INSTRUCTION MANUAL

PRELIMINARY GEK-24981

AF-3060

INVERTER DRIVE SYSTEM

A-C ADJUSTABLE SPEED DRIVE

INSTALLATION

OPERATION

TROUBLESHOOTING

GENERAL ELECTRIC

INVERTER AF-3060

ABBREVIATED START-UP PROCEDURE

If any difficulties are encountered during start-up and checkout, refer to Section 4 of instruction book for detailed start-up and checkout procedure.

WARNING

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

1. Verify that the 3-phase a-c power input to the drive is of the proper value as listed on the equipment data nameplate(-5, +10%).

2.1 AF-3060 - Verify that cables P5 metal connection TAB is disconnected from the L2 choke assembly. Apply three phase a-c power to the inverter; "POWER ON" indicator illuminates.

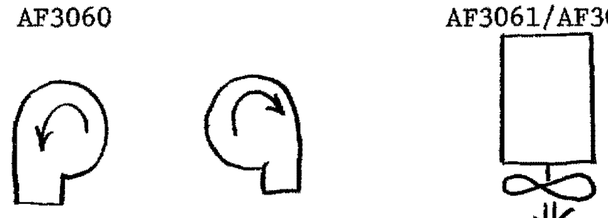
2.2 AF-3061 & AF-3063 - Verify that cables P1 are disconnected and separated from conducting objects, from all 3 phase modules. Apply 3 phase a-c power to the Inverter. "POWER ON" indicator illuminates.

2.3 Verify that blower or fan rotation is proper.

CAUTION

CHECK FOR PROPER AIR FLOW OF 3 PHASE BLOWER MOTOR (IF SUPPLIED). APPLIES TO SINGLE SQUIRREL CAGE BLOWER ONLY.

AF3060 AF3061/AF3063



LEFT SIDE AIR FLOW RIGHT SIDE DOWN AIR FLOW

3. Press the Inverter "START" pushbutton; "INVERTER ON" indicator illuminates (if supplied). "RESET" indicator (if supplied) should not be illuminated.

4. With the "Test" card in test socket "B" and the oscilliscope connected to "Read" apply a 10% to 20% speed reference command and verify that firing signals are present on 1B through 12B selector positions. Scope settings are: 5V/CM and 5 milli-sec/CM.

5. Press "INVERTER STOP/RESET" pushbutton. "INVERTER ON" indicator extinguishes.

6. Switch off or disconnect 3 phase input power to Inverter unit, "POWER ON" indicator extinguishes. Check that capacitors have discharged.

7.1 AF-3060 - Connect P5 cable assembly metal tab to L2 assembly P5 tab.

7.2 AF-3061 & AF-3063 - Connect P1 cables on all three phase modules.

8. Set "Speed Control" potentiometer to zero.

9. Apply 3 phase a-c power to the Inverter unit. Verify that the "POWER ON" indicator is illuminated.

10. Press the Inverter "START" pushbutton; "INVERTER ON" indicator illuminates (if supplied).

11. Increase the "Speed Control" potentiometer until motor base speed is reached.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I

GENERAL

1.1 SCOPE OF MANUAL

This instruction manual is structured around a basic system. It is a guide for the installation, checkout and operation of the equipment furnished with general troubleshooting procedures for the basic system. Any special purpose equipment, as requested on the requisition, will normally be covered in the schematic drawings included with this package. 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 the General Electric Company.

The drive system can be made up of one of 3 power assemblies and 1 of 2 driver assemblies. The different assemblies are -

AF-3060 Power Conversion	- 150HP max. 0 to 460V AC, 3 phase
AF-3061 Power Conversion	- 50 KVA max. 0 to 230V AC, 3 phase
AF-3063 Power Conversion	- 60 KVA max. 0 to 460V AC, 3 phase
AF-3062 Driver Assembly	- Standard Driver used w/Power Conv. Asm.
AF-3122 Driver Assembly	- Standard phase-shifting driver used with two or more Power Conv. Asm's.

Where there is a significant difference between the power assemblies, it is noted at the appropriate place in the manual. Otherwise, the term AF-3060 is understood to mean AF-3060, 3061 & 3063.

1.2 SAFETY, PERSONNEL AND EQUIPMENT

The following paragraphs list some general safety reminders and safety recommendations to be followed when operating or installing this equipment.

Only authorized electrical and electronics personnel should install and maintain this equipment.

Definition of terms and sign colors:

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, will result in damage ~~to~~, or ~~destruction of~~, ~~the equipment~~.

Color: Black lettering on amber field.

NOTE: Denotes an operating procedure or condition that should be highlighted.

Color: Black lettering on white field.

WARNING: HIGH VOLTAGE

ELECTRIC SHOCK CAN CAUSE PERSONAL INJURY OR LOSS OF LIFE. WHETHER THE AC VOLTAGE SUPPLY IS GROUNDED OR NOT, HIGH VOLTAGES TO GROUND WILL BE PRESENT AT MANY POINTS WITHIN THE SCR DRIVE. EXTREME CARE MUST BE EXERCISED IN THE SELECTION AND USE OF TEST INSTRUMENTS. OPERATOR SHOULD NOT STAND ON GROUNDED SURFACES OR BE IN CONTACT WITH GROUND WHEN APPLYING TEST INSTRUMENTS TO TEST POINTS. CONVENTIONAL TEST INSTRUMENTS SHOULD NOT HAVE CHASSIS GROUNDED WHILE TESTS ARE BEING MADE. THUS, THE CHASSIS CAN BE AT A HIGH VOLTAGE WITH RESPECT TO GROUND DURING TESTING. EXTREME CARE SHOULD BE TAKEN WHILE ATTEMPTING TO ADJUST, TROUBLESHOOT, OR MAINTAIN ANY DRIVE SYSTEM DESCRIBED HEREIN.

When working on or near the equipment with power/voltage applied, it is recommended that all metal objects such as rings, watches, and tie clasps be removed.

It is highly recommended that all personnel working on this equipment wear rubber soled shoes (insulated).

WARNING

WHEN WORKING AROUND ROTATING EQUIPMENT, DO NOT WEAR ANY LOOSE CLOTHING THAT COULD BECOME CAUGHT IN THE EQUIPMENT.

CAUTION

DO NOT REMOVE PRINTED CIRCUIT CARDS FROM THE EQUIPMENT WHILE POWER IS APPLIED OR OPERATING: THIS CAN DAMAGE THE EQUIPMENT.

NOTE

ALWAYS READ THE COMPLETE SUBSECTION (EXAMPLE 3.2) PRIOR TO ANY TURN-ON OR TROUBLESHOOTING OF THE EQUIPMENT. FOLLOW THE PROCEDURE STEP BY STEP.

READ AND HEED ALL WARNING, CAUTION AND NOTE SIGNS POSTED ON THE EQUIPMENT.

1.3 WARRANTY AND SHIPPING

1.3.1 Warranty Statement

The Company warrants to the Purchaser that the equipment to be delivered hereunder will be free from defects in material or workmanship and will be of the kind and quality designated or specified in the contract.

This warranty shall apply only to defects appearing within one year from the date of shipment by the Company.

1.3.2 Receipt of Shipment

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 the General Electric Company, Speed Variator Products Section, but when seeking assistance, please use the purchase order number, requisition number, and model number to help us in assisting you.

SECTION II

SYSTEMS EQUIPMENT DESCRIPTION

2.1 EQUIPMENT PURPOSE

The AF-3060 Inverter drive is an adjustable frequency a-c drive system designed for industrial applications where the use of a-c motors is desirable or required. Single motor operation or multi-motor group operation from a single power unit is standard. Adjustment of motor(s) speed results from changing the motor voltage and frequency.

2.2 EQUIPMENT FURNISHED - GENERAL

The AF-3060 Inverter drive system consists of three basic parts as follows:

2.2.1 Power Unit

A floor mounted NEMA 1 ventilated enclosure housing the power, regulating and logic circuitry plus other required control devices.

Input voltage: 230/460V AC, 3 phase, 60 Hz.
Output voltage: 0 to 230/460V AC, 3 phase

2.2.2 Operator's Station

A NEMA 1 wall or machine mounted control station including the speed setting potentiometer or frequency reference and "START-STOP" pushbuttons and any other command or monitor functions that were ordered for the operator's station.

2.2.3 A-C Drive Motor(s)

See Elementary Diagram.

2.2.4 Special Purpose Equipment

See Elementary Diagram.

2.2.5 Receiving, Handling and Storage

2.2.5.1 Receiving

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

2.2.5.2 Handling

Power units 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 with a spreading bar used.

2.2.5.3 Storage

This equipment may be stored at ambient temperature of -20°C to 40°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 and will be 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).

Filter capacitors require forming after a three month or longer storage period.

Capacitor Forming

Electrolytic capacitors have a limited shelflife when not energized. It is, therefore, necessary to form the capacitors before normal charging can take place. Type of forming is dependent on how long a period of time the drive has not been in operation.

a) Less than 3 months: No forming required.

b) 3 to 9 months: Charge the filter in the inverter through a 100 ohm resistor. Connect in the P2 connection. Leave energized for 15 min. before operating.

c) More than 9 months: Charge through a 100 ohm resistor for 30 min. before operating.

2.3 EQUIPMENT FUNCTIONAL DESCRIPTION

This subsection provides a listing (in tabular form) of the controls, indicators and assemblies together with their functions and illustrations of the equipment. Also provided is a brief theory of operation at the system level.

2.3.1 Function of Controls, Indicators and Assemblies

Table 2-1, in conjunction with Figures 2-1 through 2-4, will give a listing of the controls, indicators and assemblies and their functions (the most often requested modification options are also included and are indicated by an asterisk*). The circled numbers/letters under "EQUIPMENT/ITEM" also appear on the illustrations, Figure 2-1.

2.3.2 Location of Controls, Indicators and Assemblies

Figures 2-1 through 2-4 will locate the majority of assemblies, controls and indicators.

2.3.3 Theory of Operation

To best understanding the theory of operation of the AF-3060 Inverter drive system the simplified block diagram (Fig. 2-5) should be referred to when reading this section.

The total system can be divided into five parts for a clearer understanding. The five parts are: command and logic, rectifier, driver, filter and power conversion modules and a-c motor(s). The following is a brief description of the functions of each of the five parts of the system.

2.3.3.1 Command and Control Logic and System Protection Circuitry

This part of the system circuitry contains all the operator's controls and indicators with their associated relays and logic, input power devices, 115V AC control power, and system protective devices such as fuses, thermal switches and system fault logic indication.

The three phase, 230/460V AC power enters the power unit through current limiting fuses (one per input phase) and is fed directly to the three phase full-wave rectifier bridge. Also tapped off a-c input from two phases is 115V control power from the control power transformer 1T. 115V control power from the transformer is fused by FX1 and is used for all operator's control devices and relays except for the speed reference signal. POWER ON indicator may be connected across two of the three phases on the power unit side of the three input fuses.

CAUTION

THE POWER ON INDICATOR IS NOT A TRUE INDICATION OF THE PRESENCE OR ABSENCE OF HIGH VOLTAGE IN THE UNIT. WHEN FUSE OR LAMP FAILURE OCCURS HIGH VOLTAGE CAN STILL BE PRESENT IN THE UNIT. VERIFY THAT EXTERNAL DISCONNECT SWITCH IS OFF PRIOR TO CHANGING FUSES OR CHECKING LAMP.

115V AC control power is fed through the motor thermal switches (unless otherwise specified) where it is fed into the "Stop-Start" operation devices and their associated relays. For the exact circuit connection, consult the elementary diagram furnished.

TABLE 2-1

FUNCTION OF CONTROLS, INDICATORS AND ASSEMBLIES

EQUIPMENT/ITEM	CONTROL/INDICATOR	FUNCTION
Inverter Door (Figure 2-1)		
1 *	Circuit Breaker "ON-OFF" Control Handle	Control application of three phase, a-c power unit to the drive system, plus indication of power shutdown trip.
2	"POWER ON" Indicator	Provides a visual indication that the input power is applied to the drive system.
3 *	"INVERTER ON" Indicator	Provides a visual indication that the "START" pushbutton has been pressed and the IS relay has energized and there are no "faults" in the system.
4 *	"START" pushbutton (normally on Operator station) Fig.2-2	Applies power to the Inverter Start relay coil.
5	"STOP/RESET" pushbutton (normally on Operator station) Fig. 2-2	Interrupts power to the Inverter start relay coil which shuts the system down and extinguishes the "INVERTER ON" indicator.
6 * (not shown)	"RESET" Indicator (Fault)	Provides a visual indication that the system has shutdown due to the "fault monitor" protection circuitry. (The "INVERTER ON" indicator will extinguish.)
7 * (not shown)	Ammeter	Displays output current from phase one Inverter module to the motor(s).
8 * (not shown)	Voltmeter	Displays a-c output voltage from Inverter module to motor(s).
9	Speed Control potentiometer (normally on Operator station) Fig. 2-2	Provides a means of selecting the operating speed of the motor.
10 * (not shown)	"FORWARD-REVERSE" selector switch (Normally on Operator station) Fig.2-2	Provides a means of reversing the direction of motor rotation.
11 * (not shown)	"RUN-JOG" (Thread) selector switch (Normally on Operator Station) Fig.2-2	Provides a means of selecting a preset speed point for momentary operation by holding the "START" pushbutton depressed when in the "JOG" position.

* Identifies modification options which may be supplied (if ordered).

TABLE 2-1

FUNCTION OF CONTROLS, INDICATORS AND ASSEMBLIES

EQUIPMENT/ITEM	CONTROL/INDICATOR	FUNCTION
Inverter Interior (Fig.2-3 & 2-4)	See Fig. 2-3 or 2-4 for location of Assemblies and Devices	
±20V DC Power Supply Card		Supplies +20V DC and a -20V DC for cards and circuits operating power. Fused inputs FU1 and 2.
+5V DC Power Supply Card		Supplies +5V DC for digital logic circuitry in the Inverter. Fused input on card.
Isolator Power Supply Card		Provides voltage feedback isolation. Provides -5V DC for -5V reference. Provides firing power (delayed) for pulse transformers. Provides an RX relay for Inverter on-off readout. Provides under and overvoltage trip signal.
Monitor Card		Provides test points for test instruments and for indicating lights.
	"Fault Monitor" Indicator (Trip) (IOC indicator will also illuminate)	Provides a visual indication that the Drive Protection Trip circuit has actuated due to a fundamental overfrequency or high-low d-c buss condition or momentary loss of 115V AC.
	"Fault Monitor" Indicator (IOC)	Provides a visual indication that the Drive Protection IOC circuit has actuated due to an instantaneous overcurrent condition.
	"Monitor" Indicator (CL)	Provides a visual indication that the drive is operating in a current limiting condition.
	"Monitor" Indicator "1FFA)	Provides a visual indication that the fundamental frequency is present from the three phase generator.
	Test Connection #1 (FILTER)	Provides test instrument access to the Filter Module Current Feedback.
	Test Connection #2 CCA	Provides test instrument access to Commutation Current Feedback from phase A Inverter module.

TABLE 2-1

FUNCTION OF CONTROLS, INDICATORS AND ASSEMBLIES

EQUIPMENT/ITEM	CONTROL/INDICATOR	FUNCTION
	Test Connection #3 CCB	Provides test instrument access to Commutation Current Feedback from phase B Inverter module.
	Test Connection #4 CCC	Provides test instrument access to Commutation Current Feedback from phase C Inverter module.
	Test Connection #5 1FFA	Provides test instrument access to the Fundamental Frequency, phase A, three phase generator output. (Same signal that drives light 1FFA).
	Test Connection (COMM)	"Common" for preceding five test points.
"Regulator" Card		Provides the input reference conditioning with a proportional output for the selected base frequency in synchronization with a master oscillator output plus the three phase generator outputs.
	Volts/Hz adjust potentiometer	Provides a means of adjusting the Inverter output volts per Hz in a 15% band about rated.
	Minimum Frequency adjust potentiometer	Provides a means of setting the master oscillator lower frequency operating point. (Below min. freq. only output voltage is reduced).
	Current Limit adjust potentiometer	Provides a means of setting the current limiting circuit from 50% to 150% of drive rated current.
	Voltage Boost adjust potentiometer	Provides a means of increasing the input voltage reference independent of frequency (if ordered).
Reverse Logic Card		Provides timed acceleration and deceleration for a voltage input reference, selective phase current sensing, motor compensation signals and a current limit signal. Also motor reversing (if supplied).
	Slip Comp. adjust potentiometer	Provides a means of compensating for motor slip (if ordered).

TABLE 2-1

FUNCTION OF CONTROLS, INDICATORS AND ASSEMBLIES

EQUIPMENT/ITEM	CONTROL/INDICATOR	FUNCTION
	I.R. Comp. adjust potentiometer	Provides a means of compensating for voltage loss due to motor load (if required).
	Time-up adjust potentiometer	Provides a means of setting the acceleration time from 2 to 32 seconds with analog input only.
	Time-down adjust potentiometer	Provides a means of setting the deceleration time from 2 to 32 seconds depending on load with analog input only.
Drive Modulator Card		Contains the voltage regulator and provides the driving signals to the three commutation Cards.
Synchronizer II Card (AF-3062 Driver only)		Provides pulse train to commutation cards for firing pulses; triangle and square waves for synchronization signal and current feedback signal amplification.
Test "B" Receptacle		Provides a receptacle to receive the Test Function Card. (See Table 6-2 for Test B monitored signals).
Test "A" Receptacle with Test Function Card Shown		Provides a receptacle to receive the Test Function Card. (See Table 6-2 For Test A monitored signals).
Test Function Card		Provides external test equipment connection points for monitoring of Inverter signals and power supply voltages. All test connections except "COM" have a 15k ohms impedance to the signal being monitored.
	+20V DC Test Connection	Provides monitoring access to +20V power supply.
	Delayed Firing Power (DFP) Test Connection	Provides access to the delayed Firing power signal.

TABLE 2-1

FUNCTION OF CONTROLS, INDICATORS AND ASSEMBLIES

EQUIPMENT/ITEM	CONTROL/INDICATOR	FUNCTION
	Select (SEL) Test Connection	Provides the capability of a reconnectable test point that can be internally connected (to back of Driver Receptacles) to any point for monitoring. (Normally connected to itself at time of shipment).
	-5V DC Test Connection	Provides monitoring access to -5V power supply.
	+5V DC Test Connection	Provides monitoring access to +5V power supply.
	-20V DC Test Connection	Provides monitoring access to -20V power supply.
	Thumb Wheel Selector Switch	Provides a means of selecting prewired test points 1 through 19 (A or B test receptacles) to test a point "Read" and "Common".
	"Read" Test Connection	Provides access to signal selected (1-19) of Thumb Wheel Selector Switch.
	"Common" Test Connection	Provides access to system "Common" for the above listed signal test connections.
Drive Protection Card		Provides driver logic to insure proper conditions exist before allowing firing pulses to be applied to the power conversion modules; under or over d-c buss voltage trip signal; driver trip signal for fundamental frequency upper limit and firing and lockout signals for an instantaneous over-current (IOC) condition.
Commutation Card for phases A, B and C		Provides for proper firing coordination of main Inverter SCR's; proper firing of the commutating SCR's; execution of driver trip signals initiate starting and stopping of firing pulses to all SCR's and power modules; and generation of a "Recalibrate" signal to the Drive Protection card to increase the IOC level during commutation. Also provides the instantaneous current limit.

TABLE 2-1

FUNCTION OF CONTROLS, INDICATORS AND ASSEMBLIES

EQUIPMENT/ITEM	CONTROL/INDICATOR	FUNCTION
Shown in Fig.2-3 & 2-4 located on lower cover panel of Driver Asm.	Min. Speed Adjust potentiometer	Provides a means of setting minimum (lower limit) of motor(s) speed when an analog "speed control" voltage input is used.
	Max. Speed adjust potentiometer	Provides a means of setting max. (upper limit) of motor(s) speed when an analog "speed control" voltage input is used.
Driver Card		Divides down frequency of master oscillator. Generates 3 phase logic signal that is either 1/96, 1/48 or 1/24 master oscillator frequency for ranges X1, X2, X4 respectively. Selects optimum chop frequency ratio.
Synchronizer Card (AF-3122 Driver only)		Provides pulse train to commutation cards for firing pulses; triangle and square waves for synchronization signals and current feedback signal amplification. Divides master oscillator frequency by 8 or 16 for 3 phase generator.
Phase Shift Card (AF-3122 Driver only)		Coordinates the phase shifting of the master Inverter; provides phase delays for the slave Inverter. Inverts the triangle wave. Boosts the IOCP for increased fanout. Provides distribution commoning blocks; three current signal amplifiers; and a 3 phase generator.

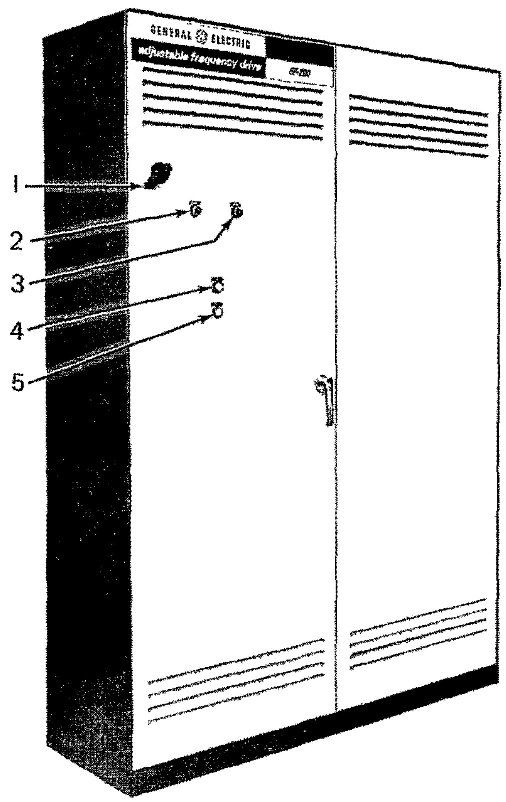
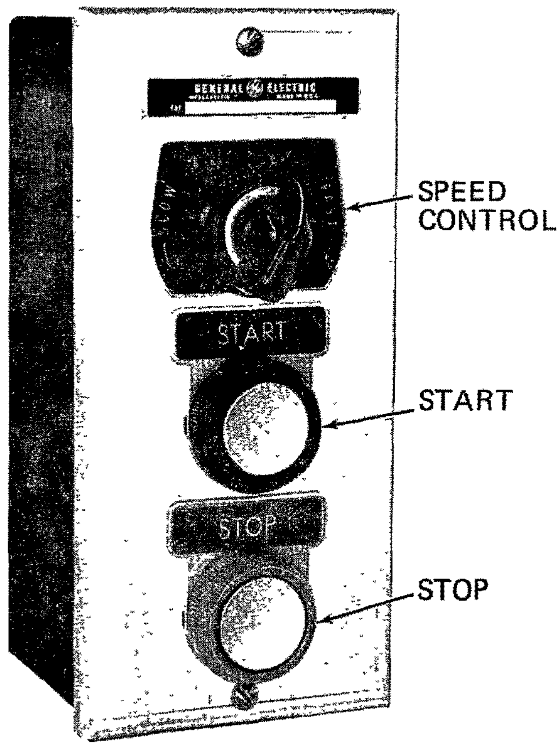
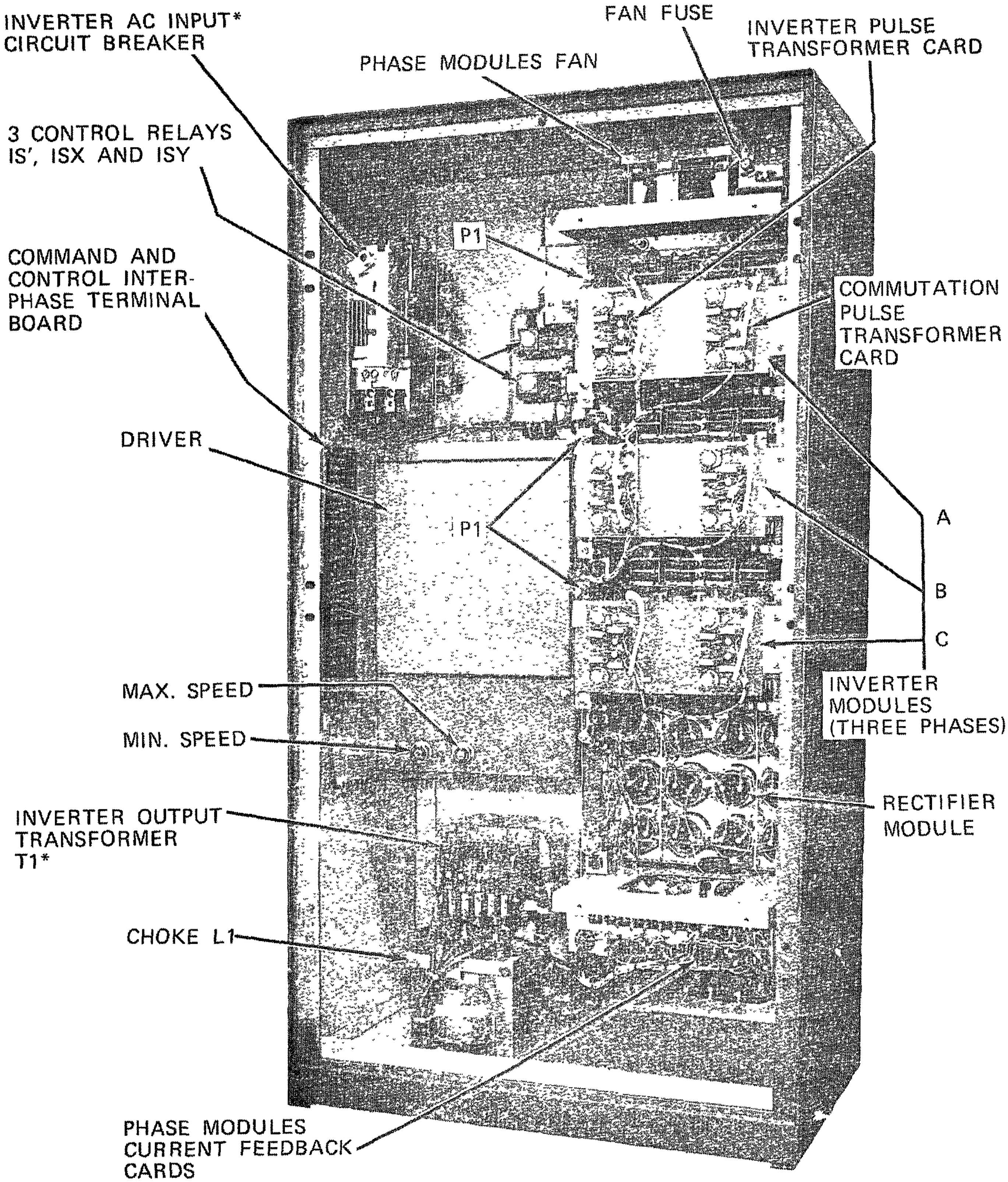


FIGURE 2-1 INVERTER ENCLOSURE
Left Hand Door Controls and Indicators (Typical Modifications)



OPERATOR STATION – BASIC

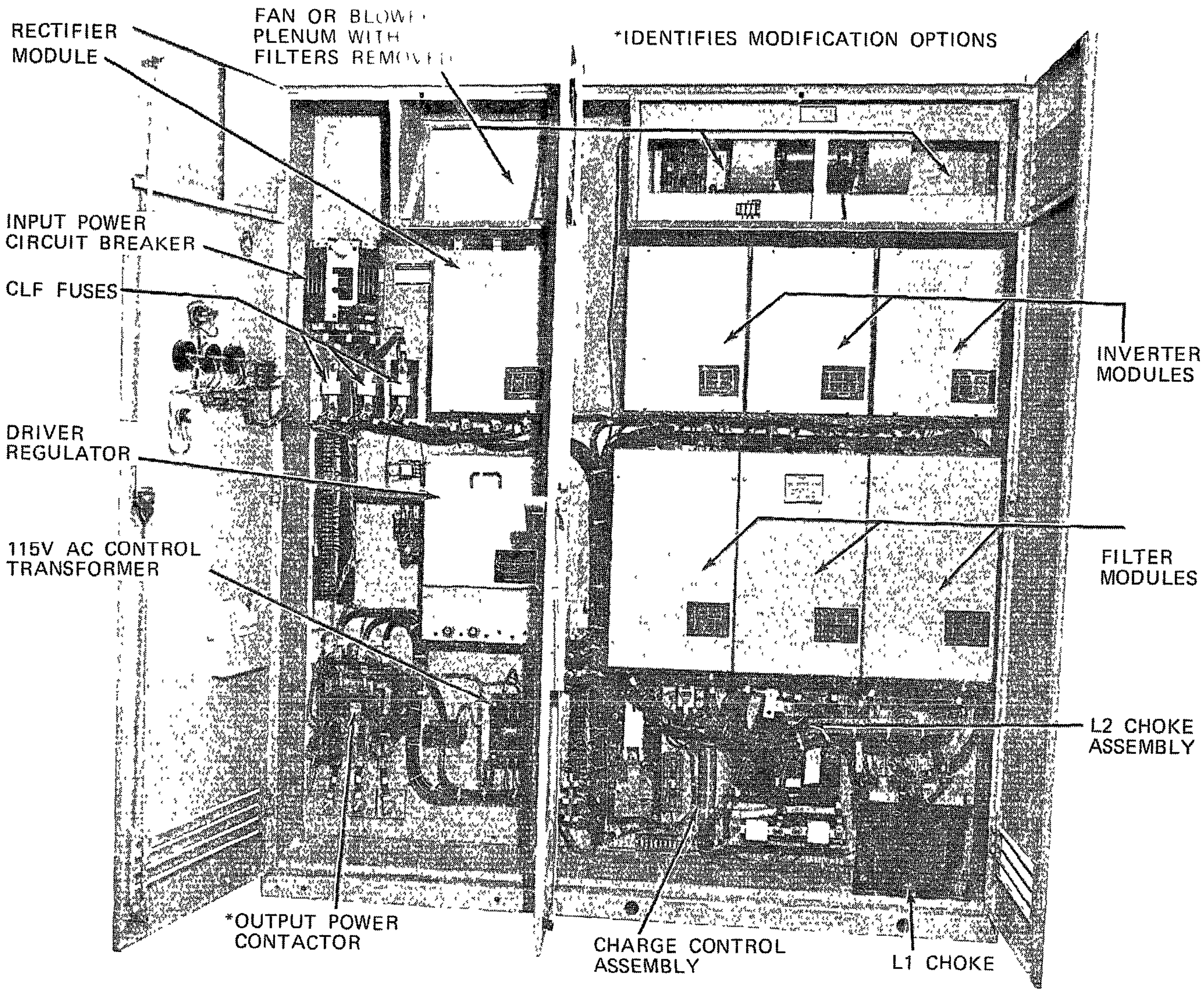
FIGURE 2-2



INVERTER INTERIOR

AF-3061 & AF-3063

FIGURE 2-3



AF-3060 INVERTER INTERIOR
TYPICAL LOCATION OF ASSEMBLIES AND COMPONENTS

FIGURE 2-4

2.3.3.1 (continued)

Typical control logic for an inverter system is as follows: When the Start button is actuated the inverter start relay (IS) is actuated and sealed in by IS contacts paralleling the "Start" button. Another set of IS contacts close actuating the inverter start auxiliary relay. The inverter relay (RX) has contacts in the INVERTER ON indicator circuit (if supplied) and the RESET indicator (if supplied). A set of N.O. contacts may be in the speed reference input circuit to the driver which will open in case of a loss of 115V AC control power, which will remove the input speed reference command. Inverter ON and Reset indicator logic is as follows: If no fault exists in system (RX relay), the Inverter ON indicator will illuminate when the START button is actuated, but if a fault exists in the system or a fault should occur in the system while operating the INVERTER ON indicator will extinguish and RESET indicator will illuminate.

NOTE

WHEN THE RESET INDICATOR ILLUMINATES (IF SUPPLIED) OPEN THE DRIVER COVER AND CHECK THE FAULT MONITOR INDICATORS ON THE MONITOR CARD (WILL INDICATE TYPE OF TRIP) PRIOR TO RESETTING THE INVERTER SYSTEM BY PRESSING THE "STOP/RESET" PUSHBUTTON.

2.3.3.2 Rectifier Module

The three phase, 230/460V AC power is fed directly from the three line fuses into the rectifier module. The rectifier module utilizes a three phase full-wave diode bridge which converts the a-c voltage to d-c voltage. The 310/620V DC output is fed directly to the filters and three inverter phase modules.

NOTE

FOR AF-3060 POWER CONVERSION ONLY, THE RECTIFIER MODULE ALSO HAS A FUSED COOLING FAN AND A THERMAL PROTECTION DEVICE (THSWR) THAT OPENS ON AN OVER-TEMPERATURE CONDITION WHICH CAUSES THE "IS" RELAY IN THE "START" CIRCUIT TO DE-ENERGIZE. "INVERTER ON" INDICATOR TO EXTINGUISH AND THE SYSTEM SHUTS DOWN. THERMAL DEVICE IS NORMALLY IN "CONTROL" CIRCUIT UNLESS OTHERWISE SPECIFIED.

NOTE

DRIVES MAY HAVE PHASE SEQUENCE RELAYS TO INSURE PROPER FAN ROTATION. IF PROPER PHASE SEQUENCE IS NOT APPLIED, DRIVE WILL NOT START.

2.3.3.3 Driver Assembly

Reference Figure 2-6 for the following signal paths while reading this paragraph.

Either a voltage or frequency (speed) reference ia applied to the Drive Assembly. A voltage reference goes through a linear timing function on the Reverse Logic card and then to a voltage controlled oscillator on the AC regulator card. A frequency reference is fed directly to a discriminator on the AC Regulator card. The discriminator produces a voltage proportional to the reference for the voltage controlled oscillator (VCO).

A variable frequency pulse train from the oscillator is fed to the divider card where the frequency is divided by sixteen, 8 or 4 for BFX1, X2 or X4. This frequency is six times the fundamental frequency of the drive. This signal goes to a Three Phase generator on the Divider card. This generator produces a Three Phase square wave plus the inverse of each phase... (phases at this point are labeled X, Y and Z). Phase X and its inverse is fed directly to the Driver Modulator card where it becomes Phase A. Phases Y and Z are fed to the Reverse Logic card. This card switches Phases Y and Z between Phases B and C. See table for phase relation.

Phase	Forward	Reverse
X	A	A
Y	B	C
Z	C	B

The Reverse Logic card also produces the inverse of Phases B and C.

All three phases and their inverse are fed into a multiplexer on the Drive Modulator card. This card also receives a signal called "Modulator Voltage" (MV) from the AC Regulator card.

This modulator voltage along with a voltage feedback is fed into a switching regulator to create the chopping for the pulse width modulator. This chopping is fed into the multiplexer along with the Three Phases and their inverse. (For low frequency the entire cycle is pulse width modulated.) The output is a Three Phase square wave with the center portion of each half cycle pulse width modulated. The phase signals are fed into three Commutation cards which coordinates the firing signals to the four SCR's per phase so that a power phase will be produced similar to the PWM signal out of the Modulator Card.

Figure 2-6 shows the Driver feedback signals.

There also is a frequency feedback from the Synchronizer II card that is half the frequency of the oscillator on the AC Regulator cards. This feedback goes to the discriminator and is only meaningful when a frequency reference is used. Using this feedback means that the incoming frequency reference must be forty-eight, 24 or 12 times the fundamental frequency for base frequency ranges of X1, X2 and X4 respectively.

Voltage feedback comes from the d-c buss. This voltage is isolated, scaled down, and fed to the switching voltage regulator on the Modulator card. The Isolator card also produces a "TRIP" signal on "under" and "over" voltage conditions. This signal is fed to the Driver Protection card where the appropriate signals are sent to the Commutation cards to trip the drive. Voltage feedback is also fed to Synchronizer II card where it is combined with other signals for optimum chopping control.

Current feedback signals from each phase are fed to signal amplifiers on the Synchronizer II card. These signals are in phase with their respective driver phase signals. (i.e. CSA is in phase with 1FFA.) These current signals are fed to the Reverse Logic card where the components of current in phase with their respective voltage signals are summed. This sum is fed into a spill-over circuit and the resultant current limit signal is fed back to the Regulator card where it will over-ride the reference to limit current. The current signals from the Synchronizer card are also fed to the Commutation cards. Here the current signals are compared with a preset upper level ($\pm$5.5V). The result over-rides the voltage regulator to immediately increase or decrease output voltage to limit current. This instantaneous current limit will normally not be activated. This limit serves only to protect the drive under shock loads or a motor "Breakdown" (Induction) or "Pull Out" (Synchronous) condition.

There is also a current feedback from the drive filter. Capacitor current is detected since any fast rising fault will first show up as capacitor current. This current signal is fed to a level detector to detect instantaneous over-current. When this signal reaches a pre-set upper level, the Drive Protection card stops all normal firing and initiates a firing of all Inverter SCR's. This allows all power conversion modules to commutate off by means of a secondary commutation circuit.

Commutation current is fed back to each Commutation card. This signal is referenced at -5 volts and is used to coordinate the firing of the main inverter SCR's.

2.3.3.3 (continued)

There are several coordinating signals in the driver that are explained here:

OMV	This is a logic signal that goes to the "0" state when the drive is at minimum voltage. This signal is used to coordinate starting, stopping and reversing.
FV	This is a voltage signal that is proportional to frequency. It is used in the optimum chopping control circuit.
TW	The triangle wave is used to synchronize the chopping in the switching regulator to the fundamental frequency.
OFT	The firing train oscillator is a series of "0" state pulses and is used to insure the main SCR's are fired.
0 START RELAY	This is a buffered logic input and must be put in the zero state to start the drive.
0 RUN	This signal goes to the zero state when the inverter is ready to run. It is used to lift the clamp on the reference.
OSI	The signal is used to start and stop commutation and inverter firing pulses.
DFP	This is the firing power supply. It goes directly to the pulse amplifiers in the conversion modules.
0 REV	This is a buffered logic input with preconditioning that is used for reversing.
IOCR	This is a current signal and is used to recalibrate the IOC level during commutation.
OTRX & OTRP	These signals are used to trip the drive.
1IOCL & 01OCP	These signals are used to initiate an IOC trip and lockout using the secondary commutation circuit.

2.3.3.4 Inverter Assembly

The d-c power from the rectifier module is filtered by the filter and is supplied to the SCR's where it awaits the proper gate signals to allow conduction. The phase modules consist of pulse transformer cards, main inverter SCR's (2 each), commutation diodes (2 each) and commutation SCR's (2 each). Upon receiving the proper firing commands from the commutation card in the driver, these SCR's fire (conduct) in the proper sequence to supply three phase alternating power to the motor(s). This power is variable in voltage and frequency. Reference Figure 2-7.

2.3.3.5 AC Motor(s)

The motor(s), either induction or synchronous, react to the amount of conduction that the SCR's have allowed. The output of the SCR's to the motor, is variable in frequency and voltage and is controlled by the "Speed Control" input reference setting. Each motor input phase is spaced 120 degrees in time (per cycle) from the preceeding phase; phase A to phase B 120° apart, B to C 120° apart. Reference Fig. 2-8 for motor per phase wave shapes.

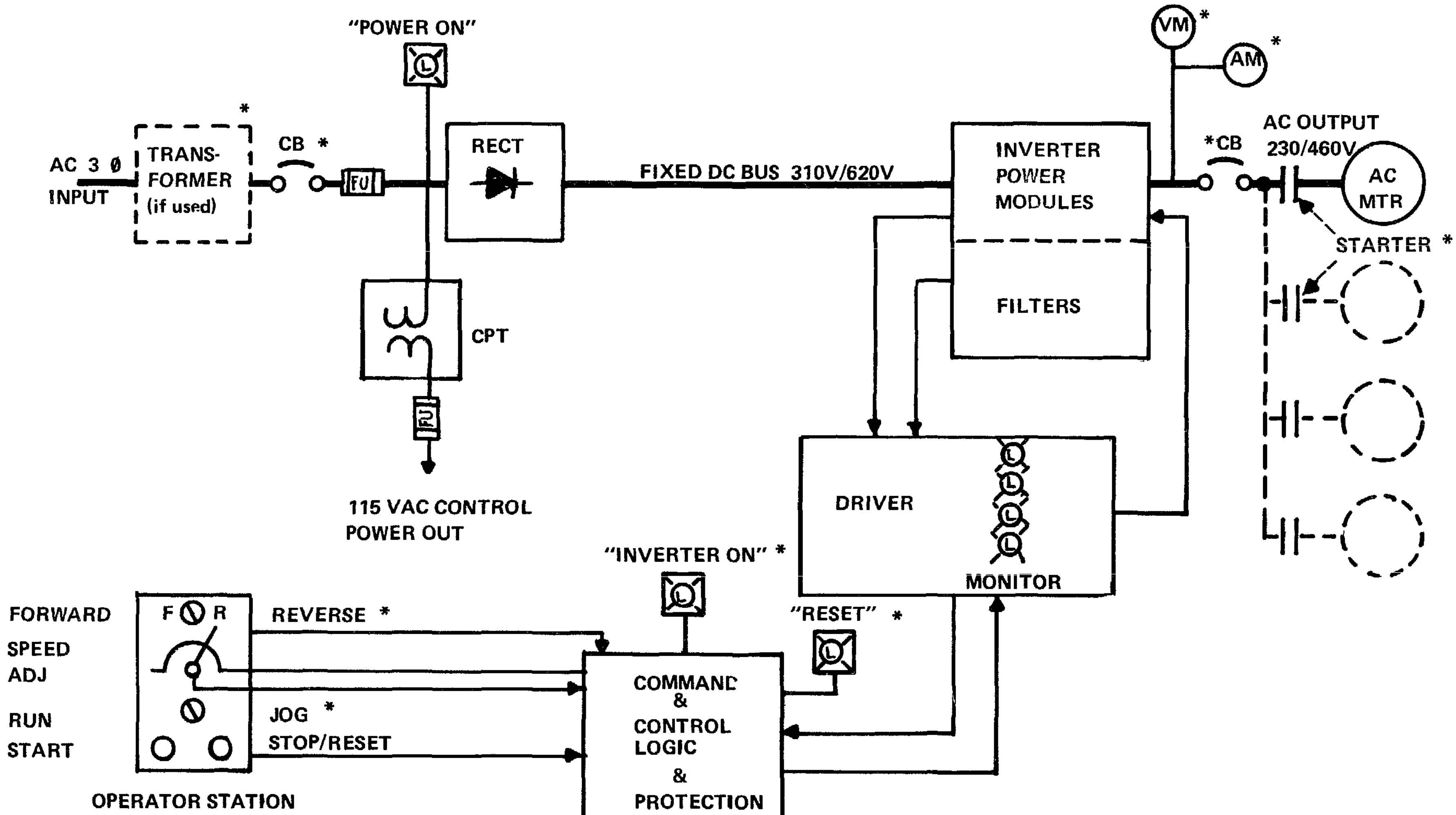
2.3.3.6 Direct Paralleling Inverter Assemblies

When two or more inverter assemblies are used to provide a higher KVA rating, the only equipment addition is a Signal Distribution Assembly (SDA) which provides a means of distributing the firing signals to the modules and combining the feedback signals to the driver. Also supplied are three interphase transformers for load sharing. For exact information on circuits and connections, consult the elementary and assembly diagrams.

2.3.3.7 Phase Shifted Paralleling Inverter Assemblies

Parallel phase shifting is used to provide a higher KVA rating for the system and also reduce motor heating due to harmonics. When used, only an even number of modules (three phase) can be utilized to increase the KVA rating. The additional equipment required (to double the rating) is as follows:

1. Three additional "Commutation" cards.
2. One additional drive "Modulator" card.
3. One "Phase Shift" card.
4. One "Test Socket C" receptacle.
5. Interphase transformer (three).



* IDENTIFIES MODIFICATIONS OPTIONS WHICH MAY BE SUPPLIED (IF ORDERED).

FIGURE 2–5 INVERTER SIMPLIFIED BLOCK DIAGRAM

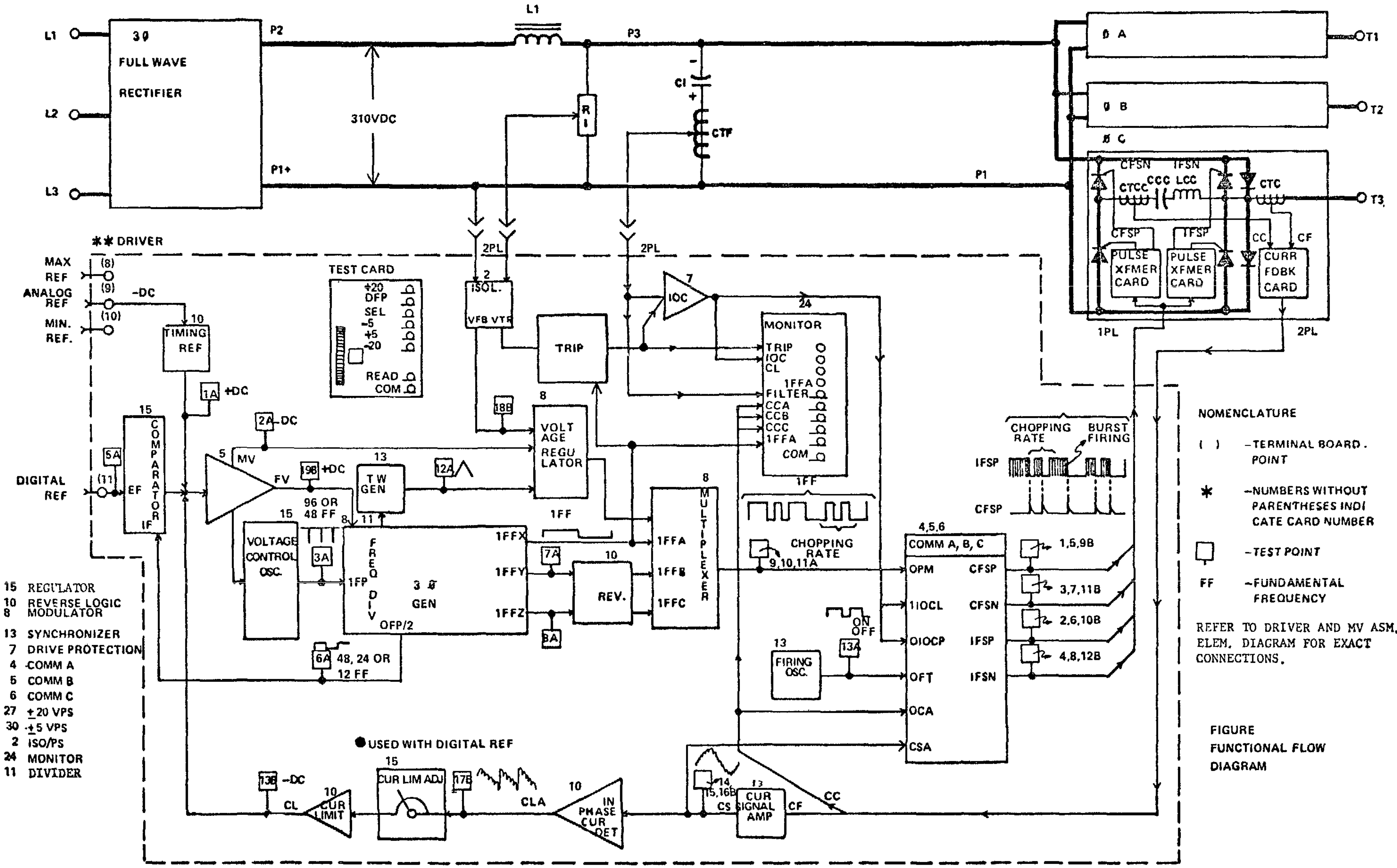


FIGURE
FUNCTIONAL FLOW
DIAGRAM

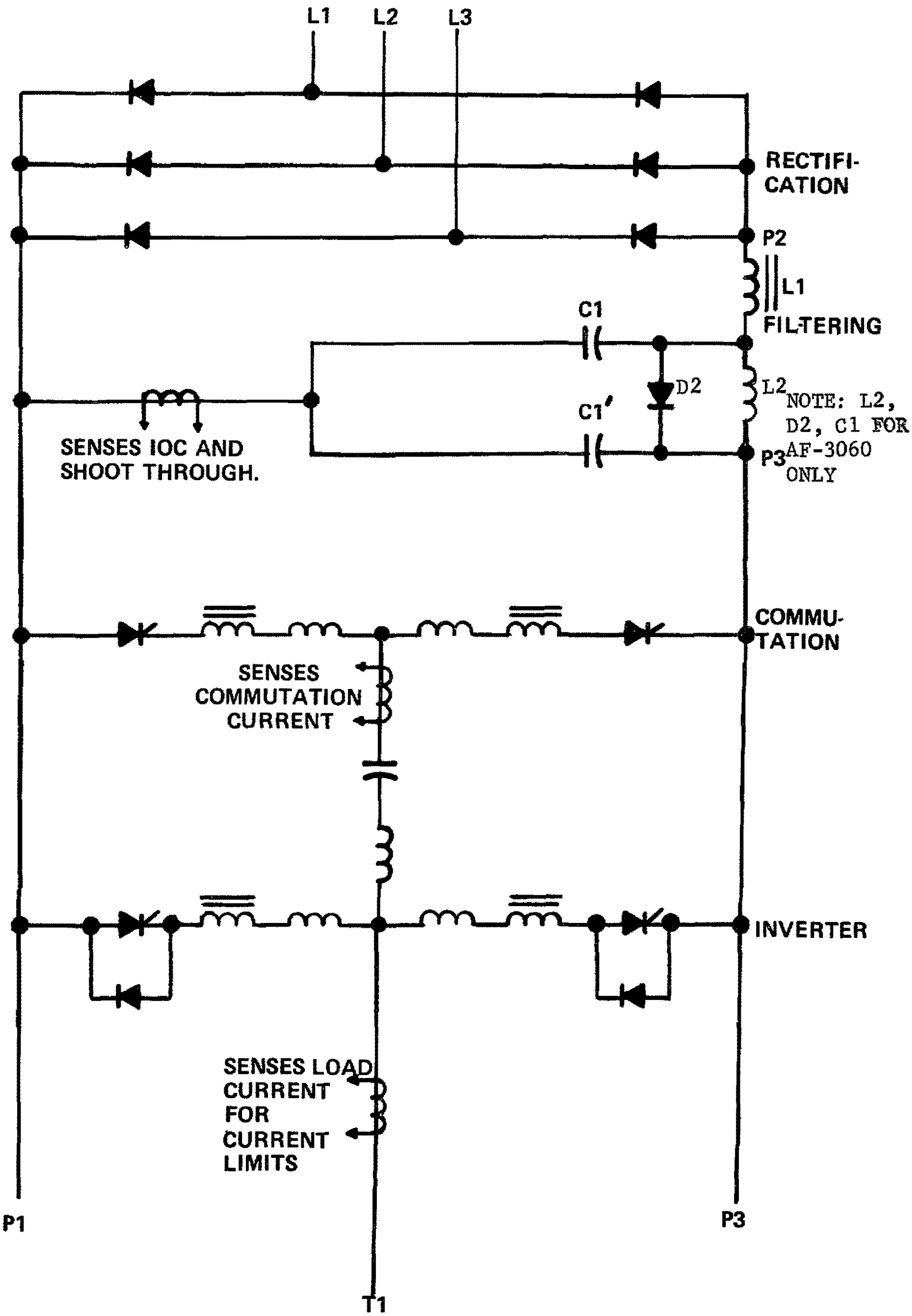
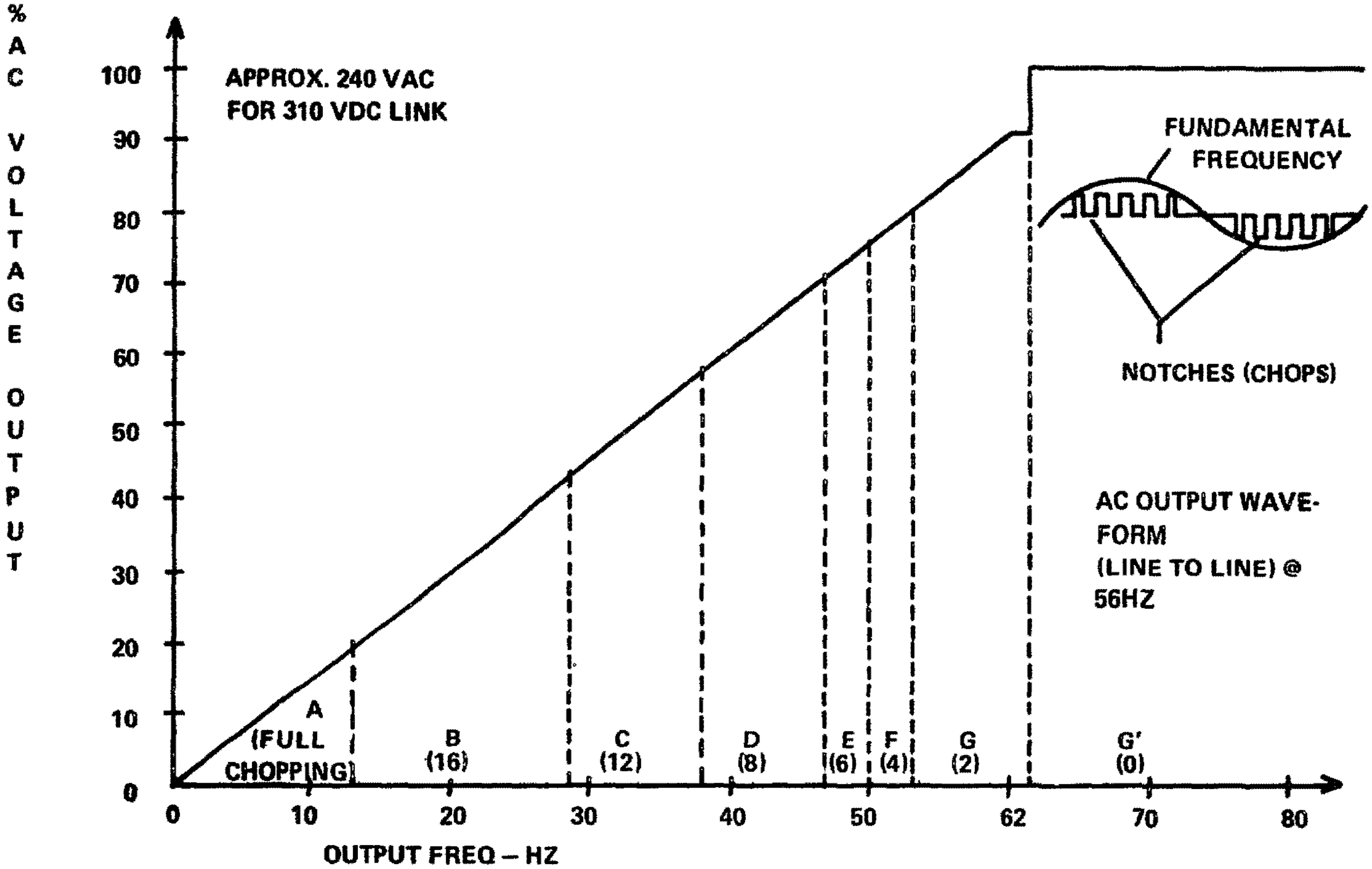


FIGURE 2-7 AF3060 POWER CIRCUIT (ONE PHASE)



NOTE: NUMBER (IN BRACKETS) UNDER LETTERS A THRU G ZONES INDICATES THE NUMBER OF NOTCHES (CHOPS) PER HALF CYCLE OF OPM SIGNALS. THE VERTICAL DASHED LINES INDICATE THE SHIFT POINTS.

FIGURE 2–8 60HZ BASE FREQUENCY OPERATION SHOWN

SECTION III

INSTALLATION

3.1 GENERAL

All internal electrical connections between devices in the power unit have been made at the General Electric factory.

3.1 EQUIPMENT LOCATION

Speed Variator power units equipped with filters are suitable for most factory areas where other inductrial equipment is installed. Locations subject to steam vapors or excess moisture, oil vapor or chemical fumes should be avoided. The power unit has filters and a blower system. The filters should be changed or cleaned before they become clogged. Power units should be installed in a well ventilated area in an ambient temperature range from 10°C to 40°C (104°).

WARNING

EQUIPMENT SHOULD NEVER BE INSTALLED WHERE HAZARDOUS, INFLAMMABLE OR CONBUSTIBLE VAPORS OR DUSTS ARE PRESENT. SUFFICIENT CLEARANCE IN FRONT OF THE UNITS SHOULD BE ALLOWED FOR THE ACCESS OF MAINTENANCE OR REPAIR.

3.3 TOOLS REQUIRED

The normal electrical and mechanical tool boxes maintained in most factories are all that is required for the installation of this equipment.

3.4 MECHANICAL INSTALLATION

Normally there are three types of equipment that require mechanical installation: power unit, operator's station and motor(s).

3.4.1 Power Unit

Cases may be bolted down using 3/8 diameter mounting bolts or studs. If studs are cast in floor, they should extend 3-1/2" minimum above floor. Conduit entry openings through base are fitted with removable sheet steel covers. Other conduit entry area available through top of case.

CAUTION

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

3.4.2 Operator's Station

The operator's station must be disassembled for mounting and wiring. First, remove the two 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 back and bottom back of enclosure. The operator's station is suitable for either wood screws or #10 machine screws.

3.4.3 AC Motor(s)

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

3.5 ELECTRICAL WIRING AND INTERCONNECTION

All wiring shall be in accordance with the National Electrical Code and be consistent with all local codes. All internal electrical connections between components and the Speed Variator power units were made at the General Electric factory. When installing speed variators, 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 each 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 interconnection diagram and verified by continuity tests. It is recommended that as each connection or wire is connected to the equipment it be checked off on the interconnection diagram.

WARNING

ALL MOTOR BASES AND EQUIPMENT ENCLOSURES HOUSING SHOULD BE CONNECTED TO THE FACTORY OR FACILITY EARTH GROUNDING SYSTEM.

3.5.1 Motor(s) Connections

For proper motor(s) connection, connect at motor(s) end as indicated on the motor(s) connection diagram plate for proper voltage connection. Wire sizes should be selected in accordance with NEMA standards based on the motor(s) nameplate data. Be sure to connect motor thermal switch back to the power unit. Tape all motor connections.

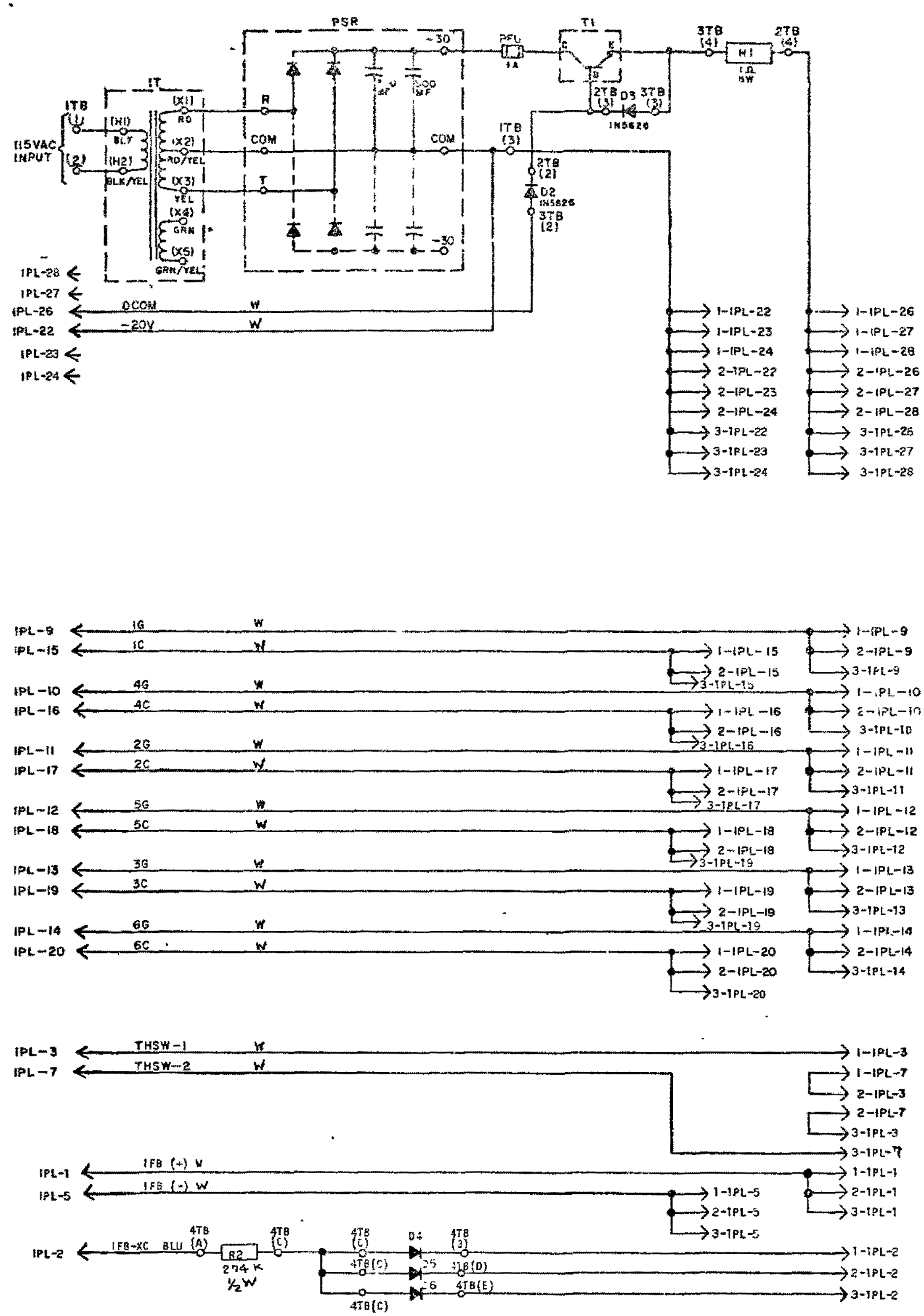
3.5.2 Power Unit Connections

Electrical codes generally require the use of a fused disconnecting switch or circuit breaker in the a-c power line ahead of the SCR drive 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 relays are added to the system, R.C. suppression networks must be added across the relay coils.

3.5.3 Operator's Station Connection

Using the interconnection diagram make all the required wiring connections between devices and 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.

PROPRIETARY INFORMATION OF THE GENERAL ELECTRIC COMPANY



GENERAL ELECTRIC

ELEMENTARY DIAGRAM
SIGNAL DISTRIBUTION ASM
3 PARALLEL NON REGENERATIVE
STANDARD LINE

36C764891AA

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