

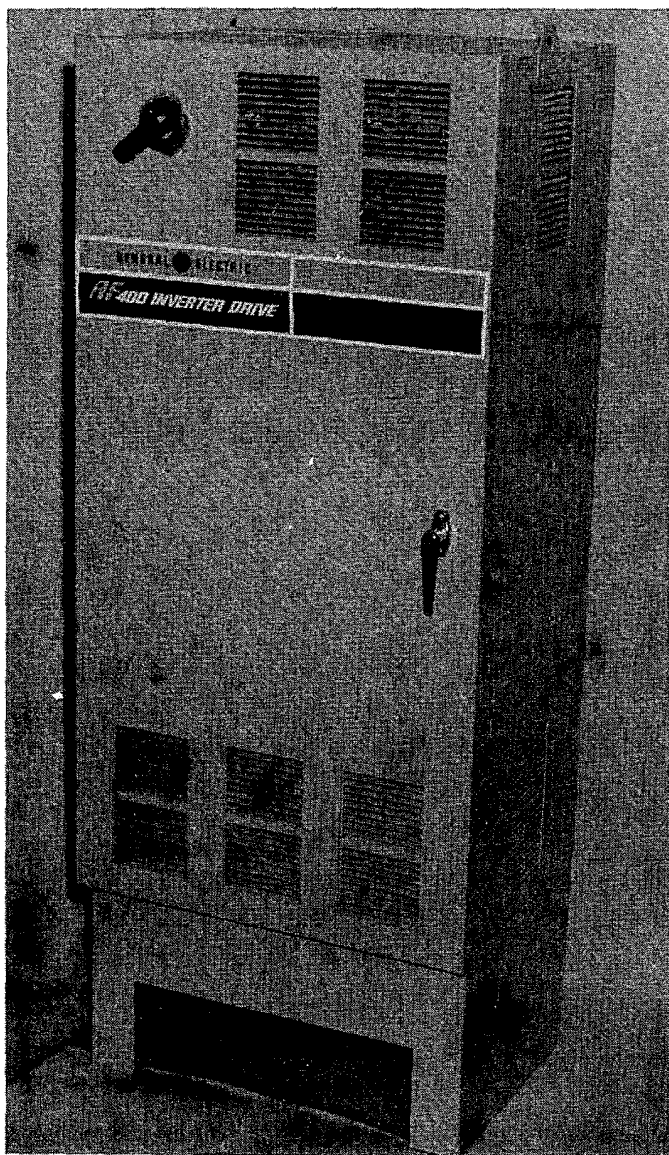


INSTRUCTIONS

PRELIMINARY GEK-24998

AF-400 *GP

AC ADJUSTABLE SPEED DRIVE



These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to General Electric Company.

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NOTE

In the text that follows, there will be a standard format for device descriptions. This format is shown below:

XPL Signifies Module Plugs, i.e., APL = Phase A-Inverter Module

TBX (XX) Signifies terminal board connections, i.e., TB2 (31) = Terminal Board 2, Terminal 31

GENERAL

INTRODUCTION

This instruction manual is structured around a general purpose drive. It is a guide for the installation, checkout and operation of the equipment furnished with general troubleshooting procedures for the basic drive. It is designed for the installation or maintenance electrical technician or engineer. In order to use the manual effectively, the individual must be familiar with basic electronic terms and concepts and be able to use the required test equipment effectively.

These instructions do not purport to cover all details or variations in the equipment nor to provide for every possible contingency to be met in connection with the installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to General Electric Company.

RECEIVING

This equipment should be placed under adequate cover immediately upon receipt as packing is not suitable for out-of-doors or unprotected storage.

All equipment is factory inspected before shipment and is shipped in good condition. Any damages or shortages evident when the equipment is received must be immediately reported to the commercial carrier who transported the equipment. If required, assistance may be received from *General Electric Company, Speed Variator Products Operation, Erie, PA*. When seeking assistance, please use the purchase order number, requisition number, serial number, and model number to help us in assisting you **Telephone (814) 455-3219**.

HANDLING

Power unit can be transported by lift trucks with the forks completely under the wooden shipping base. Crane lifting eyelets are supplied on the top of the unit for handling by a crane. A spreader bar must be used when lifting from above.

WARNING

IMPROPER LIFTING PRACTICES CAN CAUSE SERIOUS OR FATAL INJURY. LIFT ONLY WITH ADEQUATE EQUIPMENT AND TRAINED PERSONNEL.

STORAGE

This equipment may be stored at ambient temperatures of -20°C to $+20^{\circ}\text{C}$ for a period of up to one year. Air must be free of chemical and electrically conductive contaminants, and other conditions must be such that no moisture condensation occurs in or on the equipment.

In addition, when a control that has been in operation is shut down for either a short or extended period of time, it is recommended the environmental conditions be maintained the same as when in operation.

It is recommended that space heaters or equivalent devices be used to maintain the equipment in its normal operating environment (temperature).

The electrolytic filter capacitors require "forming" after a six month or longer storage period without being energized. It is necessary to form the capacitors to prevent excessive leakage which can result in capacitor failure. The procedure for forming the filter capacitor is given in step 13 of the Start-up Instructions.

SAFETY RECOMMENDATIONS

Only qualified electrical and electronics personnel should install and maintain this equipment. They should read the complete instructions prior to applying power or troubleshooting the equipment. They should heed all **WARNING** and **CAUTION** notes or labels listed in the Manual or posted on the equipment. Definitions of label terms and colors are as follows:

WARNING

DENOTES OPERATING PROCEDURES AND PRACTICES THAT MAY RESULT IN PERSONAL INJURY OR LOSS OF LIFE IF NOT CORRECTLY FOLLOWED.

COLOR: BLACK OR WHITE LETTERING ON RED FIELD.

CAUTION

DENOTES OPERATING PROCEDURES AND PRACTICES THAT, IF NOT STRICTLY OBSERVED, MAY RESULT IN DAMAGE TO, OR DESTRUCTION OF, THE EQUIPMENT.

COLOR: BLACK LETTERING ON AMBER FIELD.

INSTALLATION

LOCATION

AF-400 drive power units are suitable for most factory areas where other industrial equipment is installed. They should be installed in well-ventilated areas with ambient temperatures ranging from 10°C(50°F) to 40°C(104°F) and relative humidities up to 90%. It should be recognized, however, that since the life expectancy of any electronic component decreases with increased ambient temperature, reduction of the ambient temperature will bring about extended component life. For example, longer component life should be expected if the ambient temperature is held between 20°C(68°F) and 30°C(87°F).

Proper performance and normal operational life can be expected by maintaining a proper environment for the drive system. Environments which include excessive amounts of one or more of the following characteristics should be considered hostile to drive performance and life:

1. Dirt, dust and foreign matter.
2. Vibration and shock.
3. Moisture and vapors.
4. Temperature excursions.
5. Caustic fumes.
6. Power line fluctuations.
7. Electromagnetic interference (noise).

WARNING

NORMAL OPERATION OF THIS EQUIPMENT PRODUCES ELECTRICAL ARCING. BECAUSE OF POTENTIAL FIRE AND EXPLOSION HAZARD, THIS EQUIPMENT SHOULD NEVER BE INSTALLED WHERE INFLAMMABLE OR COMBUSTIBLE VAPORS OR DUSTS ARE PRESENT. TO AVOID CONTACT WITH LIVE PARTS SUFFICIENT CLEARANCE IN FRONT OF THE UNITS SHOULD BE ALLOWED FOR ACCESS DURING MAINTENANCE OR REPAIR.

CAUTION

THIS EQUIPMENT IS DESIGNED TO OPERATE IN A NORMAL INDUSTRIAL ATMOSPHERE. OPERATING RADIO TRANSMITTERS NEARBY MAY CAUSE THE CONTROL EQUIPMENT TO MISOPERATE. IT IS RECOMMENDED THAT RADIO TRANSMITTERS NOT BE OPERATED WITHIN THE VICINITY OF THE CONTROL EQUIPMENT WHEN THE PANEL DOORS ARE OPEN, NOR AT ANY TIME WITHIN THE CONFINES OF THE POWER CONTROL ROOM.

MOUNTING

POWER UNIT

The standard power unit is 50" high, 25" wide, 20" deep, NEMA I enclosure mounted on 11" high base. Total height equals 61". Cases may be bolted down using 3/8" diameter mounting bolts or studs through holes provided in base feet. Cases may be bolted to a wall through holes provided in the top flange. Conduit entry openings with removable covers are provided in the top and bottom of the case, see Figure 1. If studs are cast in floor, they should extend 3 1/2" minimum above floor. Conduit entry openings through the base are fitted with removable sheet steel covers. Other conduit entry area is available through the top of the case.

CAUTION

IF CONDUIT ENTRY OPENINGS ARE TO BE CUT IN THE TOP OF THE CASE, ADEQUATE PRECAUTIONS SHOULD BE TAKEN TO PREVENT METAL PARTICLES FROM ENTERING DEVICES AND COMPONENTS.

OPERATOR'S STATION

The Operator's Station must be disassembled for mounting and wiring. First, remove the screws securing the cover to the Operator's Station enclosure and then remove the cover (with control devices mounted on the cover) from the enclosure.

When using either rigid or thin wall conduits, it is generally easier to attach the unit to the end of the conduit before locating and installing the mounting screws.

Mount the Operator's Station on any firm, reasonably flat, vertical surface by means of mounting holes in both top and back and bottom back of enclosure. The Operator's Station is suitable for either wood screws or No. 10 machine screws.

AC MOTOR(S)

A separate instruction book is provided giving information on location, conduit location and mounting of the motor. The motor should be mounted on the drive machine (or as appropriate for the installation) before proceeding with wiring, set up and adjustment.

ELECTRICAL WIRING & CONNECTIONS

All wiring shall be in accordance with the National Electrical Code and be consistent with all local codes. All internal electrical connections between components in the power units are made at the factory. When installing AF-400 drives, all connections should be checked for tightness. Connections may become loose in shipping or storage. A diagram showing the connections between the power unit and the related components is furnished with the equipment. All terminals to which the external connections are to be made are numbered on the diagram. The equipment should be wired as per the elementary diagram and verified by continuity tests. It is recommended that as each connection or wire is connected to the equipment, it be checked off the elementary diagram.

WARNING

ALL MOTOR BASES AND EQUIPMENT ENCLOSURES MUST BE CONNECTED TO THE FACTORY OR FACILITY GROUNDING SYSTEM TO AVOID PERSONAL INJURY OR LOSS OF LIFE AS A RESULT OF SHOCK HAZARDS.

MOTOR CONNECTIONS

The motor leads should be connected for the drive nameplate voltage rating according to the connection diagram plate on the motor. Connecting wire sizes and motor protection should be selected in accordance with NEC Standards based on the motor nameplate data. Be sure to connect motor thermal switch (if supplied) back to the power unit. Tape all motor connections.

POWER UNIT CONNECTIONS

Electrical codes generally require the use of a fused disconnecting switch or circuit breaker in the AC power line ahead of the power unit and transformer (if used). The disconnecting switch and fuse (or circuit breaker) should be selected in accordance with the National Electrical Code and/or local code requirements based on the power input data on the power unit nameplate. If any additional relay, solenoids, brakes, etc., are added to the system, R.C. suppression networks must be added across the coils, (.5uf, in parallel with 220 ohms @115/230V).

OPERATOR'S STATION CONNECTION

Using the elementary diagram, make all the required wiring connections between devices in the Operator's Station and the connections to the power unit. Reassemble the Operator's Station. Carefully dress the interconnecting wire into the back of the station so that the device assembly

may be installed. Keep the wires away from sharp edges and do not force the device assembly into place. Replace the station cover and secure with cover retaining screws.

DESCRIPTION

The AF-400 drive is an adjustable frequency AC motor drive designed for industrial applications. Either single motor or multi-motor operation from a single power unit can be accomplished. Adjustment of motor speed is achieved by changing both motor frequency and voltage. This is accomplished in separate sections of the drive, since the AF-400 drive is a variable DC link type of inverter.

The various modules and components to be described are physically located in the AF-400 drive power unit as shown in Figure 1. These modules and components are also shown in the system block diagram of Figure 2. Following, is a description and operating explanation of each system block, starting with power blocks and finishing with control blocks.

CONVERTER MODULE

The converter module is a three-phase, full-wave controlled rectifier which converts the incoming three-phase AC power to variable voltage DC power. The six SCR converter is shown in more detail in the power circuit of Figure 3. The SCR snubber circuits (not shown) act to protect the converter SCR's against voltage transients. The converter module also contains the commutating power supply (card) and the commutating feedback circuitry described below. The converter DC output voltage is varied from zero to maximum output by adjusting the firing point of each SCR relative to its AC supply phase voltage. The resultant DC output voltage, therefore, contains six times AC supply frequency ripple component of voltage. This ripple voltage must be filtered to improve the wave-form before being applied to the inverter section.

DC LINK FILTER

An iron core reactor L1 and bank of electrolytic capacitors C1 act as an LC filter in the DC link, as shown in Figure 3. In addition to filtering the output of the converter, it also prevents inverter commutation transients from being applied back to the converter. The C1 capacitor also acts to supply motor reactive power.

INVERTER MODULES

The three-phase inverter consists of three identical single-phase inverter modules, as shown in Figures 2 and 3. Each module consists of two inverter SCR's, two commutating SCR's, two bypass diodes and an LC commutating circuit. Output phase A (T1) of Figure 3 will be described, since all three phases operate in an identical manner, except for being displaced by 120 degrees in phase relationship. For simplicity, only Phase A commutating circuit is shown.

The AC motor lead T1 is alternately connected to the positive P3 DC bus or the negative N2 DC bus, by inverter SCR's ISP or ISN, respectively. The frequency that terminal T1 is alternately connected to the two DC potentials is the fundamental frequency applied to the AC motor, which determines its speed.

Although a SCR can readily be turned on by applying a firing signal to its gate, it must be commutated off by supplying an alternate path for the current which was flowing through the SCR, and by applying a small reverse voltage to the SCR for a short period of time. This is accomplished by means of the commutating SCR's CSP and CSN, and by the commutating reactor LC and commutating capacitor CC.

At the time when inverter SCR ISP is to be commutated off, capacitor CC is charged such that the T1 side is positive. When commutating SCR CSP is fired, the motor current flowing through ISP is diverted to the alternate path of CSP, CLP, LC and CC due to the voltage charge on CC. When the commutating current in this alternate path exceeds the motor current, no more current exists in ISP. As capacitor CC discharges further, the excess commutating current (above the motor current level) flows through the LP and diode DP back to CSP. The voltage drop across DP produces a small reverse voltage across ISP to cause it to return to its blocking or off state. Therefore, for successful commutation, the commutation current must exceed the motor current for the amount of turn-off time required for the SCR. In order to minimize this time and the commutating energy required, special inverter grade SCR's are used which have a short turn-off time.

The commutating current pulse takes the form of a half-cycle sine wave because of the interaction of capacitor CC with reactor LC. After the commutating current peaks and starts diminishing, the charge on capacitor CC reverses, and the energy stored in reactor LC charges CC up in the opposite direction. At the point in time when the commutating current falls below the level of the motor current, the current in diode DP goes to zero and the potential of the motor T1 motor lead changes from the inverter positive bus P3 to the negative bus N2 so that diode

DN can furnish the motor current. The above action occurs if the oncoming inverter SCR ISN is not fired before this point in time. If ISN is fired earlier, the transition of T1 from positive to negative bus will occur earlier in the commutation interval. In any case, capacitor CC becomes charged up in the opposite direction (T1 side negative) at the end of the ISP commutation interval. It is now charged correctly to commute off inverter SCR ISN when commutating SCR CSN is fired. This commutating action is the same as the one just described. At the end of each commutating interval, the commutating SCR is commutated off by the charge on capacitor CC producing a reverse voltage to the commutating SCR which had just been conducting.

The four leg reactors, CLP, CLN, LP and LN act in conjunction with the SCR snubber circuits (not shown in Figure 3) to limit dv/dt and protect the SCR's against voltage transients. The leg reactors also serve to limit current if an inverter fault should occur.

The commutation losses, although small in relation to the total commutation energy, must be replaced in order to keep the commutation capacitor charged up to the proper voltage. These losses are replaced from the variable voltage DC link (P12 to N2) when it is near its maximum value. The amount of energy replaced, and thus the level of the commutation capacitor voltage, is determined by the firing point of the oncoming inverter SCR in the commutation interval. As the DC link voltage is reduced to zero volts, the commutation losses are replaced from another source, the commutation power supply.

COMMUTATION POWER SUPPLY

This card contains three diodes and two resistors (R3 and R4). It is located in the converter module (lower left hand rear). These devices are all relatively small since the commutating losses this card furnishes are a very small percentage of the drive rating.

The diodes, in Figure 3, form a three-phase, half-wave bridge which operates in conjunction with the negative SCR portion of the converter (1SN, 2SN and 3SN) to provide a constant voltage bus relative to DC link bus. This DC supply is filtered by resistor R3 and capacitor C2.

The amount of energy furnished by the commutation power supply to each inverter phase commutation circuit depends, on the level of the DC link voltage and on the point in the commutation interval when the appropriate oncoming inverter SCR is fired. Since the energy loss per commutation is small, the losses are replaced only every other commutation in each phase; that is, only during each positive inverter SCR commutation in each phase. The

driver regulates the commutating current and voltage over the whole DC link voltage operating range, irrespective of how much of the commutating losses are supplied from the commutating power supply or from the DC link.

PROTECTION AND COOLING

Drive short circuit protection is provided by current limiting fuses in the AC supply. An incoming circuit breaker can be supplied (if ordered) to provide both AC disconnection and short circuit protection.

Power unit cooling is provided by a fan which is mounted at the bottom of the power unit case, as shown in Figure 1. A thermoswitch, which opens on an overtemperature condition, is placed in the cooling air stream to detect fan failure. This switch may be connected either to shut down the drive or sound an alarm.

SYSTEM CONTROL

The system control and associated operator's devices will vary considerably depending on the application of the drive. Refer to the system elementary diagrams and instructions for description of the AF-400 general-purpose drive. See drawing 36B590264AB Sheets 1 through 7.

DRIVER MODULE

The driver takes the operator and system control commands and translates them into SCR firing signals to the various power modules to obtain the commanded drive operation. It makes use of several voltage and current feedbacks to monitor the commanded operation, and to protect the drive from misoperation and fault conditions. It contains adjusting means to provide the desired operation performance. It also contains indicating lights to provide visual indication of operating or fault conditions. Finally, it provides a number of signal readouts to alert the system control of various operating and fault conditions.

The driver rack shown in Figure 1 contains five control cards plus a power supply card. In addition, the optional meter card can be provided (if ordered) for drive set-up and diagnostics. All cards are plug-in type for ease of replacement. Interconnections between driver and all power modules is by wire harnesses which plug into receptacles at both ends. Inputs and outputs are on the terminal boards located on the bottom front of the filter capacitor panel. See connection diagram for the inverter 36D870024AA, Sheet 1 for inputs, outputs and for card layout and interconnections.

Control power for the driver module is provided by a control power transformer (TX1) located on the filter capacitor panel directly below the ventilating fan.

A functional block diagram of the driver is shown in Figure 4. A more detailed description of the driver functions on each card, plus signal flow, is given under the following card heading. Also refer to the "Driver Notes" on the driver elementary diagram for detailed information on inputs, feedback, adjustments, readouts, etc.

SYSTEM CARD

The system card consists mainly of logic elements, and acts as the logic interface between the system control and the driver.

The Start-Stop logic insures that starting occurs at minimum frequency and voltage, and that acceleration to the reference input is through the timed acceleration circuit. Stopping is accomplished by first decelerating at the set timed rate until a low voltage level is reached, at which time the inverter is stopped.

A DMF input provides a special decelerate to minimum frequency operation, from the set reference level, without stopping the inverter, the deceleration can be connected to the inverter at this minimum frequency operating level without disturbance, and will then be accelerated to the reference level at the set timed rate when the DMF signal is removed.

The minimum voltage and frequency detection logic contained on this card provides an MVFR signal readout to alert the system control when this drive condition is reached. A RUNR readout provides a signal dependent on whether the inverter is operating or in a stopped condition. An IF indicating light on this card gives a visual idea of inverter operating frequency by its blinking frequency.

If a fault shutdown of the drive occurs due to any cause, the FTR readout provides a signal for the system control. Reset of the fault logic and fault indicating lights will normally occur if a normal stop operation is accomplished. However, if a separate fault reset operation is desired in addition to STOP operation, the XFR input can be used for this purpose.

An inverse time overcurrent trip function, plus trip indicating light ITOC, is provided to shut down the drive. This operates immediately for overcurrents above 175 to 200% of rated current. For overcurrents where the current limit function on the Regulator card is limiting, the shutdown will occur in 15 seconds to 1 minute after current limiting begins, depending on the overcurrent level.

If synchronization of the inverter frequency to another frequency is desired, a SYNC signal input will cause the inverter frequency to follow the external frequency signal. A digital discriminator compares the oscillator frequency with the external frequency, and provides logic signals to the Regulator card to cause the oscillator frequency to be synchronized to the external frequency in the correct phase relationship. When phase and frequency lock-in is achieved, a SYNC indicating light on the card lights and an SR inverter synchronized readout signal is provided.

A logic output, LG will change the gain of the regulator filter section to a low level when taken low. This occurs when a protective function overrides and unlocks the Phase Locked Loop (PLL). Current limit, linear time override, slowdown control override due to high link voltage, inverter not synchronized or not started are conditions making LG for low gain operation.

REGULATOR CARD

The regulator card contains mainly analog regulating circuitry plus adjustment potentiometers in the driver.

A midpoint control voltage level (+10 volts) is generated on this card to provide a midpoint around which the internal regulating control can swing both positive and negative. However, all input and readout control signals are relative to the control power common potential.

This card accepts the analog reference input and, except when this signal is clamped at zero or some other level by the start-stop or other logic on the System card, applies it to the linear timing circuit. This function provides separately adjustable timed acceleration and deceleration to or from the set reference level, or to a new reference level. The timing is adjustable from 5 to 50 seconds for maximum reference change in either direction.

An adjustable link current limit function is provided to override the analog reference if motor current exceeds the current limit setting. This setting can be adjusted from 50% to 150% of rated drive output current. A current limit stability potentiometer *CLST* is adjusted depending on the motor and load inertia to obtain stable current limit operation.

The resultant RFV output signal is fed to both the voltage regulator and the frequency generator in two separate paths.

The reference to the voltage regulator is affected by the adjustment of four potentiometers. The V/Hz potentiometer provides a gain adjustment that will result in rated output voltage for a reference range of 50% to 105%.

The voltage boost potentiometer, VB, adds a fixed amount of voltage irrespective of the frequency, adjustable over a range from zero to 7% of rated output.

The IR compensation potentiometer, IRC, adds a variable amount of voltage proportional to the link current feedback signal, LCS. The adjustment range is zero to 10% of rated voltage with rated link current (LCS = 1 volt).

The voltage limit, VLIM, limits the voltage reference to prevent the converter from phasing full on and saturating. This function is only required in the constant horsepower range where a reference increase from base to maximum frequency would otherwise increase the voltage reference past the saturation point and unbalance the stability circuit.

The voltage regulator compares this modified reference with a feedback signal proportional to converter DC output voltage which is obtained from the Converter card. The output of the voltage regulator is then fed to the Converter card as reference signal to the phase control.

The other path of the RFV reference signal to the frequency generator is affected by the adjustment of two potentiometers and a jumper selection. The *MINF* potentiometer adjusts the inverter minimum frequency from 3% to 12% of set base frequency. The *BF* potentiometer adjusts the inverter base frequency over a minimum 2 to 1 range within either of the three base frequency ranges, 37.5 to 75 Hz, 75 to 150 Hz, or 150 to 300 Hz, selected by the jumper on the regulator card.

The frequency generator takes the analog frequency voltage signal and converts it into a pulse train whose frequency is 6 times the desired fundamental motor frequency. This frequency signal is fed to the Inverter card. The analog frequency voltage signal input to the frequency generator is also used to provide the FVR frequency voltage readout, which is a voltage signal proportional to actual inverter frequency.

The stability-slowdown control provides the following functions:

1. Provides stabilizing for motors at their underdamped operating points.
2. Overrides the frequency reference, when it calls for substantially faster than motor coast slowdown, to keep the volts/Hz applied to the motor within normal limits.
3. Provides system stabilizing during slowdown and current limit operation
4. Provides the input to the high link voltage detection circuit.

CONVERTER CARD

The Converter card controls the firing to the converter SCRs to obtain the correct DC link voltage to be applied to the inverter.

The three AC supply phase voltages are fed to this card through high impedance isolating resistors contained in the wire harness. The Converter card isolating circuits produce three voltage signals equivalent in phase relationship and magnitude to the AC supply phase to neutral voltages. These signals are used in the phase control to determine the correct firing points of the six converter SCRs. They are also used to detect incorrect phase sequence or loss of one or more phases, which produces a PS/LOP light indication and prevents drive operation under these conditions.

The phase control takes the Regulator card voltage regulator output and uses it in conjunction with the three AC line signal to generate the six converter SCR firing signals. These six firing signals are modulated by the firing oscillator signal from the Inverter card to produce pulse train signals, which are amplified and fed to the Pulse Transformer card in the converter power module. The actual amplified firing signals are fed from a delayed firing supply from the Inverter card which delays firing signal transmission until the control has settled down after driver energization.

The converter output voltage is fed back to this card through high impedance isolating resistors in the wire harness. The isolating circuit produces a converter voltage feedback signal which is fed to the voltage regulator on the Regulator card.

The DC link voltage applied to the inverter is fed back through high impedance isolating resistors in the wireharness. This isolating circuit produces a link voltage feedback signal which is fed to the stability-slowdown circuit on the Regulator card and to the minimum voltage detection logic on the System card. It is also used to detect DC link overvoltage, which produces a LOV light indication and an immediate drive shutdown.

Converter firing shutdown, after a fault is detected, occurs in two steps. The first step is an immediate phase back of firing signals to the maximum retard condition to quickly reduce converter output current to zero. The second step occurs about 0.1 seconds later when all firing signals are locked out to stop converter operation.

INVERTER CARD

The Inverter card controls the inverter commutation process and provides fault detection and inverter shutdown logic.

The six times fundamental frequency pulse train generated on the Regulator card is used to initiate each commutation interval, since there are six inverter commutations per cycle. The commutation control generates the logic signals which are fed to the Phase Logic card to accomplish the following inverter firing sequence during each commutation interval:

1. Stops firing the inverter SCR to be commutated off.
2. Fires the proper commutation SCR to begin the commutation process.
3. Initiates firing of the proper oncoming inverter SCR at a point sometime after the midpoint of the commutation interval, dependent on the commutation current regulator.

A jumper on this card sets the correct commutation timing. This jumper is placed on the 230V AC or 460V AC position depending on the equipment rating.

The commutation current regulator affects the commutation interval firing in order to maintain the commutation capacitor voltage within the desired limits over the whole inverter operating range for proper SCR commutation. This is accomplished by monitoring the commutation current feedback from the Current Feedback circuit in the converter module. The current peaks are compared to a desired level and the regulator then initiates earlier or later firing of the oncoming inverter SCRs in the commutation interval to control the amount of energy added to the inverter commutation circuit. If the commutation current and voltage become too high because of excessive motor current or circuit misoperation, a commutation overcurrent detection circuit produces a COC light indication and an immediate drive shutdown.

The pulse train oscillator on this card produces a pulse frequency which is used to modulate the continuous firing signals generated on the Converter and Phase Logic cards. The resultant firing signals are then applied to pulse transformers in the power modules to obtain isolation of the control from the power.

The delayed firing supply on this card is used to provide firing signal power on the Converter and Phase Logic cards. This supply is not energized until approximately 1 second after driver control power is applied so that the control logic can become operative before any SCR firing is possible. If the delayed firing supply voltage goes below a set level, an immediate drive shutdown is produced and the control undervoltage light CUV will light. If the main +20 volt control voltage goes below approximately 18 volts, it

also produces an immediate drive shutdown and CUV light indication. In addition the delayed firing supply is locked out for control voltages under the shutdown level so that inadvertent SCR firing cannot occur.

A short circuit fault in any phase module of the inverter will produce a large discharge current from the DC link filter capacitor. This is detected by current transformer CTC and fed back to the Inverter card. When this current exceeds a set level indicating an inverter fault has occurred, an immediate drive shutdown is produced and the inverter fault light, IOC, will light. The immediate drive shutdown produced by either an inverter fault, a control undervoltage, a commutation overcurrent, or a DC link overvoltage causes all normal inverter firing to be locked out and produces a firing of six inverter SCRs by means of signals supplied to the Phase Logic card. This immediate shutdown action, however, always causes the inverter fault light IOC to light when any of the other three faults described above occur.

The overfrequency trip function provides a drive shutdown and IOF light indication if the inverter frequency exceeds a set limit due to any reason. This overfrequency limit is selectable by means of an inverter card jumper to either 75 Hz, 110 Hz, 165 Hz, 275 Hz or 400 Hz.

PHASE LOGIC CARD

The Phase Logic card translates the Inverter card logic signals into three-phase logic to control the firing of all commutation and inverter SCRs.

The six times fundamental frequency logic from the Inverter card is translated into three-phase, full-wave logic in a positive ABC phase sequence by the Phase Logic card. This three-phase logic is used to sequentially steer the six times per cycle commutation logic from the Inverter card to the proper phase SCR firing logic dependent on the three-phase sequence.

The SCR firing pulse generators take power from the delayed firing supply on the Inverter card to produce firing pulses for six inverter SCRs and six commutating SCRs in the three inverter phase modules. The firing signals for the six inverter SCRs are half-cycle long signals which are modulated by the firing oscillator pulse train from the Inverter card, whereas, the other nine firing signals are single short time pulses.

The fault shutdown logic produces an immediate inverter shutdown in response to fault logic signals from the Inverter card. This logic locks out all normal inverter firing

signals and produces a firing of the six inverter SCRs to produce a shoot-through commutation of the whole inverter.

POWER SUPPLY CARD

A 26 volt winding on the control power transformer provides single-phase AC power to the Power Supply card. A full-wave rectifier and filter capacitor on this card provides unregulated DC power to the series pass power transistors which produce the regulated +20 volt control power output. Short circuit protection is provided by a fuse while output overvoltage protection is provided by an overvoltage detection and crowbar circuit.

The power transistors are controlled by a regulator circuit which provides accurate +20 volt regulation from a reference zener. This zener also provides the reference for the control undervoltage trip function on the Inverter card.

This card has the provision for DC input supply power for AC power outage ride-through.

METER CARD

The optional Meter card fits into a prewired driver receptacle and is a valuable tool for drive set-up and diagnostic checkout.

This card contains a 19 position signal selector switch for connecting to the meter and test posts any preselected and prewired signals or a back plane probe and its associated buffer circuitry to the meter and test probe. It also enables reading almost all card signals without affecting driver operation. This card also contains a 3 position scale selector switch plus the necessary circuitry to enable the meter to read either AC rms, DC average, or the peak reading of any signal. These functions provide this card with the capability of reading inverter link current peak commutating current, and peak levels of short time logic pulses, as well as the normal analog signals.

CURRENT ISOLATOR CARD

This card is located in back of the driver module and connected with spade terminals to terminal board TB3.

This card contains an oscillator for switching the incoming DC current signal to AC. It also contains a transformer which provides isolation between the line voltage side and the control side. The current feedback potentiometer, CFA on the isolator card is normally set to make the current output (LCS) equal to 1 volt RMS with rated output current.

The inverter commutation current transformer is connected to a rectifier bridge and specified loading resistor to provide a unidirectional voltage signal. This signal peak is 12.5 volts for the desired commutation current level of each inverter rating. An additional negative commutation current loading resistor is included so that the commutation current regulator will mainly regulate the positive commutation current in each phase.

PULSE TRANSFORMER CARDS

These cards are mounted on the converter and inverter phase modules. Their major function is to provide voltage isolation between the driver control and the SCR power circuit.

Each card consists of identical pulse transformer circuits. These provide current amplification of the actual SCR firing signals over the signals received from the driver. They also contain input noise suppression and self-protection from abnormal loading.

The following two cards are mounted on the power modules and act as interface between the driver and power modules:

1. Pulse Transformer card with current feedback (193X389AAG01). This card is mounted on the front insulation cover of the converter power module.

The pulse transformer card is a six channel for firing six isolated SCRs with each channel providing voltage isolation between the driver control and the SCR power circuits.

This card also contains the commutation current feedback circuit.

2. Pulse Transformer card (193X390AAG01). This card is mounted on the front insulation cover of each of the Inverter Phase Modules (Qty. 3). This card is a four channel for firing four isolated SCRs with each channel providing voltage isolation between the driver control and SCR power circuits.

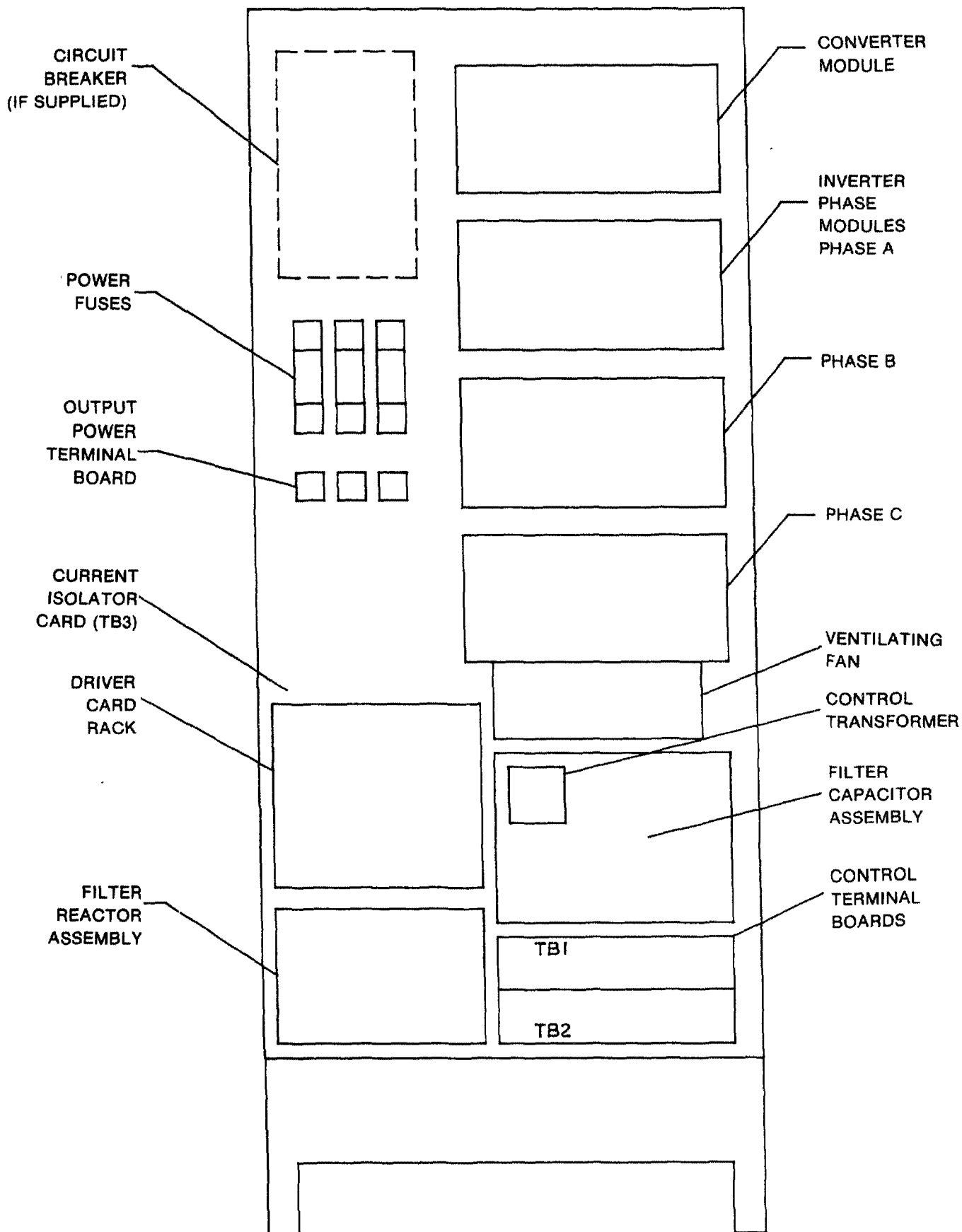


FIG 1. AF-400 DRIVE POWER UNIT

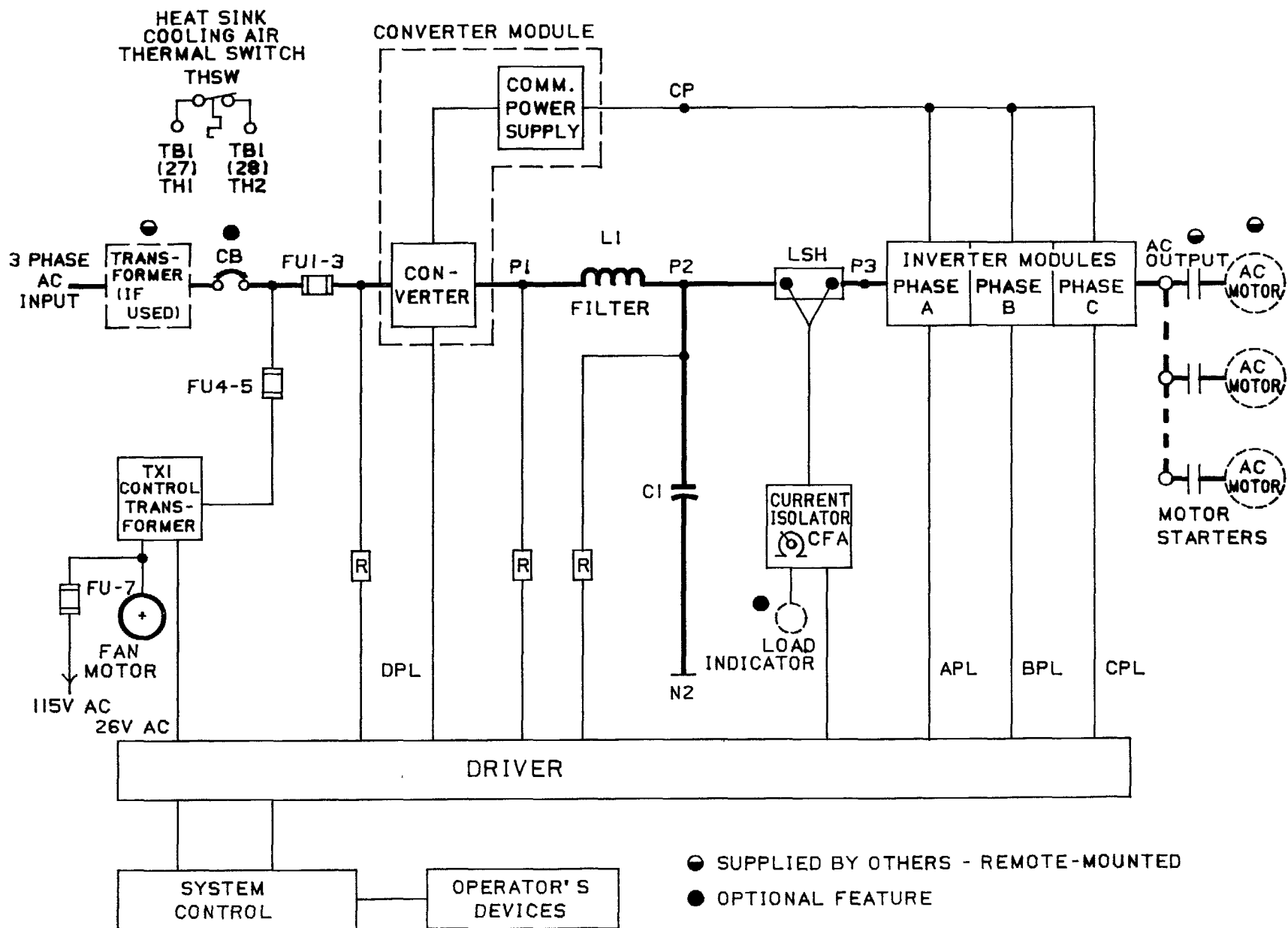
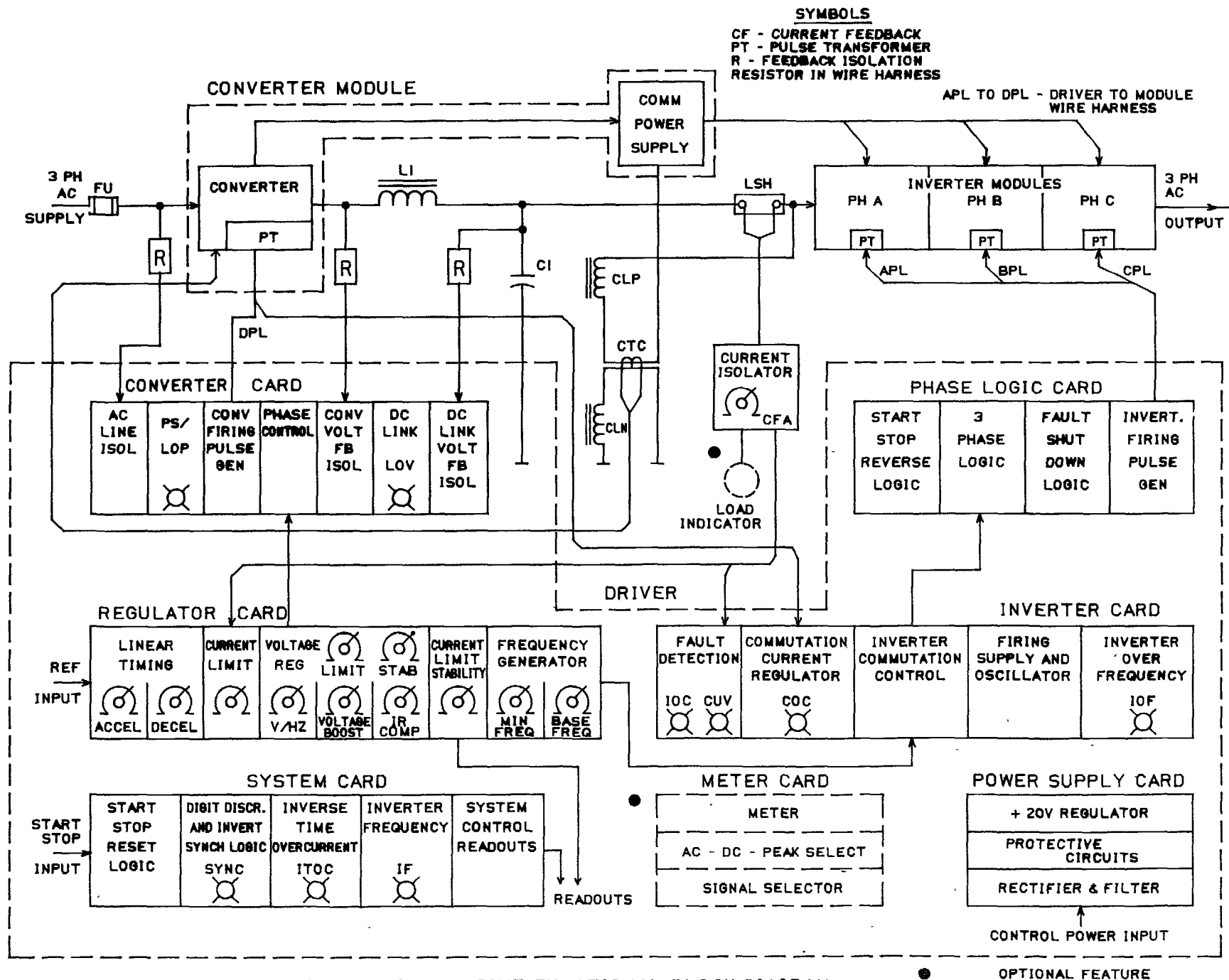


FIG. 2 AF-400 DRIVE SYSTEM BLOCK DIAGRAM



FIG.3 AF400 DRIVE POWER CIRCUIT



START—UP AND CHECK—OUT

Every AF-400 Inverter drive has been factory tested and is ready to operate, provided that the external power and control connections have been properly made and no shipping and installation damage has been sustained. It is recommended that the following step-by-step start-up procedure be followed to ensure proper operation of the equipment.

WARNING

IF DOOR INTERLOCKS (IF SUPPLIED) ARE DEACTIVATED OR BYPASSED, EXTREME CAUTION MUST BE USED. BE SURE TO RETURN INTERLOCKS TO OPERATING CONDITION AFTER START—UP OR TROUBLESHOOTING TO ELIMINATE THE POSSIBILITY OF PERSONAL INJURY OR LOSS OF LIFE RESULTING FROM OPERATION WITHOUT THOSE DEVICES.

TEST EQUIPMENT REQUIRED

The following listed equipment should be available during start-up and check-out. The first two items listed are recommended for normal operation and maintenance.

Meter Card — 193X481AAG01

Volt-Ohmmeter — Digital preferred, 20K per volt min.
input impedance

Clamp-on Ammeter — Adjustable range up to 300 amp.

If the Meter card is not available, an oscilloscope (preferably dual trace) will be required.

TESTING SAFETY PRECAUTIONS

Certain precautions need to be observed in testing this equipment.

All of the control in the driver, with the exception of the 115 volt AC supply to the Option card (when furnished), is at a low voltage level with respect to ground. The control common is connected to the driver case which is connected to an earth grounding system. Any control circuitry on the driver side of the Pulse Transformer cards, is also at the low voltage level.

All power modules, power components, power wiring, and control wiring and components connected to the power must be assumed to be at a high voltage to ground. The following safety precautions must be strictly observed when testing in the power area:

WARNING

ELECTRIC SHOCK CAN CAUSE PERSONAL INJURY OR LOSS OF LIFE. WHETHER THE AC SUPPLY IS GROUNDED OR NOT, HIGH VOLTAGES TO GROUND WILL BE PRESENT AT MANY POINTS THROUGHOUT THE DRIVE. **CHARGED CAPACITORS REQUIRE AT LEAST ONE MINUTE DISCHARGE TIME TO 50 VOLTS OR LESS.**

WHEN TESTING IN THE POWER AREA, TURN THE EQUIPMENT OFF WHEN CONNECTING OR DISCONNECTING THE TEST EQUIPMENT.

WARNING

GREAT CAUTION SHOULD BE OBSERVED WHEN INSTRUMENTS SUCH AS OSCILLOSCOPES ARE USED TO TEST LIVE (ENERGIZED) POWER CIRCUITS. THE INSTRUMENT COMMON LEAD SHOULD NOT BE CONNECTED TO ANY UNGROUNDED POINT IN THE SYSTEM UNLESS THE INSTRUMENT IS ISOLATED FROM GROUND AND ITS METAL PARTS TREATED AS LIVE EQUIPMENT. USE OF AN INSTRUMENT HAVING BOTH LEADS ISOLATED FROM THE CASE PERMITS GROUNDING OF THE INSTRUMENT CASE, EVEN WHEN MEASUREMENTS MUST BE MADE BETWEEN TWO LIVE POINTS IN THE CIRCUIT. FAILURE TO HEED THIS WARNING COULD RESULT IN ELECTRIC SHOCK CAUSING PERSONAL INJURY OR LOSS OF LIFE.

When testing in the control area, remember that these are low voltage circuits (20 volts) and can be damaged by improper test procedures.

CAUTION

DO NOT CONNECT POWER AND CONTROL CIRCUITRY TOGETHER IN ANY TEST HOOKUP. THIS DEFEATS THE PURPOSE OF THE CONTROL ISOLATION FUNCTION AND CAN DAMAGE THE EQUIPMENT.

CAUTION

DO NOT REMOVE OR INSERT PRINTED CIRCUIT CARDS IN THE EQUIPMENT WHILE POWER IS APPLIED. THIS CAN DAMAGE THE EQUIPMENT.

POWER—OFF CONTINUITY TEST

WARNING

VERIFY THAT THE MAIN THREE—PHASE AC POWER INPUT TO THE SYSTEM EQUIPMENT IS DISCONNECTED OR SWITCHED OFF, FAILURE TO DO SO COULD RESULT IN PERSONAL INJURY OR LOSS OF LIFE DUE TO ELECTRIC SHOCK.

Perform a point-to-point continuity test for all newly installed wiring and interconnection. Continuity is defined as 1/2 ohm or less.

DRIVER SELECTIONS

These are two card selections and two driver terminal board selections which should be checked before starting up the drive.

NOTE

IF EITHER THE INVERTER CARD (193X476AAG01) OR THE CONVERTER CARD (193X477AAG01) IS REPLACED, THE NEW CARD SHOULD HAVE THE SAME PRESENCE OR ABSENCE OF ITS JUMPER AS THE CARD BEING REPLACED.

230/460V JUMPER ON INVERTER CARD (193X476AAG01 or equivalent)

This jumper should be positioned for 230V or 460V AC to agree with the drive rating.

OVERFREQUENCY TRIP JUMPER — ON INVERTER CARD

This jumper selects the upper inverter frequency at which the drive will trip and shut down to prevent motor overspeed. The frequency trip levels are selected by placing the jumper in the appropriately marked socket position

- 75 Hz frequency — 75 Hz socket position
- 110 Hz frequency — 110 Hz socket position
- 165 Hz frequency — 165 Hz socket position
- 275 Hz frequency — 275 Hz socket position
- 400 Hz frequency — 400 Hz socket position

Consult your specific drive elementary for diagram proper jumper placement.

CAUTION

INCORRECT JUMPER CONNECTION OR DISCONNECTION WILL RESULT IN MALFUNCTION AND POSSIBLE DAMAGE TO THE INVERTER

60 HZ JUMPER — ON CONVERTER (193X477AAG01 or equivalent)

This jumper should be present on all drives supplied from 60 Hz AC power, and should be removed on all drives supplied from 50 Hz AC power.

REGULATOR BASE FREQUENCY RANGE JUMPER — 75, 150 and 300 HZ ON REGULATOR CARD

This jumper selects the inverter base frequency range. It should be placed in the appropriately marked socket position.

- Base Freq. Range of 37.5 to 75 Hz — 75 Hz socket position
- Base Freq. Range of 75 to 150 Hz — 150 Hz socket position
- Base Freq. Range of 150 to 300 Hz — 300 Hz socket position

Base Frequency is the frequency at which the inverter reaches full voltage and is adjusted by the BF potentiometer (on the Regulator card) within any of the above ranges. Consult your specific drive elementary diagram for proper jumper selection.

CAUTION

IMPROPER JUMPER CONNECTION OR DISCONNECTION MAY RESULT IN DRIVE MALFUNCTION AND DAMAGE.

WARNING

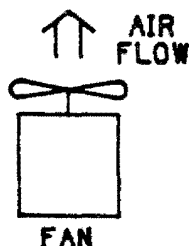
IMPROPER JUMPER PLACEMENT MAY PRESENT AN EQUIPMENT OR PERSONNEL HAZARD RESULTING IN PERSONAL INJURY, LOSS OF LIFE OR EQUIPMENT DAMAGE OR DESTRUCTION DUE TO MOTOR OVERSPEED.

START—UP PROCEDURE

Perform the following step-by-step procedure in the sequence below. If during this procedure a problem is encountered, refer to the Troubleshooting Section of this manual.

1. Before applying AC supply power to the drive, verify that it is the proper voltage, phase and frequency as denoted on the equipment data nameplate.
2. Disconnect the three-phase output cables from the drive terminals T1, T2 and T3, or inactivate the output contactor if one is provided.

3. Disconnect control wire harness APL, BPL, CPL and DPL from their plug receptacles at the converter and phase modules.
4. Using a volt-ohmmeter selected to the X1 ohms scale, check that no short exists between DC link busses P2 and N2. Also, check the three AC supply power fuses and all control power fuses to confirm that they are not blown.
5. Apply AC power to the drive.
6. Check the driver card indicating lights. Only the IF inverter frequency light should be indicating and it should be blinking at a low frequency. If the PS/LOP phase sequence/loss of phase light is indicating. Check that the correct voltage is present on all three AC supply power terminals L1, L2 and L3. If these are correct, the phase sequence is wrong. Disconnect the AC power, interchange any two cables, and repeat steps 5 and 6.
7. Check that the fan is operating properly and producing air flow through the power modules. Refer to the sketch below and to labels on the air distribution chamber for correct operation.



If no rotation occurs, check if 115V AC is present between TB1 (AC3) and TB1 (AC2).

8. Set the driver reference input at zero. Check for zero reference voltage by selecting Meter card switch position 2, or measure the voltage between driver terminal board points TB2(32) to TB2(48).
9. Interrupt AC power to the drive, connect the DPL wire harness plug to the converter module and reapply AC power.
10. Check the driver lights again. Only the IF light should be on, blinking at a low frequency. Run through the Meter card selector switch positions 1 through 17 and compare these readings with the readings shown on the driver label mounted on the inside of the power unit enclosure door. This label is

also included in the instruction book. The readings taken should compare with those given for the "Off Condition".

If a Meter card is not available, use a volt-ohmmeter to check REF TB2(32) to TB2(48), FVR TB2(44) to TB2(48), and the converter output voltage between P2 and N2. The P2 to N2 voltage should not exceed 30 volts DC for 230 volt AC drives or 60 volts DC for 460 volt AC drives, before the inverter is started.

11. Press the drive "Start" pushbutton. Check driver lights and Meter card position 4, or P2 to N2 voltage. They should be the same as for step 10.
12. Increase reference input to the driver slowly until the P1 to N2 voltage reaches half of rated DC link voltage (150 volts DC for 230 volt AC drives and 300 volts DC for 460 volt AC drives). The Meter card positions 2 and 4 should both read 7.5 [7.5 volts between TB2(32) and TB2(34)].

CAUTION

WHEN THE DRIVE HAS NOT BEEN OPERATED FOR 6 MONTHS OR MORE, THE ELECTROLYTIC CAPACITORS IN THE FILTER CAPACITOR ASSEMBLY MUST BE RE-FORMED. FOLLOW THE PROCEDURE IN STEP 13 IF FORMING IS REQUIRED.

13. If capacitor forming is required, increase the P1 to N2 DC link voltage in the following steps, pausing for 5 minutes at each step in the forming process.

Operating Voltage Level		Operating Time
230VAC Drive	460VAC Drive	
200 Volts DC	400 Volts DC	5 Min.
250 Volts DC	500 Volts DC	5 Min.
300 Volts DC	600 Volts DC	5 Min.
(or at maximum reference)		

During each step of the forming process, check the voltage at the Q or midpoint of the seriesed capacitor assembly (460 volt AC drives only). The difference between the P1 to Q and Q to N2 voltage readings should not exceed 5% of the P1 to N2 voltage. For example, at a P1 to N2 voltage of 600 volts, the difference between the P1 to Q and Q to N2 voltages should not exceed 30 volts. If the Q midpoint varies more than 5%, refer to the Troubleshooting Section of this manual. In no case should more than 400 volts DC be applied across a single capacitor.

14. Press the drive "Stop" pushbutton and decrease the driver reference to zero. The DC link voltage between P2 and N2 (Meter position 4) should discharge down to less than 10% of maximum in about 30 seconds.
15. Interrupt AC supply power to the drive, connect the APL, BPL and CPL wire harness plugs to the phase modules and reapply AC power.
16. With reference input to the driver at zero, press the driver "Start" pushbutton and check the driver card lights. Run through the Meter card positions 1 through 17 and compare these readings with those given on the driver label for "0 Ref. 0 Load."

If a Meter card is not available, use an oscilloscope to check the inverter commutation current feedback signals, at the DF connector point of DPL on the converter pulse transformer card. The peak voltage level of the higher commutation pulse in each phase should agree with the values given on the driver label, and the waveshapes should appear as shown in Figure 5. The positive commutation current pulse is normally the higher since the negative pulse is attenuated on the Current Feedback card.

17. Slowly increase the driver reference input up to maximum while checking the inverter commutation current peak level of each phase, by means of an oscilloscope as described in step 16. The commutation current peaks should increase as shown on driver label, but should remain in the ranges shown.

Also, check that the base frequency is correct for your motor drive system and readjust if necessary. See Base Frequency in the Adjustments section for checking and adjustment instructions.

18. Press the drive "Stop" pushbutton and reduce the driver reference to zero. The inverter should decelerate down to about one-fourth of rated frequency and voltage, and then stop.
19. Interrupt the AC power to the drive. Reconnect the three-phase output cables to drive terminals T1, T2 and T3, or reactivate the output contactor, to connect the motor(s) to the inverter.
20. Reapply AC power to the drive. With reference input to the driver at zero, press the drive "Start" pushbutton and slowly bring the reference up to half rated. Run through the Meter card positions 2

through 17 and compare these readings with those given on the driver label for "1/2 Ref. 1/2 Load." If the motor loading is different than one-half of rated, the positions 7 and 9 readings will be different from those given.

If any Meter reading discrepancies exceeding 5% full scale (1.0) from those values given in the drive table are found, proceed to the Adjustments Section. If a Meter card is not available, use a clamp-on ammeter to read the inverter AC output current in each phase to check that they are balanced. Also, check the AC supply input currents to the converter to check that they are balanced.

21. Slowly increase the driver reference up to the maximum of 15 volts. Run through the Meter card positions 2 through 17 and compare these readings with those given on the driver label for "1 Ref., 1 Load." Again, positions 7 and 9 readings will depend on the actual motor load.

CURRENT FEEDBACK CALIBRATION

A potentiometer adjustment (*CFA*) on the current isolator card provides the means to calibrate the link-current feedback signal. This card is located in back of the "pull out" driver card rack. The *CFA* potentiometer is normally adjusted, such that the *LCS* signal reads 1.0 volts *rms* with rated load at base frequency. This would normally occur with 100 millivolts across the shunt *LSH*.

ADJUSTMENTS

Although the drive has been adjusted in factory test, it is recommended that these adjustments be checked to determine if they are correct for your application and power system. The following sequence should be followed in checking and modifying the driver adjustments, all of which are located on the Regulator card. (The *VLM* and *STAB* potentiometers are located at the card top edge rather than the front edge, and is adjusted through the top opening in the driver rack). Before starting, record the factory adjustment positions of each potentiometer. The driver label may be used for this purpose, and for recording any changes in adjustment that may be made.

NOTE

IF THE DRIVER REGULATOR CARD IS REPLACED, SET ALL POTENTIOMETER ARROWS ON THE NEW CARD THE SAME AS ON THE CARD BEING REPLACED. THE FOLLOWING ADJUSTMENT PROCEDURE SHOULD THEN BE FOLLOWED TO CHECK THE ADJUSTMENT OF THE NEW CARD.

VB — VOLTAGE BOOST

This adjustment is dependent on the amount of motor torque required at speeds below about one-fourth of rated, or the amount of breakway torque required. If motor torque requirements below one-fourth rated speed are less than 25% of rated torque, no voltage boost is required and **VB** should be set fully counter-clockwise. For higher motor loading at low speeds, a certain amount of voltage boost is required to prevent the motor from "pulling out" and stalling. The amount of adjustment of the **VB** potentiometer from the CCW end depends on the amount of motor load torque at low speeds and type of motor (larger motors require less voltage boost than smaller motors). Adjust **VB** only enough so that the motor(s) accelerates smoothly from rest.

IRC - IR COMPENSATION

Turning the **IRC** potentiometer clockwise will increase the output voltage proportional to link current feedback, LCS. With the **IRC** pot fully clockwise the voltage increase will be 10% of rated for LCS = 1.0 volts corresponding to rated current.

IR compensation will normally only be required if the starting and low speed running torque exceeds 100% of rated. Again, the amount of **IRC** setting depends on both the amount of torque required and the type motor.

Too much voltage boost or IR compensation will produce excessive motor peak currents which will cause torque pulsations or "cogging". If this occurs at low speeds the **VB** and/or **IRC** setting should be reduced.

V/HZ — VOLTS/HERTZ

Operate the drive at a reference 12 volts at driver TB2(32) to TB2(48) (reading of 12 on Meter card position 2). Adjust the **V/HZ** potentiometer to obtain a DC link voltage between P2 and N2 of 240 volts DC for 230 volt AC drives and 480 volts DC for 460 volts AC drives. This corresponds to 12.5 reading on Meter card position 4.

The above volts/hertz setting should include the effects of the **VB** voltage boost setting. If the **VB** setting is changed, the volts/hertz should be readjusted to maintain proper motor excitation.

VLIM — VOLTAGE LIMIT/CONSTANT HP OPERATION (located at top edge card)

The voltage limit function is not required and may be turned fully CW unless constant horsepower operation is used. In this case the **V/HZ**, **BF** and **VLIM** adjustments can

be made as follows:

1. With **BF** set CCW, **V/HZ** set CCW and **VLIM** set CW apply maximum reference of 15 volts at REF, TB2(32). Adjust **BF** for maximum frequency.
2. Reduce the reference until the inverter operates at base frequency. Adjust **V/HZ** for a DC link voltage of 300 or 600 volts for 230 or 460 volts drive respectively.
3. With **VLIM** set CCW increase the reference back to maximum. Adjust **VLIM** for a DC voltage of 300-310 volts for 230V drives or 600-620 volts for 460V drives.

BF — BASE FREQUENCY

With the driver reference at the rated 15 volts (TB2(32) to TB2(42) or Meter card position 2), adjust the **BF** potentiometer to obtain the desired motor base frequency. This frequency can be read by means of a frequency counter connected between driver TB2(52) (IPAD) and TB2(48) (COM). It can also be read to within $\pm 2\%$ accuracy by connecting a digital voltmeter between TB2(44) (FVR) and TB2(48) (COM). The frequency is obtained by multiplying the voltage reading by 5 for the 75 Hz base frequency range, by 10 for the 150 Hz range and by 20 for the 300 Hz range. A third method of reading frequency, to within $\pm 5\%$ accuracy, is by taking the Meter card position 3 reading and applying the 5, 10 or 20 times multiplier just described.

MINF — MINIMUM FREQUENCY

Normally the **MINF** potentiometer is set at or near the counter-clockwise end for best starting of motors, especially if any breakaway torque is required. If a transformer is used between the power unit and the motor, the minimum frequency will have to be set higher to prevent transformer saturation. A higher minimum frequency can be obtained by turning **MINF** in a clockwise direction.

ATIM & DTIM — ACCELERATION AND DECELERATION TIME

With the driver reference at the rated 15 volts, start the drive from rest and check the acceleration time and the Meter card position 10 reading. If the meter reading goes below 10 during acceleration, the drive is going into current limit, and it is probably desirable to increase the acceleration time by adjusting the **ATIM** potentiometer in the clockwise direction. If a Meter card is not available, the motor current can be read with a clamp-on ammeter to measure the acceleration load.

With the drive operating at rated speed, quickly adjust the driver reference to zero and check the deceleration time and the Meter card position 6 reading. If the meter reading goes above 10 before deceleration is completed, the drive is going into slowdown limit, and it is desirable to increase the deceleration time by adjusting the **DTIM** potentiometer in the clockwise direction.

If shorter acceleration or deceleration times are desired, the **ATIM** or **DTIM** potentiometers should be adjusted in the counter-clockwise direction, and the operation checked as described above. The minimum times obtainable, with the 5 to 50 second adjustment range, are limited by the current limit and slowdown limit control.

CLIM — CURRENT LIMIT

The percentage of rated drive output current at which current limit will occur can be approximated by the setting position of the **CLIM** potentiometer, per the following table:

CLIM Setting	CCW End	1/4 from CCW End	Mid-point	1/4 from CW End	CW End
% Rated Current	50 to 60%	75 to 90%	105 to 120%	130 to 145%	155 to 175%

CLST — CURRENT LIMIT STABILITY

This stability adjustment for current limit operation is dependent on the motor and load inertia, motor HP rating, and on the current limit setting. The correct setting of the **CLST** potentiometer can be determined by using the following table:

Load Inertia	CLST Setting for Motor HP	
	10 to 100 HP	100 to 400 HP
Negligible load inertia	CW end to 1/3 from CW end	1/3 from CW end to midpoint
Load inertia equals motor inertia	Midpoint to 1/3 from CCW end	1/3 from CCW end to 1/4 from CCW end
Load inertia equals 2 x motor inertia	1/4 from CCW end to 1/6 from CCW end	1/6 from CCW end to 1/8 from CCW end
Load inertia equals 5 x motor inertia or greater	1/8 from CCW end to CCW end	CCW end

The setting ranges given in the table cover the current limit (**CLIM**) setting range, such that the **CLST** setting varies toward the clockwise end of its setting range as the **CLIM** setting is adjusted towards its clockwise end, and vice-versa.

If instability occurs during current limit operation, the **CLST** potentiometer should be adjusted toward its counter-clockwise end.

STAB - STABILITY

To prevent an oscillatory interchange of energy between the DC link capacitor and AC motor rotational inertia an error signal obtained by comparing the DC converter reference with the DC link capacitor voltage is used to modulate the inverter frequency.

DIGITAL FOLLOWER OPERATION

Digital Follower Operation is typically set up as the AUTO mode of a MAN/AUTO mode selection. In MAN the drive operates from an analog (potentiometer) reference signal. The set up procedure is made in this mode as described above. In the AUTO mode the drive follows a digital frequency reference (*pulse* train) applied at DPF, TB1(23). To enable the frequency/phase comparator, SYNC, TB2(42) must be connected to common. (The extra contact on the MAN/AUTO switch may be used).

In the digital mode the BF potentiometer should be adjusted for a RFVX, TB2(47) voltage 16.0 volts at maximum frequency.

The regulator timing circuit will override the frequency reference signal. If it is desirable for the drive to follow the digital reference during acceleration and deceleration the regulator accel time must be set faster and the decel time must be set slower than the accel and decel times of the digital reference.

TROUBLESHOOTING

A systematic approach to troubleshooting will reduce the time required to find the problem. This approach consists of trying to localize the problem or cause, in the following step-by-step fashion.

1. Is the problem inside the AF-400 Drive power unit or caused by external conditions or equipment?
2. Which module in the power unit is causing the problem?
3. Which component within the module is at fault or has failed?

The means to accomplish these are through the use of the recommended test equipment and the troubleshooting procedures outlined in this section. The efficiency with which they are used will be dependent on the skill and experience of the test personnel, and how well they understand the drive operation, as explained in the Description Section of this manual.

TEST EQUIPMENT REQUIRED

The following test equipment should be available for troubleshooting, and is listed in the order of recommended preference. The first two items are recommended for normal operation and maintenance.

Meter Card	193X481AAG01
Volt Ohmmeter	Digital preferred — 20K per volt min. input impedance.
Oscilloscope	Dual trace preferred
Clamp-on Ammeter	Adjustable range up to 300 amps

TESTING SAFETY PRECAUTIONS

Certain precautions need to be observed in testing this equipment.

All of the control in the Driver, with the exception of the 115 volt AC supply to the option card (when supplied) is at

a low voltage level with respect to ground. The control common is connected to the driver case which is connected to the power unit enclosure, which should be connected to an earth grounding system. Any control circuitry on the Driver side of the pulse transformers on Pulse Transformer cards, is also at the low voltage level.

All Power modules, power components, power wiring, and control wiring and components connected to the power must be assumed to be at a high voltage to ground. The following safety precautions must be strictly observed when testing in the power area:

WARNING

ELECTRIC SHOCK CAN CAUSE PERSONAL INJURY OR LOSS OF LIFE. WHETHER THE AC SUPPLY IS GROUNDED OR NOT, HIGH VOLTAGES TO GROUND WILL BE PRESENT AT MANY POINTS THROUGHOUT THE DRIVE. CHARGED CAPACITORS REQUIRE AT LEAST ONE MINUTE DISCHARGE TIME TO 50 VOLTS OR LESS.

WHEN TESTING IN THE POWER AREA, TURN THE EQUIPMENT OFF WHEN CONNECTING OR DISCONNECTING THE TEST EQUIPMENT.

WARNING

GREAT CAUTION SHOULD BE OBSERVED WHEN INSTRUMENTS SUCH AS OSCILLOSCOPES ARE USED TO TEST LIVE (ENERGIZED) POWER CIRCUIT. THE INSTRUMENT COMMON LEAD SHOULD NOT BE CONNECTED TO AN UNGROUNDED POINT IN THE SYSTEM UNLESS THE INSTRUMENT IS ISOLATED FROM GROUND AND ITS METAL PARTS TREATED AS LIVE EQUIPMENT. USE OF AN INSTRUMENT HAVING BOTH LEADS ISOLATED FROM THE CASE PERMITS GROUNDING OF THE INSTRUMENT CASE, EVEN WHEN MEASUREMENTS MUST BE MADE BETWEEN TWO LIVE POINTS IN THE CIRCUIT. FAILURE TO HEED THIS WARNING COULD RESULT IN ELECTRIC SHOCK CAUSING PERSONAL INJURY OR LOSS OF LIFE.

When testing in the control area, remember that these are low voltage circuits (20 volts) and can be damaged by improper test procedures.

CAUTION

DO NOT CONNECT POWER AND CONTROL CIRCUITRY TOGETHER IN ANY TEST HOOKUP. THIS DEFEATS THE PURPOSE OF THE CONTROL ISOLATION FUNCTION AND CAN DAMAGE THE EQUIPMENT.

CAUTION

DO NOT REMOVE OR INSERT PRINTED CIRCUIT CARDS IN THE EQUIPMENT WHILE POWER IS APPLIED. THIS CAN DAMAGE THE EQUIPMENT.

FAULT INDICATION

The two basic indications of a drive problem are:

A. Operates Improperly

1. Driver is at fault — refer to Driver Troubleshooting in this section.
2. System Control is at fault — refer to the system elementary diagrams for system logic and control circuits and operating notes.

B. Drive Shuts Down, or Will Not Start

1. Driver card fault lights are indicating — refer to Fault Indicating Lights in this section.
2. Driver is at fault — refer to Driver Troubleshooting in this section.
3. System control is at fault — refer to the system elementary diagram for system logic and control circuits and operating notes.
4. AC supply fuses or circuit breakers have interrupted, or control power fuses have blown — Disconnect AC power from drive and check AC supply fuses. If fuses blown, or if AC breaker tripped, check the converter and inverter modules for faulty SCRs. Refer to Converter Troubleshooting and Inverter Module Troubleshooting in this section. Also, check control fuses, if these check out all right, check for defective filter capacitors (See DC Link Filter Troubleshooting in this Section) or for power cable or bus bar shorts in the AC supply, DC link and AC output. Also, check for grounds in power cables in motor windings.

FAULT INDICATING LIGHTS (on driver cards)

The IF inverter frequency light and the SYNC inverter synchronized light are not fault lights but indicate operating conditions. The IF light should be indicating at all times that the driver is energized, even after a fault. Its blinking frequency indicated the driver operating frequency.

IOF ONLY — This indicates an inverter overfrequency shutdown. Refer to Driver Troubleshooting in this section.

COC and IOC — This indicates a commutation overcurrent trip which produces an inverter fault shutdown. Check for drive overloading at or near full speed operation. Also refer to Driver Troubleshooting in this section.

COC, IOC and ITOC — This indicates a combination commutation overcurrent motor overcurrent shutdown. Check for drive overloading at or near full speed operation. Also refer to Driver Troubleshooting and Commutation Power Supply Troubleshooting in this section.

CUV only — This indicates a control undervoltage condition. Refer to Driver Troubleshooting in this section.

CUV, IOC and PS/LOP — This indicates a combination control and power undervoltage shutdown. Check the AC supply for outage problems.

LOV and IOC — This indicates a DC link overvoltage trip which produces an inverter fault shutdown. Refer to Driver Troubleshooting in this section.

LOV, IOC, COC and/or ITOC — This indicates a combination shutdown which would normally occur due to the effects of the DC link overvoltage. Refer to Driver Troubleshooting in this section.

PS/LOP only — This indicates the presence of, or a shutdown caused by wrong AC supply phase sequence or a loss of one or more AC supply phases. Disconnect the AC power and check the AC supply fuses or circuit breaker, especially if the driver is supplied from another power source. Check that the drive is connected to the AC supply in the correct phase sequence..

ITOC only — This indicates an inverter output overcurrent shutdown, either due to an instantaneous trip for current levels over 175% of rated drive current, or an inverse time trip of from 15 seconds to 1 minute limit setting. Check for motor overloading, excessive volts/hz adjustment, locked rotor, or for motor single phasing. Check that the *CFA* potentiometer is adjusted for $LCS = 1.0$ volt at rated load. Also, check for motor being switched on to the inverter at other than synchronized operation or minimum voltage and frequency. Finally, check for motor cable shorts or grounds. Also refer to Driver Troubleshooting in this section.

ITOC and IOC — This indicates an inverter output overcurrent which is excessive enough to also cause an inverter fault. Check for motor jam-ups, excessive volts/hz adjustment, locked rotor, or for motor single phasing. Also, check for motor being switched on to the inverter at other than synchronized operation or minimum voltage and frequency. Finally, check for shorts or grounds in output cables and motor windings.

DRIVER TROUBLESHOOTING

The driver consists of six or more cards, each of which contains quite a few circuits. To help in understanding and troubleshooting the driver, the functions contained on each card are shown in the Functional Block Diagram of Figure 4. These functions are described in the Description Section of this manual.

The optional Meter Card is a great help in troubleshooting the driver. If a Meter card is available, an oscilloscope is not required except in only the most difficult cases. Normally, the use of the Meter card will allow pinpointing of the problem to a specific card, which can then be replaced, or to a certain power module.

The driver label, mounted on the inside of the enclosure door, gives the normal readings for the Meter card selector switch positions for five operating conditions. This label also is in the drive instruction book. These normal readings are given for the 17 selected signals, plus the inverter and converter firing signals selected by the position 19 back plane selector probe.

The Meter card can be used in several ways. It is useful in checking through the 17 key driver signals when operating at the conditions specified, to determine if any readings are abnormal. When position 19 is selected, the red wire back plane selector probe can be used to check card (receptacle) terminal signals. The troubleshooting notes will specify correct and incorrect readings for special test conditions to determine if various faults exist.

If a Meter card is not available, these same readings can be made using a digital volt-ohmmeter or an oscilloscope.

When using the back plane selector probes, there are a few sensitive card terminals which should be avoided when the drive is operating with a motor, since connection of an instrument may cause changes in the drive output. These sensitive terminals are:

Receptacle F Converter Card	Receptacle H Regulator Card	Receptacle G System Card
term. 16—LVP term. 17—LVN term. 19—CVN term. 20—CVP term. 22—L2S term. 23—L1S term. 24—L3S	term. 7—SSDI term. 11—BFI term. 12—BFD term. 23—SSDO term. 32—RFC	term. 28—RFC

Care should also be used in connecting an instrument to the driver reference REF receptacle H, term. 30, receptacle K, term. 18 since this may produce a small motor speed change.

Other diagnostic points are provided for oscilloscope usage. These are:

LPA — Meter —A square wave logic signal which is in
Pos. 17 phase with the AC supply line phase
A (or phase 1) to neutral voltage.

IPAD — —A square wave logic signal which is in
TB2(52) phase with the inverter output phase
A to neutral voltage. May be used
for a frequency counter reference.

These signals are especially useful for oscilloscope triggering when reading other signals.

CAUTION

IF DURING TROUBLESHOOTING, ONE OF THE FOLLOWING CARDS IS REPLACED, THE NEW CARD SHOULD HAVE THE SAME POTENTIOMETER SETTINGS AND JUMPER CONNECTIONS AS THE OLD CARD.

REGULATOR CARD — TEN POTENTIOMETERS (INCL. VLIM AND BASE FREQUENCY JUMPER 75 HZ, 150 HZ AND 300 HZ)

CONVERTER CARD — 60 HZ JUMPER

INVERTER CARD — 230/460V JUMPER AND OVERFREQUENCY JUMPER (75 Hz, 110 Hz, 165 Hz, 275 Hz & 400 Hz).

A. Drive Operates Improperly

1. Cannot obtain maximum rated frequency and speed.

- a) Check the driver reference REF volts [Meter card pos. 2 or driver receptacle K, terminal 18 to terminal 2 (COM)]. If less than 15 volts check the reference potentiometer (should be 5000 ohms) or check the system control (see system elementary diagrams).
- b) Check the converter voltage reference CVR (Meter card pos. 6 or driver receptacle K, 14 voltage to common). This voltage should decrease at an even rate to approximately 3.5 volts as the driver reference is increased to 15 volts. If this is the case, continue on to part (c). However, if the CVR voltage suddenly decreased to about 1.5 volts, it indicates the converter is saturating. Check the DC link voltage. It should read approximately 15 at Meter card pos. 4 or should read either approximately 310 volts DC or 620 volts DC between power circuit terminals P2 and N2, for 230 volt AC or 460 volt AC drives respectively. If this voltage is significantly less, check the AC supply voltage level and check the converter. See Converter Troubleshooting in this section. If the DC link voltage is approximately 1.35 times the AC supply voltage, the voltage limit **VLIM** potentiometer on the Regulator card is not adjusted properly. Refer to Adjustments section.
- c) Check the inverter frequency voltage FVR [Meter card pos. 3 or driver receptacle K, terminal 17 to terminal 2 (COM)]. The drive output frequency should be 5 times this voltage reading when the 75 Hz base frequency jumper is selected or 10 times when the 150 Hz base frequency jumper is used and 20 times for the 300 Hz base frequency jumper. If the FVR reading agrees with the output frequency and all jumpers are correct, then the **BF** potentiometer on the Regulator card should be adjusted. (Refer to Adjustments section). If the output frequency does not agree with the FVR reading, or if the **BF** adjustment appears faulty, replace the Regulator card and check the operation.

2. Motor will not accelerate from stall or low speed.

- a) Check the driver REF volts (Meter card pos. 2 or driver receptacle K, terminal 18 to terminal 2). If it is less than 2 volts, check the reference

potentiometer or system control (see system elementary diagrams).

- b) Check if the inverter is operating. Meter card pos. 11 (RI), or driver receptacle K, term. 9 voltage to common, should be near 20. If zero, refer to Drive Shuts Down, or Will Not Start.
- c) Check the DMF input at driver TB2, terminal 35. It should be high (near 20 volts to common). If it is near zero volt to common, check the system control connected to this input.
- d) Check if the drive is in current limit. (The drive should shut down with an ITOC fault light after about 45 seconds). Meter card, pos. 10 (CL), or driver receptacle K, term. 10 voltage to common, should be near 20. If less than 10, check the settings of the current limit **CLIM** and voltage boost **VB** potentiometers on the Regulator card. Refer to Adjustments section.

3. Motor operation is rough or unstable.

- a) Check voltage boost potentiometer adjustment. Excessive voltage boost at low speed and light load operation will cause motor "cogging" or a grinding noise. Refer to Adjustments section.
- b) Check IR compensation, **IRC** potentiometer adjustment. Too high a setting may result in rough or unstable operation. Refer to Adjustments section.
- c) If unstable motor operation occurs below one-half rated speed, check that the stability-slowdown circuit is connected. On driver receptacle H, terminal 23 should be connected to terminal board 7. If low frequency instability occurs it may be necessary to turn the stability potentiometer **STAB** clockwise. For constant HP and digital follower operation the **STAB** potentiometer may have to be turned CCW to reduce to stability circuit gain.
- d) If unstable operation occurs when in current limit, stability potentiometer, **CLST** is not adjusted properly. Refer to Adjustments section.
- e) Check for low AC supply voltage to the driver TB1, terminal 3 and 4. This should not be less than 105 volts AC.

- f) Check for uneven motor loading or motor single phasing.
- g) If the problem cannot be found, replace the Regulator card and check operation.

4. Cannot control motor speed.

- a) Check the driver reference REF (meter card pos. 2 or TB2(32) voltage) to see if the problem is in the driver or in the system control. If the problem appears to be in the system control, refer to the system elementary diagrams.
- b) Check the SYNC input at driver TB2(42). It should be about 20 volts to common except when operating in the digital follower mode.
- c) Check the FU4, FU5 and control fuses. Refer to Commutation Power Supply Troubleshooting in this section.
- d) If the problem cannot be found, replace the Regulator card and check operation.

5. Cannot stop motor.

NOTE

IF MOTOR CANNOT BE STOPPED BY THE NORMAL MEANS, INTERRUPT AC POWER TO THE DRIVE.

- a) Check the STOP input at driver TB2(34). It should be low (near zero volts to common) to stop the drive. If it is higher than 3 volts to common, check the system control connected to this input (see system elementary diagrams).
- b) Check the FU4 and FU5 and control fuses. Refer to Commutation Power Supply Troubleshooting in this section.
- c) Check for low DC link Voltage. If the Meter card pos. 4 reads less than 3, or if the DC voltage between power circuit terminals P3 and N2 is less than 70 volts (230 volt AC drive) or 140 volts (460 volt AC drive), and the STOP driver input is low, then the System card is probably defective and should be replaced.
- d) Check for high DC link voltage. If the Meter card pos. 4 reads higher than 4, or if the DC voltage between power circuit terminals P3 and N2 is greater than 75 volts (230 volt AC drive) or 150 volts (460 volt AC drive), and the STOP driver

input is low, the converter is not turning off. Check the converter reference voltage CVR (Meter card pos. 6 or driver receptacle K, term. 14). If this voltage to common is about 10 volts, the problem is either in the Converter card or in the converter power module. Refer to Converter Troubleshooting in this section. If the CVR voltage to common is less than 8, then the problem is either in the Regulator card or the System card. Try replacing each card separately and checking the operation.

6. Cannot obtain rated motor horsepower.

- a) Check the motor nameplate for the rated voltage and frequency for rated horsepower. Check the inverter output voltage and frequency at rated reference. See the driver label for Meter card pos. 2, 3, 4, 7, 8 and 9 readings for the 1 REF, 1 LOAD condition. If these readings and/or the inverter output voltage is too low, refer to Adjustments section for proper base frequency, volts per Hz, and voltage limit settings. Rated power output cannot be obtained at a driver reference voltage, that is much less than 15 volts since this voltage is closely related to the DC link voltage and thus the inverter AC output voltage.
- b) Check the AC power supply voltage. It should not be less than 5% below rated nameplate AC input voltage to the drive.

7. Cannot synchronize inverter with external frequency.

- a) Check that SYNC input at driver TB2(42) is low (near common). If it is not, check the system control (refer to the system elementary diagrams).
- b) If SYNC is low, check IS at Meter card, pos. 12 or receptacle K, term. 8. If IS is high (near +20 volts), use an oscilloscope to determine if the proper frequency signals appear at receptacle C terminals 9 and 10. The oscillator frequency, OP, should be applied to terminal 9 and the external frequency reference should be applied to terminal 10. Also check that RFC is not clamped to common.

- c) If the IS signal is low, check the SYNC light and the SR readout at driver TB2(36). If the light does not indicate and SR remains high, try replacing the System card and the Regulator card separately and check operation after each replacement to determine if either card is defective.

B. Drive Shuts Down, or Will Not Start

1. IOF fault light

- a) Check the frequency trip selection on the Inverter card. Refer to the driver label, or Start-up and Check-out section of this manual, for proper jumper placement.
- b) Check for an overhauling load pumping back into the inverter DC link to increase the voltage and frequency.
- c) If the problem keeps occurring, replace the Inverter card and check operation.

2. COC and IOC (and ITOC) fault lights on.

- a) Check the peak voltage of the three commutation current feedback signals over the whole operating range of the drive. This can be read on Meter card position 9 or with an oscilloscope by probing receptacle K, terminal 11. Refer to the driver label for the normal peak voltage reading. See Figure 5 for wave shape of a normal commutation current pulse. A COC trip should not occur until one of these peaks reaches about 18 volts.
- b) If one of the commutation current peaks is significantly higher than the others, the commutation reactor LC or capacitor CC in one of the phase modules could be defective or have the wrong value. Replace the phase module if LC or CC appears to be defective and check drive operation.
- c) If all current feedback signals are the same, but go too high near rated output, check for motor overloading or for high AC supply voltage.
- d) If excessive commutation currents persist, replace the Inverter card and check operation.

3. CUV (and IOC) fault lights on.

- a) Check the +10 volt (Meter card, pos. 1) and +20 volt TB2(40) control power. A CUV trip will occur at about 18 volts. If the +20 volt measures low, check the 115 volt AC supply to the driver TB1(1) and (2). It should be no lower than 105 volts AC. If the AC supply is all right, check for excessive loading of the Power Supply card, especially from external loads connected to driver TB2(40). If the low +20 volt problem cannot be found, replace the Power Supply card and check operation.
- b) If the +20 volt is all right, check the DFS voltage (Meter card, pos. 13, or receptacle K, term. 7 voltage to common). If it is below 16 volts interrupt AC power to the drive and disconnect driver wire harnesses APL, BPL, CPL and DPL. Check if DFS is being pulled down by either the Converter card or the Phase Logic card by energizing the driver with either one of these cards pulled out. If either of these cards loads DFS down, it should be replaced and the test repeated. If DFS is pulled down with both cards pulled, the Inverter card should be replaced and the operation checked.
- c) If the DFS voltage is above 18 volts, but the CUV light stays on when the fault is reset with the Stop pushbutton (or external fault reset), disconnect the DPL wire harness at the Converter Module. If the CUV light can then be reset, the problem is in the Pulse Transformer card on the Converter Module. Refer to Converter Troubleshooting in this section.
- d) If the DFS voltage is above 18 volts, and the CUV light does not indicate until the inverter is started (to start the motor), disconnect wire harnesses APL, BPL and CPL. If the CUV light does not come on, stop the drive and connect only one of the (APL, BPL or CPL) wire harnesses to the driver and check for the CUV light when a drive start is initiated, with the driver reference set at zero.

CAUTION

NEVER TRY TO START THE INVERTER WITH TWO OF THE THREE (APL, BPL OR CPL) WIRE HARNESSSES CONNECTED WHEN THE MOTOR IS CONNECTED TO THE DRIVE. ALSO, THE DRIVER REFERENCE SHOULD NEVER BE INCREASED FROM ZERO WITH ANY OF THE WIRE HARNESSSES DISCONNECTED,

UNLESS THE DC LINK IS OPENED. (SEE INVERTER MODULE TROUBLESHOOTING).

If the CUV light comes on when any one wire harness is connected, the problem is in the Pulse Transformer card on the Inverter Module related to that wire harness. Refer to Inverter Module Troubleshooting in this section.

4. LOV and IOC (and COC, ITOC) fault lights on.

- a) Check that the slowdown control is connected. On driver receptacle H, terminal 23 should be connected to term. 7.
- b) Check for overhauling load or for excessive AC supply voltage.
- c) Check that the link voltage feedback and the converter voltage feedback at driver receptacle F, terminals 15 and 21 are at the same voltage to common. If their voltage levels are different, either the Converter card is defective or the resistance isolated feedback signals through RF4-7 are incorrect. Check the FU4 and FU5 voltage feedback fuses on the commutation power supply. Replace the Converter card and check the operation.

5. ITOC (and IOC) fault lights are on.

- a) Check the Converter DC Link (LCS) feedback signals, over the whole operating range of the drive. This can be read on Meter card position 7, or with an oscilloscope by probing TB3(LCS). The normal feedback signal voltage should be adjusted for 1 volt rms with rated load. See Figure 6 for the wave shape of normal motor current. An instantaneous ITOC trip should not occur until the peak of the current feedback reaches about 5 volts as seen on the oscilloscope.
- b) If the current feedback signal is significantly more than 1.0 volt, RMS, adjust the *CFA* potentiometer on the Current Isolator card until the DC Link (LCS) output current feedback signal equals 1.0 volt for 100% reference and 100% load. Replace the card if it appears to be defective and check driver operation.
- c) Check the current limit *CLIM* potentiometer setting on the Regulator card to see if it is too low for the motor loading. If shutdown occurs because the motor cannot get started, check the voltage boost *VB* setting. Refer to Adjustments section.

- d) If a transformer is used between the power unit and the motor, check the settings of the *MINF* and *VB* potentiometers. Increase the minimum frequency by turning *MINF* clockwise and decrease the voltage boost by turning *VB* counter-clockwise, until the drive can be started and stopped satisfactorily.

6. Cannot reset fault lights.

- a) Check that fault is not a maintained fault that has not been cleared.
- b) Check that the STOP input at driver TB2(34) is low (near common) and that XFR input at driver TB2(43) is high (near +20 volt). If they are not, check the system control (refer to the system elementary diagrams).
- c) Check that the RUNR readout at driver TB2(31) is high and the MVFR readout at driver TB2(38) is low. If they are not, check the DC link voltage. Meter card, position 4 should read 1.5 or less, and the P3 to N2 voltage should read no higher than 30 volts DC (230 volt AC drives) or 60 volts DC (460 volt AC drives). If inconsistent or higher voltages are read, refer to part 7c.
- d) If the above four logic signals are correct, try replacing the System card and checking operation.

7. Drive shuts down (no fault lights on), or drive will not start (no fault lights on).

- a) Check that the STOP input at driver TB2(34) is high (near +20 volt) and the START input at TB2(33) is low (near common). If they are not, check the system control (refer to the system elementary diagrams).
- b) Check that the RUNR readout at driver TB2(31) and the MVFR readout at TB2(38) are both low. If they are not, check that the FTR fault readout at driver TB2(37) is low. Also, check the DC link voltage. Meter card position 4 should read 1.5 or less, and the P3 to N2 voltage should read no higher than 30 volts DC (230 volt AC drives) or 60 volts DC (460 volt AC drives).
- c) If inconsistent or higher DC link voltages are present when the drive is at standby, check the converter reference voltage CVR (Meter card, position 6 or driver receptacle K, term. 14). If this voltage to common is about 10 volts, the

problem is either in the Converter card or in the Converter Power Module. Refer to Converter Troubleshooting in this section. If the CVR voltage to common is less than 8, then the problem is either in the Regulator card or in the System card. Try replacing each card separately and checking the operation.

8. IF light not indicating or on continuously at standby.

- a) Check the +10 volt (Meter card, position 1) and the 115 VAC between TB1(3) to TB1(4) control voltages. If they are zero, but 115 volt AC appears between driver Terminal 1 and Terminal 2, check the fuse FU7 on the Power Supply card. If no voltage is present between Terminal 1 and Terminal 2, check the control power transformer and its fuse (see system elementary diagram).
- b) If +20 volt control power is all right, check the IPAD signal at driver TB2(51) with an oscilloscope. If a square wave frequency is present, replace the System card and check the operation. If no frequency appears at IPAD, check the OP signal at driver connector K, terminal 19. If there is no pulse frequency signal at OP (consists of 35 usec wide, low going pulses), replace the Regulator card and check operation. If frequency pulses appear at OP, replace the Phase Logic card and check operation. If no frequency pulses appear at IBL, replace the Inverter card and check operation.

9. SCR firing signals not reaching power modules.

- a) Check that there are no fault lights indicating and that the FTR fault readout at driver TB2(37) is low. If a fault has occurred, it will lock out all firing signals. Clear the fault and reset the fault circuits to enable the firing signals.
- b) Converter firing signals should be present at drive standby. Check for firing signals at driver receptacle F, terminals 26 through 31. Use the red wire back plane selector probe with the Meter card, position 19 and compare with readings on the driver label, Figure 7.
- c) If any firing signals are present at the driver but missing at the converter modules, check the plug connections at both ends of wire harness DPL for loose pins or bad connections, and check the wire harness for broken wires. If any firing signals are missing or faulty at the driver, replace the Converter card and check the operation.
- d) Inverter firing signals will not be generated until the drive is started. Check that Meter card, position 11 reads high or that driver TB2(31) RUNR reads low. Check for firing signals at driver receptacle D terminals 5 through 19. Use the red wire back plane selector probe with the Meter card, position 19 and compare with the readings on the driver label, and compare with the wave shapes of Figure 8.
- e) If any firing signals are present at the driver but missing at the inverter modules, check the plug connections at both ends of the appropriate wire harness APL, BPL or CPL (refer to driver elementary diagram). Check the plugs for loose pins or bad connections and check the wire harness for broken wires. If any firing signals are missing or faulty at the driver, replace the Phase Logic card and check the operation.

COMMUTATION POWER SUPPLY TROUBLESHOOTING

The commutation power supply components are contained in the Converter Module and consist of the Commutation Power Supply card, CPS, the filter capacitor, C2, the commutation leg reactors, CLP and CLN, the DC link decoupling rectifier, DC, and the commutation current transformer, CTC.

To help in troubleshooting, refer to the elementary diagram. Wait 3 minutes after disconnecting power and verify that capacitors are discharged by checking the voltage between terminal CP and N1 before removing the Converter Module from its rack.

1. CPS Card

Remove and inspect the card for damaged components and etching runs or loose connections. Verify proper resistor values per elementary diagram, Table I. The power supply diodes may be checked with a VOM on the X1K resistance scale. Good diodes will have a low forward resistance and almost infinite reverse resistance. If any components appear to be defective, replace the card.

2. Filter Capacitor, C2

The capacitor may be checked with a VOM on the highest resistance scale to determine if it charges up. Also, verify that the discharge resistor, R2, mounted on the capacitor terminals is undamaged and has the correct value.

3. Reactors CLP and CLN

The reactors should indicate a very low resistance when checked with a VOM. During operation the reactors will run hot and will typically show some discoloration. However, there should not be any charring or cracking of the insulation tape wrapped around the coils.

4. Rectifier, DC

This rectifier is mounted on a heatsink in back of the module. With a VOM on the X1K resistance scale the rectifier should have a low forward resistance and essentially infinite reverse resistance.

5. Current Transformer — CTC

Disconnect the CT1 or CT2 connection at the pulse transformer card and with a VOM check that the winding resistance measures between 15 and 25 ohms. Check that arrow marked on the outside of the transformer points from the CLP reactor towards the CP terminal.

Inspect the transformer for any mechanical damage and make sure it is not in direct contact with the reactors or any terminals.

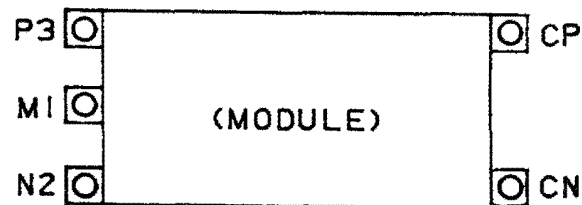
INVERTER MODULE TROUBLESHOOTING

Each of the three identical inverter modules contains the power circuitry for one phase of the three-phase inverter. To help in troubleshooting these modules, refer to the Inverter Phase Module elementary diagram and to the simplified overall power circuit of Figure 3. Since practically all of the circuitry on these modules is at AC supply potential, troubleshooting should be done with the AC power off where possible. Wait 3 minutes after disconnecting power before doing any checking, to allow capacitors to discharge.

1. Checking SCRs, Diodes and Snubbers

The inverter phase module SCRs and diodes can be checked with the power off, and the module disconnected. The measure points for the phase modules are as follows:

10 TO 60 KVA



P3 to M1 Checks positive inverter SCR and diodes.

N2 to M1 Checks negative inverter SCR and diodes.

CP to MC Checks positive commutation SCR.

CN to MC Checks negative commutation SCR.

Using a volt-ohmmeter selected to read ohms on the X1K ohms scale, the normal readings indicating good devices are as follows, with the positive meter lead connected to the first point.

P3 to M1 High resistance

M1 to P3 Low resistance

M1 to N2 High resistance

N2 to M1 Low resistance

CN to MC, MC to CN High resistance

CP to MC, MC to CP High resistance

If any of the above readings are zero, refer to the Maintenance and Repair section for removal, disassembly and replacement information. The individual SCRs and diodes should be rechecked when they are disconnected from each other to ensure that a short in one device does not produce a faulty reading across another device. See the checking SCR portion of this section.

Whenever a phase module has been removed for replacement of SCRs or diodes, the RC snubber circuits around the SCRs, commutating capacitors and choke, leg chokes and wiring should be inspected and checked out for damage.

2. Checking Commutation Capacitor CCA,CCB and CCC.

These capacitors may be checked by connecting the volt-ohmmeter, selected to X 1K scale, between M1 and MC for each phase module. A good capacitor will read above 100K resistance (after a brief charging period) whereas a bad capacitor will give a low or zero reading. The capacitors should be checked again after the phase module has been removed and the capacitors have been disconnected from the other power circuitry. Refer to Maintenance and Repair section.

3. Inverter Module Operational Test

If checking all phase module SCRs, diodes and commutation capacitors according to the preceding instructions does not indicate any failed devices, but inverter fault shutdowns still occur, the following procedure should be used to locate the problem.

Interrupt the DC link between N1 and N2 to prevent power flow from the converter into any inverter fault condition. This is easiest to accomplish on 10 through 60 KVA drives by disconnecting the N1 to N2 jumper wire at N1.

With the DC link disconnected between N1 and N2, the drive can be started and the inverter operated up to full reference. With the motor disconnected from the inverter, the P3 to N2 link voltage will build up somewhat as the reference is increased. With the motor connected to the inverter, the DC link will stay close to zero. The maximum inverter frequency that can be obtained at full reference will be limited to less than half of rated by the below normal DC link voltage. Except for these differences from normal, the inverter can be operated to check out the inverter SCR firing and commutation operation without danger of further damaging the equipment if a fault problem is present. In addition by disconnecting the plugs of two of the three wire harnesses APL, BPL or CPL, just one phase module can be operated at a time to simplify checking and to help in pin-pointing the problem.

The inverter phase commutations can be checked in the driver by checking the commutation current feedback signal (CF). The peak value of commutation current can be read on the Meter card. (See the driver label on the inside of the power unit door for normal readings). The commutation

current can also be read with an oscilloscope connected driver TB39 (SEL1) and TB34 (COM), and using the black wire, back plane selector probe to receptacle K terminals. See Figure 5 for normal commutation current wave shapes.

4. Checking Pulse Transformer Cards

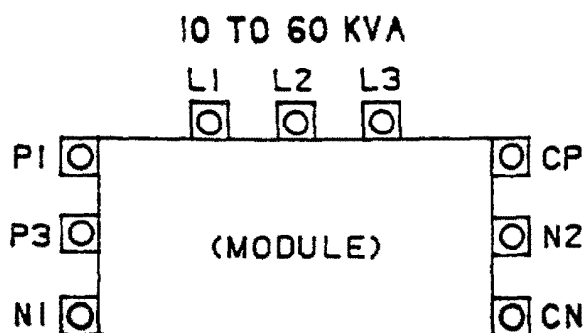
The Pulse Transformer card on the front of the phase module may be checked with an oscilloscope to see if SCR firing signals from the driver are being applied to the pulse transformers. Connect the ground lead of the oscilloscope to the card COM terminal, and connect the probe lead to the top (cooling) tab of one of the red power transistors. A normal pulse wave shape is shown in Figure 9. Change the oscilloscope probe lead to the top tab of the other red power transistors to check this four channel card. If normal pulses are observed when that inverter phase is operating, the card is probably good. If no pulses are observed, connect the oscilloscope probe to 1P, 2P, 1N and 2N input terminals to check for driver firing signals. See Figure 8 for normal firing signals. Also, Check for +20 volt firing power at the 20V input terminal. If input firing power and firing pulses are present, then the card is probably defective. Replace the card and check operation. If no input power or firing pulses are present, refer to part 9 of Drive Shuts Down or Will Not Start in the Driver Troubleshooting portion of this section.

CONVERTER MODULE TROUBLESHOOTING

To help in troubleshooting this module, refer to the Converter Module elementary diagram and to the simplified overall power circuit of Figure 3. Since practically all of the circuitry on this module is at AC supply potential, troubleshooting should be done with the AC power off where possible. Wait 1 minute after disconnecting AC power before doing any checking to allow capacitors to discharge.

1. Checking SCRs and Snubbers

The converter SCRs can be checked with the power off, without disconnecting anything. The measurement points for the module are as follows:



- | | |
|----------|------------------------------------|
| L1 to P1 | Checks positive phase 1 SCR, (1SP) |
| L1 to N1 | Checks negative phase 1 SCR, (1SN) |
| L2 to P1 | Checks positive phase 2 SCR, (2SP) |
| L2 to N1 | Checks negative phase 2 SCR, (2SN) |
| L3 to P1 | Checks positive phase 3 SCR, (3SP) |
| L3 to N1 | Checks negative phase 3 SCR, (3SN) |

Using a volt-ohmmeter selected to read ohms on the X 1K scale, check across all six SCRs in both directions. Good SCRs should read over 100K in both forward and reverse directions, while failed SCRs will read zero ohms in one or both directions.

If any SCRs appear to be failed, the converter module should be disconnected from the rest of the power circuitry at terminal points L1, L2, L3, P1 and N1. (The module may have to be pulled partly out to accomplish this). Recheck the above readings at the disconnected converter module terminals. If the readings still indicate a bad device, refer to the Maintenance and Repair section for removal, disassembly and replacement information. The individual SCRs should be rechecked when they are disconnected from the converter circuit to ensure that a short in one device does not produce a faulty reading across another device. See the Checking SCRs portion of this section.

Whenever the converter module has been removed for replacement of SCRs, the RC snubber circuit around the SCRs AC line chokes and wiring should be inspected for damage.

2. Converter Module Operational Test

If the converter misoperation is suspected, but all converter SCRs appear to be good, the following procedure should be used to perform an operational test.

Interrupt the DC link between N1 and N2 to prevent any power flow from the converter from reaching the filter capacitor or inverter. This is easiest to accomplish by disconnecting both the cable and

control wire from one side of the L1 reactor, connecting the cable and wire together, and taping the connection.

With the DC link disconnected between N1 and N2, the drive can be started and the converter operated up to full voltage. The inverter will operate also, but at a low voltage and reduced frequency, with or without the motor connected.

The converter operation may be checked by means of the driver Meter card selected to position 5. The reading should change from 10 at zero reference to 5.5 at full reference. The converter output voltage may also be checked by connecting a volt-ohmmeter across the P1 to N1 terminals. The DC output voltage should be controllable from near zero to approximately 300 volts DC (230 volts AC input drives) or 600 volts DC (460 volt AC input drives).

If full output voltage cannot be obtained, it is possible that one or more converter SCRs are not firing, or that the driver is not putting out the proper signals. Refer to part 1, of Drive Operates Improperly and Part 9 of Drive Shuts Down, or Will Not Start under Driver Troubleshooting. If the driver is putting out the proper firing signals, check the converter Pulse Transformer cards. If these check out good, an open SCR or open gate SCR should be suspected. Refer to Checking SCRs to test for this problem.

3. Checking Pulse Transformer Cards

The Pulse Transformer Cards on the front of the converter module may be checked with an oscilloscope to see if SCR firing signals from the driver are being applied to the pulse transformer. Connect the ground lead of the oscilloscope to the card COM terminal, and connect the probe lead to the top (cooling) tab of one of the red power transistors. A normal pulse wave is shown in Figure 9. Change the oscilloscope probe lead to the top tab of the other red power transistor to check the other circuits of this card. If normal pulses are observed when the converter is operating, the card is probably good. If no pulses are observed, connect the oscilloscope probe to 1P, 2P, 1N, 2N input terminals to check for driver firing signals. See Figure 7 for normal firing signals. Also, check for +20 volt firing power at the 20V input terminal. If input firing power and firing pulses are present, then the card is probably defective. Replace the card and check operation. If not input power or firing

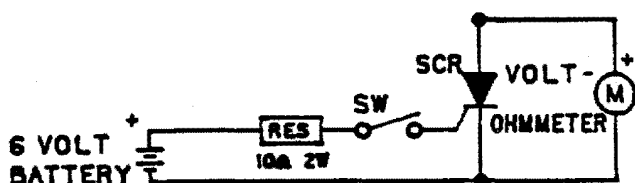
pulses are present, refer to Part 9 of Drive Shuts Down, or Will not Start in the Driver Troubleshooting portion of this section.

CHECKING SCRS

Disconnect the suspected SCR as much as possible from the remainder of the power circuitry. Using a volt-ohmmeter selected to read ohms on the X1K scale, check the forward and reverse resistance of each individual SCR cell (See the Module Elementary diagram). Good or faulty SCRs will give the following typical readings:

SCR Description	Forward Reading	Reverse Reading
Good SCR	100K to Infinity	100K to Infinity
Shorted SCR	Zero	Zero
Inoperative SCR	1 to 2 K	100K to Infinity
Open SCR	100K to Infinity	100K to Infinity

Since an open SCR will give about the same resistance reading as a good SCR, another method must be used to find this type of fault. It should be pointed out, however, that practically all cells fail by shorting a very few by opening. If an open SCR is suspected, or if it is desired to check the switching operation of an SCR, the following circuit should be used:



The volt-ohmmeter is selected to read ohms on the 1K scale, and is connected to read the forward resistance of the SCR. When switch SW is closed, the forward resistance of a good SCR will change from a high value (100K to infinity) to a low value (1 to 10K). When the switch is opened, a good SCR will revert to its high forward resistance or blocking state if the holding current source (volt-ohmmeter battery) is momentarily removed. A faulty SCR will not switch, remaining in either an open or a conducting state.

If any SCRs are suspected of being faulty from the above resistance checks, the SCR conversion module should be removed from the case. After the SCR (cathode) and gate leads have been disconnected, recheck the forward and reverse resistances before replacing the SCR.

This should be done before the SCR is definitely classified as damaged or faulty, since a fault in another SCR or another part of the circuitry can produce a faulty reading from a good SCR before it is disconnected from the circuit. After a Press-Pak SCR is removed from the heatsink it may read open due to lack of pressure against the internal cell structure. Apply pressure to obtain a true reading.

DC LINK FILTER TROUBLESHOOTING

The DC link filter consists of the L1 filter choke and the C1 filter capacitor assembly.

I. C1 Filter Capacitor Assembly

This consists of one assembly of paralleled (230 volt AC drives) or series—paralleled (460 volt AC drives) electrolytic capacitors. When the drive has not been operated for 6 months or more, these capacitors start to degrade and their leakage current increases. A procedure called forming is required to return the electrolytic capacitors to their rated operating capability. Refer to step 13 of the Start-up Procedure in the Start-up and Check-out section for the proper forming procedure.

Electrolytic capacitors can fail by shorting, can exhibit excessive leakage current, or can dry up and lose their capacitance. The latter usually results from a ruptured vent plug due to "gassing" from excessive current and/or temperature.

The filter capacitor assembly can be checked for shorted capacitors using a volt-ohmmeter after the power has been off for more than 1 minute and the N1 to P2 voltage is less than 10 volts. On 460 volt AC drives with seriesed capacitors, the assembly can be checked for excessive leakage capacitors by checking the midpoint or Q point voltage when the drive is operating. Using a volt-ohmmeter, check the difference between the P2 to Q and the Q to N2 voltages at maximum DC link voltage. This difference should not exceed 5% of the P2 to N2 voltage. If the above tests indicate either a shorted or leaking capacitor, the filter assembly should be removed and disassembled to the point where the resistance of each capacitor can be individually checked. Refer to the Maintenance and Repair section for instructions. Any shorted or leaky capacitors should be replaced. The remaining capacitors should be inspected for ruptured vent plugs according to the following instructions.

The best way of evaluating the condition of the electrolytic capacitors is to visually inspect their vent plugs. These are 3/16" diameter red plugs in the top cover of the capacitor case. Internal gas pressure can cause a bubble to form in this plug and red color will lighten until it is almost white. Eventually, the plug will rupture. However, this does not cause an immediate capacitor failure, but will result in a gradual loss of capacitance. Any electrolytic capacitors which are found to have ruptured plugs should be replaced as soon as conveniently possible. If any capacitor vent plug contains a bubble larger than 1/16" in diameter, the capacitor assembly should be inspected at the next scheduled shutdown planned maintenance for ruptured vent plugs.

If more than 25% of the capacitors have broken vent plugs, and the drive has been operated over 20,000 hours, consideration should be given to replacing all of the capacitors in the filter assembly. Refer to the Maintenance and Repair section for instructions.

2. L1 Filter Choke

This choke should be visually checked for signs of overheating, damaged insulation or loose connections.

MISCELLANEOUS TROUBLESHOOTING CHECKS

The following check list of miscellaneous items is included to provide additional directions of investigation in troubleshooting this drive.

A. Cooling and Temperature Problems

1. Check for sufficient air flow through power unit.
2. Check if fan rotation is correct.
3. Check if air filters are clean (if provided).
4. Check if intake air is below 40°C.
5. Check for adjacent heat sources.
6. Check for recirculation of discharge air.
7. Check if room ventilation is adequate to remove the heat being produced.

B. Input Power

1. Check for correct voltage (within +10%, -5% of nameplate rating) and frequency.
2. Check for balanced phase voltages.
3. Check for transient over or under voltages.
4. Have transient voltages occurred due to lightening or ground faults?
5. Check for excessive line regulation due to a high impedance (soft) AC supply.
6. Is AC supply grounded or ungrounded?
7. Is the available short circuit current too high?
8. Are there power factor correction capacitors causing harmonics, or their switching causing voltage transients.

C. System Grounds

1. Check that the power unit case is properly grounded.
2. Check for grounds in motor windings or in power cables to the motor.
3. Check for grounds in control wiring.

D. Loose or Shorted Connections

1. Check incoming power connections.
2. Check connections to power modules, filter capacitor and choke, circuit breaker or fuses, etc.
3. Check outgoing power connections to starters, motors, etc.
4. Check incoming control wiring connections.
5. Check connections to Pulse Transformer cards.
6. Check for bent terminals shorting to one another on driver back plane.

E. Electrical Noise

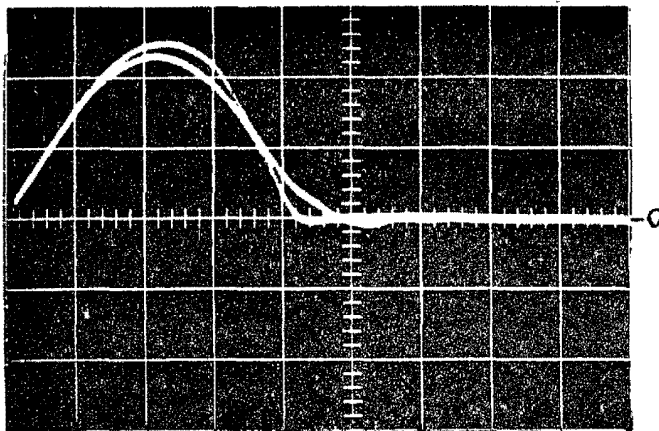
1. Check that all power unit relays have RC suppression on their coils.
2. External relays, solenoids, brakes, etc. interfacing with the power unit should also be suppressed.
3. Check for other external sources of electrical noise.

F. Output Load

1. Check starting torque requirements.
2. Check for transformer saturation at low frequencies if output transformer is used.
3. Check for motor overloads or jam-ups.
4. Check operation of motor transfer switching.

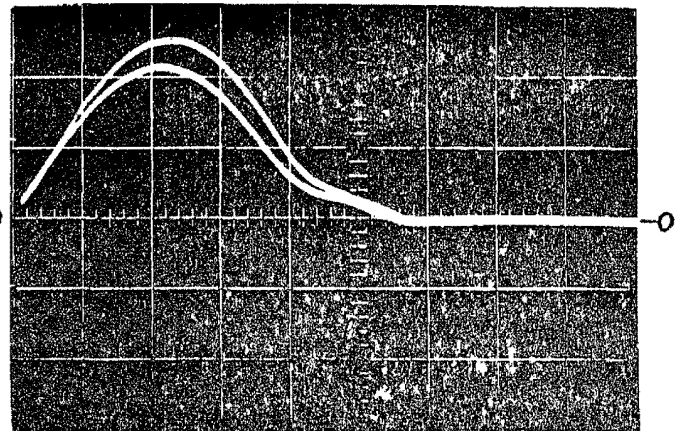
INVERTER COMMUTATION CURRENT WAVE SHAPE

At 1/2 rated voltage & frequency



10 $\mu\text{sec.}/\text{div.}$ (230V AC Drives)
20 $\mu\text{sec.}/\text{div.}$ (460V AC Drives)

At rated voltage & frequency

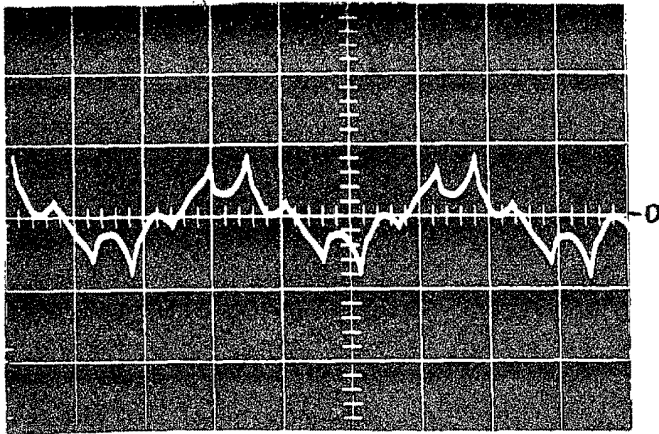


5 Volts Division

FIGURE 5

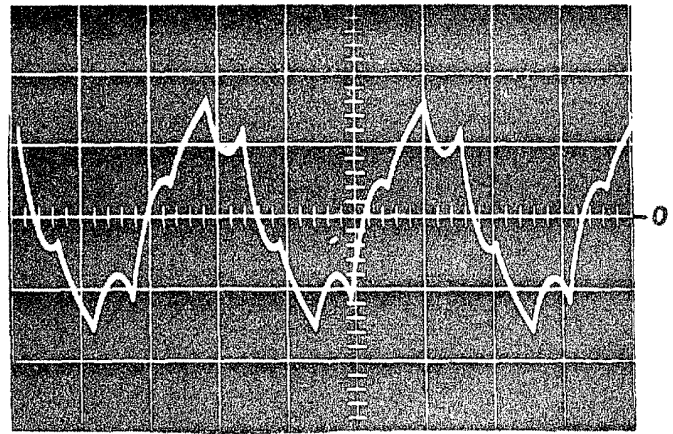
MOTOR CURRENT WAVE SHAPE

At half speed and low load



10 msec./div.
1 volt/div.

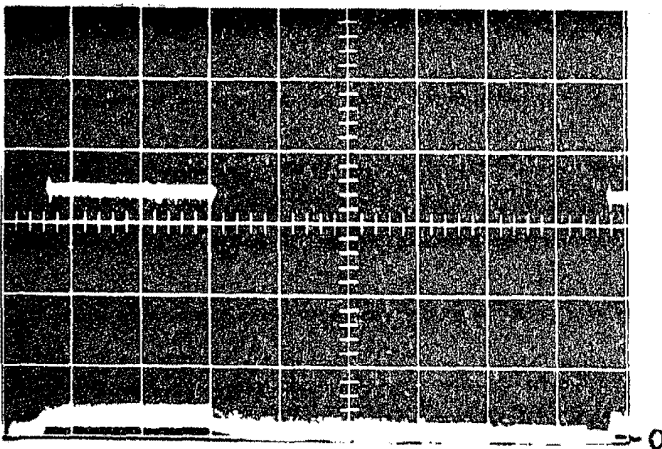
At full speed and full load



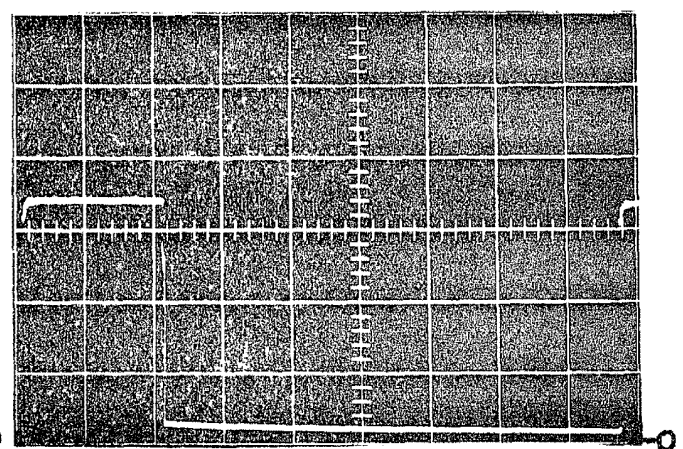
5 msec./div.
1 volt/div.

FIGURE 6

CONVERTER FIRING SIGNALS



2 msec./ division
5 volts/division

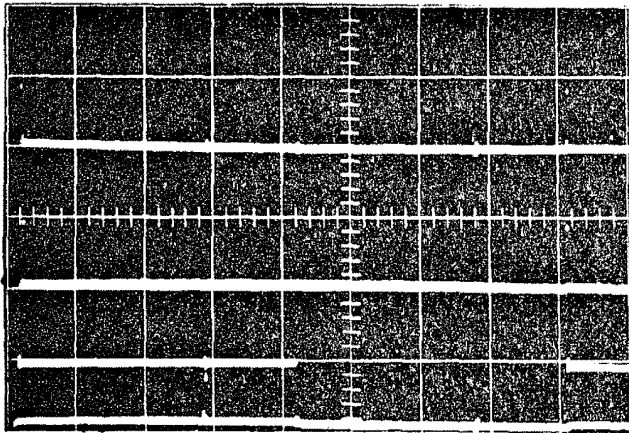


5 μ sec./division
5 volts/division

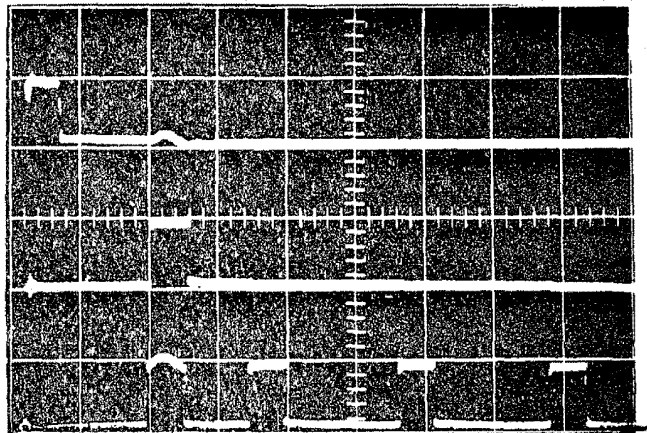
FIGURE 7

INVERTER FIRING SIGNALS

Top trace — A, B, CCP — Positive commutation SCR firing signal
 Middle trace — A, B, CA — Commutation power supply SCR firing signal
 Bottom trace — A, B, CIN — Negative inverter SCR firing signal



2 msec./division
 20 volts/division

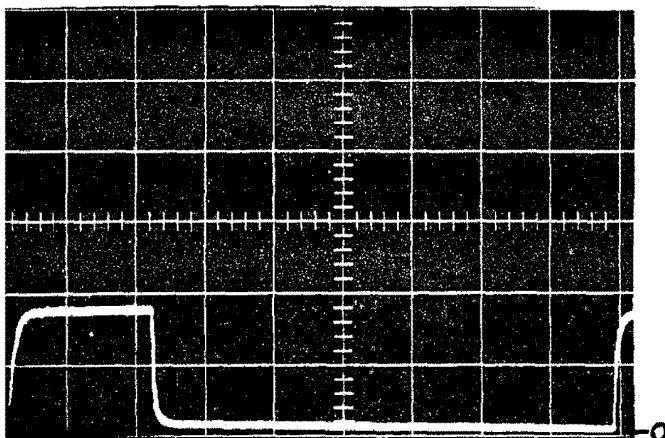


20 μsec./division
 20 volts/division

FIGURE 8

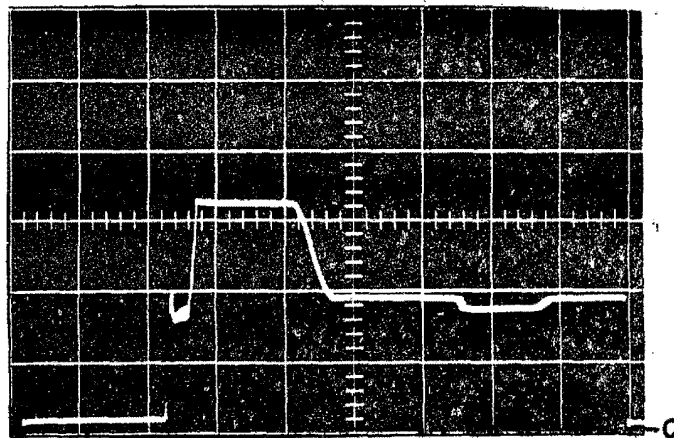
PULSE TRANSFORMER CARD PULSE WAVE SHAPE

At FS1 or FS2 card input



5 μsec./division
 10 volts/division

At power transistor tab



5 μsec./division
 10 volts/division

FIGURE 9

REMOVAL/REPAIR AND REPLACEMENT

WARNING

ELECTRIC SHOCK CAN CAUSE PERSONAL INJURY OR LOSS OF LIFE. WHEN POWER OFF MAINTENANCE IS BEING PERFORMED, VERIFY ALL POWER TO THE DRIVE IS SWITCHED OFF OR DISCONNECTED. RECOMMEND POWER SWITCHES BE RED-TAGGED DURING POWER OFF MAINTENANCE.

MECHANICAL INSPECTION

The mechanical maintenance required for the drive system is divided into two basic units; the power unit and motor. The power units only mechanical maintenance is checking that the unit is free of dirt and dust.

Motor maintenance is covered by the motor instruction book supplied with the motor and should be followed in all cases.

ELECTRICAL INSPECTION

Power off (every six months): Check all electrical connections for tightness. Look for signs of poor connections or overheating (arcing or discoloration). Manually check cooling fan for easy rotation.

POWER MODULE REPAIR

The removal, repair and/or replacement instructions vary depending on the type of power module and its KVA rating. Refer to the instructions which follow under the specific heading and rating which applies to your drive.

If minimized down-time is a critical factor, it is recommended that a complete converter module and a complete inverter phase module of your drive rating be stocked as spare.

CONVERTER MODULE REPLACEMENT

The converter module is best removed as follows:

1. Tools required:

Ratchet — 3/8"
Socket — 7/16" for 3/8" ratchet
Nut Driver — 7/16" with 6" shaft

2. Disconnect the three-phase AC input power.

3. Check voltage across capacitor C1 (P2 to N2) with a DC voltmeter. The capacitor discharge resistor (R1) should have reduced this voltage to 10 volts or less before work starts on the case.
4. Disconnect firing ribbon cable connector DPL.
5. Remove the nine (9) nuts and washers from the power connections:

L1, L2 and L3 across the top of the module.
P1, P3 and N1 to the left of the module.
CP, N2 and CN to the right of the module.
6. Carefully pull module out of the rack using the red plastic insulation cover in front of the module. (See Figure 10).

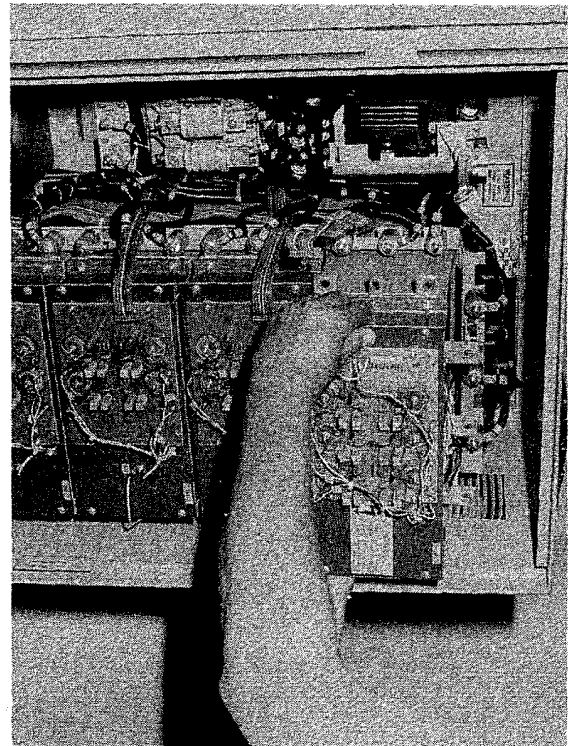


FIGURE 10
AF-400 Drive Converter Module
being removed. Press-Pak SCRs
40-60KVA, 230 or 460V AC

7. To replace cell see Press-Pak Cell replacement-Converter Module, or Stud Mounted Cell replacement-Converter Module.
8. To install the repaired or spare converter module, lift the converter module onto the top rack. Slide the assembly into the rack. Use the red plastic insulation cover in front of the module.
9. Reconnect the power terminals L1, L2, L3, P1, P3, N1, CP, N2 and CN. Reconnect the firing ribbon cable connector DPL.
10. Check to see that all electrical connections are tight before re-applying power.

INVERTER PHASE MODULE REPLACEMENT

The Inverter Phase Module is best removed as follows:

1. Tools required:

Ratchet — 3/8"
 Socket — 7/16" for 3/8" ratchet
 Nut Driver — 7/16" with 6" shaft

2. Disconnect the three-phase input power.

3. Check voltage across capacitor C1 (P2 to N2) with a DC voltmeter. The capacitor discharge resistor (R1) should have reduced this voltage to 10 volts or below before work starts on this case.

4. Disconnect firing ribbon cable connector APL, BPL or CPL.

5. Remove the five (5) nuts and washers from the power connectors:

P3, M1 and N2 to the left of the module
 CP and CN to the right of the module

6. Carefully pull the module(s) out of the rack using the red plastic insulation cover in front of the module (See Figure 11).

7. The module can be repaired on a table. See (1) Press-Pak SCR replacement — phase module, or (2) stud mounted SCR replacement — Phase module or (3) Press-Pak SCR and stud mounted SCR replacement — Phase module.

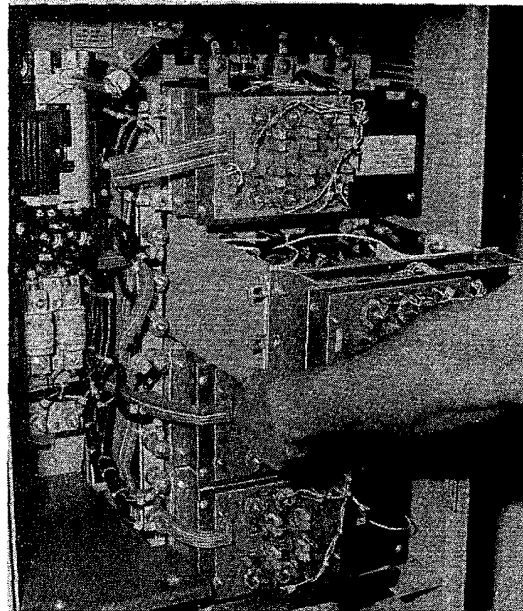


FIGURE 11
 AF-400 Drive Inverter Phase Module
 being removed. Press-Pak SCRs

8. To install the repaired module or a spare module, lift the Phase module(s) onto the Inverter rack.

9. Slide the assembly into the rack using the red insulation cover on the front of the module.

10. Reconnect the power terminals P3, M1, N2, CP and CN. Reconnect the firing ribbon cable connector APL, BPL or CPL.

11. Check to see that all electrical connections are tight

PRESS-PAK CELL REPLACEMENT — CONVERTER MODULE 40 to 60 KVA, 230V AC or 460V AC

1. Tools required:

Ratchet — 3/8"
Deep Socket — 7/16" for 3/8" ratchet
Wrench — 7/16" box
Wrench — 3/8" box
Screwdriver — 8" long with 5/16" tip

2. Stand the converter module on its back side on a table. The Pulse Transformer, printed circuit card should be on top. (Normally on the front of the module). See Figure 12.

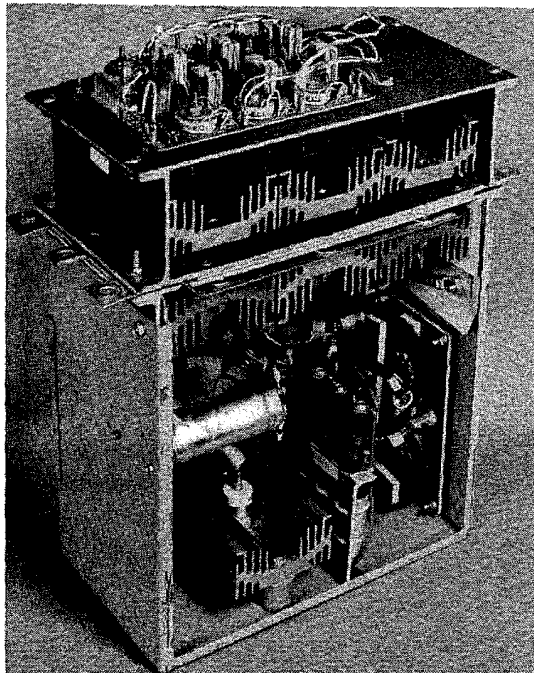


FIGURE 12
AF-400 Drive Converter Module
standing on a table. Press-Pak SCRs
40-60 KVA, 230 or 460V AC

3. After locating the defective Press-Pak SCR cell (1SP, 2SP, 3SP, 1SN, 2SN or 3SN), trace the appropriate red (cathode) and white (gate) firing circuit leads to the Pulse Transformer printed circuit card. Remove the plastic tie wraps from the appropriate firing circuit. Disconnect these circuits

from the Pulse Transformer card, fasten connectors. Free these wires from the harnesses and check to see that they are, in fact, connected to the defective cell.

4. Remove 4 machine screws and nuts that secure the front red plastic insulation cover to the converter module. See Figure 13.

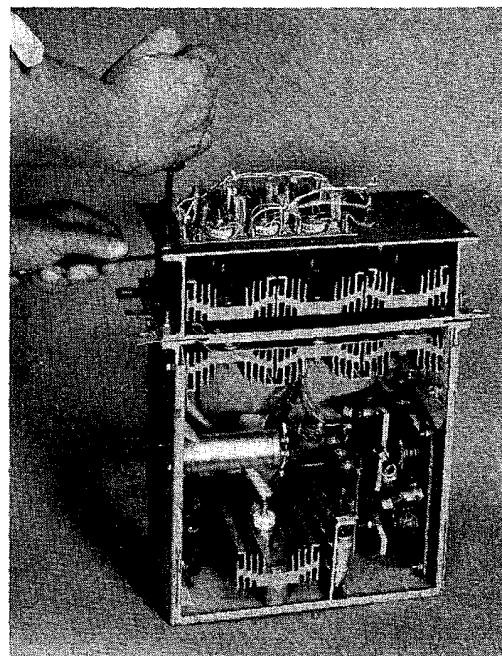


FIGURE 13
AF-400 Drive Converter Module
showing removal of machine screws that
secure the front cover, Press-Pak SCRs
40-60 KVA, 230 or 460V AC

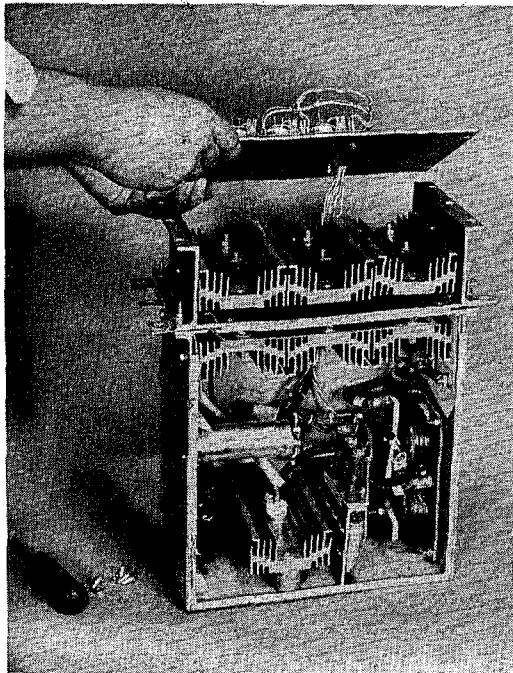


FIGURE 14
AF-400 Drive Converter Module
with front insulation cover folded back
Press-Pak SCRs
40-60 KVA, 230 or 460V AC

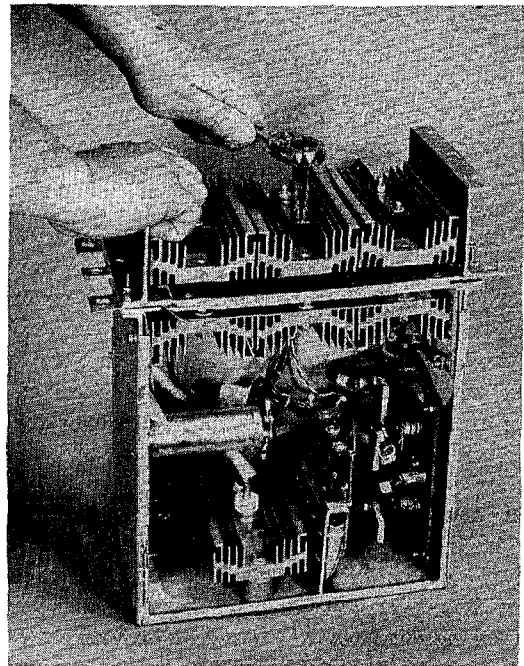


FIGURE 15
AF-400 Drive Converter Module
showing removal of the nuts and washers
that secure the heatsink clamp.
Press-Pak SCRs
40-60 KVA, 230 or 460V AC

5. Fold back the cover, thereby, exposing the Press-Pak SCR heatsink clamps. The remaining wire harnesses should support the front insulation cover while removing and replacing the defective Press-Pak cell. See Figure 14.

6. Remove the bolt, two flat washers and nut that hold the heatsink associated with the defective SCR cell to the DC bus (P1 or N1). See Figure 15.

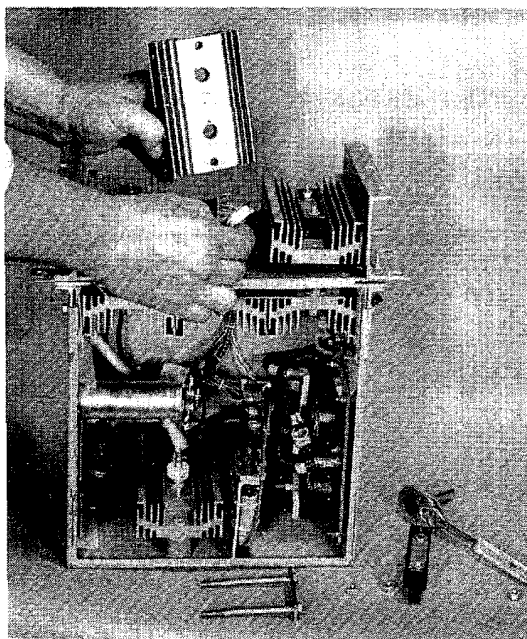


FIGURE 16
AF-400 Drive Converter Module showing
removal of heatsink
Press-Pak SCRs
40-60 KVA, 230 or 460V AC

7. Remove the two clamp nuts that secure the defective SCR, while supporting the bottom heatsink and clamp with one hand underneath the heatsink assembly. See Figure 16.
8. Note that 1SP, 2SP and 3SP SCRs are connected to the top heatsinks, whereas, 1SN, 2SN and 3SN SCRs are connected (back to back) on the bottom heatsink assembly.
9. NOTE CAREFULLY THE ARRANGEMENT OF THE CLAMP PARTS AND SCR ORIENTATION.
10. Remove the clamp rods, thereby, separating the two heatsinks and permitting the defective SCR to be removed along with its red and white firing circuit leads, which were previously removed from the pulse transformer printed circuit card.

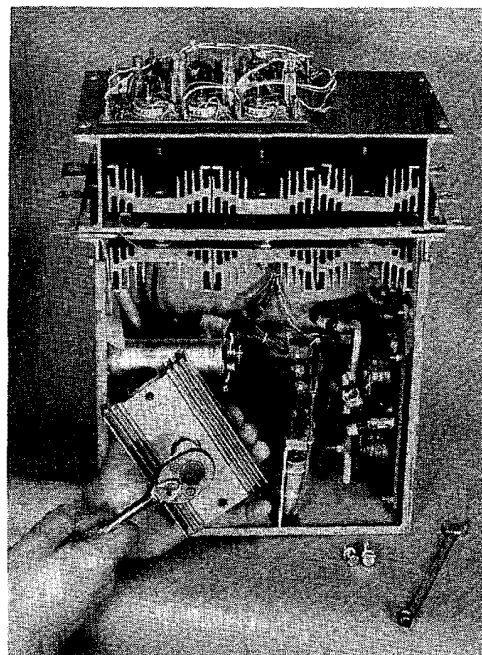


FIGURE 17
AF-400 Drive Converter Module
showing removal of the commutating
diode (DC) heatsink
40-60 KVA, 230 or 460V AC

11. The gate and cathode leads of the replacement SCR should be connected to the Pulse Transformer card per the converter module elementary diagram.
12. The other SCR associated with the clamp assembly should be carefully lifted from the heatsink mounting surfaces.
13. Inspect the surfaces that both SCRs mount between. These surfaces should be wiped clean with a lint free cloth. Inspect the surfaces and make sure they are smooth; if not smooth, replace the heatsink assembly.
14. Lubricate both mounting surfaces for each SCR using a thin coat of thermal grease, General Electric G332L Versilube® Plus (or equivalent).

15. Place both SCRs in the same orientation, as in the original assembly and place the SCR center holes over the roll pin in the mounting surface.

NOTE

THE BOTTOM SCR FITS OVER A ROLL PIN IN THE HEATSINK AND THE TOP SCR FITS OVER A ROLL PIN IN THE PLATE.

16. The clamp parts and heatsink should be assembled in the original manner and the two nuts tightened finger tight so that the threads showing are the same on both clamp rods.
17. Check to see that the SCR center holes are still over the roll pins.
18. With the nuts finger tight, use a wrench to tighten each nut, alternately in one quarter (1/4) turn steps until the clamp tightness (over finger tightness) equals one and one quarter (1-1/4) turns.

NOTE

WHEN TIGHTENING THE CLAMP USE A SOCKET WRENCH TO HOLD THE BOTTOM HEADS OF THE CLAMP RODS WHEN COUNTING TURNS.

19. Reconnect all electrical connections to both heatsinks and the SCR firing circuit leads to the Pulse Transformer card.
20. Re-install the front insulation board which includes the Pulse Transformer card and bolt in place with the four (4) machine screws and nuts.
21. Re-tie the SCR firing circuit leads with plastic clamps.
22. Check to see that all electrical connections are tight.

COMMUTATING DIODE (DC) REPLACEMENT CONVERTER MODULE 40 TO 60 KVA, 230V AC or 460V AC

1. Tools required:

Ratchet — 3/8"
Deep Socket — 9/16" for 3/8" ratchet
Deep Socket — 7/16" for 3/8" ratchet
Wrench — 7/16" box

2. Stand the converter module on its back side on a table. See Figure 12.
3. Remove the P3 connection (Anode) to the Commutating Diode (DC).
4. Remove the two bolts that secure the (DC) diode heatsink to the converter module.
5. Remove the top protective metal plate (2-1/4/20 machine screws). See Figure 17.
6. Remove the stud mounted diode from its heatsink. It is secured with a nut and lock washer.
7. Before replacing the commutating diode, inspect the mounting surface on the heatsink as well as the stud mounted diode mounting surface. These surfaces should be wiped clean with a lint free cloth. Inspect the surfaces and make sure they are smooth.
8. Lubricate both mounting surfaces using a thin coat of thermal grease, General Electric G322L, Versilube® Plus lubricant (or equivalent).
9. Insert the diode into the heatsink and tighten down the stud nut to a pressure equivalent to 100 inch pounds, using a torque wrench.
10. Replace the two bolts that secure the heatsink to the converter module.
11. Replace the anode connection P3.
12. Replace the top protective metal plate.

COMMUTATION POWER SUPPLY REPLACEMENT — CONVERTER MODULE 40 to 60 KVA, 230V AC or 460V AC

1. Tools required:

Screw driver — 8" long with 5/16" tip
Nut Driver — 1/4" with 6" shaft

2. Remove the top protective metal plate (2-1/4 x 20 machine screws).
3. The commutating power supply is contained on a printed circuit board located on the left of the converter module. It is connected through five (5) slotted terminals on terminal board TB1.

4. Loosen the five (5) terminal board screws on terminal board TB1 and slip the card away from the terminal board.
5. To replace the card, reverse the above procedure.
6. Make sure the five (5) terminal board screws are tight. These are electrical connections that also serve to support the card.

STUD MOUNTED CELL REPLACEMENT CONVERTER MODULE 10 to 30 KVA, 230V AC or 460V AC

1. Tools required:

Ratchet — 3/8"
 Deep Socket — 7/16" for 3/8" ratchet
 Wrench — 7/16" box
 Wrench — 3/8" box
 Screw Driver — 8" long with 5/16" tip

2. Stand the converter module on its back side on a table. The Pulse Transformer printed circuit card should be on top. (Normally on the front of the module).

3. After locating the defective stud mounted SCR cell (1SP, 2SP, 3SP, 1SN, 2SN or 3SN) trace the appropriate red (cathode) and white (gate) firing circuit leads to the Pulse Transformer printed circuit card. Remove the plastic tie wraps from the Pulse Transformer card, fasten connectors. Free these wires from the harnesses and check to see that they are, in fact, connected to the defective cell.

4. Remove four (4) machine screws and nuts that secure the front, red plastic insulation cover to the converter module.

5. Fold back the cover, thereby, exposing the stud mounted SCR heatsinks. The remaining wire harnesses should support the front insulation cover while removing and replacing the defective stud mounted SCR cell.

6. Remove the two (2) nuts that secure the defective SCR heatsink to the DC bus (P1 or N1).

7. Disconnect the SCR power circuits.

8. Remove the stud mounted SCR from its heatsink. It is secured with a nut and lock washer. See Figure 19.

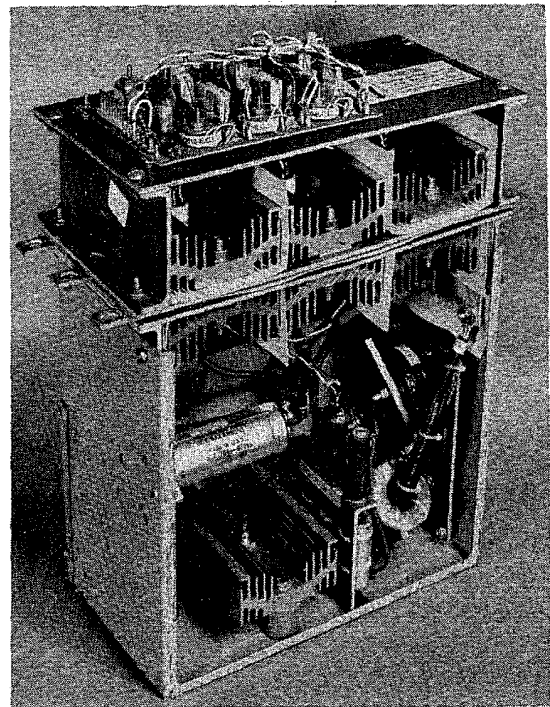


FIGURE 18
AF-400 Drive Converter Module
 with stud mounted SCRs standing on a table.
 10-30 KVA, 230 or 460V AC

9. Before replacing the stud mounted SCR, inspect the mounting surface on both heatsinks as well as the stud mounted SCR cell. These surfaces should be wiped clean with a lint-free cloth. Inspect the surfaces and make sure they are smooth.
10. Lubricate both mounting surfaces using a thin coat of thermal grease, General Electric G332L, Versilube® Plus lubricant (or equivalent).
11. Insert the stud mounted SCR into the heatsink and tighten down the stud nut to a pressure equivalent to 30 inch pounds, using a torque wrench.
12. Replace the heatsink and the two (2) nuts that secure it to the DC bus, (P1 or N1).

PRESS PAK CELL REPLACEMENT — INVERTER PHASE MODULE 40-60 KVA, 230V AC

1. Tools required:

Ratchet — 3/8"

Deep Socket — 7/16" for 3/8" ratchet

Wrench — 3/8" box

Screw Driver - 8" long with 5/16" tip

2. Stand the Inverter Phase Module on its back side on a high table. The Pulse Transformer printed circuit card should be on top. (Normally on the front of the module). See Figure 20.

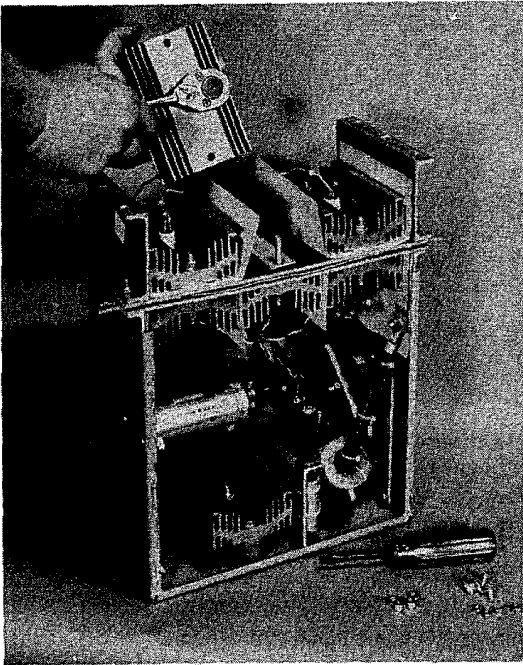


FIGURE 19

AF-400 Drive Converter Module
with stud mounted SCRs showing removal of
stud mounted SCR cell.
10-30 KVA, 230 or 460VAC

13. Reconnect all electrical connections to their respective busses and the SCR firing leads to the Pulse Transformer card.
14. Re-install the insulation board which includes the Pulse Transformer card and bolt it in place with the four (4) machine screws and nuts.
15. Carefully fold into the harnesses the power wiring and SCR firing circuit leads. Re-tie all leads with plastic clamps.
16. Check to see that all electrical connections are tight.

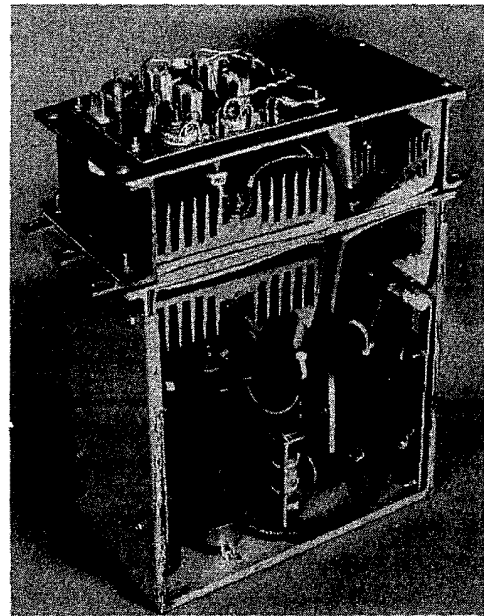


FIGURE 20

AF-400 Drive Inverter Phase Module
standing on a table. Press-Pak SCRs
40-60 KVA, 230V AC

3. After locating the defective Press-Pak SCR cell (ISP and ISN — Main SCRs or CSP and CSN — Commutating SCRs) trace the appropriate red (cathode) and white (gate) firing circuit leads to the Pulse Transformer printed circuit card. Remove the plastic tie wraps from the appropriate firing circuits. Disconnect these circuits from the Pulse Transformer card faston connectors. Free these wires from the harnesses and check to see that they are, in fact, connected to the defective cell.
4. Remove four (4) machine screws and nuts that secure the front, red plastic insulation cover to the Inverter Phase Module.
5. Fold back the cover, thereby, exposing the Press-Pak SCR heatsink clamps. The remaining wire harnesses should support the front insulation cover while removing and replacing the defective Press-Pak SCR cell.
6. Remove the two (2) clamp nuts that secure the defective SCR cell while supporting the bottom heatsink and clamp with one hand underneath the heatsink assembly.
7. Note that ISP and CSP SCR cells are connected to the top heatsinks, whereas, ISN and CSN SCR cells are connected to the bottom heatsink assembly.
8. **NOTE CAREFULLY THE ARRANGEMENT OF THE CLAMP PARTS AND SCR ORIENTATION.**
9. Remove the bottom heatsink and SCR cell by dropping the assembly so the clamp rods are free. Carefully remove the defective SCR cell along with its red and white firing circuit leads which were previously removed from the Pulse Transformer printed circuit card.
10. The gate and cathode leads of the replacement SCR should be connected to the Pulse Transformer card per the inverter phase module elementary diagram. See Figure 28.
11. The other SCR cell associated with the clamp assembly should be carefully lifted from the heatsink mounting surfaces.
12. Inspect the surfaces that both SCR cells mount between. These surfaces should be wiped clean with a lint free cloth. Inspect the surfaces and make sure they are smooth; if not, replace the heatsink assembly.

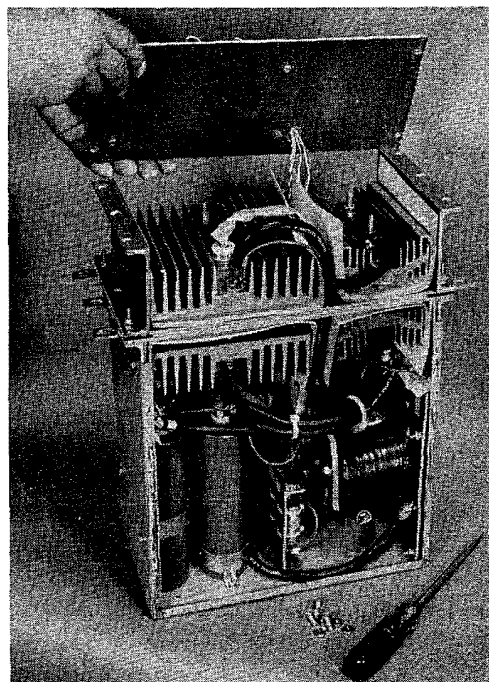


FIGURE 21
AF-400 Drive Inverter Phase Module
with the front cover folded back. Press-Pak SCRs
40-60 KVA, 230 V AC

13. Lubricate both mounting surfaces for each SCR cell using a thin coat of thermal grease, General Electric G322L, Versilube® Plus (or equivalent).
14. Place both cells in the same orientation as in the original assembly and place the cell center holes over the roll pin in the mounting surface.

NOTE

THE BOTTOM SCR CELL FITS OVER A ROLL PIN IN THE HEATSINK AND THE TOP SCR FITS OVER A ROLL PIN IN THE PLATE.

15. The clamp parts and heatsink should be assembled in the original manner and the two nuts tightened finger tight so that the threads showing are the same on both clamp rods.
16. Check to see that the SCR cell center holes are still over the roll pins.

17. With the nuts finger tight, use a wrench to tighten each alternately in 1/4 turn steps until the clamp tightness (over finger tightness) equals one and one quarter (1 1/4) turns.

NOTE

WHEN TIGHTENING THE CLAMP USE A SOCKET WRENCH TO HOLD THE BOTTOM HEADS OF THE CLAMP RODS WHEN COUNTING TURNS.

18. Reconnect all electrical connections to both heatsinks and the SCR firing circuit leads to the Pulse Transformer card.
19. Re-install the red plastic insulation board which includes the Pulse Transformer card and bolt it in place with the four (4) machine screws and nuts.
20. Re-tie the SCR firing circuit leads with plastic clamps.
21. Check to see that all electrical connections are tight.

BYPASS DIODE (DP AND DN) REPLACEMENT INVERTER PHASE MODULE 40-60KVA, 230V AC

1. Remove the anode connection to the Bypass Diode (DP or DN).
2. After separating the two main Press-Pak heatsinks (see Press-Pak SCR Replacement — Inverter Phase Module, 40-60 KVA, 230V AC) remove the stud mounted bypass diode from the appropriate heatsink. It is secured with a nut and lock washer.
3. Before replacing the bypass diode(s), inspect the mounting surface on the heatsink as well as the stud mounted diode mounting surface. These surfaces should be wiped clean with a lint free cloth. Inspect the surfaces and make sure they are smooth.
4. Lubricate both mounting surfaces using a thin coat of thermal grease, General Electric G332L, Versilube® Plus lubricant (or equivalent).
5. Insert the diode into the heatsink and tighten down the stud nut to a pressure equivalent to 30 inch pounds, using a torque wrench.
6. Replace the heatsinks according to instructions under Press-Pak SCR Replacement — Inverter Phase Module, 40-60 KV, 230V AC.

7. Replace the anode connection (DP or DN).

STUD MOUNTED SCR REPLACEMENT — INVERTER PHASE MODULE 10-30 KVA, 230V AC or 460VAC

1. Tools Required:

Ratchet — 3/8"

Deep Socket — 7/16" for 3/8" ratchet

Wrench — 3/8" box

Screw Driver — 8" long with 5/16" tip

2. Stand the phase module on its back side on a table. The pulse transformer printed circuit card should be on top. (Normally on the front of the module). See Figure 22.

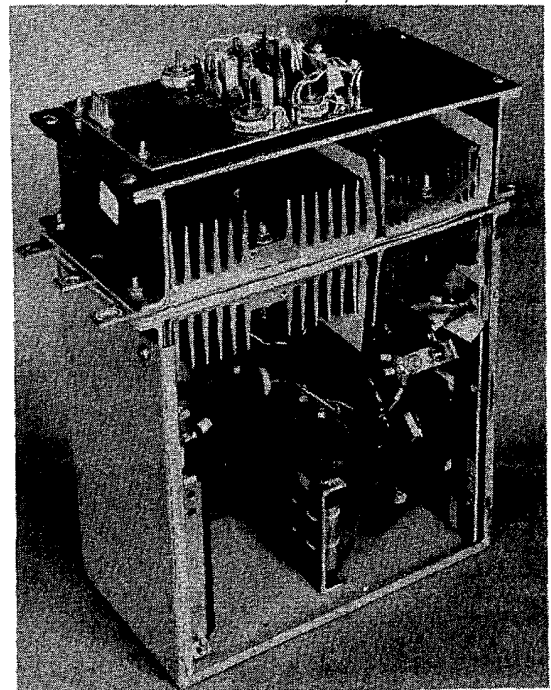


FIGURE 22
AF-400 Drive Inverter Phase Module
standing on a table stud mounted SCRs
10-30 KVA, 230 or 460V AC

3. After locating the defective stud mounted SCR cell (1SP and 1SN) — Main SCRs or CSP and CSN — commutating SCRs) trace the appropriate red (cathode) and white (gate) firing circuit leads to the Pulse Transformer printed circuit card. Remove the plastic tie wraps from the appropriated firing circuits. Disconnect these circuits from the Pulse Transformer card, fasten connectors. Free these wires from the harnesses and check to see that they are, in fact, connected to the defective SCR cell.
4. Remove four (4) machine screws and nuts that secure the front red plastic insulation cover to the inverter phase module.
5. Fold back the cover, thereby, exposing the stud mounted SCR heatsinks. The remaining wire harnesses should support the front insulation cover while removing and replacing the defective stud mounted SCR cell. See Figure 23.

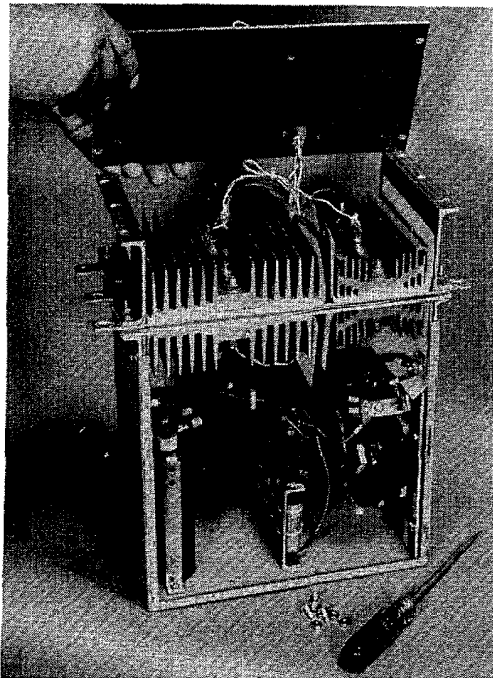


FIGURE 23
AF-400 Drive Inverter Phase Module
with front insulation cover folded back
stud mounted SCRs
10-30 KVA, 230 or 460V AC

6. Disconnect the power leads from the appropriate reactors. Replacement stud mounted SCR cells are furnished by General Electric Company with the power leads and firing circuit leads soldered to the stud mounted SCR cells.
7. Remove the two (2) nuts that secure the heatsink with the defective stud mounted SCR cell to the phase module.
8. Remove the stud mounted SCR cell from its heatsink. It is secured with a nut and lock washer.
9. Before replacing the stud mounted SCR cell, inspect the mounting surface on both the heatsink as well as the stud mounted SCR cell. These surfaces should be wiped clean with a lint free cloth. Inspect the surfaces and make sure they are smooth.
10. Lubricate both mounting surfaces using a thin coat of thermal grease, General Electric, G322L, Versilube® Plus lubricant (or equivalent).
11. Insert the stud mounted SCR cell into the heatsink and tighten down the stud nut to a pressure equivalent to 30 inch pounds, using a torque wrench.
12. Replace the heatsink and the two (2) nuts that secure it to the phase module.
13. Reconnect all electrical connections to their respective reactors and the SCR firing leads to the Pulse Transformer printed circuit card.
14. Re-install the insulation board which includes the Pulse Transformer card and bolt it in place with four (4) machine screws and nuts.
15. Carefully fold into the harnesses the power wiring and SCR firing circuit leads. Re-tie all leads with plastic clamps.
16. Check to see that all electrical connections are tight.

**INVERTER PHASE MODULE
40-60 KVA, 460V AC
PRESS-PAK SCR CELL REPLACEMENT
MAIN SCR CELLS
STUD MOUNTED SCR CELL REPLACEMENT
COMMUTATING SCR CELLS**

1. Tool Required:

Ratchet — 3/8"
Deep Socket — 7/16" for 3/8" ratchet
Deep Socket — 9/16" for 3/8" ratchet
Wrench — 3/8" box
Screw Driver — 8" long with 5/16" tip

2. Stand the phase module on its back side on a table. The Pulse Transformer printed circuit card should be on top. (Normally on the front of the inverter phase module). See Figure 24.

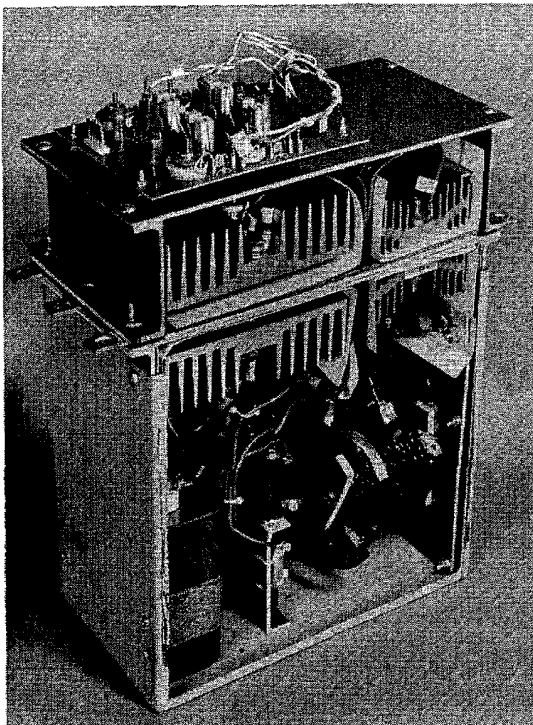


FIGURE 24
AF-400 Drive Inverter Phase Module
40-60 KVA, 460V AC
standing on a table
Press-Pak Main SCR cells stud mounted
Commutating SCR cells.

3. After locating the defective Press-Pak Main SCR cell (ISP and ISN) follow the instructions for Press-Pak Main SCR cells, 40-60 KVA, 230V AC units. See Figure 25.

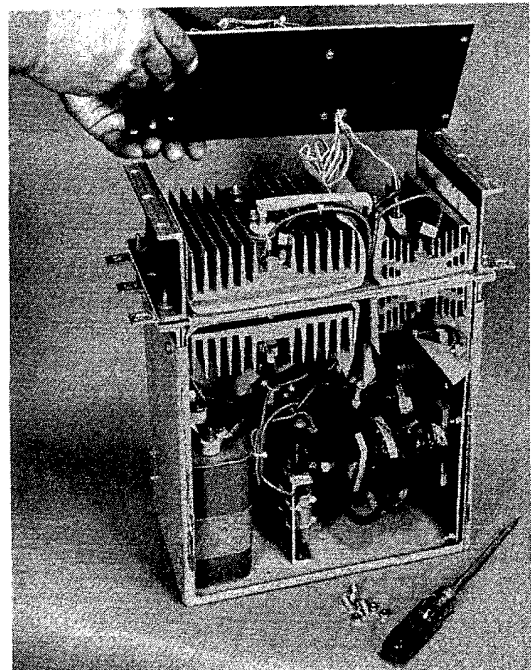


FIGURE 25
AF-400 Drive Inverter Phase Module
40-60KVA, 460V AC
with front cover folded back
Press-Pak Main SCR cells stud
mounted commutating SCR cells.

4. After locating the defective stud mounted commutating SCR cell (CSP and CSN) follow the instructions for stud mounting SCR cells, 10-30 KVA, 230V AC or 460V AC units. See Figure 25.
5. Check to see that all electrical connections are tight.

FILTER CAPACITOR REPLACEMENT

1. Tools required:

Ratchet — 3/8"
Deep Socket — 7/16" for 3/8" ratchet
Wrench — 7/16" box
Screw Driver — 5/16" shank, 8" long blade

2. Open all electrical circuits to the case in which the Filter Capacitors are located.
3. Check voltage across capacitors (N2 to P2) with DC voltmeter. The Capacitor discharge resistor (R1) should have reduced this voltage to 10 volts or below before work starts in the case.
4. Disconnect the power leads to the capacitor.
5. Loosen the capacitor clamp and remove the capacitor.
6. When the faulty capacitor is replaced, make certain that the new capacitor is connected to the electrical circuit with the same polarity orientation as was the faulty capacitor.
7. Re-connect all power lines.
8. If the replacement electrolytic capacitors have been on the shelf (non-operating) for longer than 6 months, they should be formed. Refer to step 13 of the Start-up Procedure in the Start-up and Checkout section for the proper forming procedure.

FAN REPLACEMENT — 10 TO 60 KVA

1. Tools required:
 - Ratchet - 3/8"
 - Ratchet Extension — 3/8", 6" long
 - Deep Socket — 1/2" for 3/8" ratchet
 - Nut Driver — 5/6" with 6" blade
 - Screw Driver — 5/16" shank, 8" long blade
2. Open all electrical circuits to the case in which the faulty fan assembly is located.
3. Check the voltage across the capacitor assembly (N2 to P2) with a DC voltmeter. The capacitor discharge resistor (R1) should have reduced this voltage to 10 volts or below before work starts in the case.
4. Disconnect the fan motor leads from the terminal board.
5. Remove the mounting screws from the fan housing that holds the fan to the module rack.
6. Remove the fan assembly.
7. The repaired or replacement fan assembly should be bolted in place with the air flow arrow point upwards.

8. Reconnect the motor leads to the terminal board.
9. Check all electrical connections for tightness.
10. Apply power to the fan motor. The air flow should be toward the top of the case.

STANDARD SPECIFICATIONS, OPTIONS, OPERATOR'S STATIONS AND AC MOTORS

RATINGS

Horsepower — 10 through 60 HP

Power Supply Voltage — 3 phase, 230 or 460V AC
 (+10% — 5%)
 —Frequency — 60 or 50 Hz (±2%)
 (by jumper selection on
 converter card)

Input Power

HP	RMS Amperes	
	230V AC	460V AC
10	28	14
15	42	21
20	56	28
25	70	35
30	84	42
40	112	56
50	140	70
60	168	84

Overload Capability — Service Factor 1.0
 1 Min. Overload — 150%
 Motor Starting Torque 140%
 (1 Minute)

Speed Range —Variable Torque (pump load)
 = 8 to 1
 Minimum Frequency = 7.5 Hz
 (No derating of motor or power unit)

Constant Torque
 3 to 1 Derate Power Unit
 RMS Amps — 10%
 8 to 1 Derate Power Unit
 RMS Amps — 25%
 10 to 1 Derate Power Unit
 RMS Amps — 25%

Constant Horsepower = 1.25 to 1

Refer to AF-400 Drive Application Manual, GET-6656 for details.

Service Conditions —Ambient temperature 0 to 40°C
 Altitude — 0 — 1000 meters
 (0 — 3300 feet)

Speed Regulation —3% (approximately) with
 induction motor (Due to slip)

0% with synchronous reluctance motor

Service Deviation — 1%

Function of Basic Power Unit —Drive Start and Stop
 Speed Control by Potentiometer
 Unidirectional operation
 Coast Stop

Adjustments —

- Current feedback — 0 to 100%
- Current Limit — 50 to 150%
- Linear timed acceleration — 5 to 50 sec.
- Linear timed deceleration — 5 to 50 sec.
- (Independent adjustments)
- Voltage Boost
- IR Compensation
- Current Limit Stability
- Volts/Hertz
- Minimum Frequency — (Minimum Speed)
- Base Frequency — 2 to 1
- Frequency Ranges —37.5 to 75 Hz
- 75 to 150 Hz
- 150 to 300 Hz

Trip Frequency — 75 Hz
 —110 Hz
 —165 Hz
 —275 Hz
 —400 Hz

Protective Features —

- AC line, current limiting fuses
- 115V AC Control Power Fuses
- Surge voltage protection
- Control undervoltage shutdown
- Commutation overcurrent shutdown
- Inverter overfrequency shutdown
- Inverter fault shutdown
- DC Link overvoltage fault-shutdown
- Phase sequence of loss of phase trip
- Inverse time overcurrent trip
- Isolation between power and control circuits

Indicating Lights —

ITOC — Inverse time overcurrent
 IF — Inverter Frequency
 SYNC — Synchronizing light
 Inverter to AC line
 (Not used on GP Drives)
 LOV — Link overvoltage trip
 PS/LOP — Incorrect phase sequence or loss of phase
 IOC — Instantaneous Overcurrent
 (Will also operate on DC Link overvoltage trip; commutation overcurrent or control undervoltage shutdown).
 IOF — Inverter overfrequency trip
 COC — Commutation overcurrent trip
 CUV — Control undervoltage trip

Operator's Station (Basic Standard)
 Speed Adjust Potentiometer
 Start—Stop Pushbuttons
 NEMA 1 Enclosure

Options —

- Incoming Line Circuit Breaker
 230 or 460V AC, 3 phase
- Relay Option Card
 Reversing Relay (Selective rotation)
 Fault Relay
 Run Relay (Pilot relay for AC motor contactors to and including NEMA size 2)
- Process Follower Card
- Meter Card (Diagnostic Test Card)

Operator's Stations

1. Speed Adjust Potentiometer
Start-Stop Pushbuttons
Forward/Reverse Selector Switch
NEMA 1 Enclosure
2. Speed Adjust Potentiometer
Start-Stop Pushbuttons
Manual/Automatic Selector Switch
NEMA 1 Enclosure

Speed Indicator — 0 — 100% Speed

Load Indicator — 0 — 100% Load

Enclosure for one instrument

Enclosure for two instruments

NOTE: SYNCHRONOUS SPEED AND FREQUENCY SELECTION SHOULD BE COMPATIBLE WITH MOTOR OVERSPEED DESIGN AND LOW SPEED THERMAL OPERATION.

AC Motor —

Type: Squirrel cage induction or
synchronous reluctance

Synchronous speed at 60 HZ: 3600 RPM

1800 RPM

1200 RPM

900 RPM

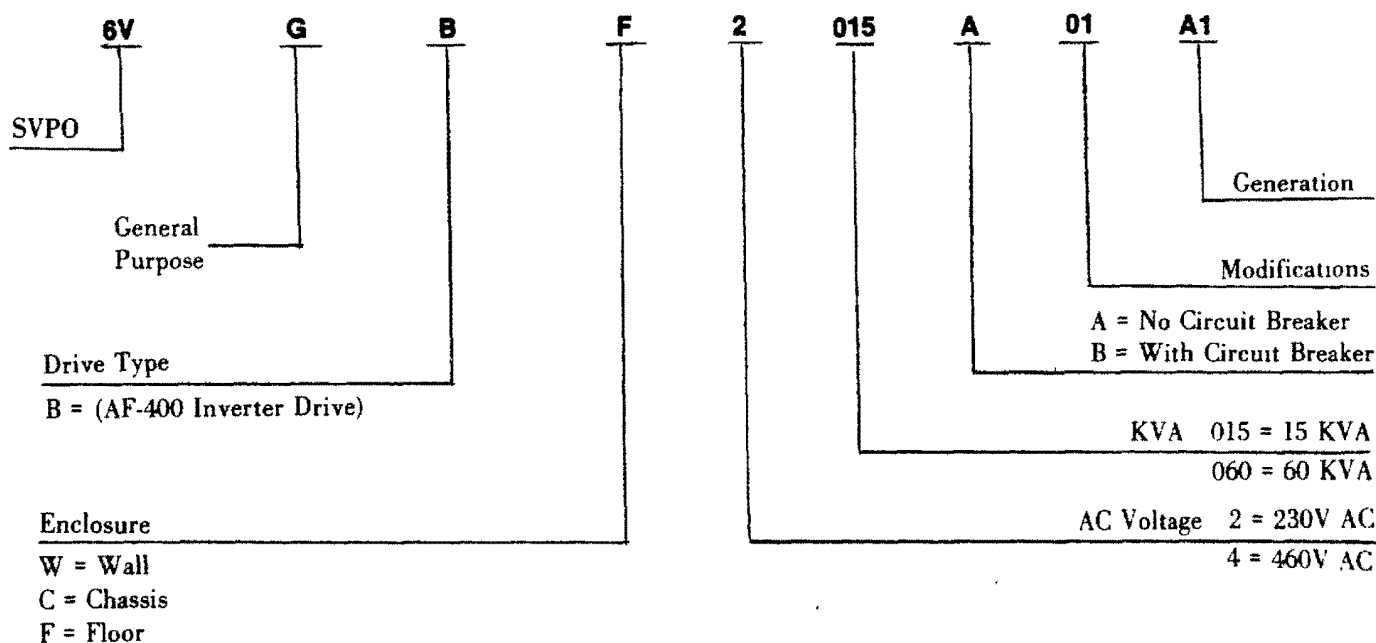
Temperature Protection: Thermotector (if
specified)

Enclosure: DPGF (Dripproof, fully guarded)

TEFC (Totally enclosed, fan cooled)

TENV (Totally enclosed, non-
ventilated)

AF-400 DRIVE GP CATALOG NUMBER ASSIGNMENT



BASIC (STANDARD) MODEL NUMBER BY HORSEPOWER

KVA	Model Number	230V	Model Number	460V
10	6VGBF2010A	6VGBF2010B	6VGBF4010A	6VGBF4010B
15	6VGBF2015A	6VGBF2015B	6VGBF4015A	6VGBF4015B
20	6VGBF2020A	6VGBF2020B	6VGBF4020A	6VGBF4020B
25	6VGBF2025A	6VGBF2025B	6VGBF4025A	6VGBF4025B
30	6VGBF2030A	6VGBF2030B	6VGBF4030A	6VGBF4030B
40	6VGBF2040A	6VGBF2040B	6VGBF4040A	6VGBF4040B
50	6VGBF2050A	6VGBF2050B	6VGBF4050A	6VGBF4050B
60	6VGBF2060A	6VGBF2060B	6VGBF4060A	6VGBF4060B

CATALOG NUMBER ASSIGNMENT — OPERATOR'S STATIONS REMOTE

Speed Adjust, Start-Stop	6VOC76
Speed Adjust, For.—Rev., Start-Stop	6VOC82
Speed Adjust, Man.—Auto., Start-Stop	6VOC52
Speed Indicator	6VSI12
Load Indicator	6VLI12
Enclosure — 1 Instrument	6VIE11
Enclosure — 2 Instruments	6VIE21

AVAILABLE OPTIONS MODEL NUMBERS

	Kit	Factory Mounted
Process Follower Card (193X391AAG01)	6VPF10A1	6VPF10FMA1
Relay Option Card (193X391AAG02)	(Included with standard GP General Purpose Drives)	
*Reversing Relay Modification	6VREV10A1	6VREV10FMA1
*Fault Relay Modification	6VFLT10A1	6VFLT10FMA1
*Run Relay Modification	6VRUN10A1	6VRUN10FMA1
**Auto/Man Relay Modification	6VRAM10A1	6VRAM10FMA1

*These options modify the Process Follower Option Card in kit 6VPF10A1 or the Relay Option card furnished with all standard GP — General Purpose Drives.

**This option modifies the Relay Option Card furnished with all standard GP-General Purpose Drives. The Process Follower Option Card (6VPF10A1) has this relay.

(AF3124)

ADJUSTABLE FREQUENCY DRIVE

DIGITAL/ANALOG DRIVER-1.5 TO 1 CONSTANT HP RANGE

GENERAL PURPOSE OPERATING NOTES

WARNING

BEFORE REMOVING A PRINTED CIRCUIT CARD OR BEFORE MAKING ANY WIRING CHANGES OR CONNECTIONS, POWER SHOULD BE REMOVED FROM THE INVERTER.

THIS IS AN ADJUSTABLE FREQUENCY AC MOTOR DRIVE BUILT IN A FLOOR MOUNTED ENCLOSURE. NOTE THAT THE CASE DOOR HANDLE IS KEY LOCKABLE.

BEFORE APPLYING POWER TO THE DRIVE, READ INSTRUCTION BOOK GEK-24998 AND FOLLOW ALL WARNINGS, CAUTIONS AND NOTES GIVEN IN THAT BOOK. THE PROPER SEQUENCE OF STEPS TO FOLLOW WHEN STARTING UP A DRIVE ARE ALSO DESCRIBED IN THE INSTRUCTION BOOK.

THIS DRIVE REQUIRES AIR FLOW THROUGH THE ENCLOSURE. IT ENTERS AT THE BOTTOM AND EXITS AT THE TOP OF THE ENCLOSURE. THE REQUIRED AIR FLOW IS 275 CFM AND THE INLET AIR TEMPERATURE SHOULD NOT EXCEED 40°C. THE AC POWER WIRES ARE NORMALLY BROUGHT INTO THE TOP OF THE ENCLOSURE THROUGH THREE, FAST ACTING, THYRISTOR FUSES. A CIRCUIT BREAKER WITH MAGNETIC TRIP MAY BE SUPPLIED AHEAD OF THESE FUSES AS OPTIONAL EQUIPMENT. WHEN THE CIRCUIT BREAKER IS SUPPLIED IT HAS AN OPERATING MECHANISM THAT EXTENDS THROUGH THE FRONT DOOR.

THE INVERTER OUTPUT WIRES ARE NORMALLY TAKEN OUT OF THE TOP OF THE ENCLOSURE, THROUGH A CHANNEL UNDERNEATH THE CIRCUIT BREAKER MOUNTING BRACKET. THE PURCHASER MAY CHOOSE TO HAVE THE OUTPUT WIRES CONNECTED TO AN AC CONTACTOR AS SHOWN ON ELEMENTARY DIAGRAM 36B590264AB SH4.

A LIST OF FUSES USED IN THESE INVERTER DRIVES BY KVA RATING FOLLOWS:

RATING		FUSES FU1-FU3		FUSES FU4-FU5		FUSE FU7	
VOLTAGE	KVA	AMPS	VOLTS	AMPS	VOLTS	AMPS	VOLTS
230	10	60	500	3	600	1	250
	15	60					
	20	100					
	25	100					
	30	100					
	40	300					
	50	300					
	60	300					
↓			↓	↓	↓	↓	↓

FIGURE 26
GP Operating Notes & Drive Elementary Diagram, Sheet 1
(continued on Sheet 1A)

RATING		FUSES FU1-FU3		FUSES FU4-FU5		FUSE FU7	
VOLTAGE	KVA	AMPS	VOLTS	AMPS	VOLTS	AMPS	VOLTS
460	10	35	500	3	600	1	250
	15	35					
	20	60					
	25	60					
	30	60					
	40	175					
	50	175					
	60	175					
↓			↓	↓	↓	↓	↓

NOTE

FOR ALL RATINGS, THE DRIVER POWER SUPPLY CARD (193X480A AG01) FUSE IS 5AMPS-250VOLTS.

THE ADJUSTMENT OF MOTOR SPEED IS ACHIEVED BY CHANGING BOTH MOTOR FREQUENCY AND VOLTAGE. THIS IS A VARIABLE VOLTAGE DC LINK TYPE INVERTER. A DESCRIPTION OF THE BASIC INVERTER IS PROVIDED IN INSTRUCTION BOOK, GEK-24998.

THE GENERAL PURPOSE (GP) INVERTER IS PROVIDED WITH AN OPTION CARD (193X391AA G02) WHICH IS PLUGGED INTO A CARD HOLDER ATTACHED TO THE TOP OF THE DRIVER RACK. THIS OPTION CARD CAN BE USED IN CONJUNCTION WITH OPERATOR'S STATION, MODEL 6V0C72 TO START AND STOP THE INVERTER DRIVE AND TO CONTROL ITS SPEED.

- NOTE: 1. RELAY CONTACTS ON OPTION CARDS 193X391A AG01 OR G02 ARE RATED 115VAC; HIGHER VOLTAGE SHOULD NOT BE USED.
2. ALL EXTERNAL RELAYS AND AC CONTACTORS MUST HAVE THEIR COILS SUPPRESSED. (EX. A 1/2 MFD-220 OHM SUPPRESSOR MAY BE USED.)

THE START/STOP PUSH BUTTONS CAN BE WIRED INTO THE CIRCUIT AS SHOWN ON ELEMENTARY DIAGRAM 36B590264AB SH5. IF WIRED AS SHOWN, THE THERMAL SWITCH (THSW) WILL CAUSE THE DRIVE TO STOP DUE TO HIGH AMBIENT TEMPERATURES OR LOSS OF COOLING AIR. IF A MOTOR OVERLOAD RELAY IS USED, ITS INTERLOCKS (OL) CAN BE CONNECTED INTO THIS CIRCUIT CAUSING THE DRIVE TO STOP WHEN THE OVERLOAD RELAY TRIPS.

THE SPEED ADJUST POTENTIOMETER CAN BE CONNECTED INTO THE CIRCUIT AS SHOWN ON ELEMENTARY DIAGRAM 36B590264AB SH6. AS SHOWN, TWO POTENTIOMETERS ON THE OPTION CARD CONTROL MINIMUM AND MAXIMUM SPEEDS AT WHICH THE DRIVE WILL OPERATE. MAX MAN ADJUSTS THE MAXIMUM SPEED LIMIT AND MIN MAN ADJUSTS THE MINIMUM SPEED LIMIT.

IF IT IS DESIRABLE TO HAVE AN EXTERNALLY, ADJUSTABLE MINIMUM AND MAXIMUM SPEED ADJUSTMENT, THE SPEED ADJUST POTENTIOMETER MAY BE CONNECTED BETWEEN TB2(40) AND TB1(18).

BEFORE APPLYING POWER TO THE INVERTER, MAKE SURE THAT THE FOLLOWING CARD JUMPERS ARE PROPERLY LOCATED TO AGREE WITH THE INTENDED APPLICATION.

1. BASE HZ JUMPER-REGULATOR CARD
SET FOR THE DESIRED BASE HZ RANGE.
2. HZ TRIP JUMPER-INVERTER CARD
SET FOR FREQUENCY WHERE FAULT TRIP IS DESIRED.
3. VOLTAGE JUMPER-INVERTER CARD
SET FOR THE INVERTER INPUT VOLTAGE.
4. 60 HZ JUMPER-CONVERTER CARD
WHEN THE INVERTER IS TO OPERATE FROM A 50HZ SOURCE,
THIS JUMPER MUST BE REMOVED.

FOLLOW THE INSTRUCTIONS IN GEK-24998 INSTRUCTION BOOK FOR START-UP PROCEDURES, PROPER ADJUSTMENT OF THE DRIVER POTENTIOMETERS AND FOR TROUBLESHOOTING.

FIGURE 26
GP Operating Notes & Drive Elementary Diagram Sheet 1A
(continued on Sheet 1B)

NOTE: CAPACITOR FORMING

ELECTROLYTIC CAPACITORS HAVE A LIMITED SHELF LIFE WHEN NOT ENERGIZED. IT IS THEREFORE NECESSARY TO FORM THE CAPACITORS BEFORE NORMAL CHARGING CAN TAKE PLACE.

- A. LESS THAN 6 MONTHS: NO FORMING REQUIRED.
- B. MORE THAN 6 MONTHS: SEE INSTRUCTION BOOK GEK-24998 (START-UP AND CHECK OUT SECTION) FOR DETAILS.

TERMINAL BOARDS, (TBI AND TB2), LOCATED IN THE LOWER RIGHT CORNER OF THE POWER UNIT, PROVIDE CONNECTIONS FOR INCOMING COMMAND SIGNALS, AS WELL AS OUTPUT SIGNALS. THE CONTROL WIRES ARE NORMALLY BROUGHT INTO THE ENCLOSURE THROUGH THE BOTTOM.

FOR THIS GENERAL PURPOSE (GP) DRIVE THERE ARE KITS AVAILABLE WITH PUSHBUTTONS, SWITCHES, INSTRUMENTS AND PRINTED CIRCUIT CARDS WHICH CAN BE USED AS SHOWN IN THE ELEMENTARY DIAGRAM 36B590264AB SHEETS 5 AND 6. THESE KITS ARE DESCRIBED BELOW:

- 1. METER CARD - 193X481A AG01
THE DRIVER IS PROVIDED WITH A RECEPTACLE WIRED TO PROVIDE SIGNALS TO THE METER CARD (WHEN USED). THE TROUBLESHOOTING SECTION OF GEK-24998 REFERS TO THIS CARD AND TO ASSISTANCE DURING SET-UP AND TROUBLESHOOTING.

THE METER CARD CAN BE OBTAINED AND PLUGGED INTO THE EXTREME RIGHT DRIVER RECEPTACLE AS INDICATED ON THE LABEL UNDERNEATH THE PRINTED CIRCUIT CARDS.

- 2. OPERATOR'S STATION
SPEED ADJUST, START-STOP - MODEL 6VOC72
SPEED ADJUST, FWD, REV, START-STOP - MODEL 6VOC82
SPEED ADJUST, MAN, AUTO, START-STOP - MODEL 6VOC52

THESE STATIONS (7.4 INCHES LONG X 3.5 INCHES WIDE X 3.06 INCHES DEEP) CONTAIN A SPEED ADJUST POTENTIOMETER, START-STOP PUSHBUTTONS, AND FWD-REV OR MAN-AUTO SELECTOR SWITCHES. THEY CAN BE WIRED INTO THE CIRCUITRY AS SHOWN ON 36B590264AB SH5 AND SH6.

WHEN POWER IS TURNED ON THE INVERTER FREQUENCY LIGHT (IF) ON THE SYSTEM CARD IN THE DRIVER RACK STARTS TO BLINK ON AND OFF AT A LOW FREQUENCY. ON THE OPTION CARD, THE MIN SPEED AND FAULT LIGHTS ALSO TURN ON. IF SELECTOR SWITCHES ARE POSITIONED TO (REV) AND (MAN) AS SHOWN ON 36B590264AB SH5, THE (REV) AND (MAN) INDICATING LIGHTS ON THE OPTION CARD WILL TURN ON IN THAT ORDER.

WHEN THE (START) PUSHBUTTON IS DEPRESSED, THE INVERTER WILL BE STARTED BY ENERGIZING THE INVERTER START (IS) RELAY, PROVIDED THE INVERTER IS AT NEARLY ZERO FREQUENCY IN ORDER TO PERMIT THE MINIMUM SPEED RELAY (MSR) TO BE ENERGIZED. WHEN THE INVERTER STARTS, THE (IS) RELAY SEALS IN AROUND THE (MSR) RELAY WHICH IS DE-ENERGIZED AS SOON AS THE INVERTER OUTPUT FREQUENCY INCREASES. THE (START) AND (RUN) LIGHT WILL ALSO TURN ON. NOTE THAT THE (FAULT), (REV), (MAN) AND (RUN) INDICATING LIGHTS WILL TURN ON EVEN THOUGH THE RELAYS ARE NOT PLUGGED INTO THEIR RESPECTIVE SOCKETS.

AFTER THE (START) PUSHBUTTON IS DEPRESSED, THE SPEED ADJUST POTENTIOMETER CAN BE TURNED CLOCKWISE IN ORDER TO INCREASE THE SPEED. THE DRIVE WILL ACCELERATE TO THE SET SPEED AT THE RATE SET BY THE (ATIM) POTENTIOMETER ON THE REGULATOR CARD. WHEN THE DRIVE REACHES APPROXIMATELY 4 PERCENT OF BASE SPEED, THE (MIN SPD) INDICATING LIGHT WILL TURN OFF. THE (MIN SPD) LIGHT INDICATES THAT (MSR) RELAY IS ENERGIZED.

WHEN THE (STOP) PUSHBUTTON IS DEPRESSED, THE INVERTER OUTPUT VOLTAGE AND FREQUENCY DROP AT THE RATE SET BY THE (DTIM) POTENTIOMETER ON THE REGULATOR CARD. WHEN THE MOTOR IS KEPT CONNECTED TO THE INVERTER OUTPUT TERMINALS (SEE SH5, JUMPER FROM TB2 (31) TO TBI (21)) THE CIRCUIT PROVIDES A CONTROLLED STOP AND THE MOTOR WILL COME TO A STOP ALONG WITH THE INVERTER OUTPUT FREQUENCY AND VOLTAGE.

HIGH INERTIA LOADS MAY RESULT IN DECELERATION TIMES LONGER THAN THE (DTIM) SET VALUE DUE TO LINK VOLTAGE PUMP UP.

FIGURE 26

GP Operating Notes & Drive Elementary Diagram Sheet 1B
(continued on Sheet 1C)

THE DRIVE CAN BE ARRANGED TO SWITCH FROM THE FORWARD TO THE REVERSE DIRECTION OF ROTATION, ELECTRONICALLY. TO ACCOMPLISH THIS A REVERSING MODIFICATION KIT (MODEL 6VREV10) SHOULD BE ORDERED. THE OPTION CARD (CAT. 193X391AA G02) SHOULD BE REMOVED FROM THE RECEPTACLE AND SUPPORTED SO THE RELAY FROM THE MODIFICATION KIT CAN BE PLUGGED INTO ITS DESIGNATED CARD SOCKET WITHOUT FLEXING THE PRINTED CIRCUIT CARD. IN ADDITION TO THE REVERSING MODIFICATION KIT, IT WILL BE NECESSARY TO PROVIDE AN OPERATORS STATION WITH A (FWD-REV) SELECTOR SWITCH SUCH AS MODEL 6VOC82. AFTER PLUGGING IN THE REVERSING RELAY, INSERT THE OPTION CARD BACK INTO ITS RECEPTACLE AND WIRE THE (FWD-REV) SELECTOR SWITCH INTO THE CIRCUIT BETWEEN TB1(14) AND TB1(24) AS SHOWN ON SHEET 5 OF 36B590264AB.

WITH THE SWITCH IN THE FWD POSITION, THE DRIVE CAN BE STARTED AND THE MOTOR WILL TURN IN THE FORWARD DIRECTION. WHEN THE SELECTOR SWITCH IS TURNED TO THE REV POSITION, THE MOTOR WILL DECELERATE TO A CONTROLLED STOP; CHANGE DIRECTION OF ROTATION AND ACCELERATE WITH PRESET RATE TO SET SPEED.

SOME TIMES IT IS DESIRABLE TO CONNECT THE MOTOR (OR MOTORS) TO THE INVERTER THROUGH AN AC CONTACTOR. A RUN RELAY MODIFICATION KIT (MODEL 6VRUN10) CAN BE ORDERED FOR THIS PURPOSE. THE RELAY IN THIS KIT CAN BE PLUGGED IN THE SAME MANNER AS DESCRIBED FOR THE REV RELAY, ABOVE. THE AC CONTACTOR (OR ITS AUXILIARY RELAY) SHOULD BE CONNECTED AS SHOWN ON SHEET 5, BETWEEN TB1(15) AND TB1(3).

NOTE: THE MAXIMUM SIZE AC CONTACTOR WHICH SHOULD BE CONNECTED BETWEEN THESE TWO POINTS IS NEMA SIZE 2.

NOW, WITH THE OPTION CARD PLUGGED INTO ITS RECEPTACLE, THE AC CONTACTOR (OR AUXILIARY RELAY) WILL BE ENERGIZED WHEN THE (START) PUSHBUTTON IS DEPRESSED. WITH A JUMPER FROM TB1(21) TO TB2(31), WHEN THE (STOP) PUSHBUTTON IS DEPRESSED THE MOTOR STAYS CONNECTED TO THE INVERTER OUTPUT TERMINALS THROUGH THE AC CONTACTOR UNTIL THE INVERTER HAS DECELERATED TO A STOP. WHEN THE INVERTER STOPS THE AC CONTACTOR IS DE-ENERGIZED. IF THE ABOVE MENTIONED JUMPER IS NOT USED, THE AC CONTACTOR IS ENERGIZED WHEN THE INVERTER (START) PUSHBUTTON IS DEPRESSED. NOW WHEN THE (STOP) PUSHBUTTON IS DEPRESSED THE AC CONTACTOR IS IMMEDIATELY DE-ENERGIZED AND THE AC MOTOR DECELERATES TO AN UNCONTROLLED STOP (COAST) INDEPENDENT OF THE INVERTER.

IT SHOULD ALSO BE NOTED THAT INTERLOCKS AVAILABLE ON THE RUN RELAY ARE FORM C - THE NORMALLY OPEN INTERLOCK AT TB1(16), THE NORMALLY CLOSED INTERLOCK AT TB1(17) AND THE COMMON POINT AT TB1(15).

IF IT IS DESIRABLE TO HAVE A SIGNAL WHICH INDICATES WHEN A FAULT CONDITION EXISTS IN THE INVERTER, A FAULT MODIFICATION KIT (MODEL 6VFLT10) CAN BE OBTAINED. THE RELAY IN THIS KIT SHOULD BE PLUGGED INTO ITS DESIGNATED OPTION CARD SOCKET IN A MANNER DESCRIBED FOR THE REV RELAY (ABOVE). WHEN THE OPTION CARD IS RE-INSERTED IN ITS RECEPTACLE AND THE DRIVE IS STARTED, THE FAULT (FLT) RELAY WILL BE ENERGIZED. SIGNALS INDICATING THE CONDITION OF THE RELAY ARE FROM TB1(13) TO TB1(12) A NORMALLY OPEN INTERLOCK; OR FROM TB1(14) TO TB1(12) A NORMALLY CLOSED INTERLOCK. WHEN A FAULT CONDITION OCCURS THE FAULT RELAY IS DE-ENERGIZED.

WHEN IT IS DESIRABLE TO HAVE THE INVERTER FOLLOW A PROCESS SIGNAL 0-10 VOLTS, 10-50 MA, 4-20 MA, OR 0-5 MA, A PROCESS FOLLOWER OPTION CARD (193X391A G01) CAN BE OBTAINED. THE OPTION CARD (193X391A G02) IN THE STANDARD GENERAL PURPOSE (GPI) INVERTER DRIVE SHOULD BE REMOVED. ALL RELAYS BEING USED ON THAT CARD (REV, RUN, AND FLT) CAN BE UNPLUGGED FROM THE 193X391A G02 CARD AND PLUGGED INTO THEIR DESIGNATED SOCKETS ON THE 193X391AA G01 CARD. CARE SHOULD BE TAKEN TO SUPPORT THE CARD WHEN UNPLUGGING AND PLUGGING IN THE RELAYS TO PREVENT CARD FLEXING.

THE PROCESS FOLLOWER OPTION CARD (193X391AA G01) SHOULD BE INSERTED INTO THE OPTION CARD RECEPTACLE ON TOP OF THE DRIVER RACK. THE PROCESS SIGNAL SHOULD BE BROUGHT INTO TB1(8) (POSITIVE SIGNAL) AND TB1(7) (NEGATIVE SIGNAL). NOTE THE JUMPER ON THE OPTION CARD SHOULD BE PLUGGED INTO THE PORT REPRESENTING THE FOLLOWER SIGNAL BEING USED. WHEN A MANUAL SIGNAL WILL ALSO BE USED THE POTENTIOMETER FOR THIS SIGNAL SHOULD COME FROM TB2(32) TO TB1(22) SEE SHEET 6. TO SELECT EITHER THE MANUAL SIGNAL OR THE PROCESS SIGNAL AN (AUTO-MAN) SELECTOR SWITCH MUST BE CONNECTED BETWEEN TB1(4) AND TB1(26).

FIGURE 26

GP Operating Notes & Elementary Diagram, Sheet 1C
(continued on Sheet 1D)

OPERATOR'S STATION (6VC52) HAS AN (AUTO/MAN) SELECTOR SWITCH, (START-STOP) PUSHBUTTON AND A SPEED ADJUST POTENTIOMETER TO CONTROL MANUAL SPEED. WHEN THE SELECTOR SWITCH IS IN THE MANUAL (MAN) POSITION, THE PROCESS FOLLOWER OPTION CARD (MA) RELAY IS ENERGIZED AND THE DRIVE WILL FOLLOW THE MANUAL SPEED ADJUST POTENTIOMETER SIGNAL. IN THE AUTOMATIC (AUTO) POSITION THE (MA) RELAY IS DE-ENERGIZED AND THE PROCESS SIGNAL CONTROLS THE DRIVE.

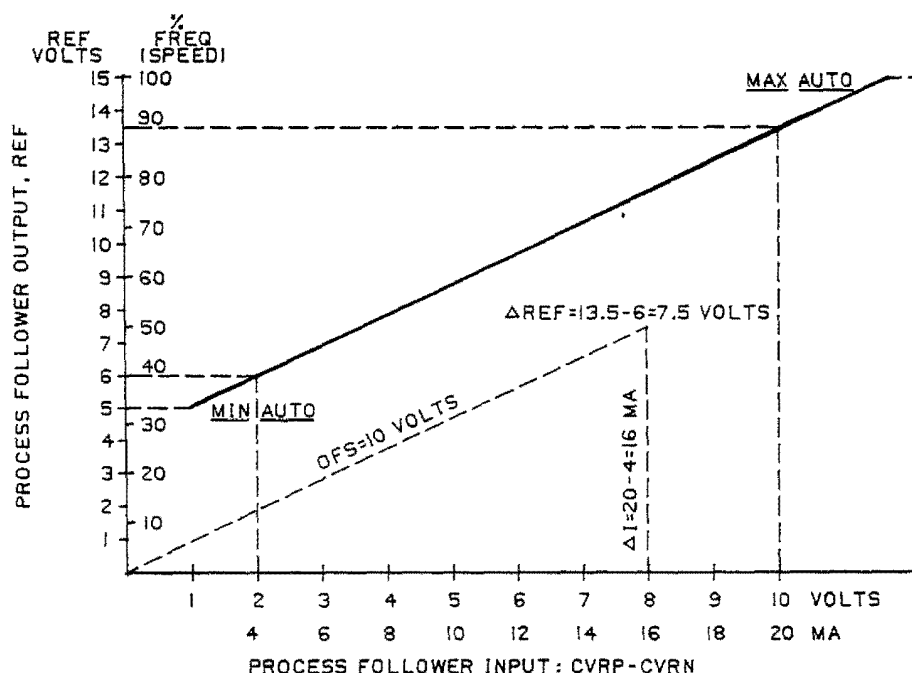
THE FOLLOWING PROCEDURE IS SUGGESTED TO SET-UP AND ADJUST THE PROCESS FOLLOWER FUNCTION.

NORMAL START UP PROCEDURE AS DESCRIBED IN GEK-24998 SHOULD BE FOLLOWED.

AFTER THE INVERTER IS OPERATING PROPERLY IN THE MANUAL MODE (MA RELAY PICKED UP), THE PROCESS FOLLOWER FUNCTION CAN BE ADJUSTED. THE SAMPLE CASE DESCRIBED BELOW ASSUMES A MANUAL SETUP AT 100% FREQUENCY (SPEED) WITH A REFERENCE OF 15 VOLTS AT REF, TB2(32). IN THE AUTO MODE A PROCESS CONTROLLER SIGNAL OF 4 TO 20 MILLIAMPERES IS CHOSEN TO COVER FROM 40% TO 90% OF THE MANUAL FREQUENCY (SPEED) RANGE AS INDICATED IN FIG. 27.

- A) ADJUST THE "OFFSET" POT TO MAKE THE (OPS) TEST POST VOLTAGE EQUAL 10 VOLTS. (THIS PRELIMINARY ADJUSTMENT SETS THE OFFSET TO ZERO).
- B) GAIN: APPLY AN INPUT SIGNAL EQUAL TO THE MAXIMUM CHANGE IN PROCESS CONTROLLER SIGNAL, I.E. $\Delta I = 20 - 4 = 16 \text{ MA}$. (THIS CORRESPONDS TO A VOLTAGE OF 8 VOLTS BETWEEN CVRP AND CVRN.) ADJUST THE GAIN POT SUCH THAT THE VOLTAGE AT REF, TB2(32) EQUALS THE VOLTAGE DIFFERENCE AT MAXIMUM (90%) AND MINIMUM (40%) FREQUENCY (SPEED); I.E., $\Delta \text{REF} = 13.5 - 6 = 7.5 \text{ VOLTS}$. (THIS SETS THE DESIRED SLOPE OF THE OUTPUT VS. INPUT CURVE.)
- C) MIN AUTO: TURN THE OFFSET POTENTIOMETER CCW UNTIL THE REF VOLTAGE IS LESS THEN THE DESIRED MIN LEVEL. TURN THE MIN AUTO POT CW UNTIL THE REF VOLTAGE EQUALS THE MIN DESIRED LEVEL (A LEVEL OF 5V OR 33% FREQ. IS INDICATED ON FIG. 27).

FIG.27



- D) MAX AUTO: TURN THE OFFSET POT CW UNTIL THE REF VOLTAGE EXCEEDS THE MAX. DESIRED LEVEL. TURN THE MAX AUTO POT CCW UNTIL THE REF VOLTAGE EQUALS THE MAX. DESIRED LEVEL. (A MAX. LEVEL OF 15V OF 100% FREQ. IS INDICATED IN FIG. 27).
- E) OFFSET: INCREASE THE INPUT SIGNAL TO THE MAX. RATED LEVEL (20MA IN THIS CASE). ADJUST THE OFFSET POT SUCH THAT THE REF VOLTAGE EQUALS THE MAX. OPERATING LEVEL, I.E. REF=13.5 VOLTS OR 90% FREQUENCY (SPEED).

FIGURE 26

THE DRIVE CAN BE ARRANGED TO SWITCH FROM THE FORWARD TO THE REVERSE DIRECTION OF ROTATION, ELECTRONICALLY. TO ACCOMPLISH THIS A REVERSING MODIFICATION KIT (MODEL 6VREV10) SHOULD BE ORDERED. THE OPTION CARD (CAT.193X391AA.G02) SHOULD BE REMOVED FROM THE RECEPTACLE AND SUPPORTED SO THE RELAY FROM THE MODIFICATION KIT CAN BE PLUGGED INTO ITS DESIGNATED CARD SOCKET WITHOUT FLEXING THE PRINTED CIRCUIT CARD. IN ADDITION TO THE REVERSING MODIFICATION KIT, IT WILL BE NECESSARY TO PROVIDE AN OPERATORS STATION WITH A (FWD-REV) SELECTOR SWITCH SUCH AS MODEL 6VOC82. AFTER PLUGGING IN THE REVERSING RELAY, INSERT THE OPTION CARD BACK INTO ITS RECEPTACLE AND WIRE THE (FWD-REV) SELECTOR SWITCH INTO THE CIRCUIT BETWEEN TBI(14) AND TBI(24) AS SHOWN ON SHEET 5 OF 36B590264AB.

WITH THE SWITCH IN THE FWD POSITION, THE DRIVE CAN BE STARTED AND THE MOTOR WILL TURN IN THE FORWARD DIRECTION. WHEN THE SELECTOR SWITCH IS TURNED TO THE REV POSITION, THE MOTOR WILL DECELERATE TO A CONTROLLED STOP; CHANGE DIRECTION OF ROTATION AND ACCELERATE WITH PRESET RATE TO SET SPEED.

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NOTE: THE MAXIMUM SIZE AC CONTACTOR WHICH SHOULD BE CONNECTED BETWEEN THESE TWO POINTS IS NEMA SIZE 2.

NOW, WITH THE OPTION CARD PLUGGED INTO ITS RECEPTACLE, THE AC CONTACTOR (OR AUXILIARY RELAY) WILL BE ENERGIZED WHEN THE (START) PUSHBUTTON IS DEPRESSED. WITH A JUMPER FROM TBI(21) TO TB2(31), WHEN THE (STOP) PUSHBUTTON IS DEPRESSED THE MOTOR STAYS CONNECTED TO THE INVERTER OUTPUT TERMINALS THROUGH THE AC CONTACTOR UNTIL THE INVERTER HAS DECELERATED TO A STOP. WHEN THE INVERTER STOPS THE AC CONTACTOR IS DE-ENERGIZED. IF THE ABOVE MENTIONED JUMPER IS NOT USED, THE AC CONTACTOR IS ENERGIZED WHEN THE INVERTER (START) PUSHBUTTON IS DEPRESSED. NOW WHEN THE (STOP) PUSHBUTTON IS DEPRESSED THE AC CONTACTOR IS IMMEDIATELY DE-ENERGIZED AND THE AC MOTOR DECELERATES TO AN UNCONTROLLED STOP (COAST) INDEPENDENT OF THE INVERTER.

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FIGURE 26

GP Operating Notes & Elementary Diagram, Sheet 1C
(continued on Sheet 1D)

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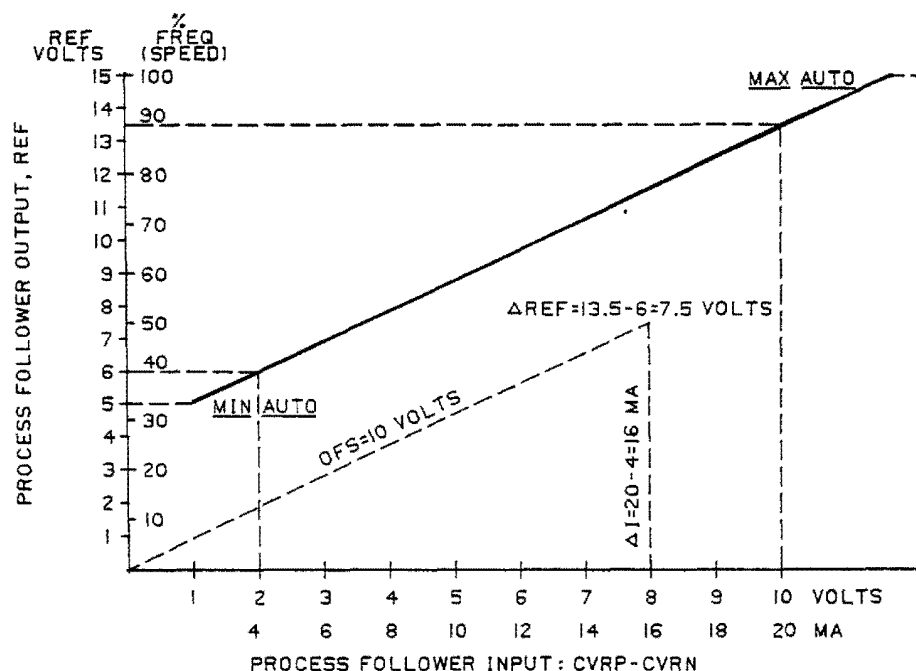
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WITH THE SWITCH IN THE FWD POSITION, THE DRIVE CAN BE STARTED AND THE MOTOR WILL TURN IN THE FORWARD DIRECTION. WHEN THE SELECTOR SWITCH IS TURNED TO THE REV POSITION, THE MOTOR WILL DECELERATE TO A CONTROLLED STOP. CHANGE DIRECTION OF ROTATION AND ACCELERATE WITH PRESET RATE TO SET SPEED.

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NOTE: THE MAXIMUM SIZE AC CONTACTOR WHICH SHOULD BE CONNECTED BETWEEN THESE TWO POINTS IS NEMA SIZE 2.

NOW, WITH THE OPTION CARD PLUGGED INTO ITS RECEPTACLE, THE AC CONTACTOR (OR AUXILIARY RELAY) WILL BE ENERGIZED WHEN THE (START) PUSHBUTTON IS DEPRESSED. WITH A JUMPER FROM TBI(21) TO TB2(31), WHEN THE (STOP) PUSHBUTTON IS DEPRESSED THE MOTOR STAYS CONNECTED TO THE INVERTER OUTPUT TERMINALS THROUGH THE AC CONTACTOR UNTIL THE INVERTER HAS DECELERATED TO A STOP. WHEN THE INVERTER STOPS THE AC CONTACTOR IS DE-ENERGIZED. IF THE ABOVE MENTIONED JUMPER IS NOT USED, THE AC CONTACTOR IS ENERGIZED WHEN THE INVERTER (START) PUSHBUTTON IS DEPRESSED. NOW WHEN THE (STOP) PUSHBUTTON IS DEPRESSED THE AC CONTACTOR IS IMMEDIATELY DE-ENERGIZED AND THE AC MOTOR DECELERATES TO AN UNCONTROLLED STOP (COAST) INDEPENDENT OF THE INVERTER.

IT SHOULD ALSO BE NOTED THAT INTERLOCKS AVAILABLE ON THE RUN RELAY ARE FORM C- THE NORMALLY OPEN INTERLOCK AT TBI(16), THE NORMALLY CLOSED INTERLOCK AT TBI(17) AND THE COMMON POINT AT TBI(15).

IF IT IS DESIRABLE TO HAVE A SIGNAL WHICH INDICATES WHEN A FAULT CONDITION EXISTS IN THE INVERTER, A FAULT MODIFICATION KIT (MODEL 6VFLT10) CAN BE OBTAINED. THE RELAY IN THIS KIT SHOULD BE PLUGGED INTO ITS DESIGNATED OPTION CARD SOCKET IN A MANNER DESCRIBED FOR THE REV RELAY (ABOVE). WHEN THE OPTION CARD IS RE-INSERTED IN ITS RECEPTACLE AND THE DRIVE IS STARTED, THE FAULT (FLT) RELAY WILL BE ENERGIZED. SIGNALS INDICATING THE CONDITION OF THE RELAY ARE FROM TBI(13) TO TBI(12) A NORMALLY OPEN INTERLOCK; OR FROM TBI(14) TO TBI(12) A NORMALLY CLOSED INTERLOCK. WHEN A FAULT CONDITION OCCURS THE FAULT RELAY IS DE-ENERGIZED.

WHEN IT IS DESIRABLE TO HAVE THE INVERTER FOLLOW A PROCESS SIGNAL 0-10 VOLTS, 10-50 MA, 4-20 MA, OR 0-5 MA, A PROCESS FOLLOWER OPTION CARD (193X391A AG01) CAN BE OBTAINED. THE OPTION CARD (193X391A AG02) IN THE STANDARD GENERAL PURPOSE (GP) INVERTER DRIVE SHOULD BE REMOVED. ALL RELAYS BEING USED ON THAT CARD (REV, RUN, AND FLT) CAN BE UNPLUGGED FROM THE 193X391A AG02 CARD AND PLUGGED INTO THEIR DESIGNATED SOCKETS ON THE 193X391AA G01 CARD. CARE SHOULD BE TAKEN TO SUPPORT THE CARD WHEN UNPLUGGING AND PLUGGING IN THE RELAYS TO PREVENT CARD FLEXING.

THE PROCESS FOLLOWER OPTION CARD (193X391AA G01) SHOULD BE INSERTED INTO THE OPTION CARD RECEPTACLE ON TOP OF THE DRIVER RACK. THE PROCESS SIGNAL SHOULD BE BROUGHT INTO TBI(8) (POSITIVE SIGNAL) AND TBI(7) (NEGATIVE SIGNAL). NOTE THE JUMPER ON THE OPTION CARD SHOULD BE PLUGGED INTO THE PORT REPRESENTING THE FOLLOWER SIGNAL BEING USED. WHEN A MANUAL SIGNAL WILL ALSO BE USED THE POTENTIOMETER FOR THIS SIGNAL SHOULD COME FROM TB2(32) TO TBI(22) SEE SHEET 6. TO SELECT EITHER THE MANUAL SIGNAL OR THE PROCESS SIGNAL AN (AUTO-MAN) SELECTOR SWITCH MUST BE CONNECTED BETWEEN TBI(4) AND TBI(26).

OPERATOR'S STATION (6VC52) HAS AN (AUTO/MAN) SELECTOR SWITCH, (START-STOP) PUSHBUTTON AND A SPEED ADJUST POTENTIOMETER TO CONTROL MANUAL SPEED. WHEN THE SELECTOR SWITCH IS IN THE MANUAL (MAN) POSITION, THE PROCESS FOLLOWER OPTION CARD (MA) RELAY IS ENERGIZED AND THE DRIVE WILL FOLLOW THE MANUAL SPEED ADJUST POTENTIOMETER SIGNAL. IN THE AUTOMATIC (AUTO) POSITION THE (MA) RELAY IS DE-ENERGIZED AND THE PROCESS SIGNAL CONTROLS THE DRIVE.

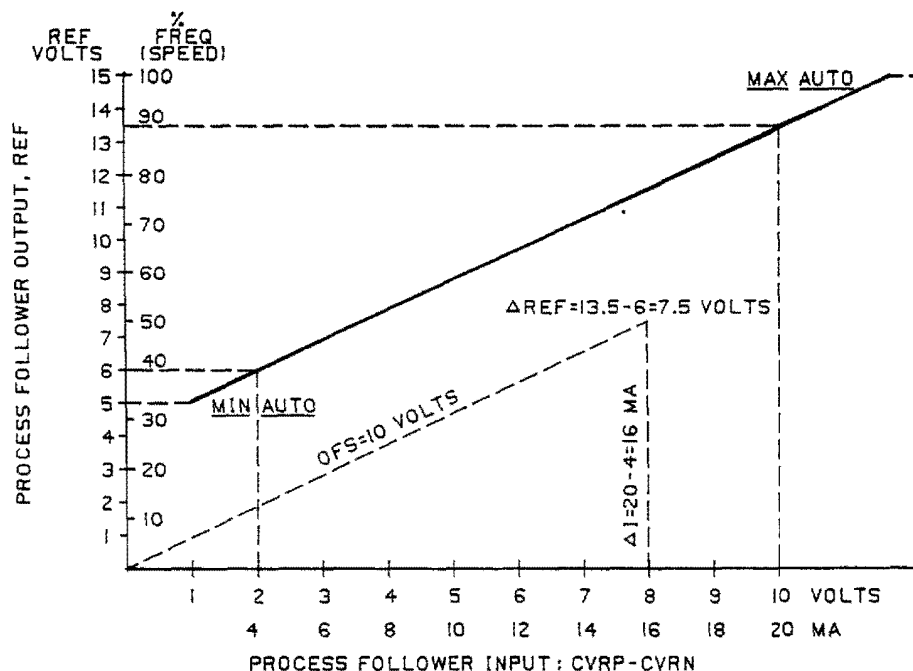
THE FOLLOWING PROCEDURE IS SUGGESTED TO SET-UP AND ADJUST THE PROCESS FOLLOWER FUNCTION.

NORMAL START UP PROCEDURE AS DESCRIBED IN GEK-24998 SHOULD BE FOLLOWED.

AFTER THE INVERTER IS OPERATING PROPERLY IN THE MANUAL MODE (MA RELAY PICKED UP), THE PROCESS FOLLOWER FUNCTION CAN BE ADJUSTED. THE SAMPLE CASE DESCRIBED BELOW ASSUMES A MANUAL SETUP AT 100% FREQUENCY (SPEED) WITH A REFERENCE OF 15 VOLTS AT REF, TB2(32). IN THE AUTO MODE A PROCESS CONTROLLER SIGNAL OF 4 TO 20 MILLIAMPERES IS CHOSEN TO COVER FROM 40% TO 90% OF THE MANUAL FREQUENCY (SPEED) RANGE AS INDICATED IN FIG. 27.

- A) ADJUST THE "OFFSET" POT TO MAKE THE (OPS) TEST POST VOLTAGE EQUAL 10 VOLTS. (THIS PRELIMINARY ADJUSTMENT SETS THE OFFSET TO ZERO).
- B) GAIN: APPLY AN INPUT SIGNAL EQUAL TO THE MAXIMUM CHANGE IN PROCESS CONTROLLER SIGNAL, I.E. $\Delta I = 20 - 4 = 16 \text{ MA}$. (THIS CORRESPONDS TO A VOLTAGE OF 8 VOLTS BETWEEN CVRP AND CVRN.) ADJUST THE GAIN POT SUCH THAT THE VOLTAGE AT REF, TB2(32) EQUALS THE VOLTAGE DIFFERENCE AT MAXIMUM (90%) AND MINIMUM (40%) FREQUENCY (SPEED); I.E., $\Delta \text{REF} = 13.5 - 6 = 7.5 \text{ VOLTS}$. (THIS SETS THE DESIRED SLOPE OF THE OUTPUT VS. INPUT CURVE.)
- C) MIN AUTO: TURN THE OFFSET POTENTIOMETER CCW UNTIL THE REF VOLTAGE IS LESS THEN THE DESIRED MIN LEVEL. TURN THE MIN AUTO POT CW UNTIL THE REF VOLTAGE EQUALS THE MIN DESIRED LEVEL (A LEVEL OF 5V OR 33% FREQ. IS INDICATED ON FIG. 27).

FIG.27



- D) MAX AUTO: TURN THE OFFSET POT CW UNTIL THE REF VOLTAGE EXCEEDS THE MAX. DESIRED LEVEL. TURN THE MAX AUTO POT CCW UNTIL THE REF VOLTAGE EQUALS THE MAX. DESIRED LEVEL. (A MAX. LEVEL OF 15V OF 100% FREQ. IS INDICATED IN FIG. 27).
- E) OFFSET: INCREASE THE INPUT SIGNAL TO THE MAX. RATED LEVEL (20MA IN THIS CASE). ADJUST THE OFFSET POT SUCH THAT THE REF VOLTAGE EQUALS THE MAX. OPERATING LEVEL, I.E. REF=13.5 VOLTS OR 90% FREQUENCY (SPEED).

FIGURE 26

THE REF VOLTAGE SHOULD NOW FOLLOW THE HEAVY CURVE OF FIG. 27 AS THE INPUT IS CHANGED FROM 4 THROUGH 20 MILLIAMPERES.

IF FINE TUNING IS REQUIRED, ADJUST THE OFFSET AT MINIMUM LEVEL AND THE GAIN AT MAXIMUM LEVEL.

NOTE: A CHANGE IN THE GAIN SETTING WILL ALSO AFFECT THE OFFSET.

IN ORDER TO OBTAIN AN INDICATION OF THE INVERTER LOAD, LOAD INDICATOR KIT, (6VLI12) MAY BE ORDERED. THE INSTRUMENT IN THE KIT IS CONNECTED TO THE CURRENT ISOLATOR TB3(LCS) AND TB3(COM). SEE 36B590264AB SH.4. AN ENCLOSURE (MODEL 6VIE11) FOR THE LOAD INDICATOR MAY ALSO BE ORDERED.

AN INDICATION OF MOTOR SPEED CAN BE OBTAINED BY ORDERING A SPEED INDICATOR KIT (6VSI12). THIS INSTRUMENT IN THE KIT IS CONNECTED TO THE FREQUENCY VOLTAGE READ OUT SIGNAL (FVR), TB2(44) AND COM TB2(48). SEE 36B590264AB SH.6. AN ENCLOSURE (MODEL 6VIE11) FOR THE SPEED INDICATOR MAY ALSO BE ORDERED.

IN THE EVENT AN ENCLOSURE IS DESIRED FOR BOTH A LOAD INDICATOR AND A SPEED INDICATOR AN ENCLOSURE (MODEL 6VIE12) FOR TWO INSTRUMENTS MAY ALSO BE ORDERED.


DIGITAL FOLLOWER OPERATION

IN THE AUTO MODE THE DRIVE CAN FOLLOW A FREQUENCY REFERENCE SIGNAL INSTEAD OF A PROCESS FOLLOWER SIGNAL. THE RELAY OPTION CARD, 193X391AAG02, INCLUDING THE MAN/AUTO RELAY KIT, 6VRA10A1, MUST BE USED.

THE FREQUENCY REFERENCE IS A PULSE TRAIN OF SIX TIMES THE DESIRED INVERTER FREQUENCY APPLIED BETWEEN DPF, TB1(23) AND COM, TB1(18). THIS SIGNAL CAN BE GENERATED BY THE DIGITAL MASTER REFERENCE STATION, 6VDMR10A1.

TO ENABLE THE FREQUENCY/PHASE COMPARATOR CIRCUITRY ON THE REGULATOR, SYNC, TB2(42) MUST BE CONNECTED TO COMMON. AN EXTRA CONTACT ON THE MAN/AUTO SELECTOR SWITCH MAY BE USED FOR THIS PURPOSE.

SYMBOLS

- ☐ SUPPLIED BY OTHERS, REMOTELY MOUNTED
 △ OPTIONAL FEATURE - SPECIAL PLUG IN RELAY FOR OPTION CARDS, (193X391AAG01 & G02)
☐ SPECIAL OPTION CARD WITH ADDITION PROCESS FOLLOWER FEATURES (193X391AAG01)
 TWISTED WIRE
 ▲ SUPPRESSED COIL

CARD

COMPONENT NOMENCLATURE

CI	- CONVERTER FILTER CAPACITORS
CB	- CIRCUIT BREAKER
CONV.MOD.	- AC TO DC CONVERSION MODULE
CURR.ISOL.	- CURRENT ISOLATOR CARD
FU 1-3	- MAIN POWER AC FUSES
FU 4-6	- CONTROL CIRCUIT FUSES
FU 7	- 115V AC CONTROL POWER FUSE
FLT	- FAULT RELAY-OPTION CARD
IS	- INVERTER START RELAY-OPTION CARD
LI	- CONVERTER FILTER REACTOR
LSH	- D.C. LINK SHUNT
MA	- A.C. MOTOR CONTRACTOR
MS	- AUTO.-MANUAL RELAY-OPTION CARD
MSR	- MINIMUM SPEED RELAY-OPTION CARD
OL	- MOTOR STARTER OVERLOAD CONTACT
PB 1-2	- PUSH BUTTONS
PH.MOD. A-C	- INVERTER PHASE MODULES
PLUG	- J1, J32, JX1, JX11, JX32 ARE DRIVER BACKPLANE PLUGS. A-D PL ARE FIRING HARNESS MODULE PLUGS.
RI	- CAPACITOR DISCHARGE RESISTOR
REV	- REVERSING RELAY-OPTION CARD
RF 1-7	- ISOLATION FEEDBACK RESISTORS
RUN	- RUN RELAY-OPTION CARD
SW 1-2	- SELECTOR SWITCH
TB 1-3	- TERMINAL BOARDS
THSW	- THERMAL SWITCH INVERTER AIR
TX1	- CONTROL TRANSFORMER

POTENTIOMETER NOMENCLATURE

AUTO.MAX.	- MAX. SPEED ADJ.-PROCESS FOLLOWER
AUTO.MIN.	- MIN. SPEED ADJ.-PROCESS FOLLOWER
ATIM	- ACCEL. TIME ADJ.-REGULATOR
BF	- BASE FREQUENCY ADJ.-REGULATOR
CFA	- CURRENT FEEDBACK ADJ.-CURR.ISOL.
CLIM	- CURRENT LIMIT ADJ.-REGULATOR
CLST	- CURR. LIM. STABILITY ADJ.-REGULATOR
DTIM	- DECEL. TIME ADJ.-REGULATOR
GAIN	- GAIN ADJ.-PROCESS FOLLOWER
IRC	- IR COMPENSATION ADJ.-REGULATOR
MINF	- MINIMUM FREQ. ADJ.-REGULATOR
OFFSET	- OFFSET ADJ.-PROCESS FOLLOWER
STAB	- STABILITY ADJ.-REGULATOR
VB	- VOLTAGE BOOST ADJ.-REGULATOR
V/HZ	- VOLTS PER HERTZ ADJ.-REGULATOR
VLIM	- VOLTAGE LIMIT ADJ.-REGULATOR

CARD

INDICATING LIGHTS

ITOC	- INVERSE TIME OVERCURRENT TRIP-INVERTER
IF	- INVERTER FREQUENCY-SYSTEM
SYNC	- INVERTER LINE SYNCHRONIZED-SYSTEM
LOV	- LINK OVERVOLTAGE TRIP-CONVERTER
PS/LOP	- PH. SEQ/LOSS OF PHASE TRIP-CONVERTER
IOC	- INSTANTANEOUS OVERCURRENT TRIP-INVERTER
IOF	- INVERTER OVERFREQUENCY TRIP-INVERTER
COC	- COMMUTATION OVERCURRENT TRIP-INVERTER
CUV	- CONTROL UNDERVOLTAGE TRIP-INVERTER

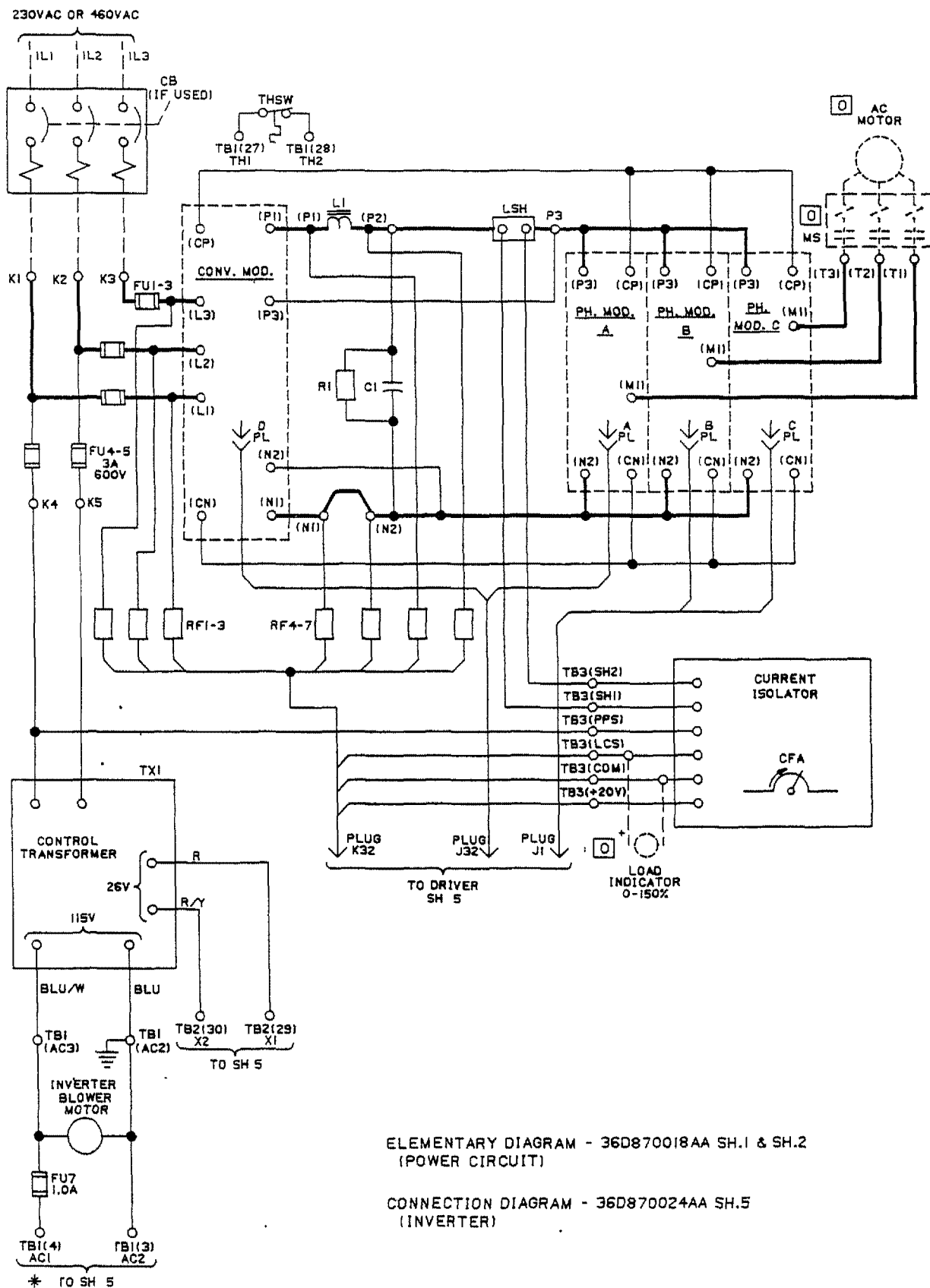
FIGURE 26
 GP Operating Notes & Elementary Diagram, Sheet 2
 (continued on Sheet 3)

TERMINAL BOARD NOMENCLATURE

AC1	-	CONTROL TRANSFORMER-115V FUSED LINE
AC2	-	CONTROL TRANSFORMER-GROUNDED LINE
AC3	-	CONTROL TRANSFORMER -115V UNFUSED LINE
COM	-	COMMON POINT-CONTROL
CVRN	-	CURRENT/VOLTAGE REFERENCE-NEGATIVE
CVRP	-	CURRENT/VOLTAGE REFERENCE-POSITIVE
DIG	-	DIGITAL REFERENCE-INPUT
<u>DMF</u>	-	DECELERATE TO MINIMUM FREQUENCY SIGNAL
DPF	-	DIGITAL FOLLOWER REFERENCE
FLTC	-	FAULT RELAY INTERLOCK-COMMON
FLTNC	-	FAULT RELAY INTERLOCK-NORMALLY CLOSED
FLTNO	-	FAULT RELAY INTERLOCK-NORMALLY OPEN
FTR	-	FAULT TRIP READ OUT SIGNAL
FVR	-	FREQUENCY VOLTAGE READOUT SIGNAL
IPAD	-	INVERTER PHASE "A" LOGIC SIGNAL
ISA	-	INVERTER START RELAY COIL
ISS	-	INVERTER START-SEAL
LCS	-	LINK CURRENT SIGNAL
MAA	-	MANUAL AUTO RELAY COIL
MSRC	-	MIN. SPEED RELAY-COMMON
MSRNC	-	MIN. SPEED RELAY-NORMALLY CLOSED
MSRNO	-	MIN. SPEED RELAY-NORMALLY OPEN
MVFR	-	MIN. VOLTAGE AND FREQUENCY READOUT
PPS	-	PRIMARY POWER SUPPLY INPUT (CURR. ISOL.)
REF	-	REFERENCE INPUT SIGNAL
REVA	-	REVERSING RELAY COIL
RFVX	-	FREQUENCY/VOLTAGE REFERENCE
RMA	-	REFERENCE MANUAL-AUTO
RMAX	-	REFERENCE POTENTIOMETER-MAXIMUM CONNECTION
RMIN	-	REFERENCE POTENTIOMETER-MINIMUM CONNECTION
RT30	-	RECTIFIED 30V D.C.
RUNA	-	RUN RELAY COIL
RUNC	-	RUN INTERLOCK-COMMON
RUNNC	-	RUN INTERLOCK-NORMALLY CLOSED
RUNNO	-	RUN INTERLOCK-NORMALLY OPEN
RUNR	-	RUN READ OUT
<u>SR</u>	-	INVERTER SYNCHRONIZED READOUT SIGNAL
<u>START</u>	-	DRIVE START INPUT SIGNAL
<u>STOP</u>	-	DRIVE STOP INPUT SIGNAL
<u>SYNC</u>	-	INVERTER SYNCHRONIZED COMMAND SIGNAL
TH 1-2	-	THERMAL SWITCH TERMINALS
VPH	-	VOLTS/HZ PROGRAMMING INPUT
X 1-2	-	CONTROL TRANSFORMER-26V A.C. TERMINALS
XFR	-	EXTERNAL FAULT RESET INPUT SIGNAL
+20V	-	+20V D.C. REGULATED POWER SUPPLY

— BAR OVER LOGIC SYMBOL INDICATES LOW LOGIC STATE

FIGURE 26
GP Operating Notes & Elementary Diagram, Sheet 3
(continued on Sheet 4)



ELEMENTARY DIAGRAM - 36D870018AA SH.1 & SH.2
(POWER CIRCUIT)

CONNECTION DIAGRAM - 36D870024AA SH.5
(INVERTER)

* 0.4 AMPS AVAILABLE FOR EXTERNAL USE

FIGURE 28
GP Operating Notes & Elementary Diagram, Sheet 4
(continued on Sheet 5)

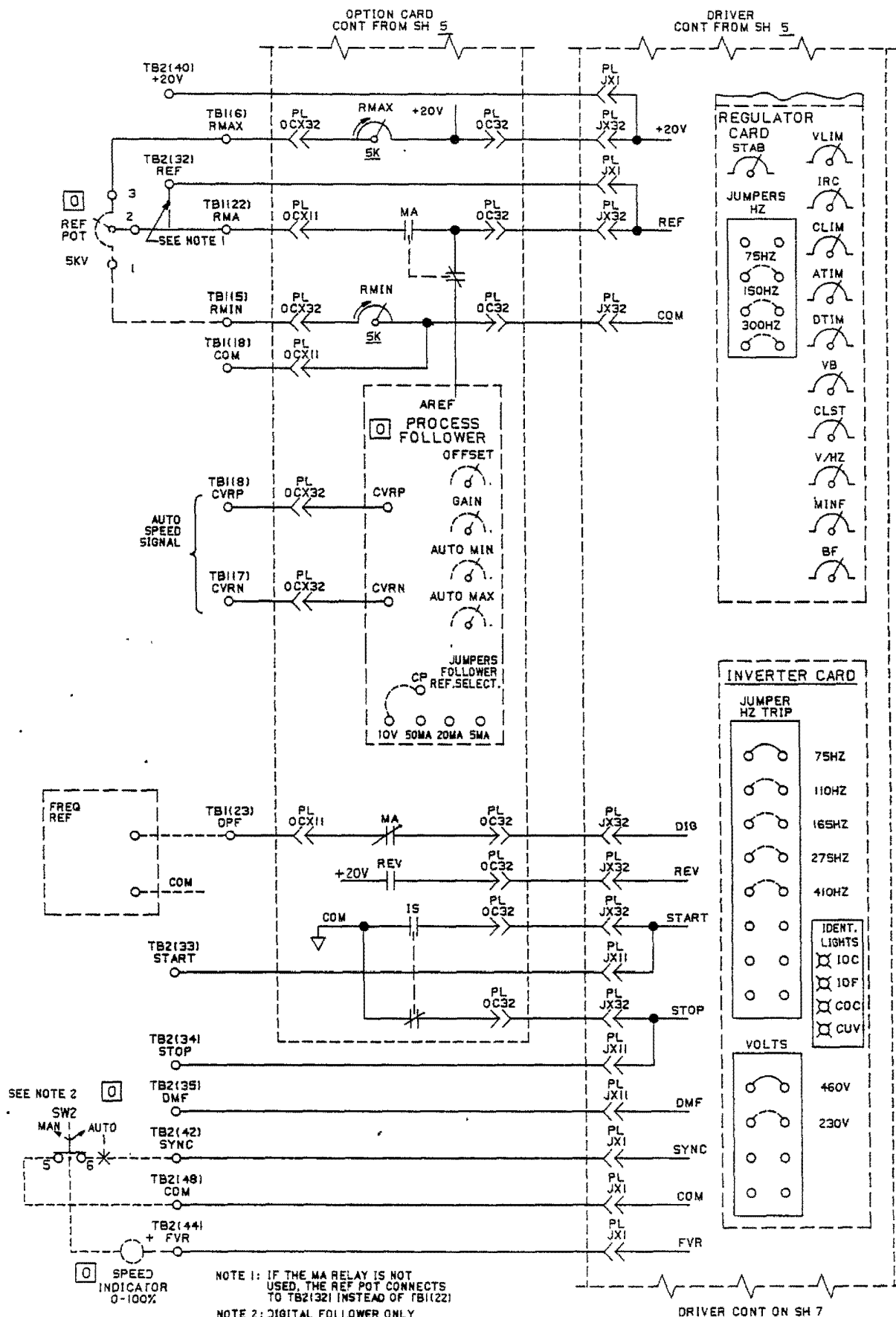


FIGURE 26
GP Operating Notes & Elementary Diagram, Sheet 6
(continued on Sheet 7)

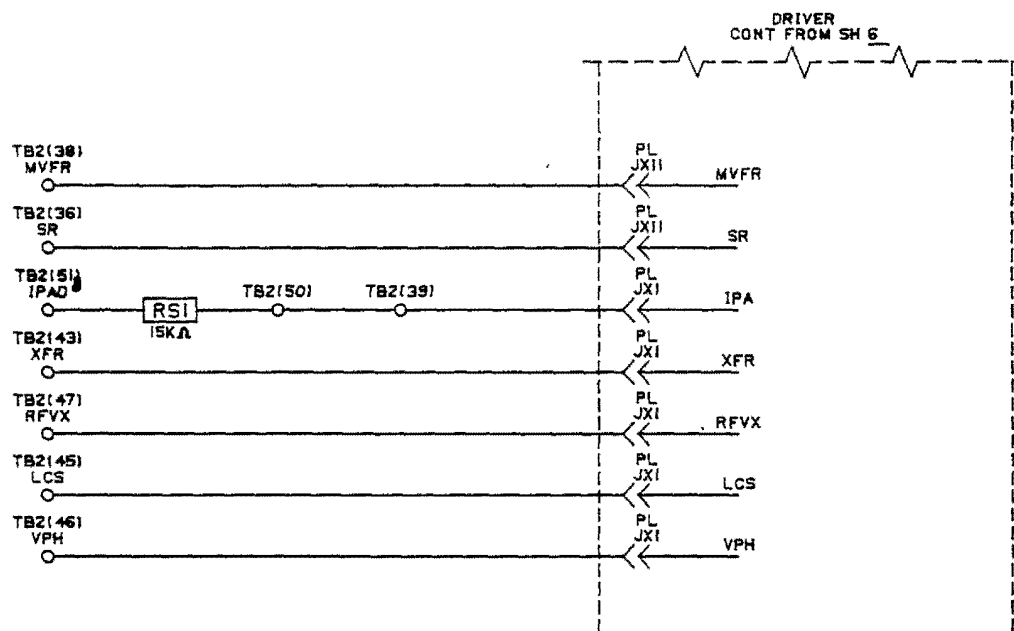
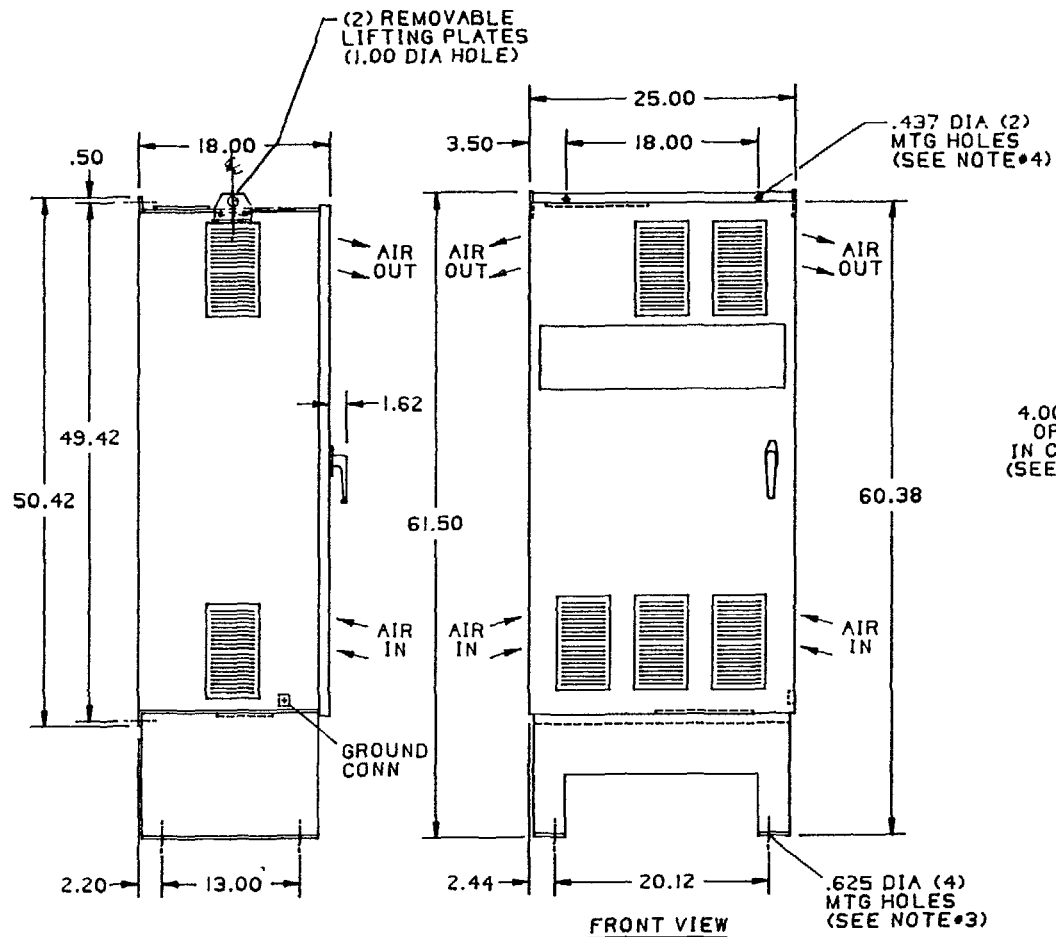


FIGURE 26
GP Operating Notes & Elementary Diagram, Sheet 7



NOTES:

1. NO MECHANICAL CLEARANCE REQUIRED AT BACK.
2. LIFT OFF DOOR OPENS 180°.
3. CASE CAN BE BOLTED DOWN THRU HOLES PROVIDED IN BASE FEET.
4. CASE CAN BOLTED TO A WALL THRU HOLES PROVIDED IN TOP FLANGE.
5. CONDUIT ENTRY HOLES WITH REMOVABLE COVERS ARE PROVIDED IN TOP AND BOTTOM OF CASE.

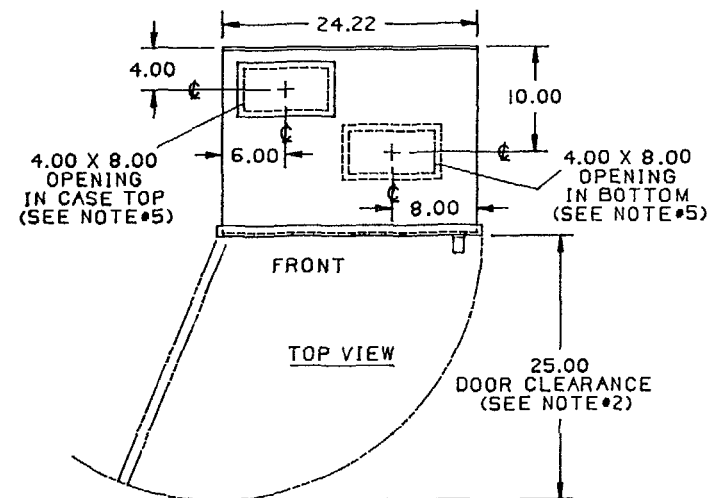


FIGURE 27
AF-400 Drive GP Outline Diagram
(36B605389AA)

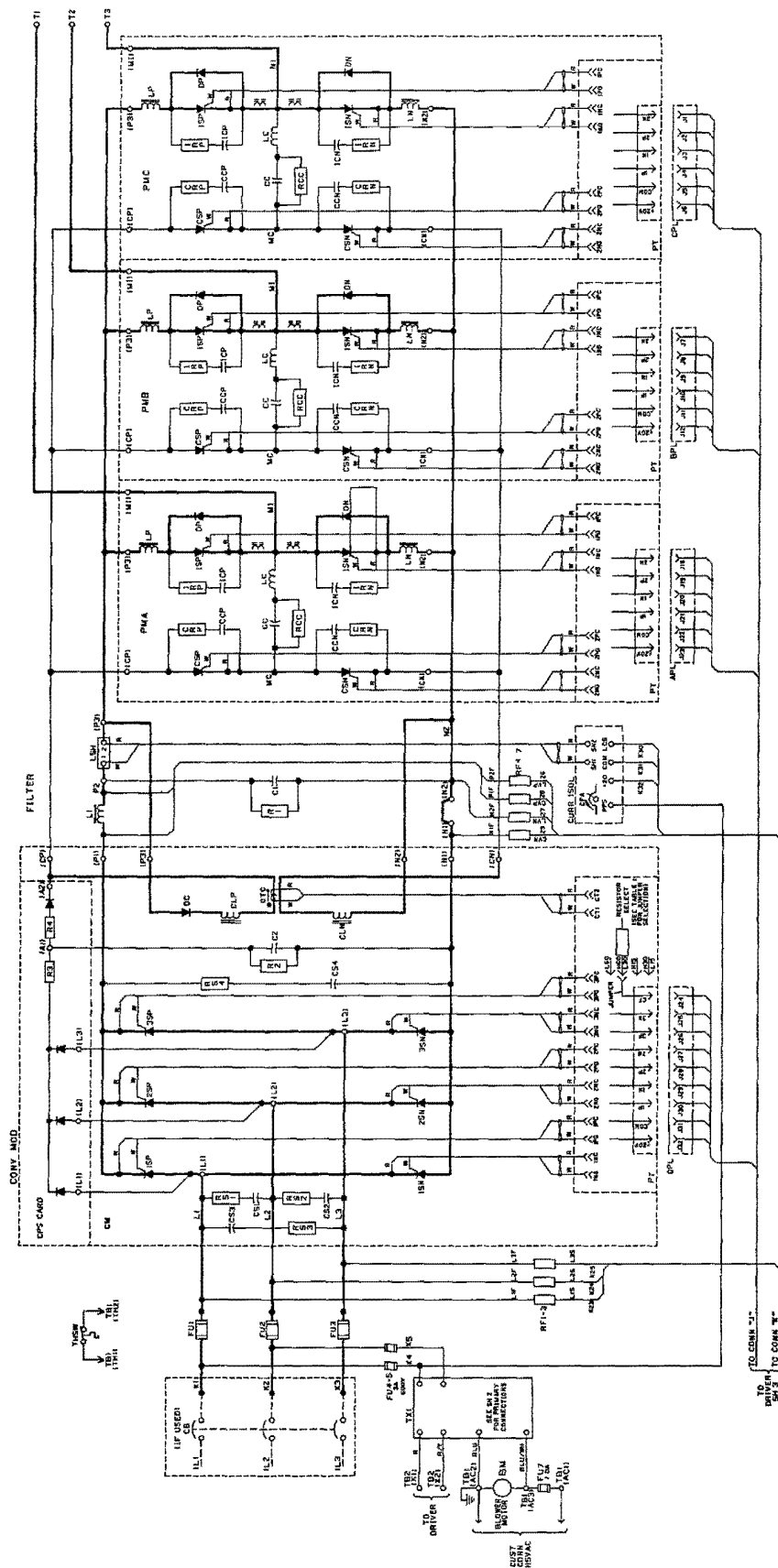
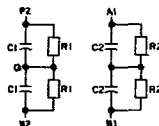


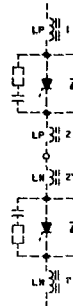
FIGURE 28A
AF-400 Drive GP Inverter Elementary Diagram
(36D870018AA, Sheet 1)

NOTES

1. FOR 460V UNITS ACTUAL CAPACITOR CONNECTIONS ARE



3. LEG REACTORS ARE MOUNTED IN POSITION 2, Z* FOR PHASE MODULES WITH STUD MOUNTED SCRS AND IN POSITION 1, P* FOR PHASE MODULES WITH PRESSPAK SCRS



2. TABLE 1

VOLTAGE	RATING	OUTPUT CURRENT	OUTPUT MAX BASE FREQ DC	FUI-3	LI	CC	RCC	LC	LP LB CLP, CLN	SHUNT SELECT	C1	R1	R2	C2	R3*	R4*	RSI-3	CSI-4	RFI-7	CCP, CCN TCP, ICN	IRP, IRN	CRP, CRN	RS4	C F PT CARD	RATING
V	KVA	AMP	AMP	AMP	μH	μF	KΩ/W	μH	μH	AMP	μF	Ω/W	KΩ/W	μF	Ω/W	Ω/W	Ω/W	Ω/W	Ω/W	Ω/W	Ω/W	Ω/W	Ω/W	Ω/W	KVA
460	60	84	150HZ	175	2400	23	600/4	24	8	100	2800	4000/200	200/4	112	750/40	20/40	10/20	22	3	22	10/20	20/20	40/20	H60/L30	60
	30	42	150HZ	60	4800	10	600/4	47	16	50	1400	5000/100	200/4	112	750/40	20/40	10/20	22	3	22	20/20	20/20	40/20	H30/L15	30
	15	21	150HZ	35	9600	5	1000/2	95	32	24	700	5000/100	200/4	112	1500/20	40/20	10/20	22	3	22	20/20	20/20	40/20	H15	15
230	60	168	200HZ	300	600	40	270/2	3	1	174	11200	1000/200	100/2	225	250/40	5/40	5/20	22	15	22	5/20	10/20	40/20	L60	60
	30	84	300HZ	100	1200	20	270/2	6	2	100	5600	2500/100	100/2	225	250/40	5/40	5/20	22	15	22	10/20	10/20	40/20	H60/L30	30
	15	42	300HZ	60	2400	10	560/2	12	4	50	2800	2500/100	100/2	225	500/20	10/20	5/20	22	15	22	10/20	10/20	40/20	H30/L15	15
460	60	84	200HZ	175	2400	20	600/4	24	8	100	2800	4000/200	200/4	112	750/40	20/40	10/20	22	3	22	10/50	20/50	40/20	H60/L30	60
	30	42	200HZ	60	4800	10	600/4	47	16	50	1400	5000/100	200/4	112	750/40	20/40	10/20	22	3	22	20/20	20/20	40/20	H30/L15	30
	15	21	200HZ	35	9600	5	1000/2	95	32	24	700	5000/100	200/4	112	1500/20	40/20	10/20	22	3	22	20/20	20/20	40/20	H15	15

* MOUNTED ON CP5 BOARD

** MOUNTED IN LINE WITH WIRE

4. ELEMENTARY WIRING SYMBOLS

- INDICATES TWISTED WIRES, COLOR INDICATED BY LETTER

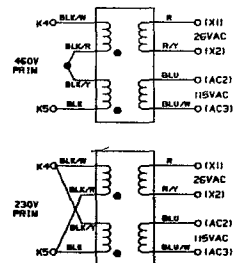
- INDICATES FLAT CABLE WITH DISCONNECT PLUG

- QUICK DISCONNECT "STAB-ON" CONNECTION

- DOT INDICATES POSITIVE TERMINAL WHEN CURRENT FLOWS IN THE DIRECTION OF THE ARROW

5. REFER TO THE CONNECTION DIAGRAM FOR A PHYSICAL REPRESENTATION OF THIS ASSEMBLY

6. CONTROL TRANSFORMER(TX1) CONNECTIONS



NOMENCLATURE

C1 -DC FILTER CAPACITOR
C2 -COMMUTATION POWER SUPPLY FILTER CAPACITOR
CB -CIRCUIT BREAKER (OPTIONAL)
CC -COMMUTATION CAPACITOR, PHASE MODULE
CCP, CCN -COMMUTATION SCR SNUBBER CAPACITORS
CLP, CLN -COMMUTATION LEG REACTORS
CM -CONVERSION MODULE (AC TO DC)
CP5 -COMMUTATION POWER SUPPLY PC CARD
CSI-4 -CONVERTER SNUBBER CAPACITORS
CRP, CRN -COMMUTATION SCR SNUBBER RESISTORS
CCP, CCN -COMMUTATION SCRS
CT -CURRENT TRANSFORMER, COMMUTATION CURRENT
CURR ISOL -CURRENT ISOLATOR PC CARD
DC -COMMUTATION DIODE
DI, DIK -INVERTER DIODES
FUI-3 -AC LINE FUSES
FU4-6 -CONTROL POWER FUSES
FU7 -15VAC FUSE
ICP, ICN -INVERTER SCR SNUBBER CAPACITORS
IRP, IRN -INVERTER SCR SNUBBER RESISTORS
ISP, ISN -INVERTER SCRS
LI -DC FILTER REACTOR
LC -COMMUTATION REACTOR, PHASE MODULE
LP, LN -INVERTER LEG REACTORS
LSA -DC LINE SNUB
PMA-B-C -PHASE MODULE A, B & C
PT -PULSE TRANSFORMER PC CARD
R3, R4 -COMMUTATION POWER SUPPLY RESISTORS
RCC, RI, R2 -CAPACITORS DISCHARGE RESISTORS
RFI-7 -FEEDBACK ISOLATION RESISTORS
RSI-4 -CONVERTER SNUBBER RESISTORS
I-JSP I-35N -CONVERSION MODULE SCRS
TX1 -CONTROL TRANSFORMER

FIGURE 28B
AF-400 Drive GP Inverter Elementary Diagram
(36D870018AA, Sheet 2)

SPARE AND RENEWAL PARTS (NOT HP RELATED)

AF-400 Drive — 10 HP, 230 or 460 Volts, AC, Three-Phase, 50 or 60 Hz

PRINTED CIRCUIT CARDS

Catalog Number	Description
193X385ABG01,G02,G03,G04	Commutation Power Supply Card
193X387AAG01	Current Isolator Card
193X389AAG01	Pulse Transformer w/C.F.B. Circuit Card
193X390AAG01	Pulse Transformer Card
193X391AAG01	Process Follower Card
193X391AAG02	Auxiliary Relay Card
193X475AAG01	Phase Logic Card
193X476AAG01	Inverter Card
193X477AAG01	Converter Card
193X488AAG01	Regulator Card
193X489AAG01	System Card
193X480AAG01	Power Supply Card
193X481AAG01	Meter Card

SUB ASSEMBLIES AND COMPONENTS (NOT HP RELATED)

Catalog Number	Description
36A353243BAG01,G02	Control transformer assembly - 460V, 230V Transformer with connected wire harness
104X156CA10	Control transformer only
104X215BA012	

SPARE AND RENEWAL PARTS (HP RELATED)

AF-400 Drive 10—60 HP, 230 or 460 Volts AC, Three-Phase, 50 or 60 Hz

Part Name		Drive HP Rating								Drive HP Rating							
Catalog Number		10	15	20	25	30	40	50	60	10	15	20	25	30	40	50	60
AC Power Fuses 104X109AG	Qty. 3																
	50 Amp									005	005						
	60 Amp	007	007									007	007	007			
	100 Amp 175 Amp 300 Amp			009	009	009									015	015	015
							021	021	021								
AC Control Circuit Fuses 104X109BC	Qty 2 3 Amp	018	018	018	018	018	018	018	018	018	018	018	018	018	018	018	018
AC Control Power Fuse 104X109AD	Qty. 1 1 Amp	075	075	075	075	075	075	075	075	075	075	075	075	075	075	075	075
Inverter Main SCR 942B279 104X125DA	Qty. 6 Assembly Unit	CDG02 127	CDG02 127	CDG02 127	CDG02 127	CDG02 127	CEG02 136	CEG02 136	CEG02 136	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CEG03 060	CEG03 060	CEG03 060
Inverter Main Diode 942B279CD 957A614BA 104X125AA	Qty. 6 Assembly Assembly Unit	G06 131	G06 131	G04 132	G04 132	G04 132	G04 G02 132 134	G04 G02 132 134	G04 G02 132 134	G07 124	G07 124	G07 124	G07 124	G07 124	G03 G01 133 135	G03 G01 133 135	G03 G01 133 135
Commutating SCR 942B279 104X125DA	Qty. 6 Assembly Unit	CDG02 127	CDG02 127	CDG02 127	CDG02 127	CDG02 127	CEG02 136	CEG02 136	CEG02 136	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CDG05 131
Commutating Diode 942B279CD 957A614BA 104X125AA	Qty 6 Assembly Assembly Unit	G06 131	G06 131	G04 132	G04 132	G04 132	G04 132	G04 132	G04 132	G07 124	G07 124	G07 124	G07 124	G07 124	G03 133	G03 133	G03 133
Converter SCR 942B279 104X125DA	Qty. 6 Assembly Unit	CDG03 083	CDG03 083	CDG03 083	CDG03 083	CDG03 083	CEG01 058	CEG01 058	CEG01 058	CDG04 090	CDG04 090	CDG04 090	CDG04 090	CDG04 090	CEG04 057	CEG04 057	CEG04 057
Phase Module 331X415AA 331X414AA	Qty. 3	G03	G03	G02	G02	G02	G01	G01	G01	G03	G03	G02	G02	G02	G01	G01	G01
Converter Module 331X425AA 331X424AA	Qty. 1	G03	G03	G02	G02	G02	G01	G01	G01	G03	G03	G02	G02	G02	G01	G01	G01
Filter Reactor — L1 104X220AB	Qty. 1	014	014	013	013	013	012	012	012	014	014	013	013	013	012	012	012

SPARE AND RENEWAL PARTS (HP RELATED)

AF-400 Drive 10—60 HP, 230 or 460 Volts AC, Three-Phase, 50 or 60 Hz
(continued)

Part Name	Drive HP Rating 230 Volts AC								Drive HP Rating 460 Volts AC							
Catalog Number	10	15	20	25	30	40	50	60	10	15	20	25	30	40	50	60
Filter Capacitor Assembly 36D877209AF 36D877209AE	G03	G03	G02	G02	G02	G01	G01	G01	G03	G03	G02	G02	G02	G01	G01	G01
Filter Capacitor — C1 104X122AA145 Qty.	2	2	4	4	4	8	8	8	2	2	4	4	4	4	8	8
Power Circuit Breaker Kit Qty. 1 104X202RA 30 Amp 104X202RA 50 Amp 104X202RA 100 Amp 104X203EA 200 Amp	G05	G05	G07	G07	G07	G01	G01	G01	G04	G04	G05	G05	G05	G07	G07	G07

SPARE AND RENEWAL PARTS

AF-400 Drive — 10 to 60 HP, or 460 Volts AC, Three-Phase, 50 or 60 Hz.

MODIFICATION KITS

Catalog Number	Description
6VPF10A1	Process Follower Kit
6VREV10A1	Reversing Relay Kit
104X166AA059	Reversing Relay
6VFLT10A1	Fault Relay Kit
104X166AA060	Fault Relay
6VRUN10A1	Run Relay Kit
104X166AA061	Run Relay
6VRAM10A1	Auto/Manual Relay Kit
104X166AA059	Auto/Manual Relay

REMOTE OPERATORS STATION

Catalog Number	Description
6VOC72	Speed Adjust — Start Stop
6VOC82	Speed Adjust — Forward/Reverse Selector — Start Stop
6VOC52	Speed Adjust — Manual/Auto Selector — Start Stop
104X169AA008	Start Pushbutton
104X152AC027	Forward/Reverse Selector Switch
104X152AC027	Manual/Auto Selector Switch
36B605269AAG05	Speed Adjust Pot Assembly

SPEED AND LOAD INDICATORS

Catalog Number	Description
6VSI12A1	Speed Indicator Kit
104X117CC003	DO-91 X O—100% Speed Meter
6VLI12A1	Load Indicator Kit
104X117CC005	DO-91 O—150% Load Meter
6V1E11	Enclosure for 1 instrument
6V1E21	Enclosure for 2 instruments

HOT LINE TELEPHONE NUMBER

The Contract Warranty for AF-400 drives is stated in the General Electric Apparatus Handbook, Section 105, Page 71.

The purpose of the following is to provide specific instructions to the AF-400 user regarding warranty and administration and how to obtain assistance on out-of-warranty failures.

AF-400 DRIVE POWER UNITS (10 TO 60 HP)

The warranty covers all major parts of the power unit, such as printed circuit boards, SCR modules, etc. but does not provide for replacement of fuses or the complete power unit.

1. In the event of failure or misapplication during "in warranty" refer to the instruction book to identify the defective part or sub-assembly.
2. When the defective part has been identified (or for assistance in identification) call:

GENERAL ELECTRIC COMPANY
ERIE, PENNSYLVANIA
(814) 455-3219
(24-Hour Phone Service)

Before calling, list Catalog numbers of the power unit, motor, operator's station or modification kits.

AF-400 MOTORS

AC motor repairs are generally handled by General Electric Apparatus Service Shops. For specific instructions on your motor, call the number listed above and furnish complete nameplate data

GLOSSARY OF TERMS

Page

APL — Inverter Control Plug — Phase A	17,19,22,23,31,33,35,43
ATIM — Acceleration Time Adjust — Regulator Card	24,25,68
AUTO MAX — Maximum Speed Adjust — Process Follower	63
AUTO MIN — Minimum Speed Adjust — Process Follower	63
 BPL — Inverter Control Plug — Phase B	17,19,22,23,31,33,35,43
BF — Base Frequency Adjust — Regulator Card	21,24,25,29,68
 C1 — Converter Filter Capacitor	9,17,18,19,36,37,66
CB — AC Power Circuit Breaker	16,17,66
CFA — Current Feedback Adjust — Current Isolator	14,17,19,23,27,32
CLIM — Current Limit Adjust — Regulator Card	25,29,32,68
CLP — Commutating Reactor — Positive	10,19,33,34
CLN — Commutating Reactor — Negative	10,18,19,33,34
CLST — Current Limit Stability Adjust — Regulator Card	12,25,29,68
CN — Commutation Power Supply — Negative	18,34,36,42,43
COC — Commutation Overcurrent Trip — Inverter	13,19,27,31,32,55,68
COM — Common Point — Control	24,29,35,36
CONV. MOD. — AC to DC Conversion Module	66
CP — Commutation Power Supply — Negative	17,18,33,34,36,42,43
CPL — Inverter Control Plug — Phase C	17,19,22,23,31,33,35,43
CSN — Commutating SCR — Negative	10,18,50,52,53,55
CSP — Commutating SCR — Positive	10,18,50,52,53,55
CTC — Current Transformer — Commutating	14,18,33,34
CURR. ISOL — Current Isolator Card	66
CUV — Control Undervoltage Trip — Inverter	14,19,27,31,32,55,68
 DIG — Digital Reference Input	68
DPL — Converter Control Plug	17,19,22,23,31,33,43
DMF — Decrease to Minimum Frequency Signal	11,29,68
DTIM — Decel Time Adjust — Regulator Card	25,68
 FLT — Fault Relay — Option Card	62,67
FTR — Fault Trip — Readout Signal	11,32,33,67
FU1-3 — Main Power AC Line Fuses	17,18,66
FU4-6 — Control Circuit Fuses	30,32,66
FU7-115V AC Control Power Fuse	17,33,66
FVR — Frequency Voltage Readout Signal	12,22,29,68
 GAIN — Gain Adjust — Process Follower	63
 IF — Inverter Frequency Light — System Card	11,19,22,27,33,55,67
IOC — Instantaneous Overcurrent Trip Light	14,19,27,28,31,32,55,68
IOF — Inverter Overfrequency Trip Light	14,19,27,31,55,68
IRC — IR Compensation Adjust — Regulator Card	24,29,68
IS — Inverter Start Relay — Option Card	30,67
ISN — Inverter SCR — Negative	9,10,50,52,53
ISP — Inverter SCR — Positive	9,10,50,52,53
ITOC — Inverter Time Overcurrent Trip — Inverter	11,19,27,28,29,31,32,55,65,67

GLOSSARY OF TERMS (continued)

Page

J1 — Driver Backplane Plug	66,67,68
J32 — Driver Backplane Plug	66,67,68
JX1 — Driver Backplane Plug	68
JX11 — Driver Backplane Plug	67,68
JX32 — Driver Backplane Plug	67,68
LCS — DC Link Current Signal	14,23,27,32,69
L1 — Converter Filter Reactor	9,17,18,35,36,37,38,67
LSH — DC Link Shunt	17,23,66
LOV — DC Link Overvoltage Trip	13,19,27,32,55,67
1L1 — 1L3 — Commutation Power Supply Input	18
MA — Manual Auto Relay Card — Option Card	62,63,67
MINF — Minimum Frequency Adjust — Regulator Card	12,24,32,68
MS — AC Motor Starter	66,67
MSR — Minimum Speed Relay — Option Card	67,68
MVFR — Minimum Voltage Frequency Readout	11,32,67,69
N1 — Negative Converter Output	18,33,35,36,37,42,43,45,48
N2 — Negative Inverter Input	9,10,17,18,22,23,24,30,32,34,35,36,37,42,43,54
OL — Motor Starter Overload	65
OFFSET — Offset Adjust — Process Follower Card	63
P1 — Converter Output — Positive	17,18,22,36,42,43,45,48
P2 — Converter Filtered Output — Positive	17,18,22,23,24,32,37,54
P3 — Inverter Positive Input	9,10,18,30,32,34,35,36,42,43,47
PB1 — 2 Pushbuttons	68
PH MOD — Inverter Phase Module	66
PS/LOP — Phase Sequence/Loss of Phase Trip	13,19,22,27,55,67
R1 — Capacitor Discharge Resistor	18,54,66
REF — Reference Input Signal	19,22,28,29,30,68
REV — Reversing Relay — Option Card	62,67
RF1-7 — Isolation Feedback Resistors	66
RT30 — Rectified 30V DC	68
RUN — RUN Relay — Option Card	60,62,67
SR — Inverter Synchronized Readout Signal	31,69
SW1-2 — Selector Switches	68
SYNC — Inverter Line Synchronized Light	11,19,25,30,31,55,67,68
STAB — Stability Adjustment— Regulator Card	23,25,29,68
TH1-2 — Thermal Switch Terminals	17,18
THSW — Thermal Switch — Inverter Air	17,66,67
TX1 — Control Transformer	11,17,66
VB — Voltage Boost Adjust — Regulator Card	12,24,29,32,68
V/Hz — Volts per Hertz Adjust — Regulator Card	12,19,24,68
VLIM — Voltage Limit Adjust — Regulator Card	12,23,24,28,29,68
XFR — External Fault Reset — Input Signal	11,32,69

**GENERAL ELECTRIC COMPANY
SPEED VARIATOR PRODUCTS OPERATION
ERIE, PENNSYLVANIA 16531**

