frequency of the equipment tested and shall be essentially sinusoidal in wave shape.

Note: Consideration shall be made for low-voltage devices, semiconductors, meters, instruments, transformers, grounding circuits, etc., in preparation for the dielectric tests.

INSULATION RESISTANCE (MEGGER) TESTS

Insulation resistance tests measure the amount of circuit resistance to current leakage. This test is performed when this resistance measurement is desired and so specified.

The test voltage and minimum insulation resistance shall be selected as specified. Examples of test values are:

a. 500 volts DC with 10 megohms minimum
b. 1000 volts DC with 1 megohm minimum
c. 1000 volts DC with 25 megohms minimum

Desired values must be specified by the customer, as no NEMA standard defines Megger values for motor controls.

ANSI STANDARD DEVICE FUNCTION NUMBERS

Dev. No.	Function
1	Master Element
2	Time-Delay Starting or Closing Relay
3	Checking or Interlocking Relay
4	Master Contactor
5	Stopping Device
6	Starting Circuit Breaker
7	Anode Circuit Breaker
8	Control Power Disconnecting Device
9	Reversing Device
10	Unit Sequence Switch
11	(Reserved for future application)
12	Over-Speed Device
13	Synchronous-Speed Device
14	Under-Speed Device
15	Speed or Frequency Matching Device
16	(Reserved for future application)
17	Shunting or Discharge Switch
18	Accelerating or Decelerating Device
19	Starting-to-Running Transition Contactor
20	Electrically Operated Value
21	Distance Relay
22	Equalizer Circuit Breaker
23	Temperature Control Device
24	(Reserved for future application)
25	Synchronizing or Synchronism-Check Device
26	Apparatus Thermal Device
27	Undervoltage Relay
28	Flame Detector
29	Isolating Contactor
30	Annunciator Relay
31	Separate Excitation Device
32	Directional Power Relay
33	Position Switch
34	Master Sequence Device
35	Brush-Operating or Slip-Ring Short-Circuiting Device
36	Polarity or Polarizing Voltage Device
37	Undercurrent or Underpower Relay
38	Bearing Protective Device
39	Mechanical Condition Monitor
40	Field Relay
41	Field Circuit Breaker
42	Running Circuit Breaker
43	Manual Transfer or Selector Device
44	Unit Sequence Starting Relay
45	Atmospheric Condition Monitor
46	Reverse-Phase or Phase-Balance Current Relay
47	Phase-Sequence Voltage Relay
48	Incomplete Sequence Relay
49	Machine or Transformer Thermal Relay
50	Instantaneous Overcurrent or Rate-of-Rise Relay
51	AC Time Overcurrent Relay
52	AC Circuit Breaker
53	Exciter or DC Generator Relay
54	(Reserved for future application)
55	Power Factor Relay
56	Field Application Relay
57	Short-Circuiting or Ground Device
58	Rectification Failure Relay
59	Overvoltage Relay
60	Voltage or Current Balance Relay
61	(Reserved for future application)
62	Time-Delay Stopping or Opening Relay
63	Pressure Switch
64	Ground Protective Relay
65	Governor
66	Notching or Jogging Device
67	AC Directional Overcurrent Relay
68	Blocking Relay
69	Permissive Control Device
70	Rheostat
71	Level Switch
72	DC Circuit Breaker
73	Load-Resistor Contactor
74	Alarm Relay
75	Position Changing Mechanism
76	DC Reclosing Relay
77	Pulse Transmitter
78	Phase-Angle Measuring or Out-of-Step Protective Relay
79	AC Reclosing Relay
80	Flow Switch
81	Frequency Relay
82	DC Overcurrent Relay
83	Automatic Selective Control or Transfer Relay
84	Operating Mechanism
85	Carrier or Pilot-Wire Receiver Relay
86	Locking-Out Relay
87	Differential Protective Relay
88	Auxiliary Motor or Motor Generator
89	Line Switch
90	Regulating Device
91	Voltage Directional Relay
92	Voltage and Power Directional Relay
93	Field-Changing Contactor
94	Tripping or Trip-Free Relay
95, 96, 97, 98, 99	Used only for specific applications in individual installations where none of the assigned numbered functions from 1 to 94 are suitable.

H

Table H.1 Motor Current Limiting Fuse And Current Transformer Ratio Selection (For Estimating Only) Based Upon 600% Locked Rotor Current

Motor Horsepower	Typical FLA	CT Ratio	EJ2 Rating	Typical FLA	CT Ratio	EJ2 Rating
	2400 volts			4160 volts		
150	35	50/5	3R	20	25/5	3R
200	46	75/5	4R	25	40/5	3R
250	57	75/5	4R	33	50/5	3R
300	69	100/5	6R	41	75/5	3R
350	81	150/5	6R	47	75/5	4R
400	92	150/5	6R	54	75/5	4R
450	105	150/5	9R	60	75/5	4R
500	113	150/5	9R	66	100/5	6R
550	123	200/5	9R	73	100/5	6R
600	135	200/5	9R	80	100/5	6R
650	145	200/5	12R	87	150/5	6R
700	155	200/5	12R	93	150/5	6R
750	166	300/5	12R	100	150/5	9R
800	176	300/5	12R	106	150/5	9R
850	186	300/5	12R	113	150/5	9R
900	197	300/5	18R	120	150/5	9R
950	207	300/5	18R	126	200/5	9R
1000	218	300/5	18R	133	200/5	9R
1200	266	400/5	18R	152	200/5	12R
1250	279	400/5	18R	158	200/5	12R
1500				187	300/5	12R
1750				217	300/5	18R
2000				246	400/5	18R

Table H.2 CT Ratio Based on Rated Load Current

Current	CT Ratio	Current	CT Ratio
10-14A	20/5	121-160A	200/5
15-24A	30/5	161-255A	300/5
25-40A	50/5	256-355A	400/5
41-60A	75/5	356-480A	600/5
61-80A	100/5	481-670A	800/5
81-120A	150/5		

Table H.3 Fuse Selection Based On Full Load Current

FUSE SELECTIONS (Assumes 600% locked rotor)	
0- 44A	3R
45-62A	4R
63-94A	6R
95-140A	9R
141-184A	12R
185-276A	18R
277-360A	24R
361-408A	P425
409-510A	P550
511-630A	P630
631-800A	P800

Table H.4 Fuse Ratings For Transformer Feeders (For Estimating Only)

Three- Phase Transformer	2400 volts		4160 volts	
	Full Load Current	Fuse	Full Load Current	Fuse
9	2.16	7E	1.25	5E
15	3.6	10E	2.08	7E
30	7.2	20E	4.2	15E
45	10.8	25E	6.2	15E
75	18	30E	10.4	25E
112.5	27	40E	15.6	30E
150	36	50E	20.8	40E
225	54	65E	31.3	50E
300	72	100E	41.6	50E
500	120	150E	69.4	80E
750	180	200E	104	125E
1000	240	250E	139	150E
1500	361	400E	208	250E
2000	—	—	278	300E
2500	—	—	347	400E

ESTIMATING POWER FACTOR CORRECTION CAPACITOR RATINGS

Table H.5 2400-Volt and 4160-Volt Motors, Enclosure Open — Including Drip-proof and Splash-proof, GE Type K (NEMA Design "B"), Normal Starting Torque and Current

Induction Motor HP Rating	Nominal Motor Speed in RPM Number of Poles											
	3600 2		1800 4		1200 6		900 8		720 10		600 12	
	kVAr	% AR	kVAr	% AR	kVAr	% AR	kVAr	% AR	kVAr	% AR	kVAr	% AR
100	—	—	25	11	25	12	50	24	25	14	25	20
125	—	—	25	9	25	12	25	13	25	14	50	20
150	25	9	25	9	25	12	50	13	50	14	75	20
200	25	9	50	9	50	12	50	13	75	14	100	20
250	25	9	25	8	50	12	75	13	75	14	100	20
300	50	9	50	8	75	12	100	13	100	14	125	20
350	75	9	50	8	75	12	100	12	100	14	125	19
400	75	9	50	8	100	12	100	12	125	14	150	19
450	100	9	75	8	100	12	125	11	125	14	150	19
500	100	9	100	8	125	12	125	11	150	14	200	19
600	125	9	125	8	175	12	150	11	150	14	200	17
700	150	8	150	8	200	11	150	10	200	14	200	15
800	175	8	150	7	175	10	175	10	225	13	250	15

Table H.6 2400-Volt and 4160-Volt Motors, Totally Enclosed, Fan-cooled, GE Type K (NEMA design "B"), Normal Starting Torque and Current

Induction Motor HP Rating	Nominal Motor Speed in RPM Number of Poles											
	3600 2		1800 4		1200 6		900 8		720 10		600 12	
	kVAr	% AR	kVAr	% AR	kVAr	% AR	kVAr	% AR	kVAr	% AR	kVAr	% AR
100	—	—	25	17	—	—	50	22	25	12	50	15
125	—	—	50	17	25	15	50	17	25	12	50	15
150	25	6	25	12	50	15	50	17	50	12	75	15
200	25	6	50	12	75	15	50	17	50	12	100	15
250	25	6	50	11	75	15	75	17	75	12	100	15
300	50	6	50	11	75	13	125	17	100	12	125	15
350	50	6	60	11	75	13	125	17	125	12	150	15
400	75	6	125	11	125	13	150	17	150	12	200	15
450	75	6	125	10	150	13	175	17	200	12	225	15
500	75	6	125	8	175	13	225	17	225	12	225	15

Table H.7 2400-Volt and 4160-Volt Motors, Enclosure Open — Including Drip-proof And Splash-proof, GE Type KG (NEMA design "C"), High-starting Torque, Normal Starting Current

Induction Motor HP Rating	Nominal Motor Speed In RPM Number of Poles							
	1800 4		1200 6		900 8		720 10	
	kVAr	% AR	kVAr	% AR	kVAr	% AR	kVAr	% AR
100	—	—	—	—	—	—	25	14
125	25	10	25	11	25	13	25	14
150	25	8	25	9	50	13	50	14
200	25	7	50	12	50	13	75	14
250	25	8	50	12	75	13	75	14
300	50	8	75	12	100	13	100	14
350	50	8	75	12	100	12	100	14

Table H.8 2400-Volt and 4160-Volt Motors, Totally Enclosed, Fan-cooled, GE Type KG (NEMA Design "C"), High-starting Torque, Normal Starting Current

Induction Motor HP Rating	Nominal Motor Speed In RPM Number of Poles							
	1200 6		900 8		720 10		600 12	
	kVAr	% AR	kVAr	% AR	kVAr	% AR	kVAr	% AR
75	—	—	—	—	—	—	—	—
100	—	—	—	—	25	12	50	15
125	25	10	50	17	25	12	50	15
150	—	—	50	17	50	12	75	15
200	75	15	50	17	50	12	100	15

H

ESTIMATED TYPICAL KW RATINGS OF EXCITERS FOR 60-HERTZ SYNCHRONOUS MOTORS

When synchronous motors have individual exciters, the kilowatt ratings in Table H.7 represent typical kilowatt ratings for such exciters.

Table H.9 Exciter ratings for synchronous motors, 60 Hz, 1.0 power factor

	Exciter Ratings, kW												
HP | RPM	1800	1200	900	720	600	514	450	400	360	300	240	200	180
200	2.0	3.0	3.0	3.0	4.5	4.5	4.5	4.5	4.5	6.5	6.5	6.5	6.5
250	2.0	3.0	3.0	4.5	4.5	4.5	4.5	6.5	6.5	6.5	6.5	9.0	9.0
300	2.0	3.0	4.5	4.5	4.5	4.5	6.5	6.5	6.5	6.5	9.0	9.0	9.0
350	3.0	3.0	4.5	4.5	4.5	6.5	6.5	6.5	6.5	6.5	9.0	9.0	9.0
400	3.0	3.0	4.5	4.5	6.5	6.5	6.5	6.5	6.5	9.0	9.0	9.0	13
450	3.0	4.5	4.5	4.5	6.5	6.5	6.5	9.0	9.0	9.0	9.0	13	13
500	3.0	4.5	4.5	4.5	6.5	6.5	6.5	9.0	9.0	9.0	9.0	13	13
600	3.0	4.5	6.5	6.5	6.5	6.5	9.0	9.0	9.0	9.0	13	13	13
700	4.5	4.5	6.5	6.5	6.5	9.0	9.0	9.0	9.0	13	13	13	13
800	4.5	6.5	6.5	6.5	9.0	9.0	9.0	13	13	13	13	13	13
900	4.5	6.5	6.5	9.0	9.0	9.0	9.0	13	13	13	13	17	17
1000	4.5	6.5	9.0	9.0	9.0	9.0	12	13	13	13	13	17	17
1250	6.5	6.5	9.0	9.0	13	13	12	13	13	13	17	17	17
1500	6.5	9.0	9.0	13	13	13	12	17	17	17	17	21	21
1750	9.0	9.0	13	13	13	13	17	17	17	17	21	21	21
2000	9.0	13	13	13	13	17	17	17	17	21	21	21	25
2250	9.0	13	13	13	17	17	17	21	21	21	21	25	25
2500	13	13	13	17	17	17	21	21	21	21	25	25	25
3000	13	13	17	17	17	21	21	21	21	25	25	33	33
3500	13	17	17	21	21	21	25	25	25	25	33	33	33
4000	17	17	21	21	21	25	25	33	33	33	33	33	40
4500	17	21	21	21	25	25	33	33	33	33	33	40	40
5000	17	21	25	25	33	33	33	33	33	33	40	40	40
5500	21	25	25	25	33	33	33	33	33	33	40	40	40
6000	21	25	33	33	33	33	33	40	40	40	40	50	50

H

Table H.10 Exciter ratings for synchronous motors, 60 Hz, 0.8 power factor

HP | RPM	Exciter Ratings, kW												
	1800	1200	900	720	600	514	450	400	360	300	240	200	180
200	3.0	4.5	4.5	4.5	6.5	6.5	6.5	9.0	9.0	9.0	13	13	13
250	3.0	4.5	6.5	6.5	6.5	6.5	9.0	9.0	9.0	9.0	13	13	13
300	3.0	4.5	6.5	6.5	6.5	9.0	9.0	9.0	9.0	13	13	13	13
350	4.5	4.5	6.5	6.5	9.0	9.0	9.0	9.0	9.0	13	13	13	17
400	4.5	6.5	6.5	6.5	9.0	9.0	13	13	13	13	13	13	17
450	4.5	6.5	6.5	9.0	9.0	9.0	13	13	13	13	17	17	17
500	4.5	6.5	6.5	9.0	9.0	9.0	13	13	13	13	17	17	17
600	6.5	6.5	9.0	9.0	13	13	13	13	13	17	17	17	21
700	6.5	9.0	9.0	9.0	13	13	13	13	13	17	17	17	21
800	6.5	9.0	9.0	13	13	13	17	17	17	17	21	21	21
900	6.5	9.0	13	13	13	13	17	17	17	17	21	21	25
1000	9.0	9.0	13	13	13	17	17	17	17	21	21	21	25
1250	9.0	13	13	13	17	17	21	21	21	21	25	25	33
1500	13	13	17	17	17	17	21	21	21	25	25	25	33
1750	13	13	17	17	21	21	25	25	25	25	33	33	33
2000	13	17	17	21	21	21	25	25	25	33	33	33	40
2250	13	17	21	21	25	25	33	33	33	33	33	33	40
2500	17	17	21	21	25	25	33	33	33	33	40	40	40
3000	17	21	25	25	33	33	33	33	33	40	40	40	50
3500	21	25	25	33	33	33	40	40	40	40	50	50	50
4000	21	25	33	33	33	40	40	40	40	50	50	50	65
4500	25	33	33	33	40	40	50	50	50	50	50	50	65
5000	33	33	40	40	40	40	50	50	50	50	65	65	65
5500	33	33	40	40	50	50	50	50	50	65	65	65	65
6000	33	40	40	50	50	50	65	65	65	65	65	65	85

H

LIMITAMP CONTROL STANDARD NOMENCLATURE

μSPM	MICROPROCESSOR BASED STARTING & PROTECTION MODULE
1AM	AC AMMETER
2AM	DC AMMETER
A	ACCELERATING CONTACTOR
AIL	AMBER INDICATING LIGHT
AM	AMMETER
AMS	AMMETER SWITCH
AT	AUTOTRANSFORMER
AX	ACCELERATION TIMING RELAY
BFI	BLOWN FUSE INDICATOR
BFIPS	BLOWN FUSE INDICATOR POWER SUPPLY
BFT	BLOWN FUSE TRIP
BIL	BLUE INDICATING LIGHT
C	CAPACITOR
CC	CLOSING COIL
CB	CIRCUIT BREAKER
CD	CALIFORNIA DISCONNECT
CH	CHOKE
CM	FIELD CURRENT CALIBRATION MODULE
CPO	CAPACITOR TRIP DEVICE
CPI	CONTROL POWER INTERLOCK
CPIX	AUX. RELAY TO CPI
CPS	CONTACTOR POSITION SWITCH
CR	CONTROL RELAY
CT	CURRENT TRANSFORMER
CTB	CURRENT TEST BLOCK
CTD	CURRENT TRANSDUCER
CTM	CONTACTOR TIMING MODULE
D	DIODE
DCCT	DC CURRENT TRANSFORMER
DMP	DIGITAL MOTOR PROTECTION AND CONTROL SYSTEM
DR	DIFFERENTIAL RELAY
DSTB	DISCONNECT TERMINAL BOARD
DSW	DISCONNECT SWITCH
EFR	EXCITER FIELD RELAY
EPM	ELECTRONIC POWER METER
ETM	ELAPSED TIME METER
EXC	EXCITER
EXC RHEO	EXCITER THEOSTAT
F1.F2	SYNC. MOTOR FIELD LEADS
FC	FIELD CONTACTOR
FCX	AUX FIELD RELAY
FCY	AUX. FIELD RELAY
FDRS	FIELD DISCHARGE RESISTOR
FGRS	FIELD GROUND RESISTOR
FLO	SYNC. MOTOR FIELD
FLR	FIELD LOSS RELAY
FLTR	FILTER
FRP	FIELD RECTIFIER PANEL
FS	FAST SPEED CONTACTOR
FS1	FAST SPEED SHORTING CONTACTOR
FSX	AUX. RELAY TO FS
FSW	FEEDER SWITCH
FTRS	FIXED TAP RESISTOR
FU	FUSE
GCT	GROUND CURRENT TRANSFORMER
GF	GROUND FAULT RELAY
GFX	AUX. RELAY TO GF
GIL	GREEN INDICATING LIGHT
GND	GROUND
GRB	GROUND BUS
GS	GROUND SENSOR
H1.H2.H3	OUTGOING TERMINALS TO TRANSFORMER
HAM	HEATER AMMETER
ISW	ISOLATING SWITCH
IXR	INCOMPLETE SEQUENCE RELAY
KX	ANTI-KISS RELAY
L.O.	LATE OPENING
L1.L2.L3	INCOMING TERMINALS OR AC BUS
LA	LIGHTNING ARRESTOR
LIT	LIGHT
LOR	LOCKOUT RELAY
LSW	LIGHT SWITCH
LT-IV	LODTRAK 4 MOTOR PROTECTION RELAY
LTAR	LODTRAK AUX. RELAY
M139	MULTILIN MOTOR PROTECTION RELAY
M269	MULTILIN MOTOR MANAGEMENT RELAY
M269+	MULTILIN MOTOR MANAGEMENT & COMMUNICATION RELAY
M	MAIN CONTACTOR
MDP200	DIGITAL TIME OVERCURRENT RELAY SYSTEM
MOT	MOTOR
MOV	METAL OXIDE VARISTOR
MP4A	MULTILIN MOTOR PROTECTION RELAY
MR	CONTACTOR HOLDING RESISTOR RELAY
MSW	MAIN DISCONNECT SWITCH
MTM	MULTILIN METERING & TRANSDUCER MODULE
MTM+	MULTILIN METERING & TRANSDUCER MODULE
MX	AUX. RELAY TO M
N	NEUTRAL CONTACTOR
NX	AUX. RELAY TO N
OC	OPERATIONS COUNTER
OCR	OVERCURRENT RELAY
OL	OVERLOAD RELAY
OT	OVERTEMPERATURE RELAY
OTX	AUX. RELAY TO OT
PM	POLARITY MARK
PB	PUSH BUTTON
PFC	POWER FACTOR CAPACITOR
PFM	POWER FACTOR METER
PG	PLUG
PHA.PHB.PHC	INCOMING LINE TERMINALS
PHF	OPEN PHASE & PHASE SEQUENCE RELAY
PLR	POWER LOSS RELAY
PRO	CT PROTECTOR (THYRITE)
PST	PHASE SHIFTING TRANSFORMER
PT	POTENTIAL TRANSFORMER
PTB	POTENTIAL TEST BLOCK
R	RUN OR REVERSE CONTACTOR
RC	RECTIFIER & VOLTAGE DROPPING CAPACITOR
REC	RECTIFIER
RECP	RECEPTACLE
REV	REVERSE CONTACTOR
RIL	RED INDICATING LIGHT
RM	RECTIFIER CONTACTOR
RS	RESISTOR
RTD	RESISTANCE TEMPERATURE DETECTOR
RX	AUX. RELAY TO R
S	START CONTACTOR
SC	SURGE CAPACITOR
SFC	STATIC FIELD CONTACTOR
S-GR	SLIP-GUARD RELAY
SH	SHUNT
SHAM	SPACE HEATER AMMETER
SP HTR	SPACE HEATER
SPR	STALL PROTECTIVE RELAY
SR	STARTING REACTOR
SR735	MULTILIN FEEDER RELAY
SR737	MULTILIN FEEDER RELAY
SS	SLOW SPEED CONTACTOR
SS1	SLOW SPEED SHORTING CONTACTOR
SSW	SELECTOR SWITCH
SSX	AUX. RELAY TO SS
ST	STAB
STB	SHORTING TERMINAL BOARD
SX	AUX. RELAY TO S
T	TRANSFORMER
TA	AUX. RELAY TO TIMING MODULE
TC	TIME CLOSING
TOAD	TIME DELAY AFTER DE-ENERGIZATION
TOAE	TIME DELAY AFTER DE-ENERGIZATION
TO	TIME OPENING
T1.T2.T3	OUTGOING TERMINALS TO MOTOR
TB	TERMINAL BOARD
TH	THERMOSTAT
THY	THYRITE
TIE	TIE SWITCH
TM	TIMING MODULE
TPI	TEST POWER INTERLOCK
TPIX	AUX. RELAY TO TPI
TPSW	TEST POWER SWITCH
TR	TIMING RELAY
TRP	TRIP RELAY
TST	THERMOSTAT ON AT OR SR
TSW	TEST-NORMAL SELECTOR SWITCH
UC	UNLATCH COIL OR CONTACT
UL	UNLATCH RELAY
UV	UNDERVOLTAGE RELAY
UVTR	UNDERVOLTAGE TIMING RELAY
VCR	VOLTAGE CHECK RELAY
VON	VOLTAGE DIVIDER NETWORK
VFC	ELECTRONIC VARIABLE FIELD CONTACTOR
VFSM	VARIABLE FIELD SUPPLY MODULE
VM	VOLTMETER
VMS	VOLTMETER SWITCH
VRM	VARMETER
VRTO	VAR TRANSDUCER
VT	VARIABLE AUTOTRANSFORMER
VTO	VOLTAGE TRANSDUCER
WHDM	WATTHOUR DEMAND METER
WHM	WATTHOUR METER
WM	WATTMETER
WTD	WATTS TRANSDUCER

This diagram shows starter with the isolating switch in the disconnect position and the test power interlock in the test position.

To test: Handle must be in the disconnect (OFF) position, and test-normal selector switch (located in the low voltage compartment) must be in the TEST position. Purchaser is to connect his test power to the proper terminals and note that the control circuit is not grounded when disconnects are open. Be sure to turn the test-normal switch to NORMAL before moving the disconnect handle to the ON position.

CPI — Opens only when CPI release on isolating switch handle is pushed in. Can not be opened when main line contactor is closed.

▲ — Start and stop push buttons are wired through terminal at "TB" in order that remote START-STOP buttons can be readily connected into the circuit when required.

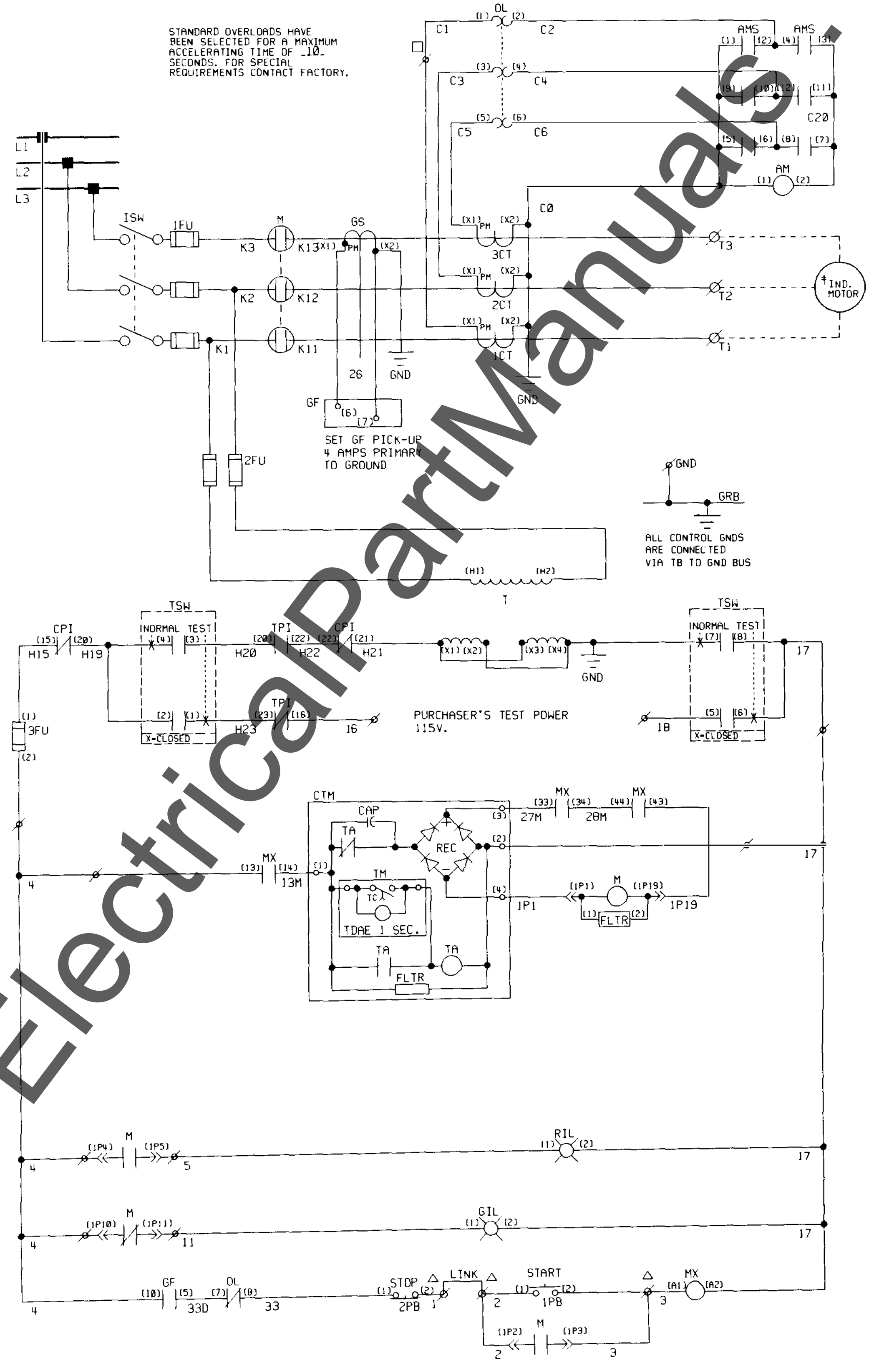
□ — At a terminal on "TB", a loop in the CT secondary circuit wire permits insertion of a hook on ammeter for measuring line current.

— Device furnished by others — mounted remote.

— Terminal board point.

FVNR INDUCTION

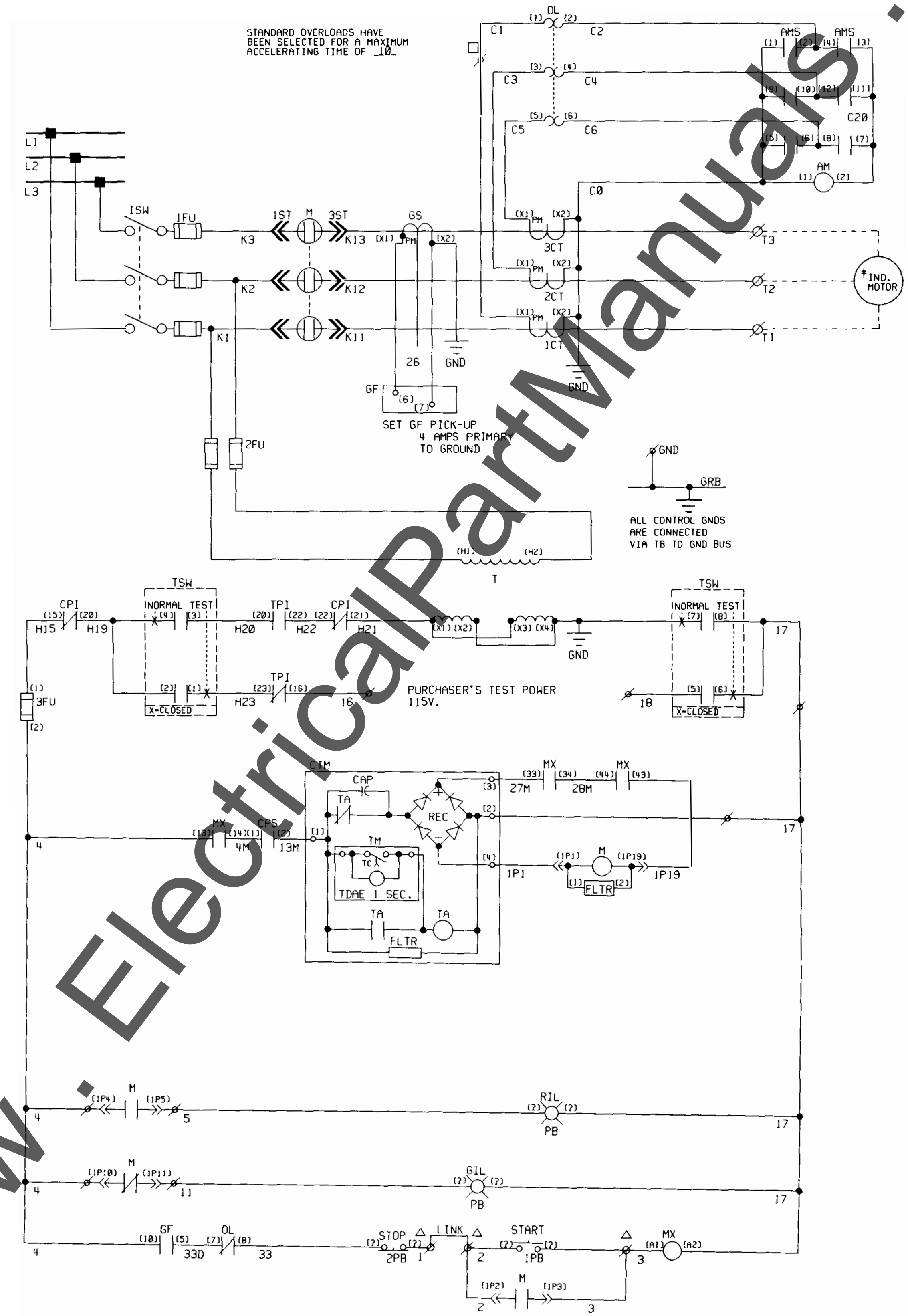
CR194 400-ampere Vacuum Stationary (Two-high)



I

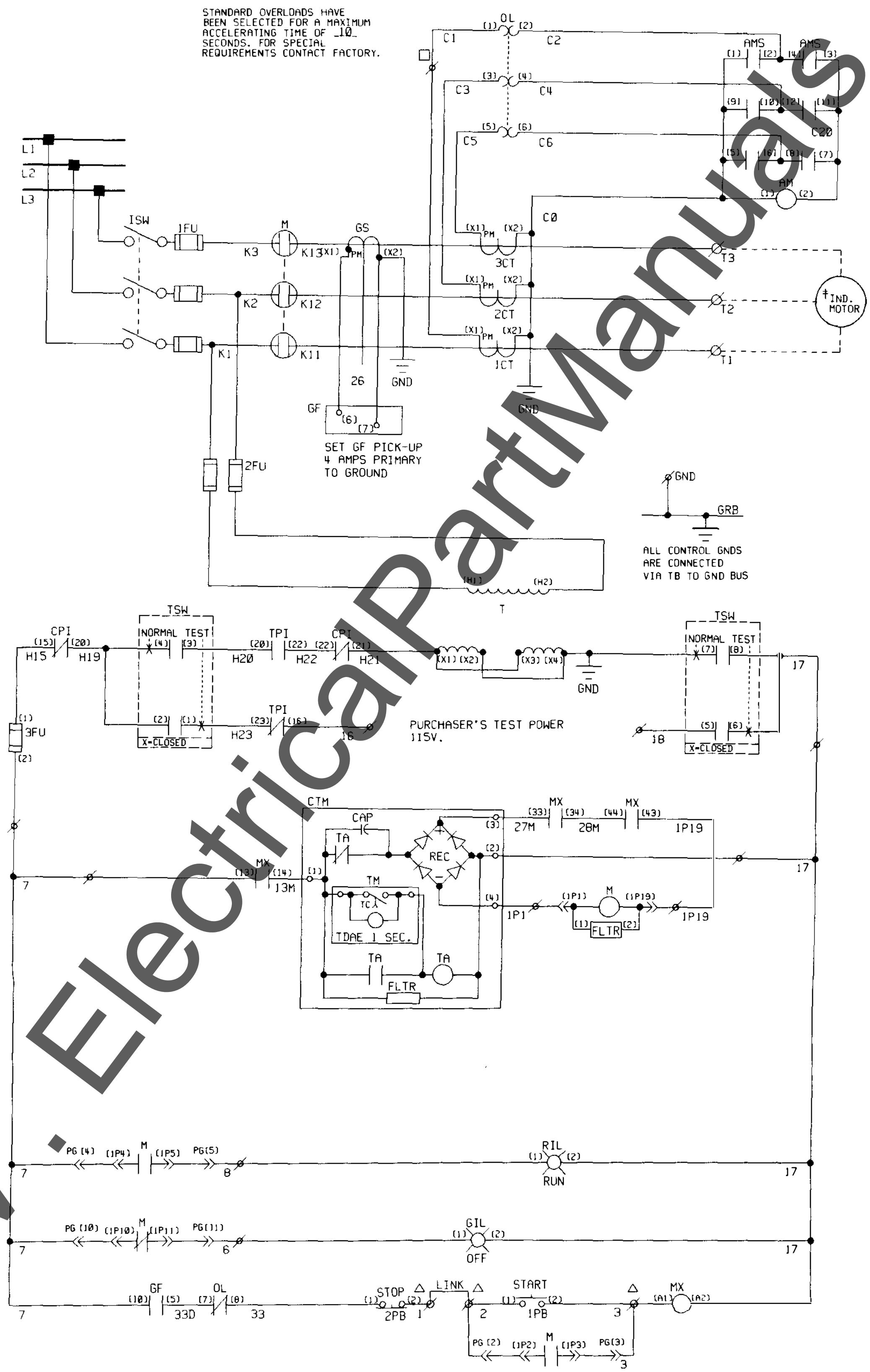
FVNR INDUCTION

CR194 400-ampere Vacuum Drawout (Two-high)



FVNR INDUCTION

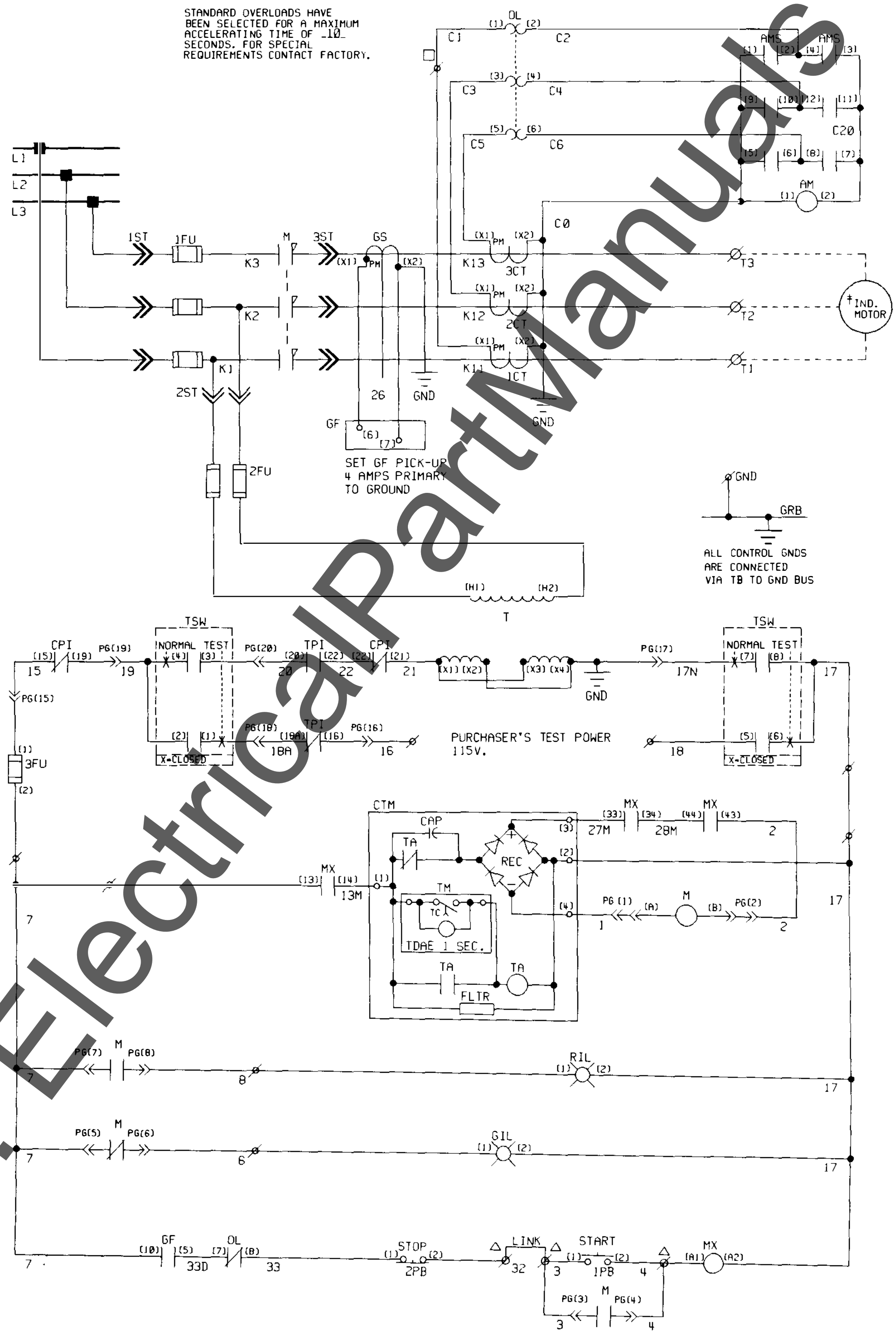
CR194 400-ampere Vacuum Stationary (One-high)



I

FVNR INDUCTION

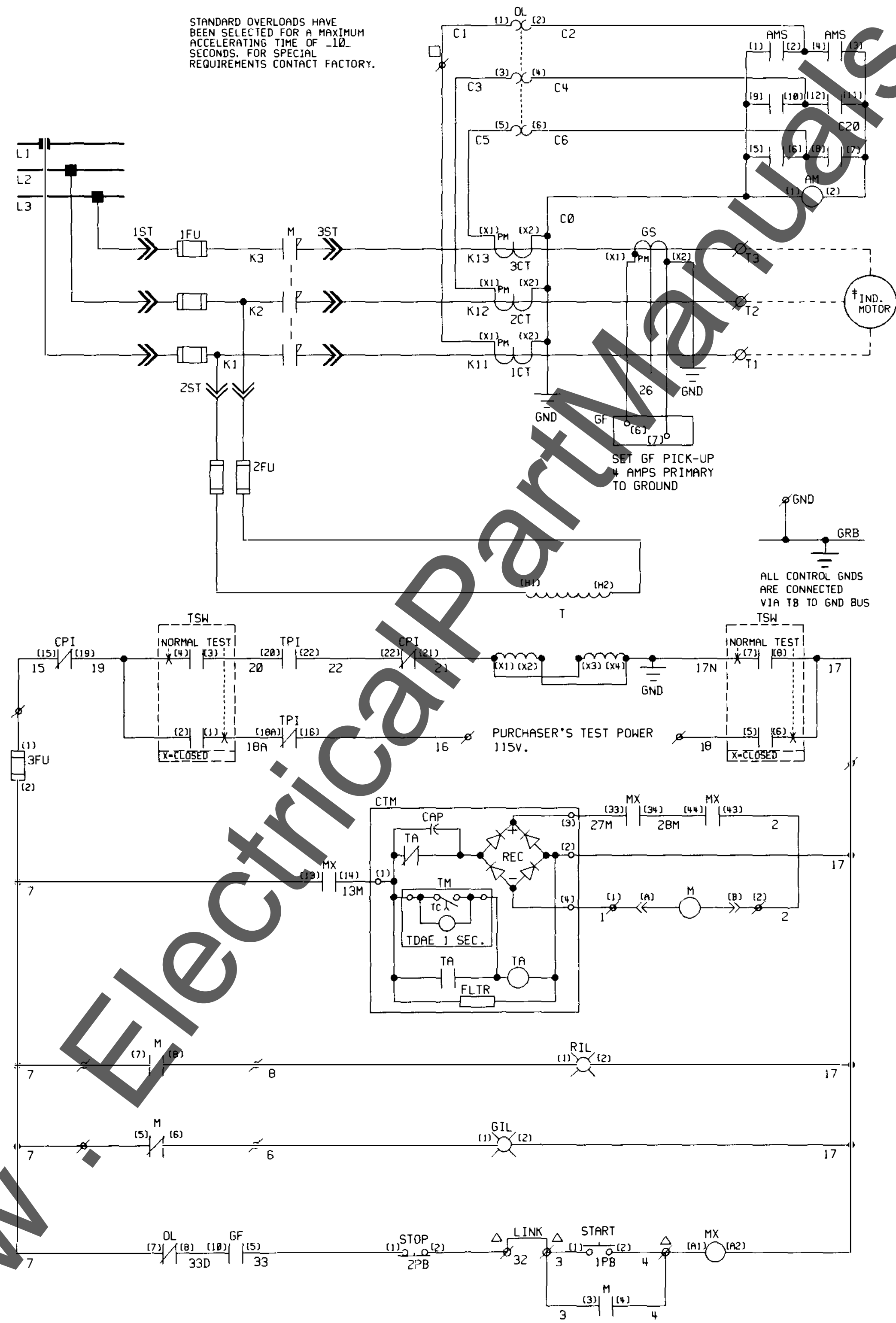
CR7160 400- and 700-ampere Air-break (One-high)



I

FVNR INDUCTION

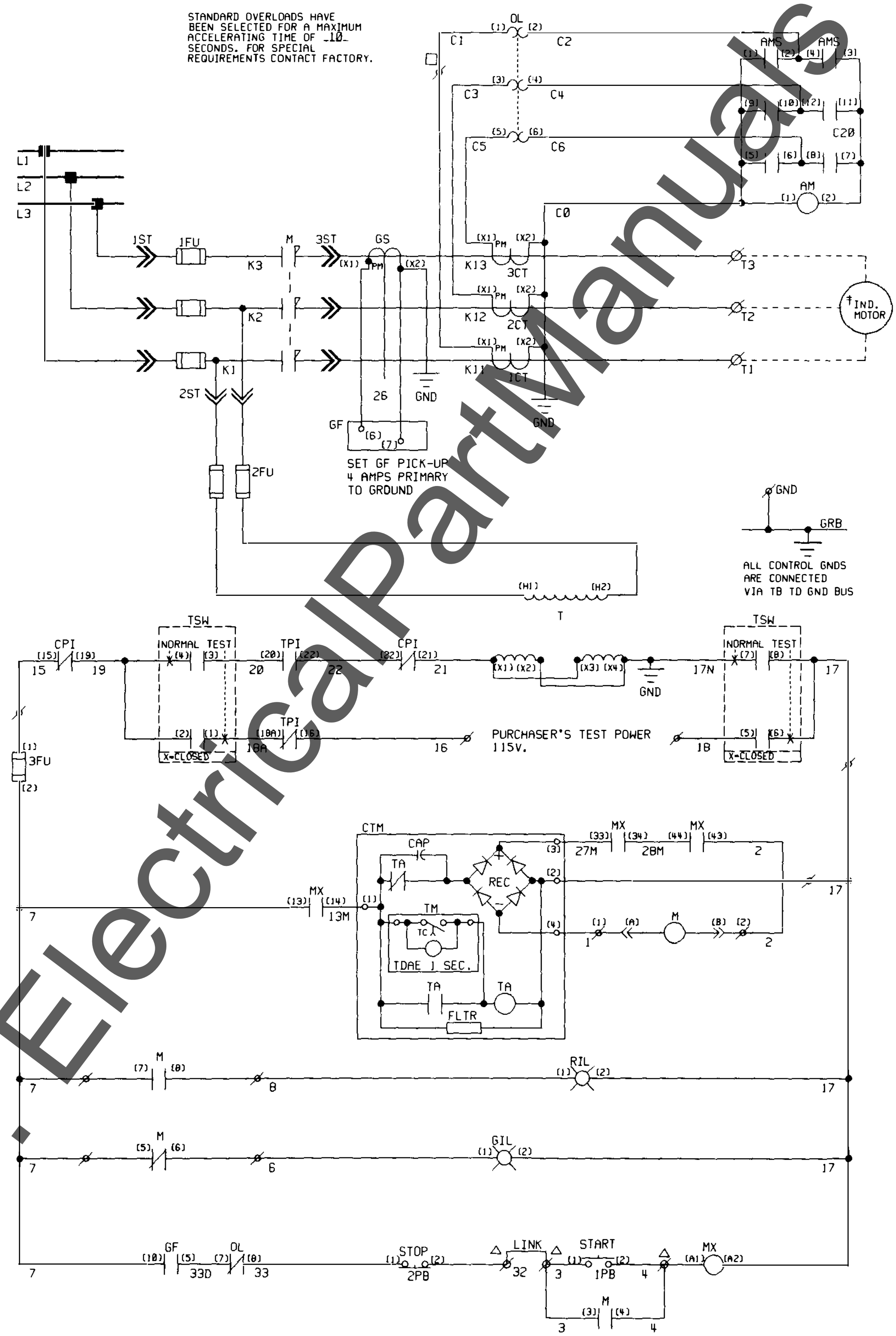
CR7160 400-ampere Air-break (Two-high)



I

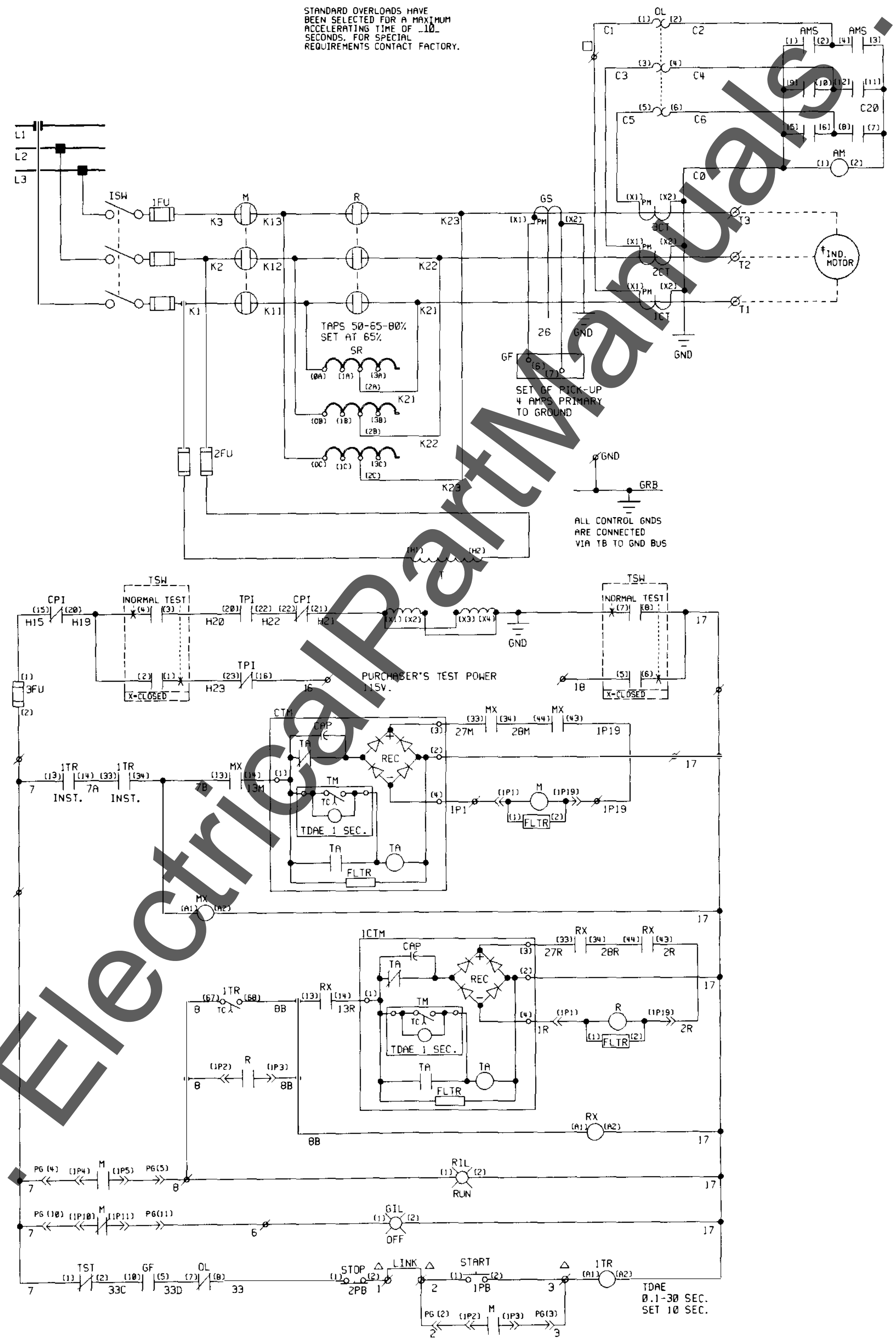
FVNR INDUCTION

CR7160 400-ampere Air-break (Three-high)



RVNR PRIMARY REACTOR INDUCTION

CR194 400-ampere Vacuum Stationary (One-high)



I

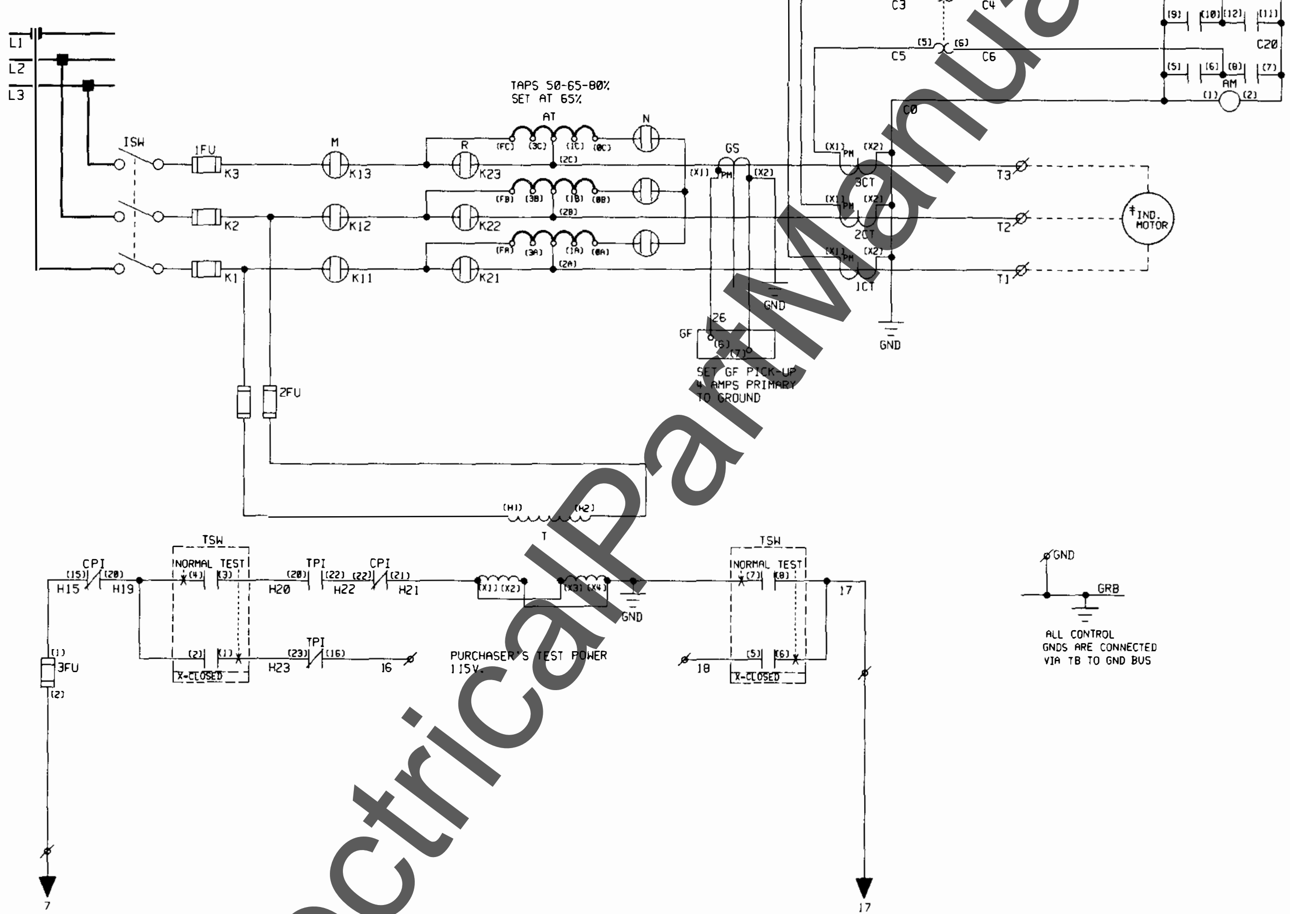
RVAT INDUCTION

CR194 400-ampere Vacuum Stationary (One-high)

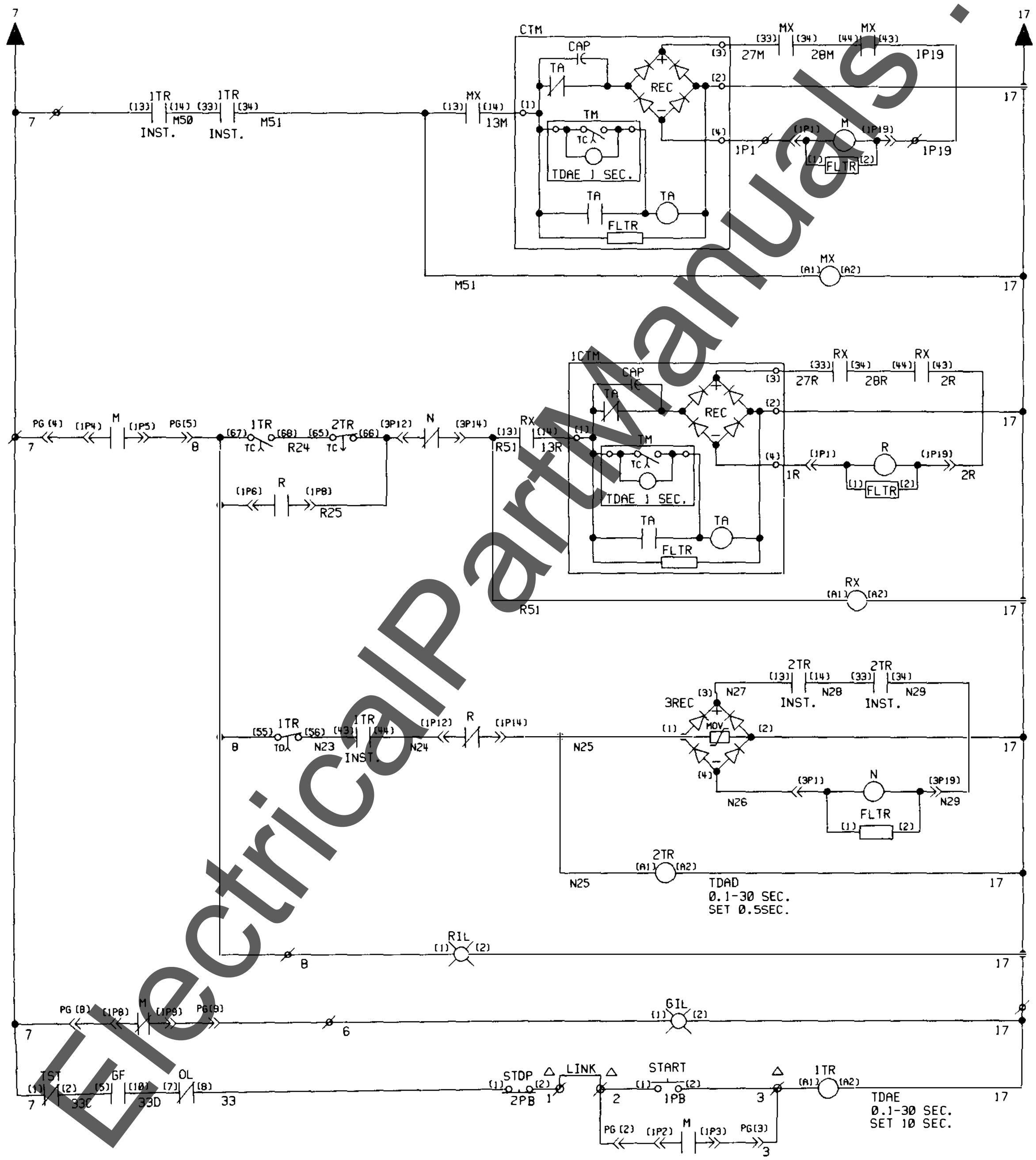
RVAT INDUCTION
400A CR194 Stationary Vacuum (1 High)

NOTE - DO NOT ENERGIZE AUTOTRANSFORMER WITHOUT MOTOR LOAD CONNECTED.

STANDARD OVERLOADS HAVE BEEN SELECTED FOR A MAXIMUM ACCELERATING TIME OF 10 SECONDS. FOR SPECIAL REQUIREMENTS CONTACT FACTORY.



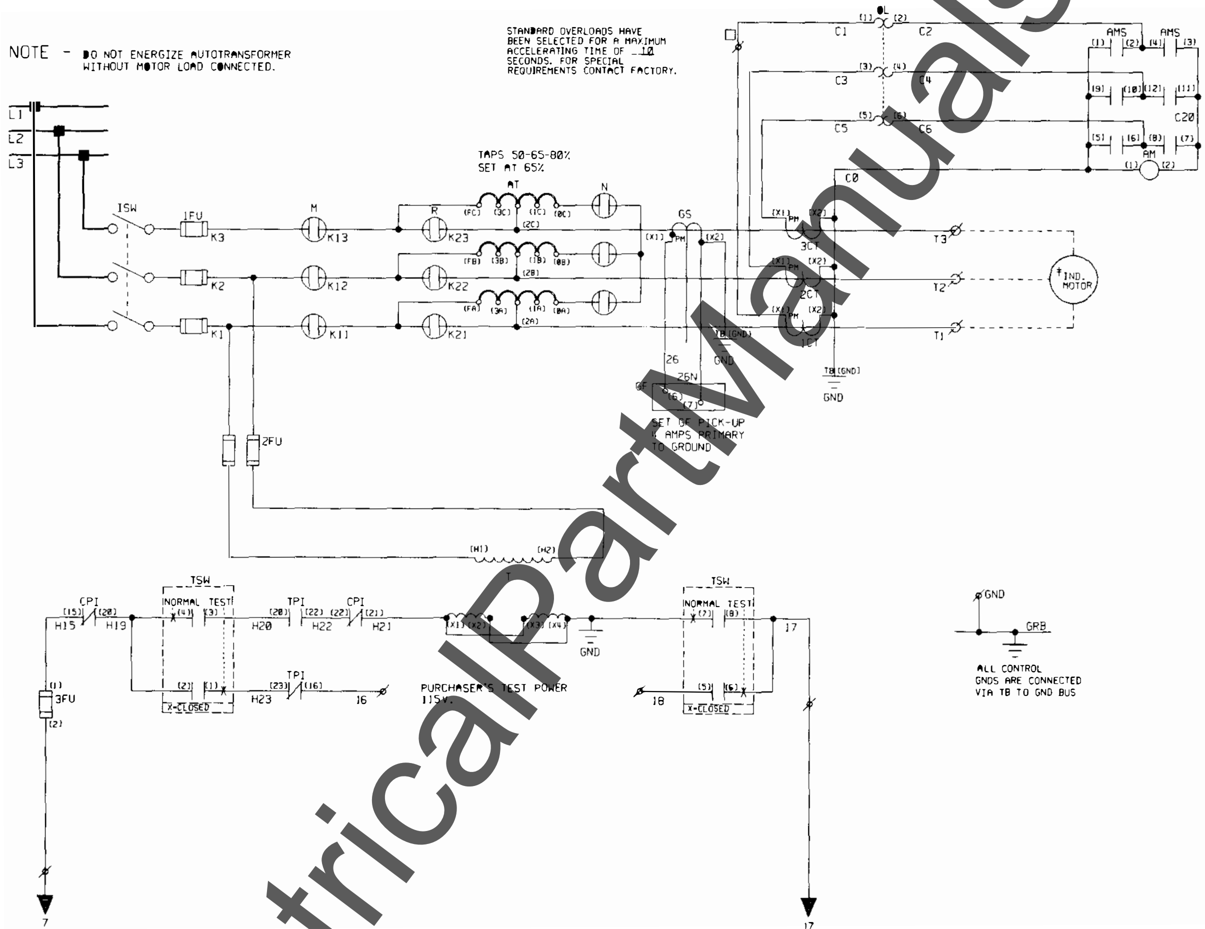
(Continued on next page)


CTM
CAP
TA
REC
TM
TDAE 1 SEC.
FLTR
MX
27M
28M
1P19
1P1
M
1TR
INST.
M50
M51
13M
1CTM
RX
27R
28R
2R
1R
R
R51
13R
PG (4)
(1P4)
(1P5)
PG (5)
2TR
R24
R25
N
3REC
MOV
N23
N24
N25
N26
N27
N28
N29
TDAD
0.1-30 SEC.
SET 0.5SEC.
R1L
GIL
TST
GF
OL
33C
33D
STOP
2PB
LINK
START
1PB
TDAE
0.1-30 SEC.
SET 10 SEC.

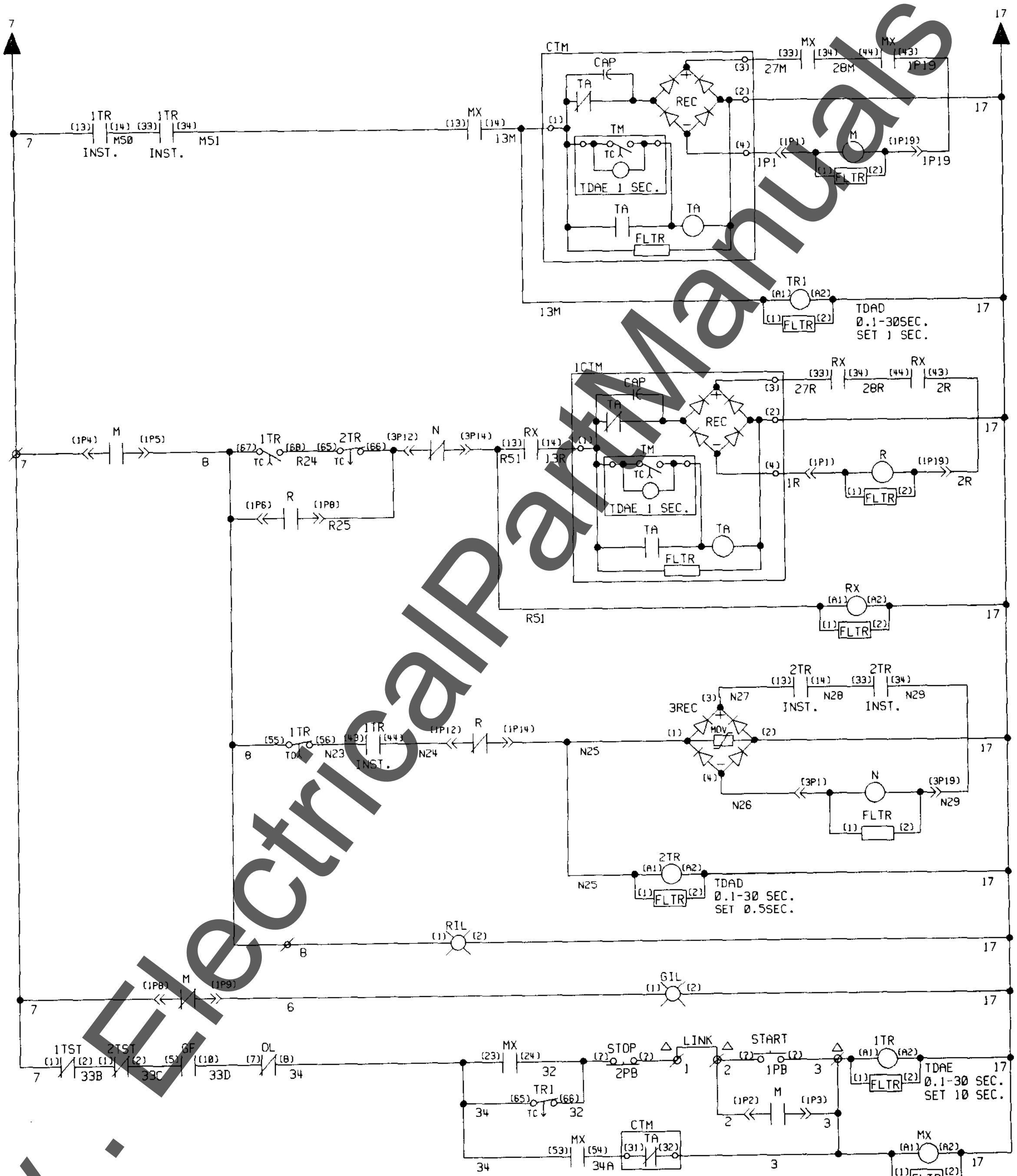
I

RVAT INDUCTION

CR194 800-ampere Vacuum Stationary (One-high)



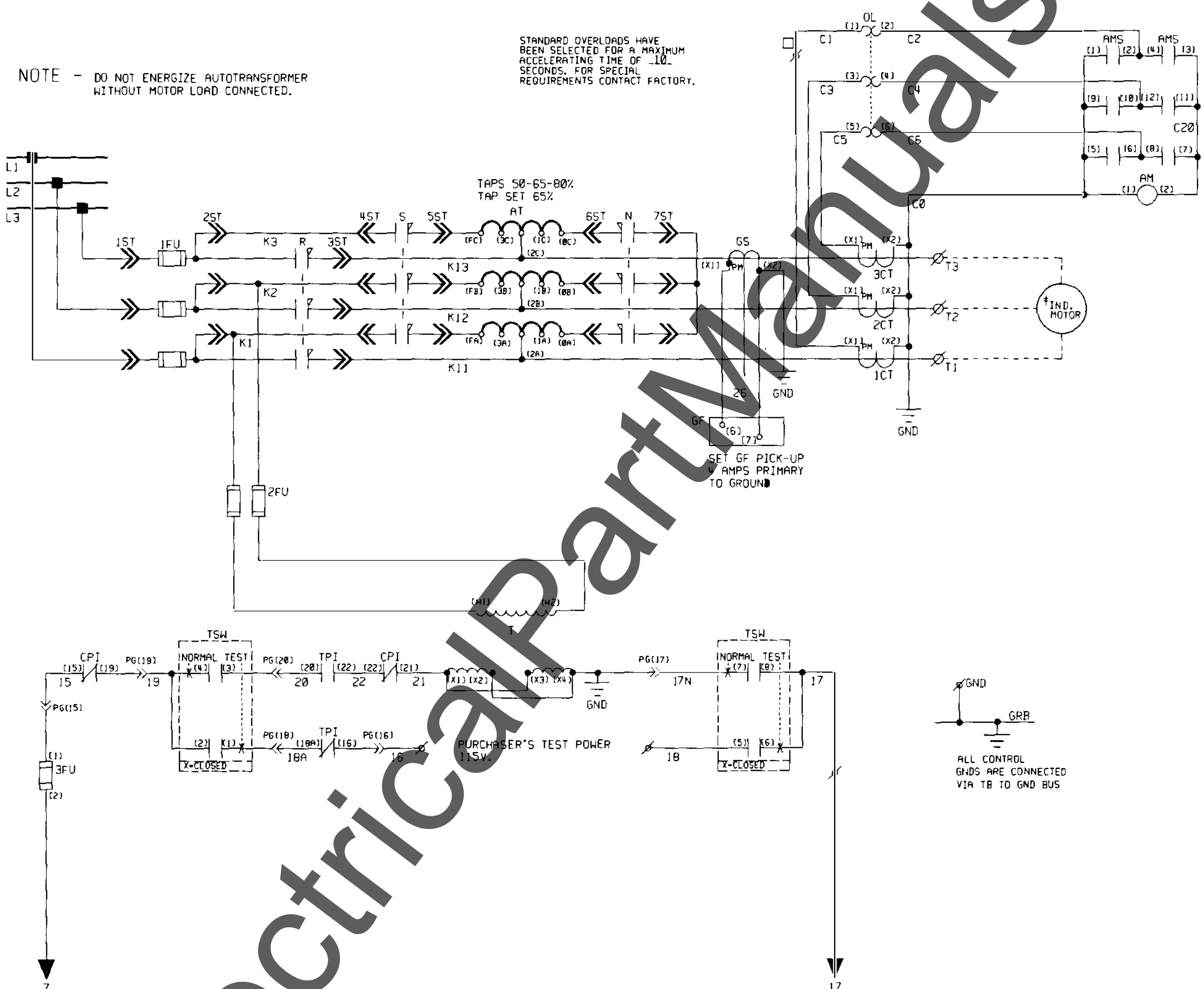
(Continued on next page)


CTM
CAP
TA
REC
TM
TDAE 1 SEC.
FLTR
MX
27M
28M
1P19
1P1
M
1TR
INST.
M50
M51
13M
TR1
TDAD
Ø.1-30ØSEC.
SET 1 SEC.
1CTM
RX
27R
28R
2R
1R
R
R51
13R
R24
2TR
N
R25
3REC
MOV
N27
N28
N29
N25
N26
N23
N24
TDAD
Ø.1-30 SEC.
SET Ø.5SEC.
RIL
GIL
1TST
2TST
GF
OL
33B
33C
33D
34
STOP
2PB
LINK
START
1PB
32
34A
TDAE
Ø.1-30 SEC.
SET 10 SEC.
17
7
8
6

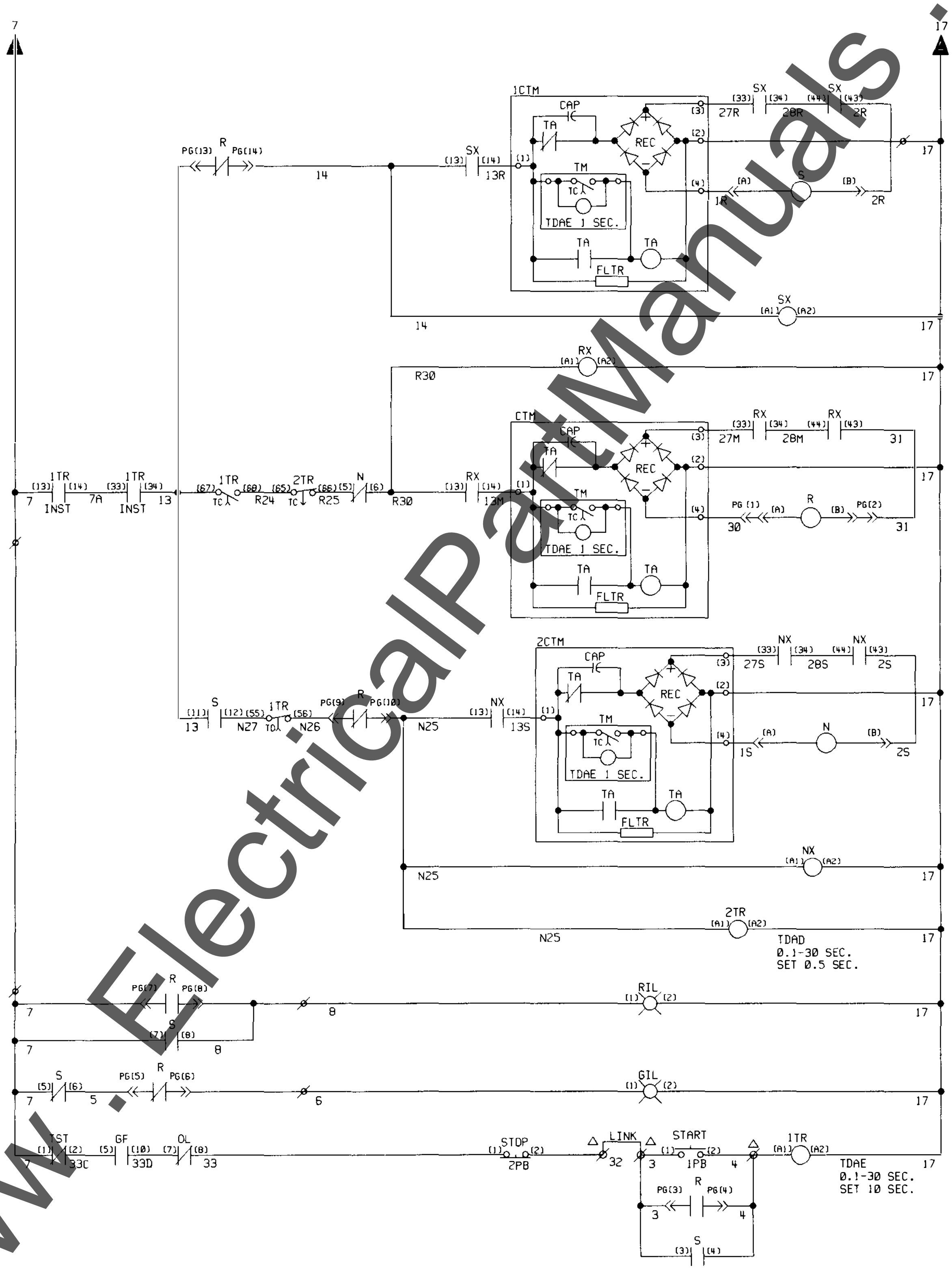
I

RVAT INDUCTION

CR7160 400- & 700-ampere Air-break (One-high)

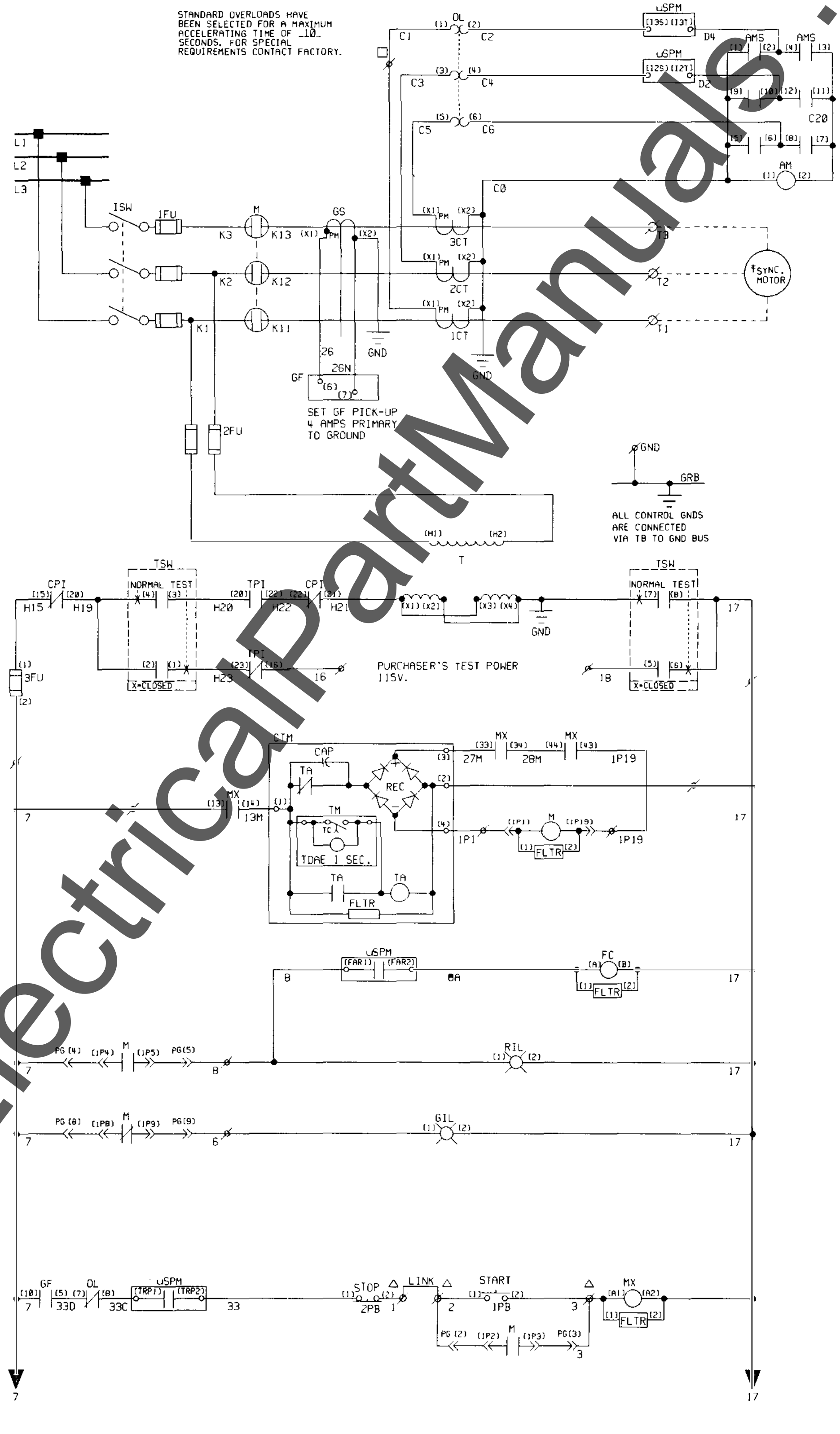


(Continued on next page)

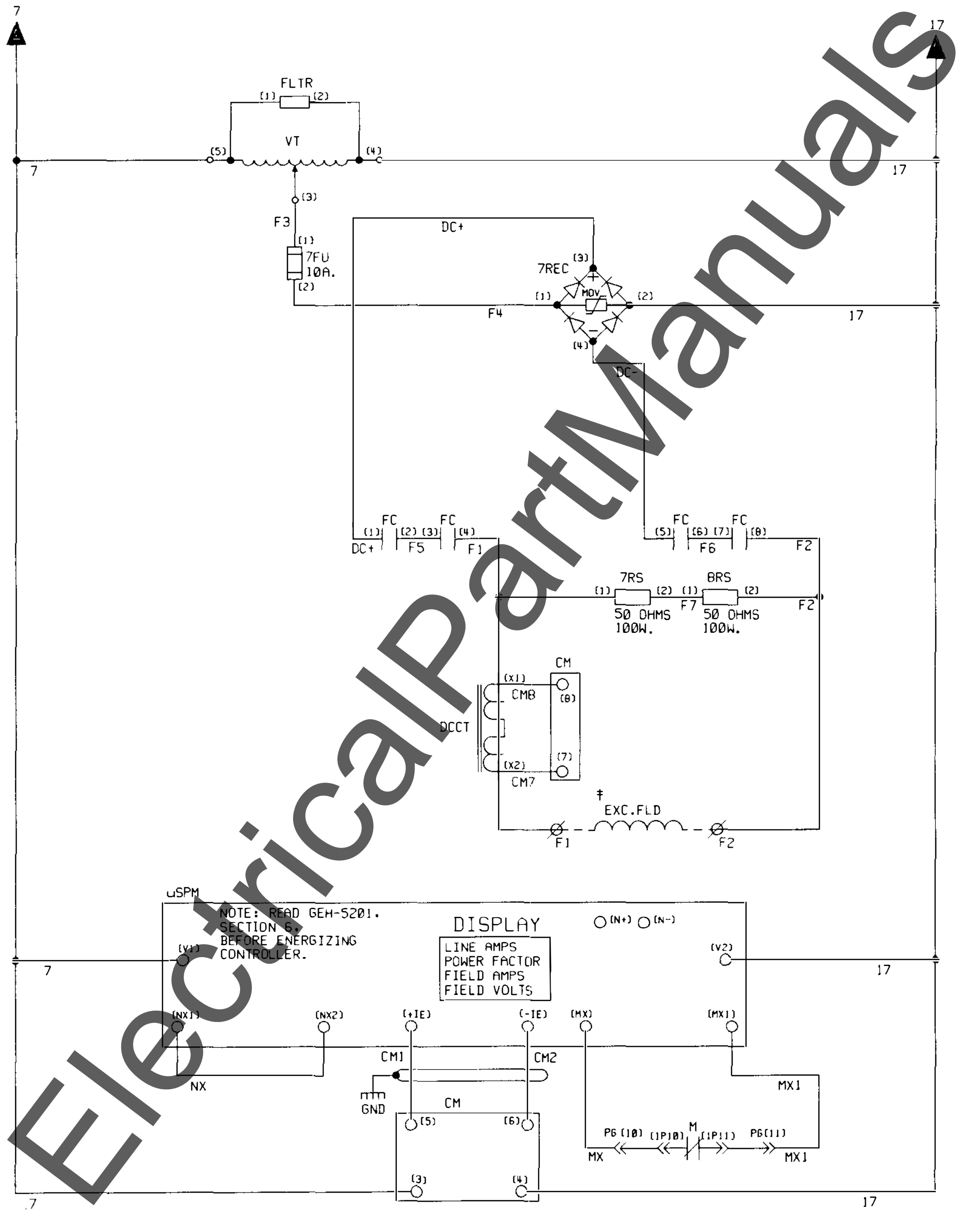

1CTM
CAP
TA
REC
TM
TDAE 1 SEC.
FLTR
SX
27R
28R
2R
13R
1R
RX
R30
CTM
27M
28M
13M
31
30
2CTM
NX
27S
28S
2S
13S
1S
N25
2TR
TDAD
Ø.1-30 SEC.
SET Ø.5 SEC.
1TR
INST
7A
13
R24
R25
N27
N26
RIL
GIL
TST
GF
OL
33C
33D
33
STOP
2PB
LINK
START
1PB
32
TDAE
Ø.1-30 SEC.
SET 1Ø SEC.
17
14
7
8
5
6
3
4

FVNR BRUSHLESS SYNCHRONOUS

CR194 400-ampere Vacuum Stationary (One-high)

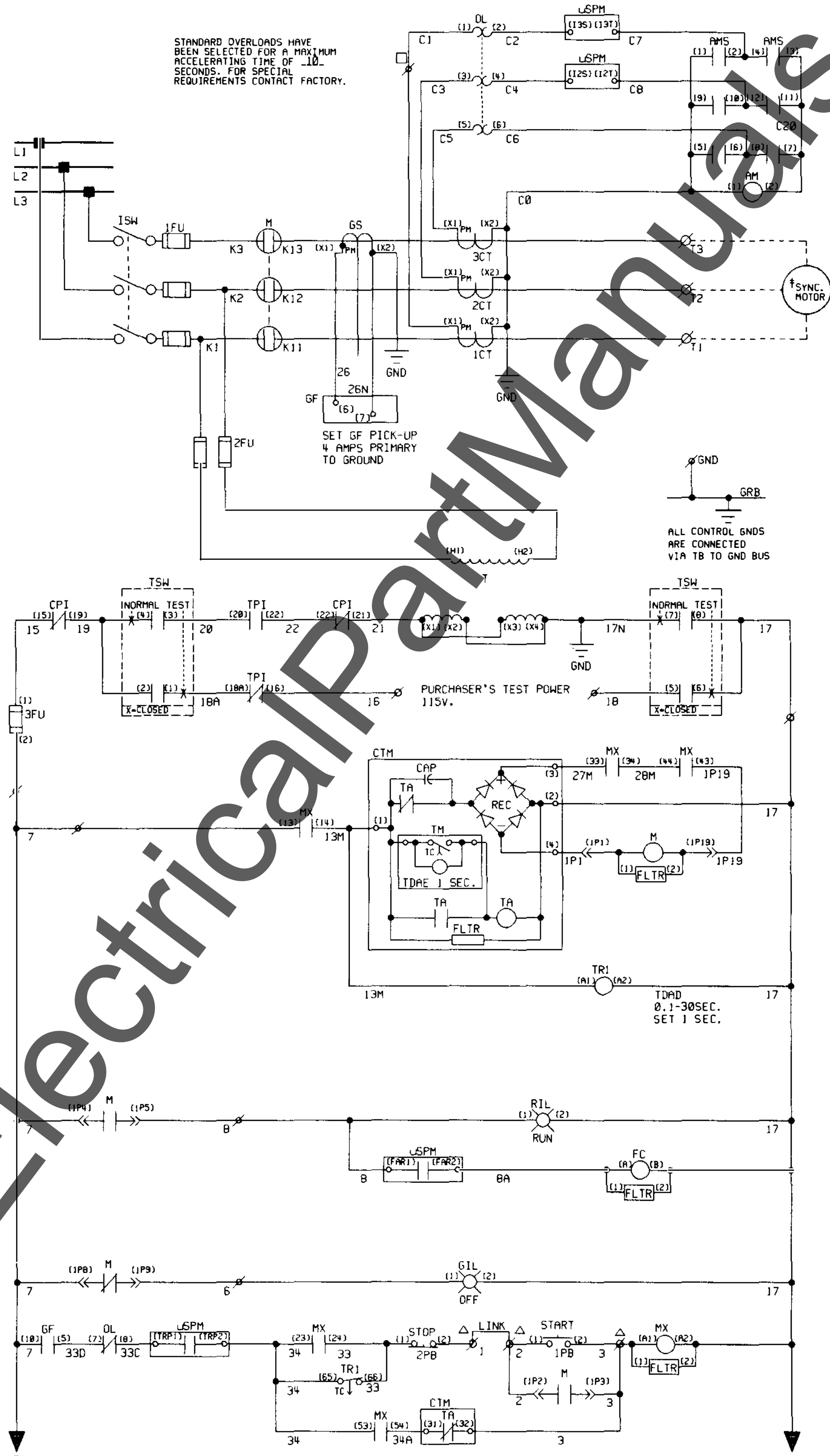


(Continued on next page)

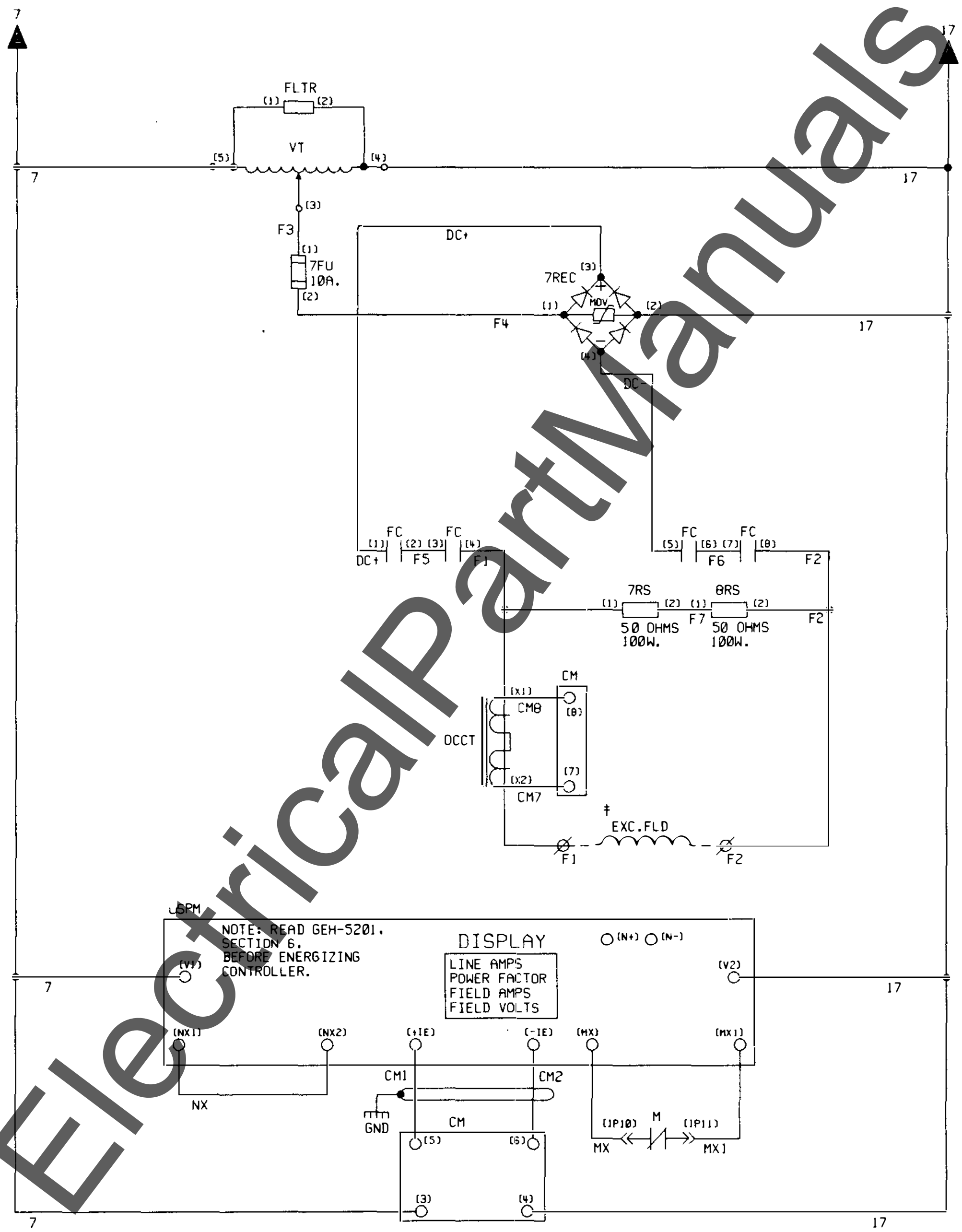

FLTR
VT
F3
7FU
10A.
DC+
7REC
MOV
F4
DC-
FC
F5
F1
F6
F2
7RS
8RS
50 OHMS
100W.
F7
CM
CM8
DCCT
CM7
EXC.FLD
uSPM
NOTE: READ GEH-5201. SECTION 6. BEFORE ENERGIZING CONTROLLER.
DISPLAY
LINE AMPS
POWER FACTOR
FIELD AMPS
FIELD VOLTS
NX
CM1
CM2
GND
MX1
MX
M

FVNR BRUSHLESS SYNCHRONOUS

CR194 800-ampere Vacuum Stationary (One-high)



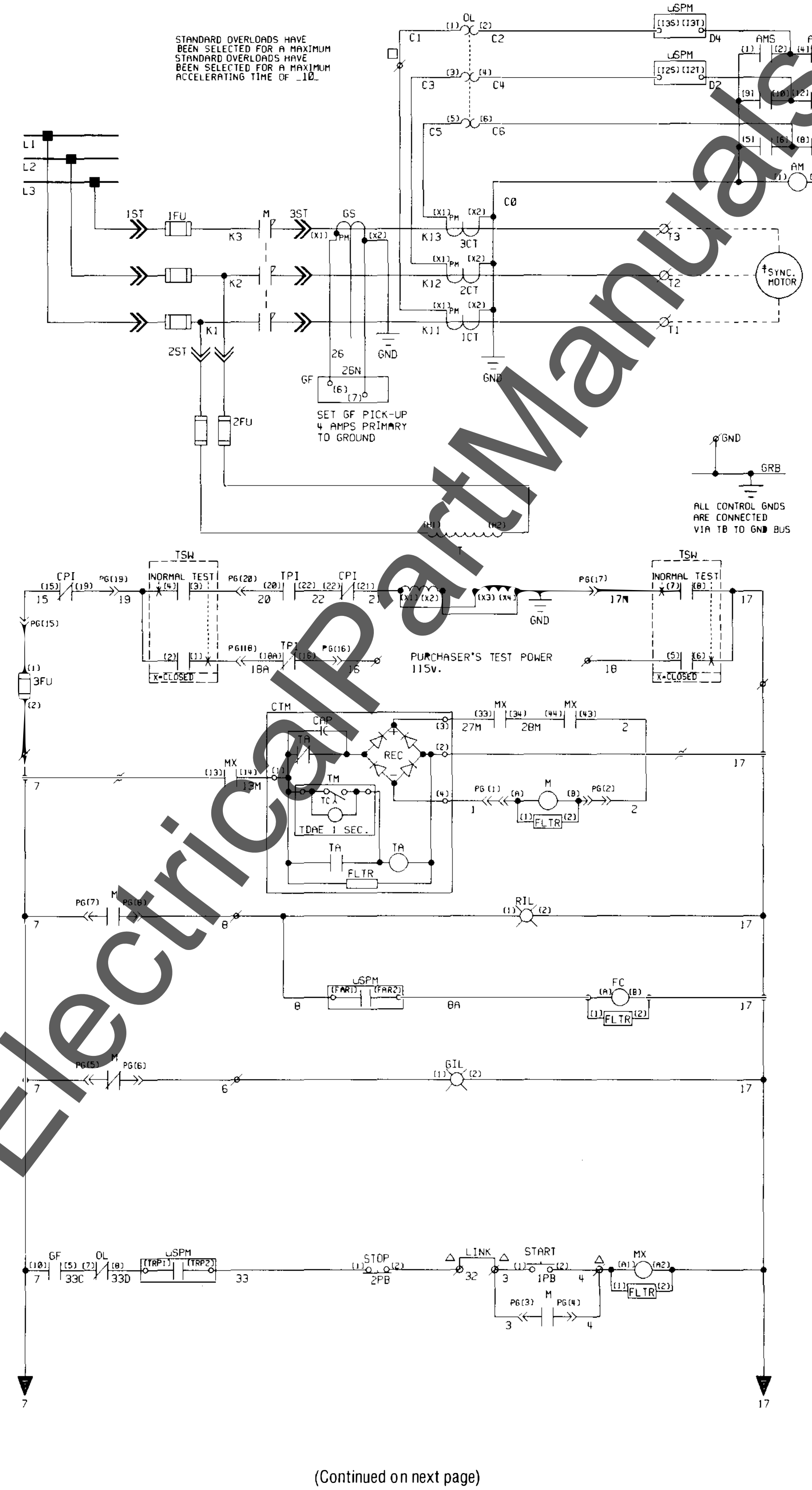
(Continued on next page)


FLTR
VT
F3
7FU
10A.
DC+
7REC
MOV
F4
DC-
FC
F5
F1
F6
F2
7RS
8RS
50 OHMS
100W.
F7
CM
CM8
OCCT
CM7
EXC.FLD
SPM
NOTE: READ GEH-5201,
SECTION 6,
BEFORE ENERGIZING
CONTROLLER.
DISPLAY
LINE AMPS
POWER FACTOR
FIELD AMPS
FIELD VOLTS
NX
CM1
CM2
GND
M
MX
MX1

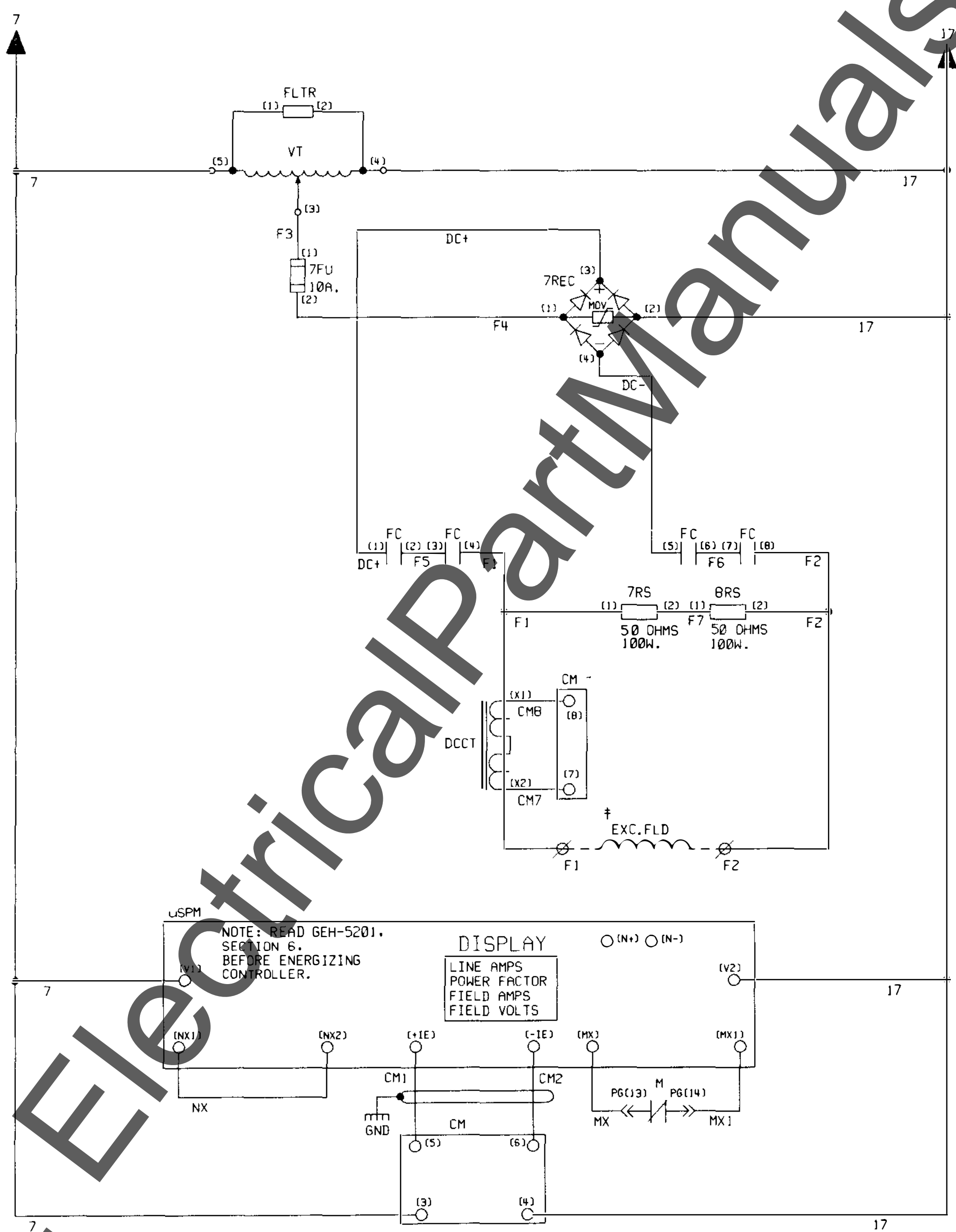
I

FVNR BRUSHLESS SYNCHRONOUS

CR7160 400- and 700-ampere Air-break (One-high)



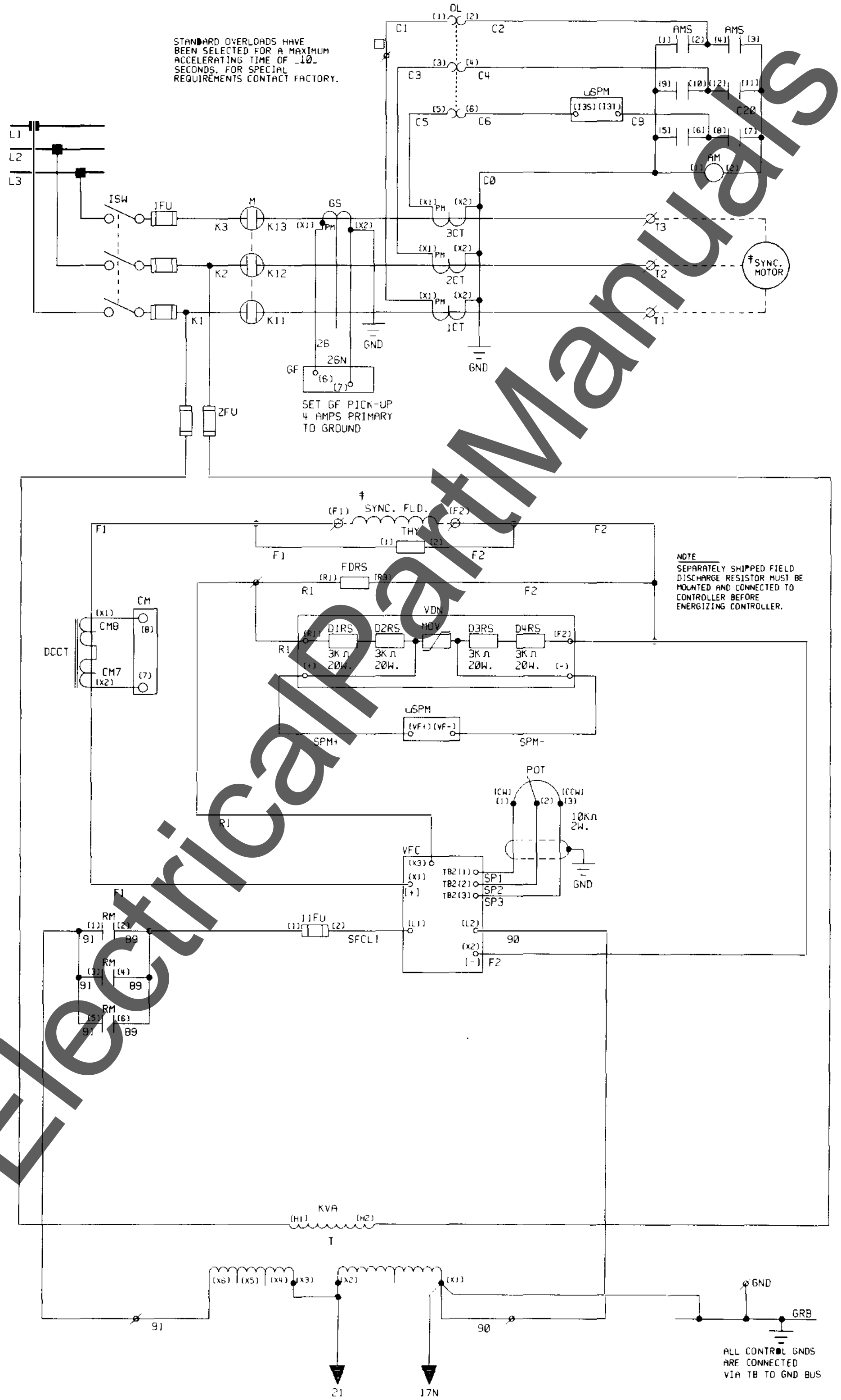
(Continued on next page)


7
17
FLTR
VT
F3
7FU
10A.
DC+
7REC
MOV
F4
DC-
FC
F5
F6
F2
7RS
8RS
F1
F7
50 OHMS
100W.
CM
CM8
DCCT
CM7
EXC.FLD
uSPM
NOTE: READ GEH-5201.
SECTION 6.
BEFORE ENERGIZING
CONTROLLER.
DISPLAY
LINE AMPS
POWER FACTOR
FIELD AMPS
FIELD VOLTS
(V1)
(V2)
(NX1)
(NX2)
(+IE)
(-IE)
(MX)
(MX1)
(N+)
(N-)
CM1
CM2
NX
GND
M
PG(13)
PG(14)
MX
MX1

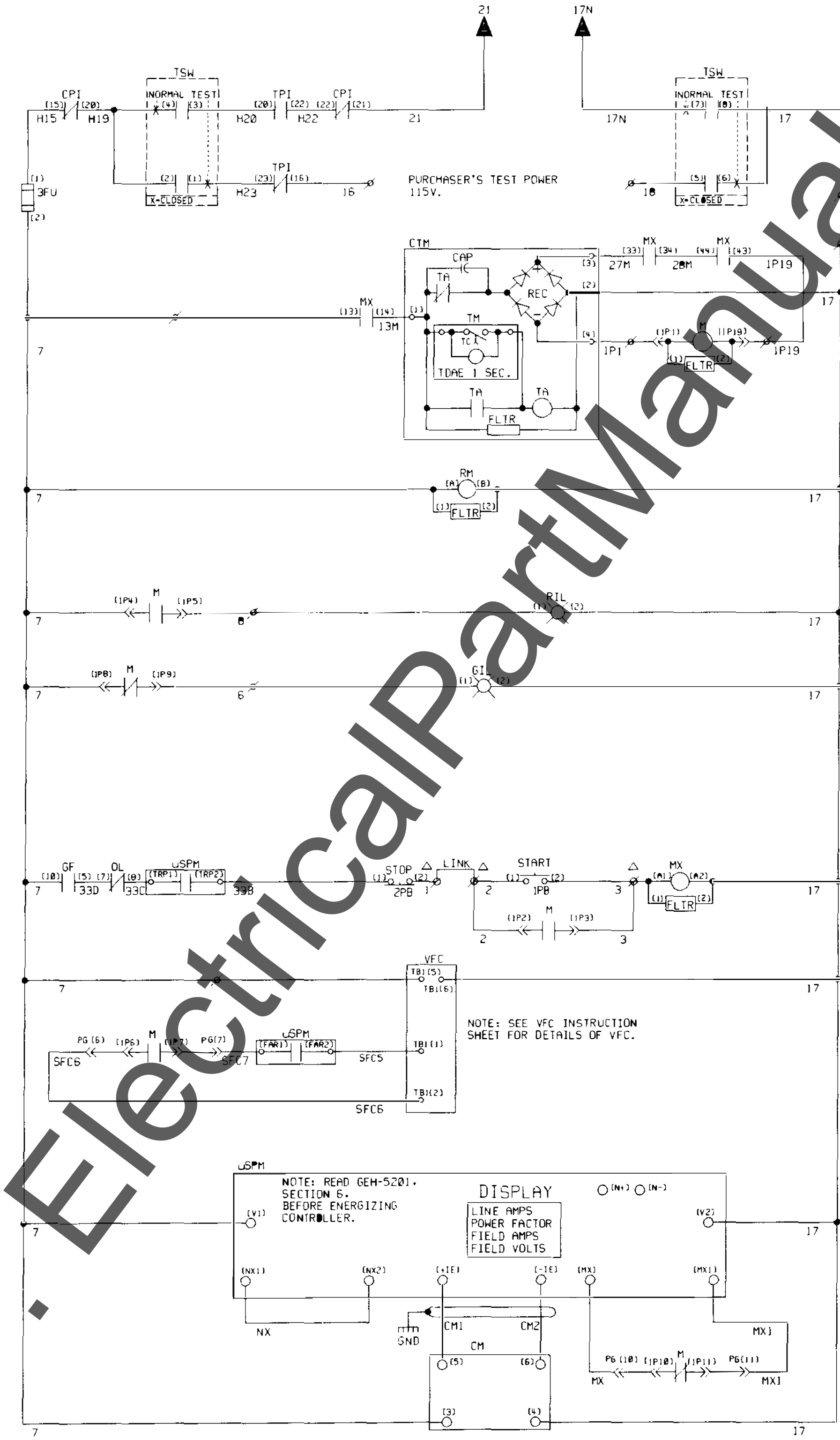
I

FVNR BRUSH-TYPE SYNCHRONOUS (With Variable Field Supply Contactor)

CR194 400-ampere Vacuum Stationary (One-high)



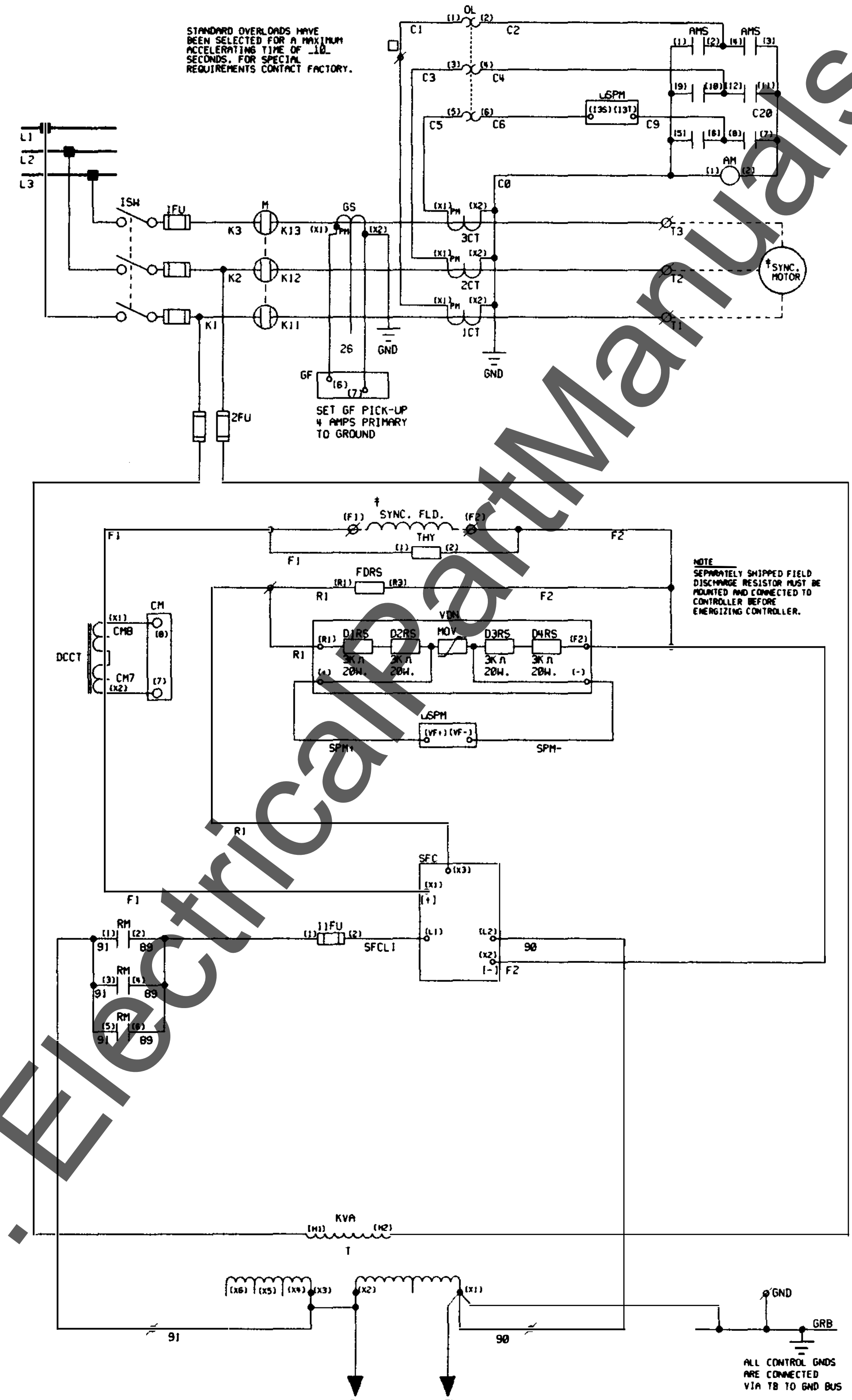
(Continued on next page)


21
17N
TSW
CPI
NORMAL TEST
TPI
H15
H19
H20
H22
X-CLOSED
3FU
H23
16
PURCHASER'S TEST POWER
115V.
18
17
CTM
CAP
TA
REC
TM
TC
TDAE 1 SEC.
FLTR
MX
13M
27M
28M
1P19
1P1
M
7
RM
RIL
GIL
GF
OL
33D
33C
μSPM
33B
STOP
2PB
LINK
START
1PB
VFC
NOTE: SEE VFC INSTRUCTION
SHEET FOR DETAILS OF VFC.
SFC6
SFC7
SFC5
NOTE: READ GEH-5201.
SECTION 6.
BEFORE ENERGIZING
CONTROLLER.
DISPLAY
LINE AMPS
POWER FACTOR
FIELD AMPS
FIELD VOLTS
NX
GND
CM1
CM2
CM
MX1

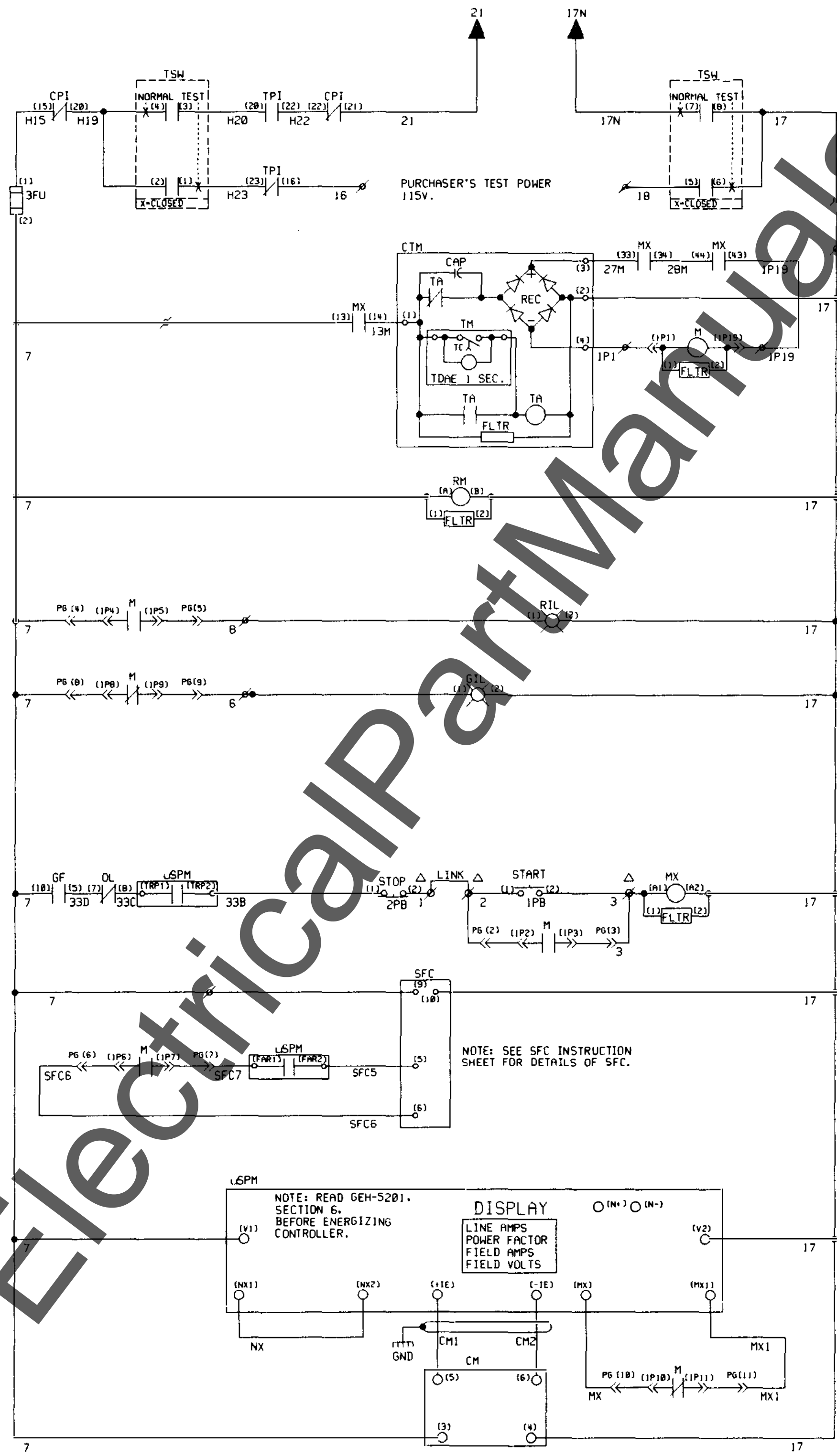
I

FVNR BRUSH-TYPE SYNCHRONOUS

CR194 400-ampere Vacuum Stationary (One-high)



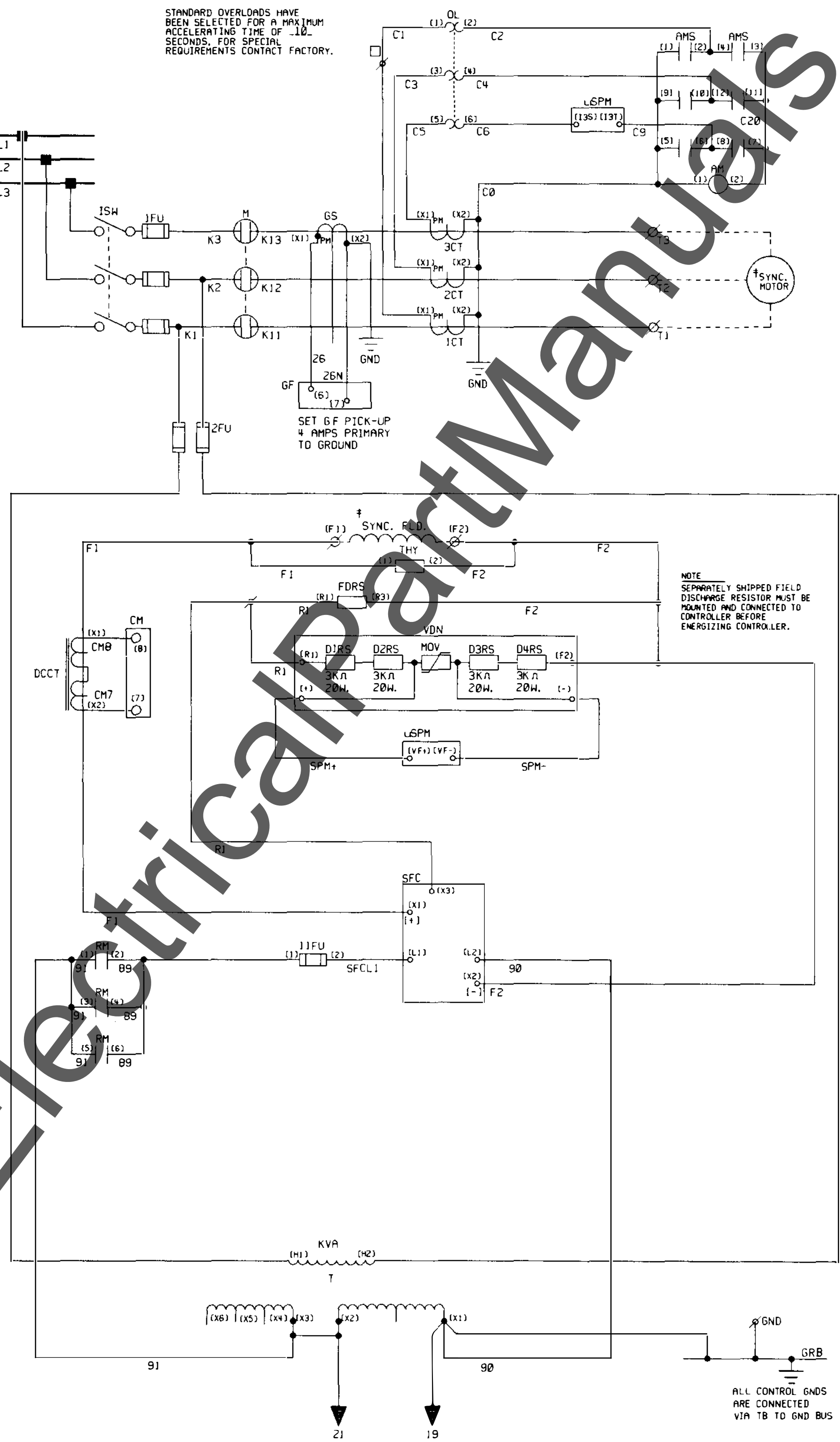
(Continued on next page)


TSW
NORMAL TEST
X-CLOSED
CPI
TPI
PURCHASER'S TEST POWER
115V.
CTM
CAP
TA
REC
TM
TDAE 1 SEC.
FLTR
MX
RM
RIL
GIL
GF
OL
STOP
2PB
LINK
START
1PB
SFC
NOTE: SEE SFC INSTRUCTION
SHEET FOR DETAILS OF SFC.
NOTE: READ GEH-5201.
SECTION 6.
BEFORE ENERGIZING
CONTROLLER.
DISPLAY
LINE AMPS
POWER FACTOR
FIELD AMPS
FIELD VOLTS
GND
CM

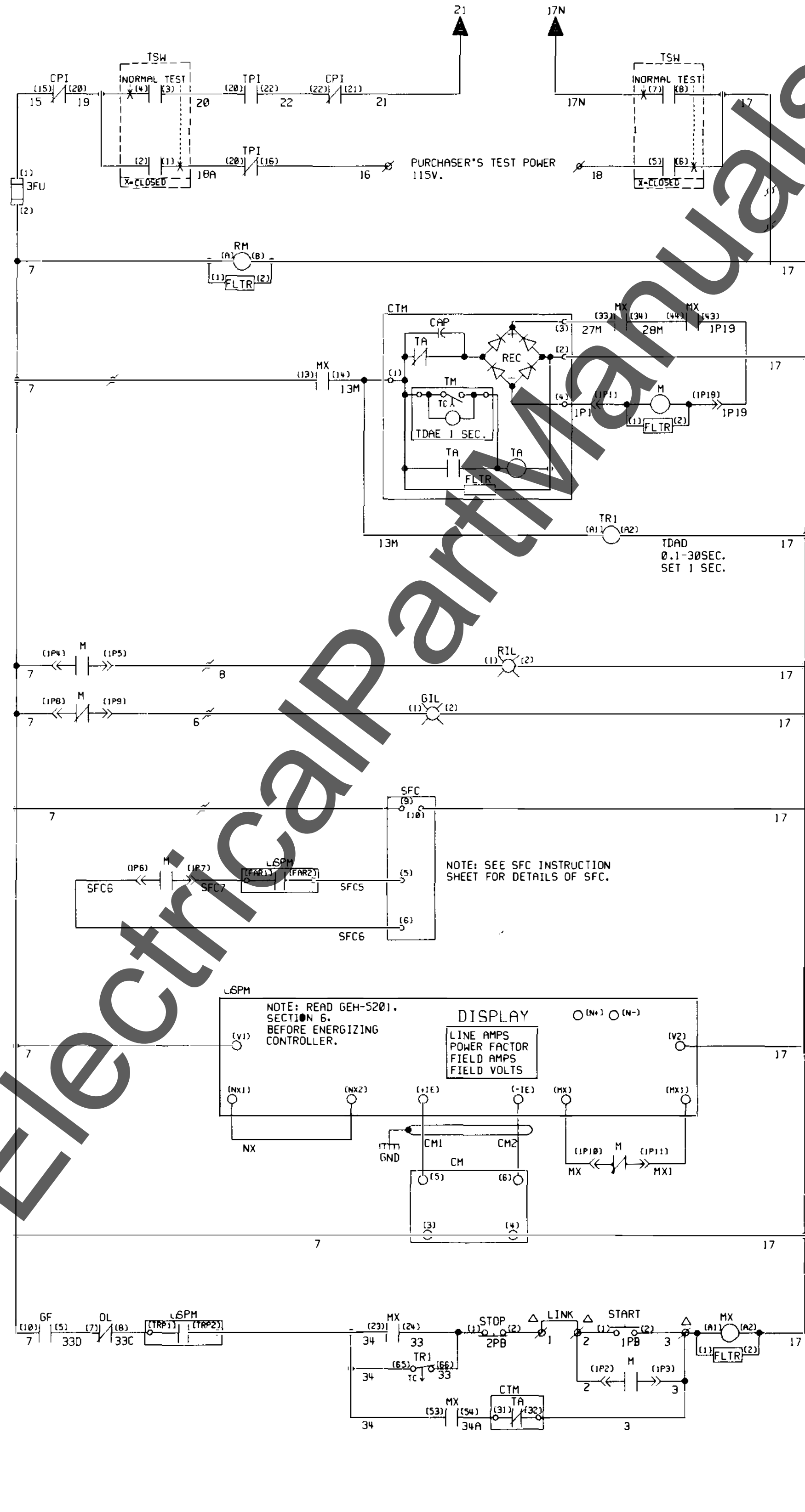
I

FVNR BRUSH-TYPE SYNCHRONOUS

CR194 800-ampere Vacuum Stationary (One-high)

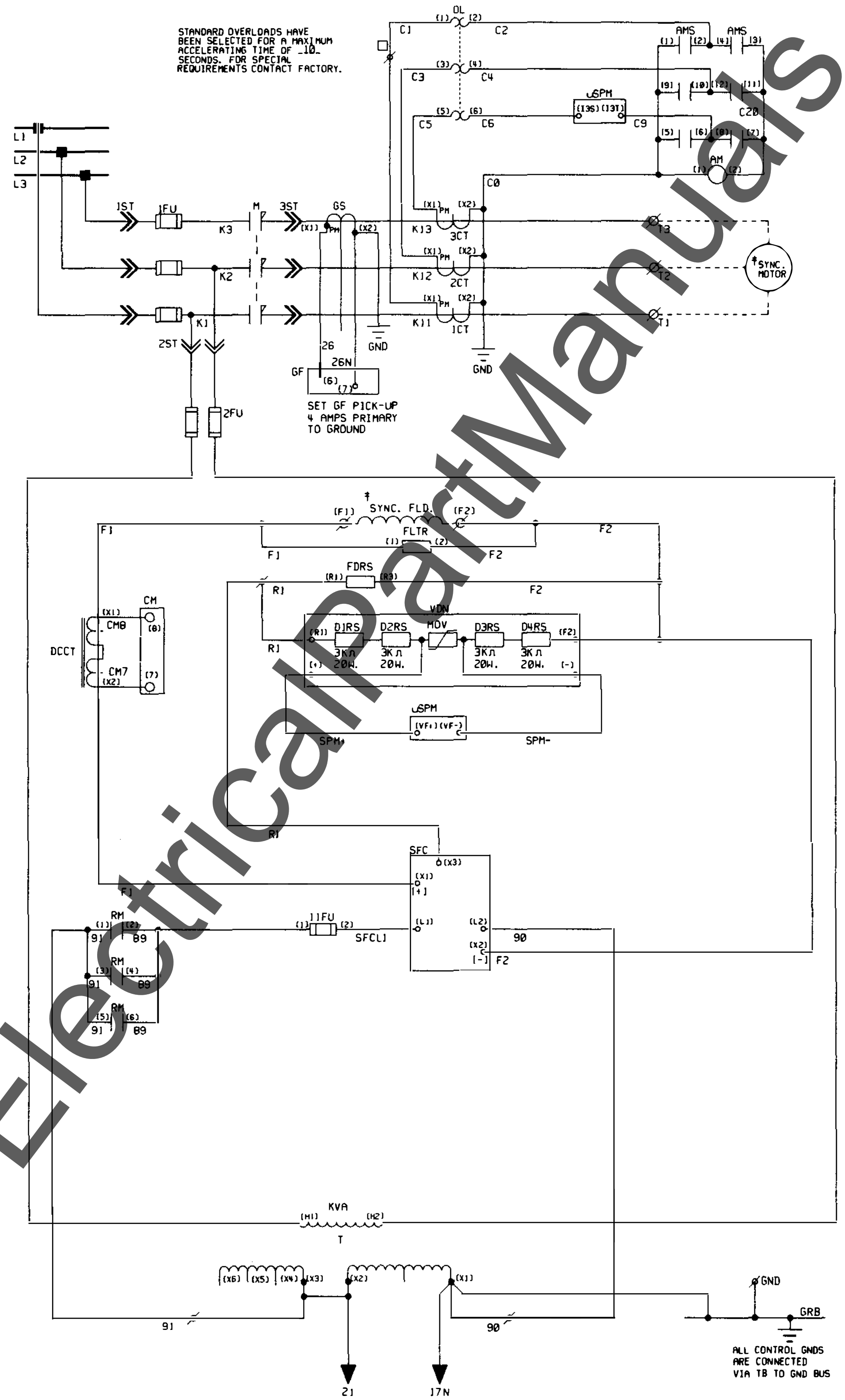


(Continued on next page)

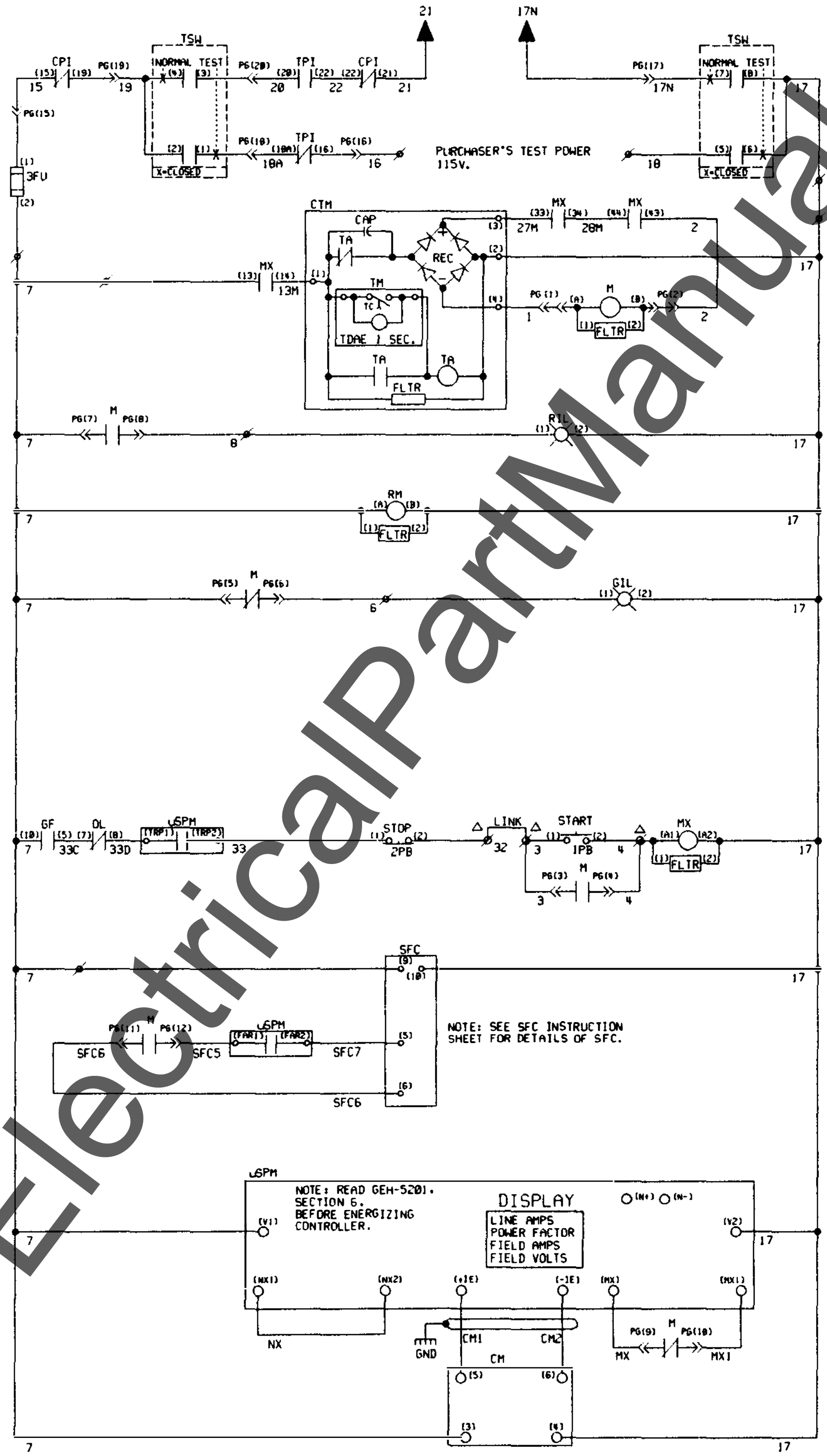

TSW
NORMAL TEST
X-CLOSED
PURCHASER'S TEST POWER 115V.
TDAE 1 SEC.
TDAD 0.1-30SEC. SET 1 SEC.
NOTE: SEE SFC INSTRUCTION SHEET FOR DETAILS OF SFC.
NOTE: READ GEH-5201, SECTION 6, BEFORE ENERGIZING CONTROLLER.
DISPLAY
LINE AMPS
POWER FACTOR
FIELD AMPS
FIELD VOLTS
STOP
LINK
START

FVNR BRUSH-TYPE SYNCHRONOUS

CR7160 400-ampere Air-break (One-high)



(Continued on next page)


TSW
NORMAL TEST
X-CLOSED
PURCHASER'S TEST POWER
115V.
CTM
CAP
REC
TDAE 1 SEC.
FLTR
START
STOP
LINK
SFC
NOTE: SEE SFC INSTRUCTION
SHEET FOR DETAILS OF SFC.
NOTE: READ GEH-5201,
SECTION 6,
BEFORE ENERGIZING
CONTROLLER.
DISPLAY
LINE AMPS
POWER FACTOR
FIELD AMPS
FIELD VOLTS
GND
CM

I

CONTROLLERS-CR194 VACUUM STATIONARY & DRAWOUT CONTACTORS, 2400 -7200 VOLTS

GENERAL

These specifications cover NEMA Class E2 high-voltage control for ____ volts, ____ phase, ____ Hertz as follows:

Controller #1:

			(Squirrel-cage induction)
(Full voltage)	(Non reversing)	controller for	(Wound-rotor induction)
(Reduced voltage)	(Reversing)		(Brush-type synchronous)
			(Brushless synchronous)

motor rated at ____ horsepower.

Controller #2, etc. **(as shown above)**

ALL CONTROLLERS

Controller(s) shall be fused type employing current-limiting sand power fuses that give the controller an interrupting rating of:

200 mVA, 3 phase symmetrical at 2400 Volts, 50/60 Hz
350 mVA, 3 phase symmetrical at 4200 Volts, 50/60 Hz
400 mVA, 3 phase symmetrical at 4800 Volts, 50/60 Hz
600 mVA, 3 phase symmetrical at 7200 Volts, 50/60 Hz

CONTACTORS

Starter(s) shall employ magnetically held vacuum contactor(s) rated at:

for welded enclosure:

400 amperes at 7200 volts maximum, interrupting rating of 75 mVA, 3 phase symm.
800 amperes at 5000 volts maximum, interrupting rating of 75 mVA, 3 phase symm.

for bolted enclosure:

400 amperes at 5000 volts maximum, interrupting rating of 50 mVA, 3 phase symm. (2-high only)

Contactor(s) shall be stationary (drawout for 400 amp contactor only) and the coil shall be removable without removing the contactor from the enclosure. The vacuum interrupter wear checks shall not require removal of the contactor.

Controller(s) shall be in a:

for welded enclosure:

One-high line-up of NEMA ____ enclosure(s) equipped with 3-ph (1000)(2000) amp horizontal AC bus

One-high individual NEMA ____ enclosure(s) equipped with provisions for terminating incoming cable

for bolted enclosure:

Two-high line-up of NEMA ____ enclosure(s) equipped with (1000)(2000) amp horizontal AC power bus

The power bus shall be braced for 80 kA RMS asymmetrical or 50 kA RMS symmetrical.

For safety to personnel, enclosure(s) shall be compartmented into low-voltage control compartment with separate door, high-voltage compartment with separate interlocked door, AC bus compartment with protective barriers and cable entrance compartment.

The controller shall be isolated by a quick-make quick-break switch operated by an externally mounted operating handle. The isolating device shall disconnect the secondary of the control power transformer before opening the main circuit contacts.

Mechanical interlocks shall be provided to prevent:

1. Closing the isolation switch with the high-voltage door open.
2. Operation of the isolation switch while under load.
3. Opening of the high-voltage door when isolation switch is on.
4. Operation of the contactor when the isolation switch is in an intermediate position.

NOTE: For overload protection, one three-pole ambient-compensated thermal-overload relay, manually reset, shall be included.

Controllers rated 400 and 800 amperes shall be rated 60 kV Basic Impulse Level (BIL).

OPTIONS:

Each controller shall contain protection against single-phasing due to a blown fuse and shall have blown fuse indication.

(Solid-state relay protection)
(Latched contactors)

Control for Wound-rotor Induction Motors

Secondary control shall be fully magnetic. It shall provide automatic acceleration through ____ starting steps with uniform torque peaks using a NEMA Class ____ resistor.

The control shall provide for continuous speed regulation with ____ points of speed reduction with a maximum reduction of ____ % from full-load speed at ____ % full load torque.

Control for Synchronous Motors

DC field control for synchronous motors shall consist of one General Electric CR192 starting and protection module equipped with digital displays for power factor, field current and line current, one field starting and discharge resistor and one electronic field contactor. Operation must be fully automatic.

Static field supplies shall be:

(tapped transformer static field contactor [SFC])
(adjustable silicon controlled rectified variable field contactor [SCR type VFC])
(adjustable VFC with power factor regulation)
(adjustable VFC with field current regulation)

Additional Functions

Control power at 120 volts shall be provided from a control power transformer in each controller. The transformer shall be protected by current-limiting fuses.

Controller(s) shall provide instantaneous undervoltage protection when momentary contact push button is used, undervoltage release when maintained contact push button is used.

(Push button)	is to be	(mounted on door)
(Switch)		(remotely located)

Finish

Finish shall be:

(ANSI-61 light gray over rust-resistant phosphate undercoat for indoor use.)

(ANSI-61 light gray over one or more rust-resistant phosphate undercoats for outdoor use.)

CONTROLLERS - CR7160 VACUUM OR AIR-BREAK DRAW OUT, 2400 -7200 Volts

GENERAL

These specifications cover NEMA Class E2 high-voltage control for ____ volts, ____ phase, ____ Hertz motors as follows:

Controller #1:

			(Squirrel-cage induction)
(Full voltage)	(Non reversing)	controller for	(Wound-rotor induction)
(Reduced voltage)	(Reversing)		(Brush-type synchronous)
			(Brushless synchronous)

motor rated at ____ horsepower.

Controller #2, etc. (as shown above)

ALL CONTROLLERS

Controller(s) shall be fused type employing current-limiting power fuses that give the controller an interrupting rating of:

200 mVA, 3-phase symmetrical at 2400 volts, 50/60 Hz
350 mVA, 3-phase symmetrical at 4200 volts, 50/60 Hz
400 mVA, 3-phase symmetrical at 4800 volts, 50/60 Hz
600 mVA, 3-phase symmetrical at 7200 volts, 50/60 Hz

Starter(s) shall employ (vacuum) (magnetic air-break) line contactor(s) rated 400 amperes, 5000 volts and have an interrupting capacity of 50 mVA, 3-phase, symmetrical.

Starter(s) shall employ magnetic air-break line contactor(s) rated 700 amperes, 5000 volts and have an interrupting capacity of 80 mVA, 3-phase symmetrical.

Controller(s) shall be in a:
one-high line-up of NEMA ____ enclosures with 3-phase (1000 amp) (2000 amp) AC power bus.
free-standing one-high individual NEMA ____ enclosure(s) with provision for terminating incoming cable.
two-high construction with NEMA ____ enclosure*, and with 3-phase (1000 amp) (2000 amp) AC power bus.
three-high construction with NEMA ____ enclosure*, and with 3-phase (1000 amp) (2000 amp) AC power bus.

For safety to personnel, enclosure(s) shall be compartmented into low-voltage control compartment with separate door, high-voltage compartment with separate interlocked door, AC bus compartment with protective barriers and cable entrance compartment.

Line contactors shall be draw out type.

The controller shall be isolated by externally operated drawout stabs with shutter mechanism. The isolating device shall also open the secondary of the control power transformer. Interlocks shall be provided to prevent (1) inadvertent operation of the isolation mechanism underload, (2) opening the high-voltage compartment door without isolating the starter, and (3) closing the isolation switch with door open.

NOTE: For overload protection, one three-pole ambient-compensated thermal overload relay, hand-reset, shall be included.

OPTIONS
(Solid-state relay protection)
(Anti-single-phase trip bar)
(Mechanical latching)

Control for Wound-rotor Induction Motors

Secondary control shall be fully magnetic. It shall provide automatic acceleration through ____ starting steps with uniform torque peaks using a NEMA Class ____ resistor.

The control shall provide for continuous speed regulation with ____ point of speed reduction with a maximum reduction of ____ percent from full-load speed at ____ % full-load torque.

Control for Synchronous Motors

DC field control for synchronous motors shall consist of one General Electric CR192 starting and protection module equipped with digital displays for power factor, field current and line current, one field starting and discharge resistor and one magnetic field contactor. Operation must be fully automatic.

Static field supplies shall be:

(tapped transformer SFC - Static Field Contactor)

(adjustable SCR type VFC - Variable Field Contactor)

(adjustable SCR type VFC with power-factor regulation)

(adjustable SCR type VFC with field current regulation)

Additional functions

Control power at 120 volts shall be provided from a control-power transformer in each controller. Transformer shall be protected by current-limiting fuses.

Controller(s) shall provide instantaneous undervoltage protection when momentary-contact push button is used, undervoltage release when maintained-contact switch is used.

(Push button)	is to be	(mounted on door).
(Switch)		(remotely located).

Finish

Finish shall be:

(ANSI-61 light gray over rust-resistant phosphate undercoat for indoor use.)

(ANSI-61 light gray over one or more rust-resistant phosphate undercoats for outdoor use.)

STARTERS - CR194 VACUUM

ALL STARTERS

Enclosure . . . . NEMA Type 1 general purpose, ventilated

Connections

Incoming Line . . Entrance top or bottom. Cables separated by barrier from both low- and high-voltage compartments.

Motor Cable . . . . Entrance top or bottom. Cables separated by barrier from both low- and high-voltage compartments.

SQUIRREL-CAGE-MOTOR STARTERS

Full-Voltage Non-Reversing (FVNR)

High-voltage compartment . . 1-Set of bolt-in current-limiting fuses and supports
1-Externally operated disconnect switch
1-Three-pole vacuum contactor
1-Set of mechanical interlocks to prevent opening the disconnect when the contactor is on, to prevent open ing the door when the disconnect is on, to prevent closing the contactor when the disconnect is in an intermediate position, and to prevent closing of the disconnect when the high-voltage door is open
1-Fused primary control power transformer (CPT)
3-Current transformers
3-Terminals for motor cable connections

Low-voltage compartment . . 1-Three-pole, ambient-compensated thermal overload relay, hand-reset
1-NORMAL-TEST selector switch
1-Control-circuit fuse

On door . . . . . . 1-START-STOP push button, oil-tight, flush-mounted

Full-Voltage Reversing (FVR)

Same as for full-voltage non-reversing with addition of following:

Auxiliary enclosure . . . . . 2-Three-pole vacuum contactors for reversing

On door . . . . . . 1-FORWARD-REVERSE-STOP push button, oil-tight, flush-mounted (replacing START-STOP push button)

Reduced-Voltage Non-Reversing (RVNR) (Primary Reactor)

Same as for full-voltage non-reversing with addition of following:

1-Three-pole vacuum contactor used as a RUN contactor

Auxiliary enclosure (1-high) . . . . . . 1-Reduced-voltage starting reactor with taps for 50-, 65- and 80-percent line voltage

Low voltage compartment . . 1-Definite time transfer relay

Reduced-Voltage Non-Reversing (RVNR) (Autotransformer closed transition)

Same as for full-voltage non-reversing with addition of following:

1-Three-pole vacuum contactor used as a RUN contactor

Auxiliary enclosure (1-high) . . . . . . 2-Three-pole vacuum contactor - neutral, and 80-percent line voltage

Low-voltage compartment . . 1-Definite time transfer relay

WOUND-ROTOR-MOTOR STARTERS

Non-Reversing

Same as for squirrel-cage FVNR with addition of following:

Secondary enclosure . . . . . 1-Set of intermediate accelerating contactors
1-Final accelerating contactor
1-Set of definite time accelerating relays

Resistor enclosure . . . . . 1-Set of starting-duty resistors, NEMA Class 135

Reversing

Same as for non-reversing with addition of following:

High-voltage compartment . . 1-Three-pole vacuum contactor used for reversing

On door . . . . . . 1-FORWARD-REVERSE-STOP push button, oil-tight, flush-mounted (replacing START-STOP push button)

BRUSH-TYPE SYNCHRONOUS-MOTOR STARTERS

Full-Voltage Non-Reversing (FVNR)

Same as for squirrel-cage FVNR with addition of following:

Low voltage
compartment . . 1-Field application and discharge contactor

On door . . . . . . 1-CR192 μSPM solid-state synchronizing device for precision-angle field application, load-angle field removal and squirrel-cage protection with built-in digital power factor and line ammeter
1-Line amps display - digital readout (part of CR192 module)
1-Field amps display - digital readout (part of CR192 module)

On top . . . . 1-Field starting and discharge resistor

Reduced-Voltage Non-Reversing (RVNR)

Same as for full-voltage non-reversing with addition of preceding reduced voltage sections contactor

BRUSHLESS, SYNCHRONOUS-MOTOR STARTERS

Full-Voltage Non-Reversing (FVNR)

Same as for squirrel-cage FVNR with addition of following:

Low voltage . . . 1-Brushless-exciter field supply (7 amps maximum)
Compartment . .1-Variable autotransformer for exciter field supply
On door . . . . . . 1-CR192 μSPM solid-state synchronizing device for precision time-delay field application, load-angle field removal and squirrel-cage protection with built-in digital power factor and line ammeter
1-Line amps display - digital readout (part of CR192 module)
1-Field amps display - digital readout (part of CR192 module)

Reduced-Voltage Non-Reversing (RVNR)

Same as for full-voltage non-reversing with addition of preceding reduced voltage sections

NOTE: Drawout contactor available only for FVNR applications.

J

STARTERS - CR7160 AIR-BREAK

ALL STARTERS

Enclosure . . . . . . NEMA Type 1 general purpose, ventilated

Connections

Incoming Line . . Entrance top or bottom. Cables separated by barrier from both low- and high-voltage compartments.

Motor Cable . . . . Entrance top or bottom. Cables separated by barrier from both low- and high-volt age compartments.

SQUIRREL-CAGE-MOTOR STARTERS

Full-Voltage Non-Reversing (FVNR)

High-voltage compartment . . 1- Draw out contactor-and-fuse (DC coil) assembly consisting of :
- 1- Set of current-limiting fuses and supports
- 1- Isolating mechanism, externally operated. Mechanism operates in sequence to (1) open secondary of control transformer, (2) withdraw stabs, (3) close shutters over power connectors.
- 1- Three-pole contactor
- 1- Set of mechanical interlocks to prevent withdrawal of stabs while contactor is closed
- 1- Control-power transformer (115-volt secondary)
- 3- Current transformers
- X-Terminals for motor cable connections
- 1- Set of mechanical door interlocks to prevent opening door to high-voltage compartment until panel is isolated and to prevent energizing panel until door to high-voltage compartment is closed
- X-Incoming-line terminals

Low-voltage compartment . . 1- Three-pole, ambient-compensated thermal overload relay, hand-reset
- X-Instantaneous undervoltage protection
- 1- Control-circuit fuse

On door . . . . . . 1- START-STOP push button, oil-tight, flush-mounted

Full-Voltage Reversing (FVR)

Same as for full-voltage non-reversing with addition of following:

Auxiliary enclosure (one-high) . . . . 1- Drawout three-pole reversing contactor

On door . . . . . . 1- FORWARD-REVERSE-STOP push button, oil-tight, flush-mounted (replacing START-STOP push button)

Reduced-Voltage Non-Reversing (RVNR)

Same as for full-voltage non-reversing with addition of following:

Auxiliary enclosure (one-high) . . . . 1- Three-pole RUN contactor
- 1- Primary starting reactor with taps for 50-, 65- and 80-percent line voltage

Low-voltage compartment . . 1- Definite time transfer relay

WOUND-ROTOR-MOTOR STARTERS

Non-Reversing

Same as for squirrel-cage FVNR with addition of following:

Secondary enclosure . . . . . 1- Set of intermediate accelerating contactors
- 1- Final accelerating contactor

Resistor enclosure . . . . 1- Set of definite-time accelerating relays
- 1- Starting-duty resistor, NEMA Class 135

Reversing

Same as for non-reversing with addition of following:

Auxiliary enclosure . . . . . 1- Drawout three-pole reversing contactor

On door . . . . . . 1- FORWARD-REVERSE-STOP push button, oil-tight, flush-mounted (replacing START-STOP push button)

BRUSH-TYPE SYNCHRONOUS-MOTOR STARTERS

Full-Voltage Non-Reversing (FVNR)

Same as for squirrel-cage FVNR with addition of following:

Low-voltage compartment . . 1- Field application and discharge contactor
- 1- CR192 µSPM for precision-angle field application, load-angle removal, and squirrel-cage protection

On door . . . . . . 1- Line amps display - digital readout (part of CR192 µSPM)
- 1- Field amps display - digital readout (part of CR192 µSPM)

J

1- Power factor display (part of CR192 µSPM)
On top . . . . 1- Field starting and discharge resistor

Reduced-Voltage Non-Reversing (RVNR)
Same as for full-voltage non-reversing with addition of following:
Auxiliary
enclosure . . . . . 1- Three-pole run contactor
1- Primary starting reactor with taps for 50-, 65-, and 80-percent line voltage
Low-voltage
compartment . . 1- Definite time transfer relay

BRUSHLESS SYNCHRONOUS-MOTOR STARTERS

Full-Voltage Non-Reversing (FVNR)
Same as for squirrel-cage FVNR with addition of following:
Low-voltage
compartment . . 1- CR192 µSPM for pullout protection, timed exciter field application and stall protection
1- Brushless exciter field supply
On door . . . . . . 1- Line amps display - digital readout (part of CR192 µSPM)
1- Power factor display (part of CR192 µSPM)
1- Field amps display - digital readout(part of CR192 µSPM)
1- Variable autotransformer

Reduced-Voltage Non-Reversing (RVNR)
Same as for full-voltage non-reversing with addition of following:
Auxiliary
enclosure . . . . . 1- Three-pole RUN contactor
1- Primary starting reactor with taps for 50-, 65-, and 80-percent line voltage
Low-voltage
compartment . . 1- Definite-time transfer relay

GE Electrical Distribution and Control

General Electric Company
41 Woodford Avenue
Plainville, CT 06062

GET-6840B 0398 BL