VT-700 Ⓣ

GENERAL PURPOSE DUPLEX DRIVE SYSTEM

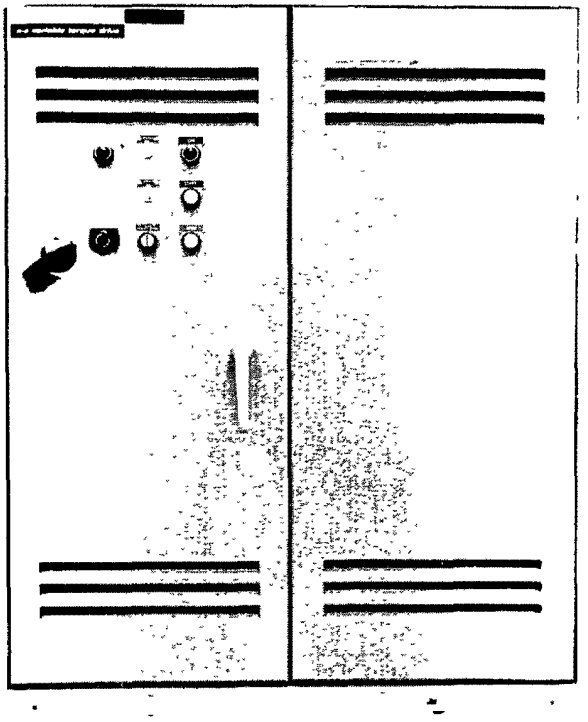
(DRIVE CODE AC-3061)

INSTRUCTION MANUAL FOR:

INSTALLATION

OPERATION

TROUBLE SHOOTING



GENERAL ELECTRIC

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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.

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 A-C VOLTAGE IS GROUNDED OR NOT, HIGH VOLTAGES TO GROUND WILL BE PRESENT AT MANY PLACES WITHIN THE SCR DRIVE.

EXTREME CARE MUST BE EXERCISED IN THE SELECTION AND USE OF TEST INSTRUMENTS.

1. OPERATOR SHOULD NOT STAND ON GROUNDED SURFACES OR BE IN CONTACT WITH GROUND WHEN APPLYING TEST INSTRUMENTS TO TEST POINTS.

2. CONVENTIONAL TEST INSTRUMENTS SHOULD NOT HAVE CHASSIS GROUNDED WHILE TESTS ARE BEING MADE. THUS THE CHASSIS CAN BE AT 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 INSERT OR 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 Department, 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 VT-700 Duplex AC Variable Torque Drive is a pre-engineered system designed for variable torque load application, such as constant pressure puming, where the torque varies as the square of the speed and the horsepower as the cube of the speed.

Adjustment of motor speed by primary voltage control by using silicon controlled rectifiers, allows the driven pump to control system parameters, such as pressure, liquid level or flow according to the sensing device used.

2.2 EQUIPMENT FURNISHED - GENERAL

The general purpose VT-700 Duplex consists of one power and control unit to operate the variable speed motor and a logic unit and a starter for operation of the constant speed motor.

2.2.1 Power and Control Unit

Input voltage: one of three: 200, 230 or 460VAC, 3-phase, 60 hertz. The power unit contains the SCR assembly, the regulator and the associated power and control components in a floor mounted enclosure.

2.2.2 AC Drive Motors

Five to fifty horsepower, four rated speed available, specially designed type KXA high-slip, squirrel cage induction motor with thermal protection. The constant speed motor is a super standard type K motor.

2.2.3 Sensor

Normally Honeywell type L91B, other types, depending upon application, are available.

2.2.4 Special Purpose Equipment

See Elementary Diagrams.

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 cases are not suitable for out-of-doors or unprotected storage.

2.2.5.2 Handling

The power units, floor mounted, can be transported by lift trucks with the forks completely under the base of the packing case. All power units have two detachable lifting brackets at the top for lifting by crane.

2.2.5.3 Storage

If the equipment is not to be installed immediately, it should be stored in a clean, dry location. Precautions should be taken to prevent moisture from accumulating in the equipment. The entrance of moisture, dust or dirt during storage or installation is detrimental to the equipment insulation.

2.3 EQUIPMENT FUNCTIONAL DESCRIPTION

2.3.1 Function of Controls and Indicators

Table 2-1 will give a listing of all the controls, indicators and adjustments with a brief functional description. This table is cross-referenced to the illustrations of the equipment.

2.3.2 Location of Controls, Indicators and Assemblies

Figure 2-1 through 2-3 provide pictures and illustrations of the equipment assemblies, controls and indicators with a cross-reference number to identify the item in Table 2-1.

2.3.3 Theory of Operation

To best understand the theory of operation of the VT-700 Duplex General Purpose AC Variable Torque Drive System, it is necessary to state what the electrical system is required to do.

a. Maintain a required pressure or level.

b. Start, stop and control motor to maintain the desired pressure or liquid level.

c. Provide automatic or manual operation.

d. Insure operator safety.

e. Provide visual status of normal operation.

f. Provide emergency override operation.

The total system can be divided into four parts (see Figure 2-4). The four parts are: command and logic, regulator, power conversion module and the AC drive motors. The following is a brief description of the function of each major portion of the four parts of the system.

2.3.3.1 Command and Logic Circuitry

The command and logic circuitry is responsible for the starting or stopping of the system, providing the protective logic and the manual run control plus the automatic transfer between drive systems. The selection of mode of operation (manual or automatic) is also included.

2.3.3.2 Regulator

The regulator's job is to receive an input signal from either the sensor or the manual speed control and prepare it as a command signal to the power conversion unit. Its other functions include system response, stability and power conversion module protection in the form of current limiting.

2.3.3.3 Power Conversion Module

The power conversion module's task is to deliver the proper amount of voltage to the motor, based on the commands received from the regulator, to cause the motor to drive at the correct speed corresponding to the required torque.

2.3.3.4 AC Motor(s)

The "KXA" AC motor's task is to drive the pump as commanded by the sensor or manual control input with the motor drive power supplied from the power conversion module.

The "K" AC motor is a constant speed motor that comes on (auto mode) when the KXA motor cannot satisfy the sensor demand. As the "K" motor comes up to speed, the KXA motor decreases speed until the sensor demand is satisfied.

For a more detailed explanation of system theory of operation, see Appendix, Section IX.

TABLE 2-1 FUNCTION OF CONTROLS AND INDICATORS

EQUIPMENT/ITEM	CONTROL/INDICATOR	FUNCTION
Control Unit Door	(Fig. 2-1)	
(1)	Circuit Breaker "ON-OFF" Control Handle	Controls application of three phase, a-c power input to drive system.
(2)	"ON" Indicator	Provides an indication that the "START" button has been pressed and the "RUN" relay has energized and there are no "faults" in the system.
(3)	"START" Pushbutton	Applies 115VAC to the "RUN" relay coil and power "ON" indicator.
(4)	"STOP" Pushbutton	Interrupts 115VAC to the "RUN" relay coil which causes the power "ON" light to extinguish, and also connects the regulator input signal to common, causing the motor to stop.
(5)	"MOTOR RUN" Indicator	Provides a visual indication of motor run voltage; brilliance will increase as the voltage or motor speed increases.
(6)	"NO.1 AUTO-NO.2 MODE" Selector Switch	In Position No. 1 the variable speed motor may be operated in manual. In the auto position the drive system operates as a function of sensor reference. In the No. 2 Position the constant speed motor may be operated at rated speed for emergency operation.
(7)	"ALARM" Indicator	With the application of external 115VAC to the alarm circuit, this indicator will illuminate whenever there is a fault due to a problem or malfunction in the system.
(8)	Manual Speedpot	With mode selector switch in No. 1 Position, provides a means of setting in a constant speed command

TABLE 2-1 FUNCTION OF CONTROLS AND INDICATORS

EQUIPMENT/ITEM	CONTROL/INDICATOR	FUNCTION
Regulator (9)	(Fig. 2-2) ±20VDC Power Supply Card (no adjustments)	Supplies ±20VDC for regulator and sensor power. Fused inputs FUA1 and 2.
(10)	"Coordination" Card	Provides input signal amplification, motor response, and stability adjustments and the oscillator circuit.
(A)	"Stability" Adjust Potentiometer	Provides a means of fine tuning the response of the motor to eliminate speed variations.
(B)	"Range" Adjust Potentiometer	Provides a means of electrically centering sensor pickoff arm to provide balanced range.
(C)	"Response" Adjust Potentiometer	Provides a means of setting the system sensitivity to control the motor response time to a pressure change.
(11)	"Driver Coordination" Card	Provides signal amplification and current limit circuit with adjustments.
(A)	"Current Limit" Adjust Potentiometer	Provides an adjustment range for overcurrent protection for the SCR's (normally set at 130%).
(B)	"Zero Adj" Potentiometer	Provides a means of minimizing the output with no input applied.
(12) (13) (14)	"Gate Pulse Generator" Cards	Provides the pulse trains to the SCR modules in the proper time sequence and phase for firing the SCR's causing the right amount of voltage at the motor to increase or decrease the motor torque.
Transfer Function TRFUNC (15)	(Fig. 2-3) Balance Pot P322	Provides a means of adjusting the point where the constant speed motor comes on.

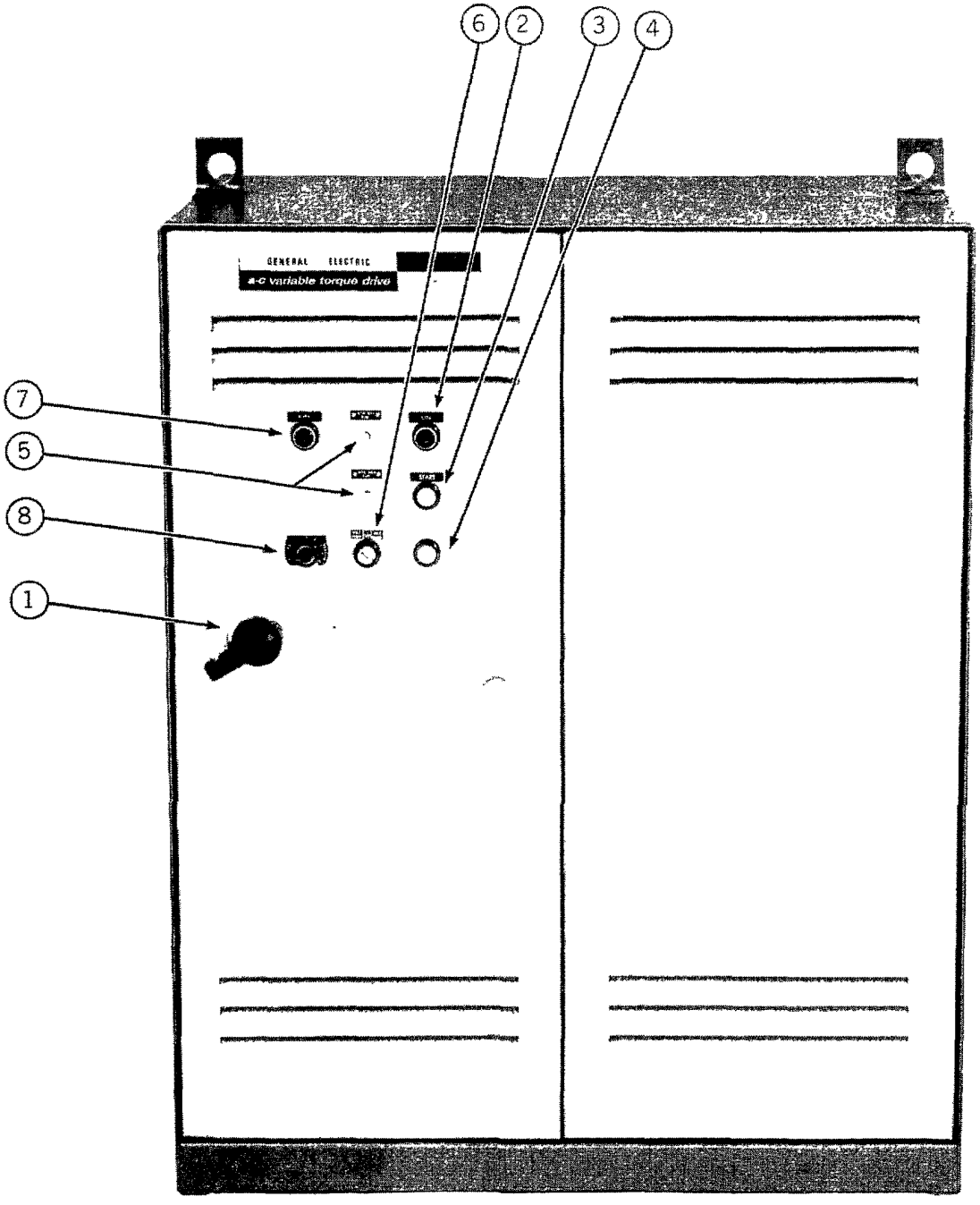
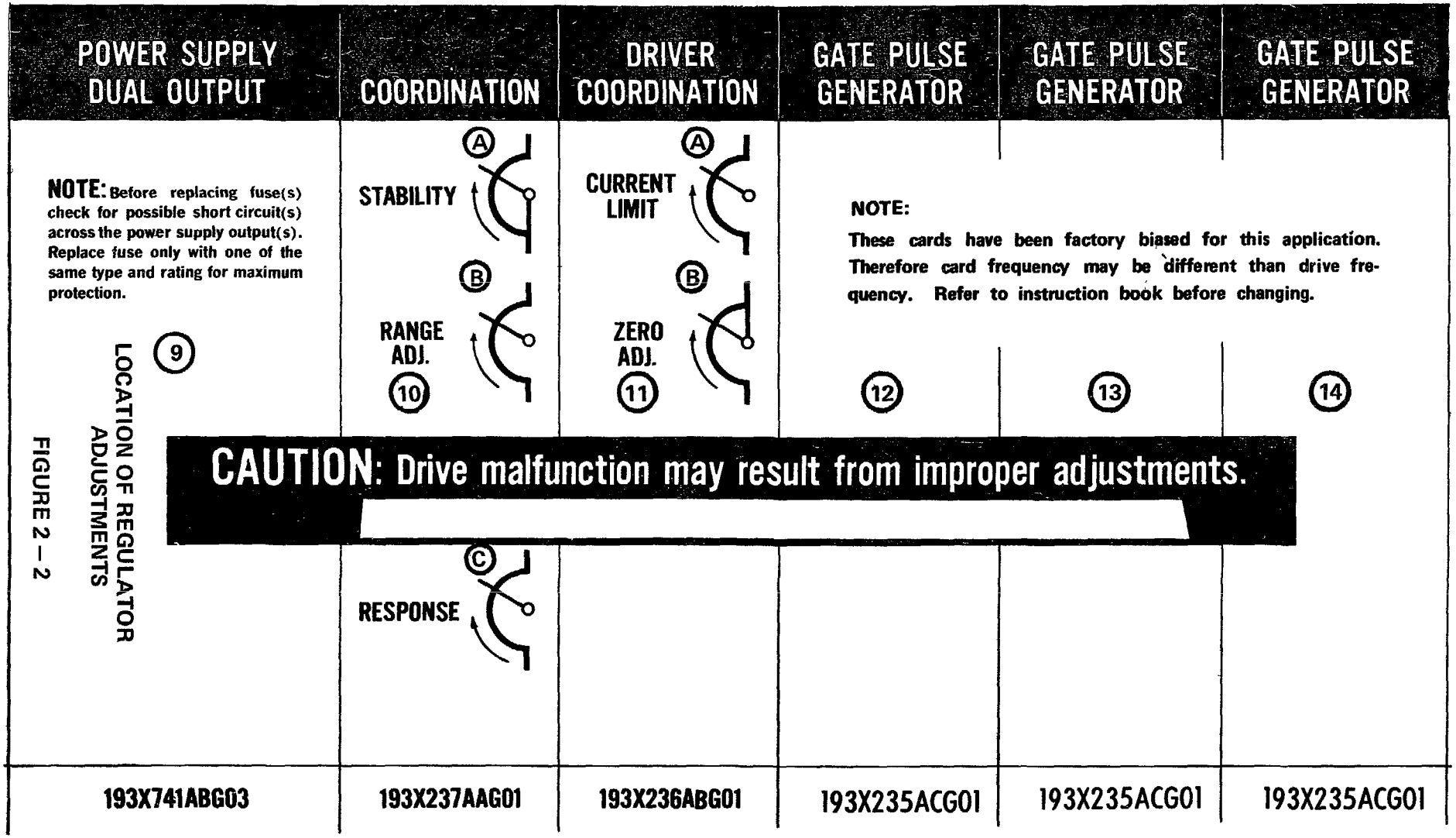


FIGURE 2 – 1 LOCATION OF CONTROLS AND INDICATORS
CONTROL UNIT (CU) DOOR



LOCATION OF REGULATOR ADJUSTMENTS

FIGURE 2 – 2

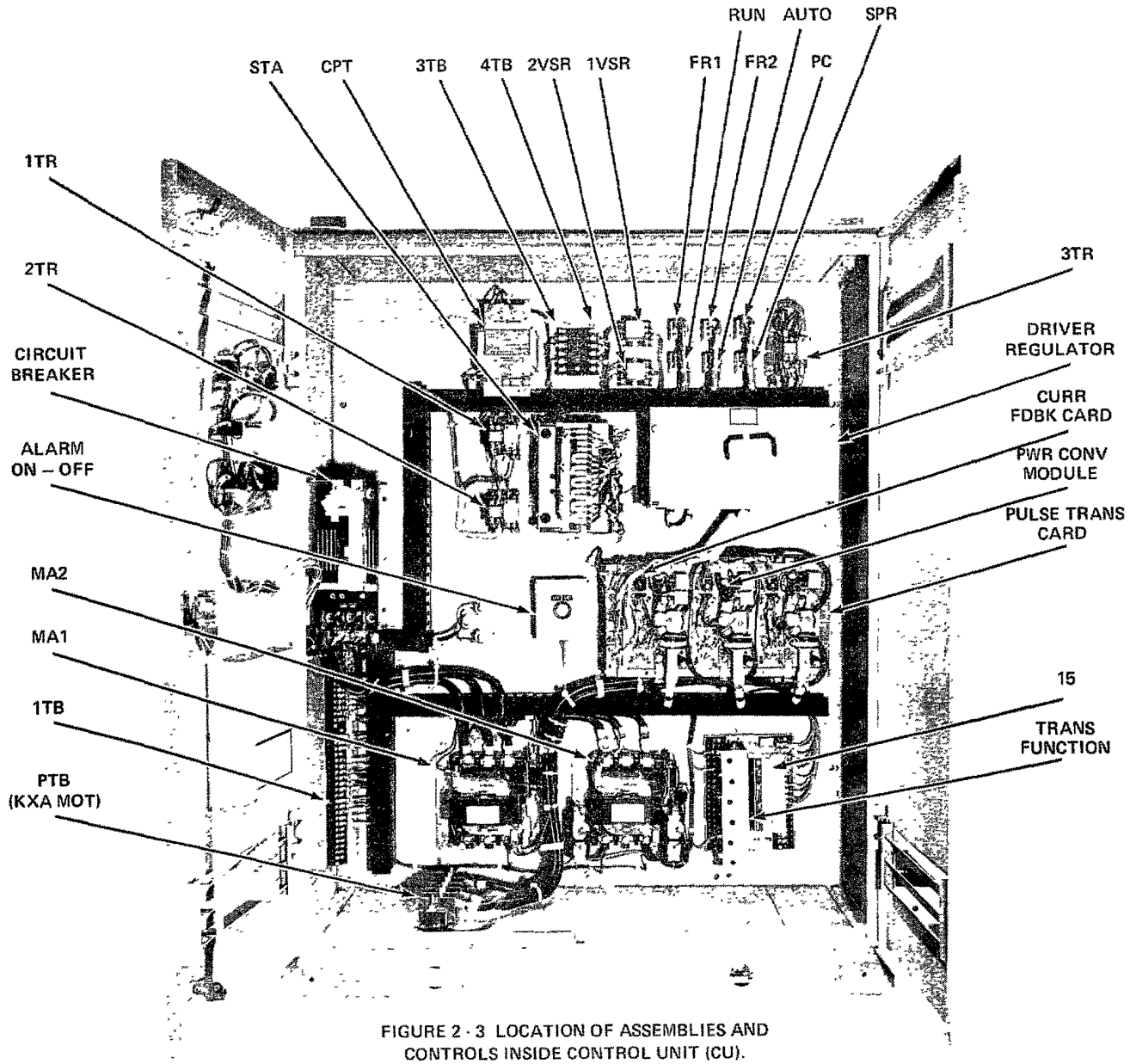
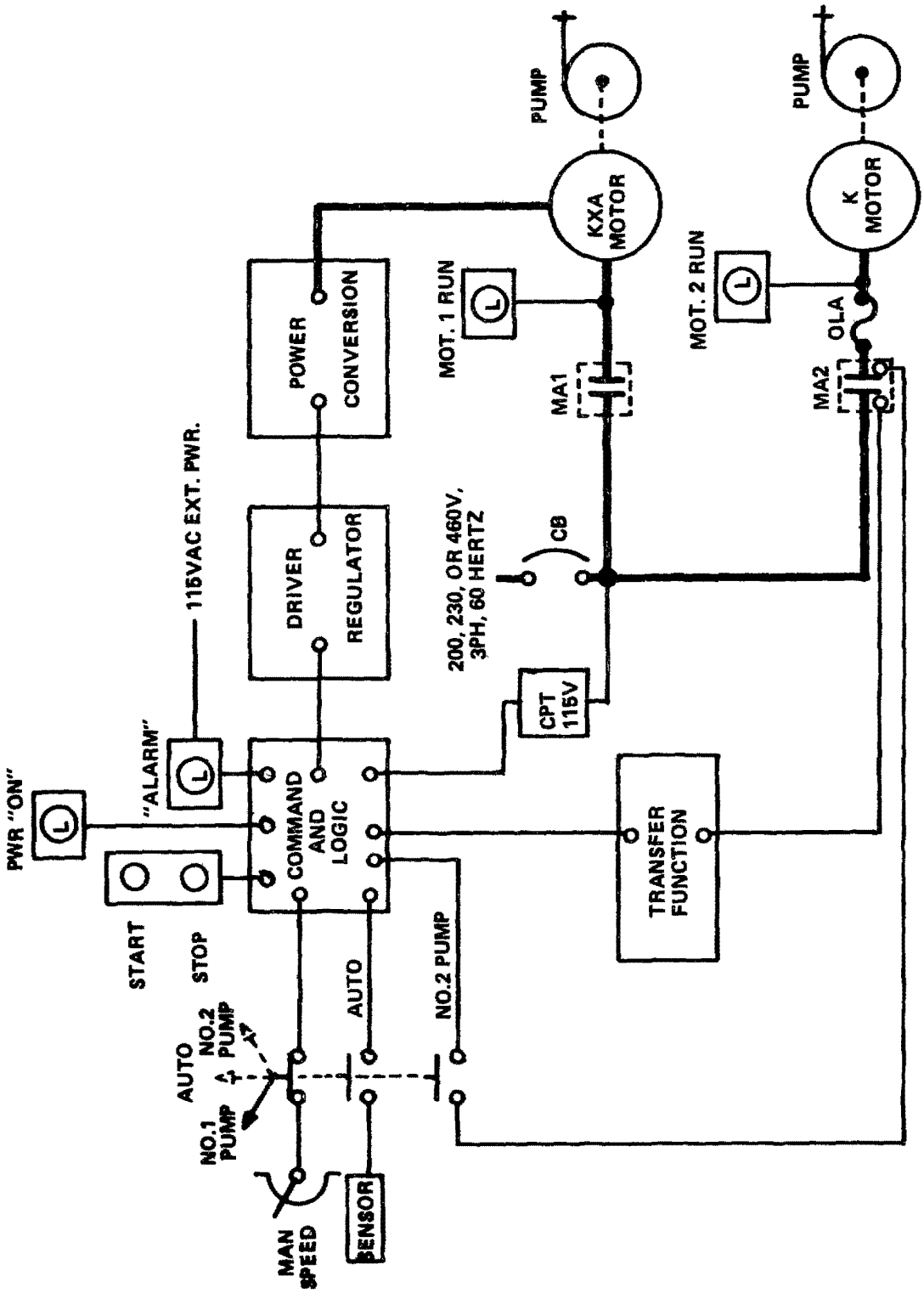


FIGURE 2 - 3 LOCATION OF ASSEMBLIES AND CONTROLS INSIDE CONTROL UNIT (CU).



SIMPLIFIED BLOCK DIAGRAM – VT700 DUPLEX

FIGURE 2–4

SECTION III
INSTALLATION

3.1 GENERAL

There are different types of drawings/diagrams created for specific purposes. The type of drawing/diagram is noted in the title block of each diagram sheet.

The three major types of diagrams are elementary (sometimes referred to as schematic), connection and interconnection.

a. The Elementary Diagram represents (in symbolic form) the fundamental operation and relationship of the electrical parts of a system. These diagrams are drawn in such a manner that the operation of the control is easily understood. Mechanical relationships of control devices are subordinated to the most simple presentation of the electrical circuits.

b. The Connection Diagram is one which shows the relative physical position of the devices on the control panel as well as other electrical components located within the same enclosure. Actual wire connections made between control devices and power devices within the enclosure, as well as outgoing terminal points, are shown on this type diagram.

c. The Interconnection Diagram indicates the type and number of connections to be made between major components of the system (power unit, motor and sensing device), the power source, and auxiliary devices.

3.2 EQUIPMENT LOCATION

Speed Variator power units are suitable for most building areas where other equipment is installed. Locations subject to steam vapors or excess moisture, oil vapors or chemical fumes should be avoided. Power units should be installed in a well-ventilated area not subjected to excessive heat (above 104°F).

WARNING

EQUIPMENT SHOULD NEVER BE INSTALLED WHERE HAZARDOUS, INFLAMMABLE OR COMBUSTIBLE VAPORS OR DUSTS ARE PRESENT. DRIVE POWER UNITS SHOULD BE INSTALLED AWAY FROM HAZARDOUS AREAS, EVEN IF USED WITH AC MOTORS SUITABLE FOR USE IN SUCH LOCATIONS.

When installing units provide for sufficient clearance in front of doors to allow access to unit.

3.3 TOOLS REQUIRED

The normal electrical and mechanical tool boxes maintained in most buildings plus a lifting device ("A" frame) with hooks and sling or fork lift.

Mounting holes for the power unit(s) are suitable for 3/8 inch mounting bolts and flat washers. (Recommend a minimum of four bolts per enclosure base.)

A volt-ohm meter (VOM) is required for verifying continuity and making voltage measurements.

A clamp-on ammeter is required.

3.4 MECHANICAL INSTALLATION

3.4.1 Power Unit

Refer to outline drawing for mounting dimensions and equipment weights.

3.4.2 Pressure Sensor

The recommended installation of the sensor is pictured in Figure 3-1. Any installation other than the ones pictured in Figure 3-1 may cause false or faulty system operation due to water turbulence, hammer or incorrect sensing.

3.4.3 Motor

Except for close coupled pumps, use of flexible couplings between the motor and the pump, to compensate for possible misalignment is recommended.

To minimize introducing noise into the hydraulic system, it may be desirable to provide vibration isolation between the motor base and the foundation, as well as flexible couplings between suction and discharge parts of the pump and distribution piping.

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 power units were made at the General Electric Factory. When installing units, 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 equipment as indicated on the connection diagram. The equipment should be wired as per the interconnection diagram and verified by continuity

tests. It is recommended as each connection or wire is connected to the equipment, that it be checked off on the interconnection diagram and the wire labeled to indicate where it is connected. When sensor leads are connected, it is recommended that they be run in separate conduit from the motor armature leads.

WARNING

ALL MOTOR BASES AND EQUIPMENT ENCLOSURE HOUSINGS SHOULD BE CONNECTED TO THE BUILDING OR FACILITY EARTH GROUNDING SYSTEM IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE.

If a separate AC line breaker, switch and/or fuse is used, the device and fuse selection should be in accordance with the National Electrical Code and/or local requirements based on power unit input data. Codes generally require the use of a fused disconnecting switch or circuit breaker.

CAUTION

MAKE CERTAIN THE INPUT VOLTAGE, FREQUENCY AND PHASE OF THE POWER SUPPLY AGREE WITH THE POWER UNIT NAMEPLATE ON THE CONTROL PANEL INSIDE THE ENCLOSURE. IT IS NECESSARY ON THE THREE PHASE POWER UNITS TO CONNECT THE AC SUPPLY IN THE CORRECT PHASE SEQUENCE FOR THE PROPER DIRECTION OF MOTOR ROTATION.

Conduit entrance can be made through the top, ends or bottom of the power unit enclosure. Recommended entry for power and control leads is through the base or the top near the left end of the enclosure. Entrance of conduit through other than the left end of the base or top may be blocked by components. Protect electrical circuit/ components when cutting conduit entrance by covering them.

CAUTION

DO NOT GROUND ANY POWER OR CONTROL CIRCUITS OF THE VT-700 DRIVE UNLESS NOTED ON THE DIAGRAMS. NATIONAL ELECTRICAL CODE AND SOUND LOCAL PRACTICES SHOULD BE CONSULTED FOR FURTHER REQUIREMENTS.

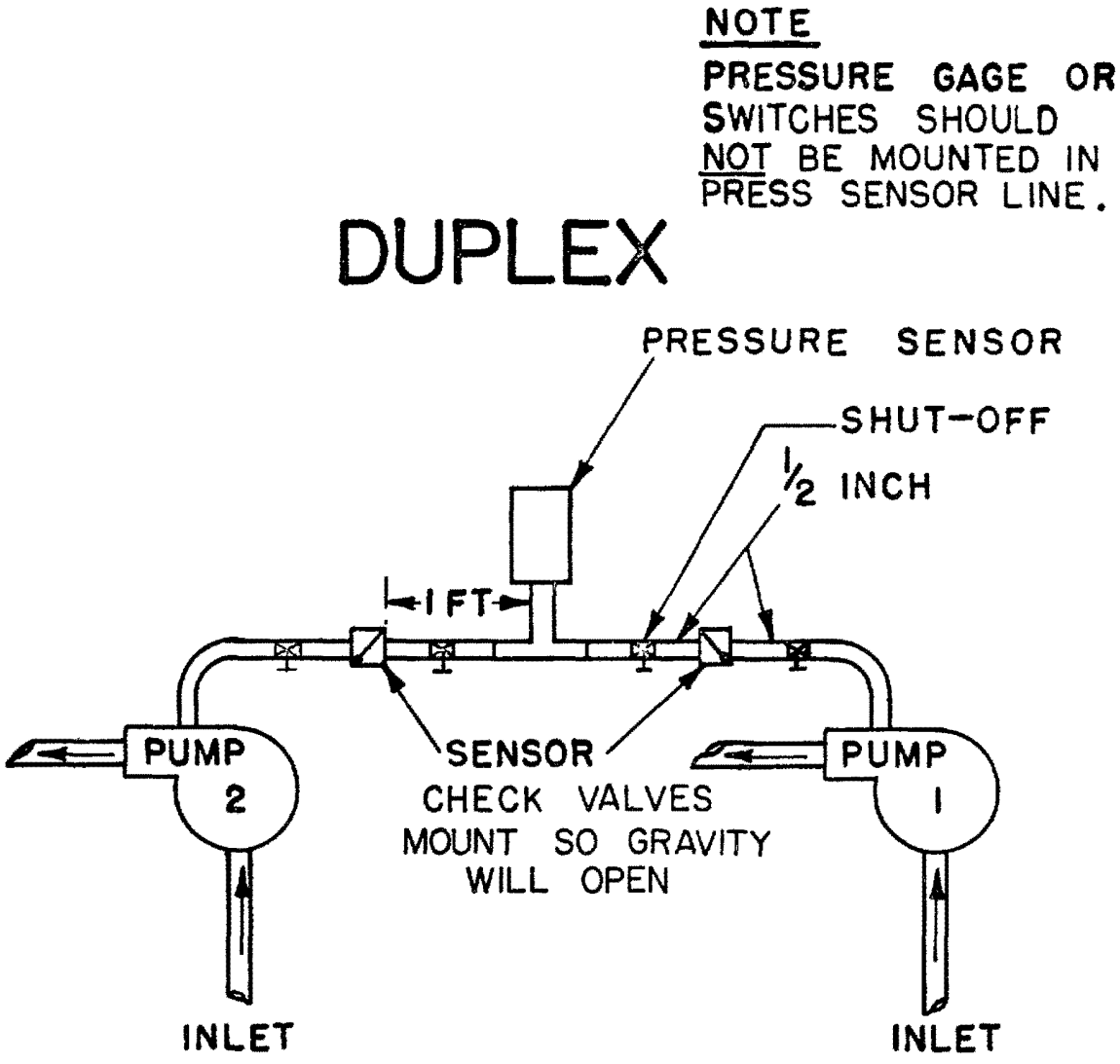
The check valves, for the sensor, may be mounted two ways. The one pictured below is the simplest and will normally provide correct system operations. If system instability occurs (after checking in Troubleshooting Table 6-1, page 6-5 under "Pressure not stable under steady demand" steps) perform the following:

1. Remove power from the system, close the sensor shut-off valves and remove the sensor check valves.

2. Drill a 1/16 inch hole in the clapper of the check valves.

3. Re-install check valves so gravity will close clapper.

4. Open shut-off valves and test system.



SENSOR INSTALLATION

FIGURE 3-1

The following table of AC input currents for several voltages is given for standard equipments to aid in the selection of breakers, switches, fuses and wire sizes.

(1) "Full Load" is the term used to define the point of maximum input current; full load current will occur at about 67% synchronous speed, and at 38% rated horsepower.

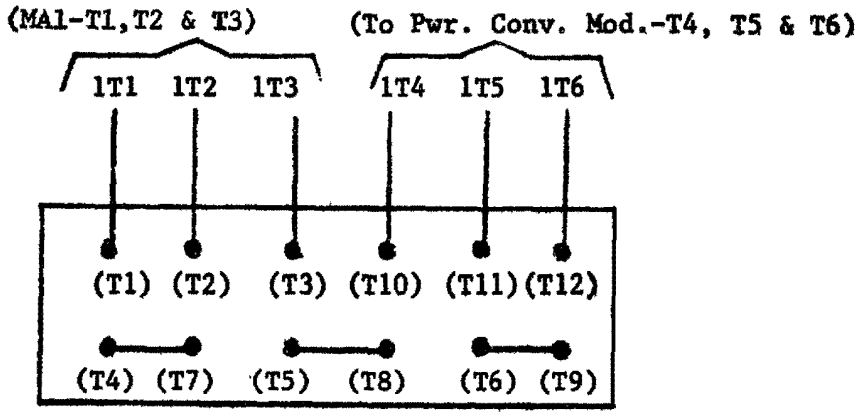
(2) "Rated Speed" is the term used to define the drive input current at nominal speed, frequency and horsepower.

	200V - 3PH - 60 CYC		230V - 3PH - 60 CYC		460V - 3PH - 60 CYC	
HP	FULL LOAD AMPS (1)	RATED SP. AMPS (2)	FULL LOAD AMPS (1)	RATFD SP. AMPS (2)	FULL LOAD AMPS (1)	RATFD SP. AMPS (2)
5	28	20	25	18	12.5	9
7½	39	29	35	26	17.5	13
10	51	38	46	34	23	17
15	69	57	62	51	31	25.5
20	89	62	80	56	40	28
25	102	73	92	66	46	33
30	114	84	104	76	52	38
40	160	114	144	102	72	51
50	205	139	186	126	93	63

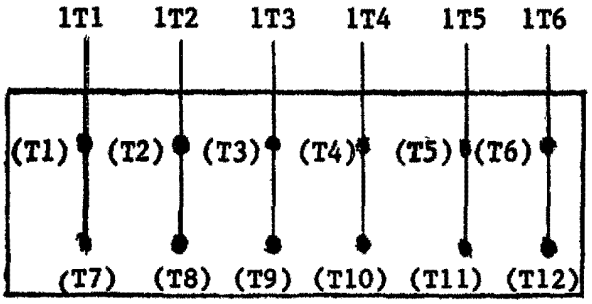
3.5.1 Motor Connections

Some motors will have dual voltage ratings of 230VAC/460VAC and therefore will have twelve (12) power leads (T1 through T12) instead of six (6) power leads (T1 through T6). If you receive one of these motors, simply connect as indicated for your voltage requirement.

The two smaller wires on the KXA motor are the thermal protection leads and are connected to 1P1 and 1P2 on 1TB terminal board.



230/460VAC connected for 460VAC operation.



230/460VAC connected for 230VAC operation.

CAUTION

AFTER MOTOR LEADS 1T1, 1T2 AND 1T3 ARE CONNECTED TO THE MA1 STARTER AND BEFORE 1T4, 1T5 AND 1T6 ARE CONNECTED TO THE POWER CONVERSION MODULE PERFORM A CONTINUITY TEST BETWEEN 1T1 TO 1T4, 1T2 TO 1T5 AND 1T3 TO 1T6. CONTINUITY IS DEFINED AS 10 OHMS OR LESS.

3.5.2 Driver Power Unit Connections

The interconnection diagram furnished with the equipment provides the detailed requirements for the connections to be made. Some general notes and reminders are listed below:

a. If no system pressure switch is to be installed, a jumper must be used on their input terminals on 1TB, 101 and 118.

b. External power (115VAC) is required for the alarm circuit (foreign circuit). This external power is connected to terminals 4 and 8 of the alarm "ON-OFF" switch by removing the alarm switch box cover.

c. Check that all printed circuit boards inside the regulator are firmly seated in their respective sockets.

d. Prior to the application of power to the units, check all switches for ease of operation and manually actuate any relays/circuit breakers. Return all circuit breakers to the "OFF" position, and all switches to the manual setting.

SECTION IV
STARTUP AND CHECKOUT

4.1 GENERAL

This section is written in a logical step by step approach to start up the VT-700B Drive System. If during the course of startup and checkout a step/indication cannot be performed, refer to Section VI, TROUBLESHOOTING, Table 6-1. This Troubleshooting table is written to follow each startup step in sequence.

4.2 STARTUP AND CHECKOUT

WARNING

ELECTRICAL SHOCK CAN CAUSE PERSONAL INJURY OR LOSS OF LIFE. WHETHER THE AC SUPPLY IS GROUNDED OR NOT, HIGH VOLTAGE TO GROUND WILL BE PRESENT AT MANY POINTS THROUGHOUT THE DRIVE.

A slash line between two words indicates two possible actions or denotes one or two functions. Normally, if the first action word is true, the second is not necessary.

4.2.1 Apply external three phase AC power to Control Unit (CU).

4.2.2 Verify three phase power is available at the top of the CU circuit breaker, and is of proper value as noted on the equipment nameplate.

4.2.3 Place alarm switch (inside unit) to "OFF" and then apply external alarm power (115VAC) to CU. Close unit doors.

4.2.4 Place mode switch to #1 position.

4.2.5 Verify/Place "Manual Adj. Pot" fully CCW (Counterclockwise).

4.2.6 Set Zero Pressure switch (if used) to 5 pounds below lowest expected suction pressure.

4.2.7 Place CU circuit breaker handle to "ON". Verify that "RUN" indicator is not illuminated.

4.2.8 Press"START" button, observe or verify "ON" indicator is illuminated.

4.2.9 Turn "Manual Speed Pot" fully CW (clockwise).

NOTE

MOTOR STARTUP TIME WILL VARY UP TO TWO MINUTES. "RUN" INDICATOR WILL ILLUMINATE AND ITS BRIGHTNESS IS A FUNCTION OF MOTOR SPEED.

4.2.10 When motor starts to rotate, check for correct direction of rotation.

4.2.11 Press "STOP" button, motor starts coasting to a halt. "ON" indicator is extinguished.

NOTE

IF MOTOR ROTATION IS INCORRECT, INTERCHANGE ANY TWO INPUT LINES AT THE TOP OF THE CIRCUIT BREAKER (NOT AT THE MOTOR).

4.2.12 Turn "Manual Speed Pot" fully CCW.

4.2.13 Place "Mode" switch to #2; press "START" button; constant speed motor accelerates to top speed. When motor starts to rotate, check for correct direction of rotation as above. Return switch to #1.

4.2.14 Set pressure sensor to 10 pounds below desired pressure to be maintained (largest screw on top of sensor housing).

4.2.15 Place "Mode" switch to "AUTO" position.

4.2.16 Variable Speed Motor starts to rotate.

4.2.17 If pressure gauge is used, verify that sensor pressure setting is obtained and is stable.

4.2.18 Place CU circuit breaker to "OFF".

SECTION V
MAINTENANCE

WARNING

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

5.1 MECHANICAL

The mechanical maintenance required for the VT-700 Drive System is very small. The motor should be checked occasionally for excessive noise or vibration that would indicate bearing wear or the need for lubrication.

The inspection requirements of the power unit(s) (POWER OFF) are as follows with an "every 6 months recommendation".

a. Check all electrical connections for tightness.

b. Look for signs of poor connections or overheating (arcing, discoloration).

c. Manually check cooling fans (if supplied) for easy rotation.

5.2 MOTOR LUBRICATION

The recommended motor lubrication period is once a year. The type lubrication to be used is given on the motor nameplate. The following procedure is recommended for motor lubrication:

a. Remove plug at bottom/underside of motor.

b. Using the grease fitting on top of motor, add grease until new grease is seen at bottom motor hole.

c. Run motor with bottom plug out for 30 minutes - a column of grease will appear at bottom plug hole due to grease expansion from heating.

d. Clean off excess grease and replace plug in bottom hole.

SECTION VI
TROUBLESHOOTING

6.1 GENERAL

The troubleshooting section has been divided into two basic tables and a paragraph on checking SCR's. Only trained and qualified electronics or electrical personnel should be allowed to troubleshoot this equipment, due to the dangers involved in having to bypass the interlock safety devices for "POWER ON" measurements. It is recommended from a safety standpoint, that the equipment be turned off, the test equipment connections be made, and the power applied for the measurement, and the equipment then be turned off again, prior to disconnecting the test equipment.

Fast, efficient troubleshooting of the drive system is based on a thorough knowledge of the theory of operation. During troubleshooting, when a card or subassembly is found or suspected of being bad, it is recommended that prior to replacing the card/subassembly, the inputs be checked for proper values. This will exclude the chance of further damage to the replacement item, due to causes beyond the suspected item.

6.1.1 Troubleshooting - Startup

Table 6-1 provides a one-to-one correlation with the startup sequence. In the left-hand column under indication will be the action/indication that failed. In the right-hand column under Check/Adjust/Replace are listed the tasks or measurements to be performed. When a step or action is completed and the malfunction still occurs, proceed to the next step. If the step locates the problem area, troubleshoot, isolate and correct the malfunction.

6.1.2 Troubleshooting - Regulator/Power Conversion Module

Table 6-2 provides a step by step troubleshooting procedure for the regulator/power conversion module. The first 10 steps of this troubleshooting table are so written that only a VOM is required and should identify the card or component to be replaced. The other steps in the table require an oscilloscope.

NOTE

WHEN MEASUREMENTS ARE TAKEN ON THE BACK OF THE CARD SOCKET, PUSH THE SMALL END OF THE RELEASE TOOL IN, BESIDE THE SOCKET TERMINAL WIRE TO BE MEASURED, AND USE IT FOR THE TEST EQUIPMENT CONNECTION POINT.

WARNING

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.

6.1.3 Checking SCR's

Whenever an SCR is suspected of being at fault, use the steps in the simplified test setup described in paragraph 6.1.3c.

WARNING

ELECTRICAL 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 SYSTEM.

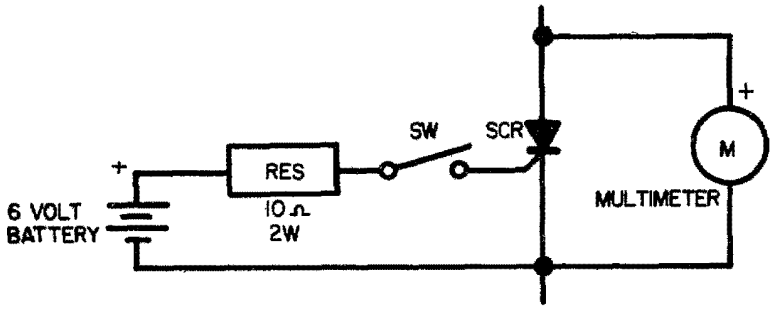
a. Disconnect the AC power into the unit, and the three leads going to the conversion unit.

b. Using a multimeter selected to read ohms on the times-1K scale, check the forward and reverse resistance of each individual SCR cell. This is done by reading across power terminals. (See conversion module elementary diagram). Good or faulty SCR's 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 2K	100K to Infinity
Open SCR	100K to Infinity	100K to Infinity

c. 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 and 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:

c. (contd)



The multimeter 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. A faulty SCR will not switch, remaining in either an open or a conducting state.

d. If any SCR's are suspected of being faulty from the above resistance checks, the SCR conversion module should be removed from the case. After the SCR pigtail (cathode) and gate leads have been disconnected, recheck the forward and reverse resistances before replacing the SCR heatsink assembly. This should be done before an 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.

Table 6-1 STARTUP

INDICATION	CHECK/ADJUST/REPLACE
"RUN" indicator illuminates without "START" button being pushed	1. Check that motor connections are as per installation and drawing instructions. 2. Disconnect motor leads T4, T5 and T6 at the power conversion module. Perform a continuity test between T1 to 1T4, T2 to 1T5 and T3 to 1T6. Continuity is defined 10 ohms or less. reconnect as necessary to meet the above stated conditions.
"ON" indicator fails to light when "START" button is pressed	1. Check that the lamp is good. 2. Verify continuity exists (wires must be disconnected) through zero pressure switch leads. 3. Verify continuity exists (wires must be disconnected) through the motor thermal leads. 4. Check fuse on CPT. 5. Turn on breaker and check that 115VAC is present between X1 and X2 on CPT.
KXA motor fails to rotate. No hum at motor.	1. Pull regulator out and disconnect terminal 19 input on Regulator TB. Restart drive. If motor rotates "RUN" relay is defective. 2. Go to Regulator Troubleshooting, Table 6-2.
KXA motor fails to rotate but hums or rotates at very slow speed (less than full 2/3 speed)	1. a. Using a clamp on ammeter, check for balance current output from T4, T5 and T6 (±10%) for motor ratings above 50 amps or ±5 amps for motor ratings less than 50 amps. NOTE IF THE ABOVE STEP CANNOT BE PASSED, CONTACT SPEED VARIATOR DEPARTMENT, GENERAL ELECTRIC COMPANY, ERIE, PA. b. Current readings should be equal to or less than 130% motor full load rating. c. Check for mechanical binding.

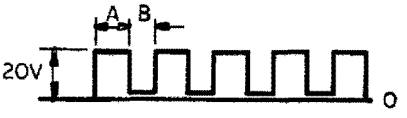
TABLE 6-1 STARTUP

INDICATION	CHECK/ADJUST/REPLACE
Motor fails to rotate but hums or rotates at very slow speed (less than full 2/3 speed)	2. Adjust "Current Limit" in steps of 1/8 of a turn CW until motor reaches top speed or adjustment reaches limit. 3. Go to Regulator Troubleshooting Table 6-2.
In "AUTO" mode motor fails to run	1. Using a VOM, verify that a 3 to 5 VDC reading is measured with the common probe on 1TB-R1 and the plus (+) probe on 1TB-R3. (If 18 to 20 volts is measured, the sensor should be replaced). 2. Using a VOM, verify that the voltage reading is 3 to 5 VDC measured with the common probe on 1TB-R1 and plus (+) probe on 1TB-R2. 3. Go to Regulator Troubleshooting Table 6-2.
Pressure not stable under steady demand	1. a. Adjust the "Response" control in such a direction as to minimize the instability. b. Adjust the "Stability" control to further improve system performance. 2. Adjust the "Throttling Range" sensor screw in such a direction to improve system stability. NOTE STEP 2 ABOVE WILL AFFECT STEP 1(a) AND (b) AND THESE WILL HAVE TO BE REPEATED. 3. Bleed sensor fitting of trapped air.

Table 6-2 REGULATOR/POWER CONVERSION MODULE

INDICATION	CHECK/ADJUST/REPLACE
Regulator Trouble-shooting - START pushbutton must be pushed	WARNING ELECTRICAL 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 SYSTEM.
Note: TB-1 Explanation: TB means terminal board; -1 indicates the terminal number.	1. Open regulator door and check that all cards are firmly seated in their sockets. 2. Pull regulator out from the case and lower it to the hinge down position. 3. Check for a +20VDC ±1V with VOM common lead on regulator TB-1 and plus (+) lead on TB-4. 4. Check for a -20VDC ±1V with VOM common lead on TB-5 and plus (+) lead on TB-1. NOTE THE FOLLOWING MEASUREMENTS REQUIRE THE MODE SWITCH TO BE IN #1 AND THE MANUAL SPEED FULLY CW (ON). 5. Check for approximately -1.5VDC to -2.5 with VOM common lead on TB-15 and plus lead on TB-1. 6. Check for +6VDC or more with VOM common lead on TB-1 and plus lead on TB-20. (Replace Coordination card if no voltage or low voltage is measured.) 7. Check for a minimum of +6VDC with VOM common lead on TB-1 and plus lead on TB-14. (Replace Driver Coordination card if less than +6VDC is measured). NOTE THE FOLLOWING MEASUREMENTS ONLY DETERMINE IF THE OUTPUT IS MISSING - THESE MEASUREMENTS WILL NOT VERIFY THE OUTPUT IS CORRECT; FOR THAT, AN OSCILLOSCOPE IS REQUIRED. 8. Check for a + voltage (approximately +13 to 15VDC) with VOM common lead on regulator TB-1 and + lead on back of socket of Coordination card on terminal connection 23. (If voltage is not in this range, replace Coordination Card.

TABLE 6-2 REGULATOR/POWER CONVERSION MODULE

INDICATION	CHECK/ADJUST/REPLACE
Regulator Trouble-shooting (contd)	9. Check for a +DC signal of 2 volts or more with a VOM common lead on regulator TB-1 and the following terminals on the back of the socket of each gate pulse generator - No. 12 and No. 20. (If measured voltage is not correct, replace the Gate Pulse Generator card that failed measurement). 10. Using a clamp on ammeter, check the current output from T4, T5 and T6 for balanced (±10%) readings. NOTE THE FOLLOWING STEPS REQUIRE THE USE OF AN OSCILLOSCOPE. WARNING THE OSCILLOSCOPE MUST BE ISOLATED FROM EARTH GROUND. HIGH VOLTAGE THEREFORE MAY BE PRESENT ON THE OSCILLOSCOPE CHASSIS. 11. Place the system in the manual mode of operation and the manual speed control fully CW (maximum). With the scope, check for the proper signals as follows. Under the indication column will be listed the function to be measured and the point of measurement - either TB terminal or card socket tab/terminal. Under this column will be given scope settings and signal observed plus approximate amplitude.
Driver Coordination Tab 28, Current Feedback	F = 60Hz Scale: 2 millisec/div 2 volts/div 
Gate Pulse Generators Tab 5, AC Synchron-izing Voltage	Scale: 2 millisec/div 20 volts/div 
Coordination Tab 23, Oscillator Output	Time 10KC 10V/div  A = 60-70 microseconds B = 20-30 microseconds continuous pulse train

INDICATION	CHECK/ADJUST/REPLACE
Gate Pulse Generator Cards Tabs 12 and 20 (each card) Pulse Train Output	Scale: 2 millisec/div 10 volts/div  (If pulse trains are missing or continuous, replace card under test.)
Driver Coordination Card "ZERO" Adjust (no scope required)	12. Remove coordination card from the regulator. With the VOM common lead on TB-1 and the + lead on TB-14, adjust the "ZERO ADJ" potentiometer on the driver coordination card to just obtain the minimum voltage possible (approximately +.8VDC).
Transfer Function TR Func. Balance Adj.	13. Turn mode selector switch to auto-start drive. Observe that KXA motor is regulating set pressure. Increase flow demand. KXA motor will increase in speed to regulate speed until it reaches top speed. At this point, the set pressure will drop and the balance pot should be adjusted slowly (CW) until the K motor starts.

SECTION VII
SPARE PARTS RECOMMENDATION

7.1 GENERAL

A realistic "on hand" spares stock coupled with the Speed Variator low cost card exchange plan will lead to faster resolution of down time of the equipment in case of malfunction. On hand spare parts avoids extended down time after the problem has been located. Time is not lost waiting for parts that must be ordered and shipped from the factory. The concept of easily removable (plug-in) printed circuit boards is a fallacy if it only takes a few minutes to discover the defective assembly but hours to order and procure a replacement. Therefore, from the standpoint of keeping the equipment/machine operating with a minimum of down time, readily available on hand spares are a must. For further information on the Speed Variator Products Department Card Exchange Plan, contact your local General Electric Company Installation and Service Engineering District Office or Speed Variator Products Department in Erie, Pennsylvania.

7.2 RECOMMENDED SPARE ASSEMBLIES, SUBASSEMBLIES AND PRINTED CIRCUIT CARD/BOARDS

NOTE

WHEN ORDERING SPARE PARTS, BE SURE TO GIVE COMPLETE PART NUMBER, AND ASSEMBLY NAME TO INSURE FAST AND EFFICIENT SERVICE.

The following is a list of recommended spare parts:

Assembly/Subassembly	Quantity
Coordination Card	1
Driver Coordination Card	1
Gate Pulse Generator Card	1
Phase Submodule Cell Panel (heatsink included)	2
Command/Control AC Relay	1
Buffer Amplifier Card/TR Function	1

NOTE

THERE ARE TWO SPARE FUSES MOUNTED ON THE HEATSINK OF THE POWER SUPPLY.

SECTION VIII
DOCUMENTATION/DRAWINGS FURNISHED

8.1 GENERAL

The following types of documentation/drawings are normally supplied with your variable speed drive to aid in the installation and operation of your system.

8.1.1 Documentation

a. VT-700 Instruction manual
b. Sensor Technical Bulletin
c. Special Control Devices Instructions/Bulletins (if applicable)

8.1.2 Drawings/Prints

a. Elementary Diagram
b. Connection Diagram
c. Interconnection Diagram
d. Outline Diagram
e. Regulator Modification Drawing
f. Regulator Drawing

SECTION IX
APPENDIX

9.1 DETAILED THEORY OF OPERATION

9.1.1 AC Power and Protective Circuits

Three phase AC power is brought into the top of the circuit breaker in each cabinet. This circuit breaker is one of the main protective devices in the system. It has two internal power shutdown (circuit breaker trip) modes. The two modes of protection are thermal trip and magnetic trip due to high current.

From the circuit breaker the three phase power goes to four places. It supplies power to the variable speed motor starter (MA1) and the constant speed motor starter (MA2). Operation of the KXA motor thermal protection or the conversion module heat sink thermal protection will drop out starter "MA1" removing AC power. Operation of one of the constant speed motor overload heaters will drop out starter "MA2" removing its power. Operation of system protective switches such as the zero suction pressure switch will drop out both starters. The circuit breaker also supplies power to the Synchronizing Transformer Assembly (STA) which in turn is responsible for all timing relationships in the system. Lastly AC power is supplied to the Control Power Transformer (CPT) which in turn supplies the 115VAC power for the control circuitry and its associated control relays. The control power transformer also supplies 115VAC to the STA which in turn supplies 25VAC input to the ±20V power supply card.

9.1.2 Command and Logic Circuits

The command and logic portion of the system will be divided into two parts; (1) command, such as start/stop or transfer, and (2) logic, which is the command that initiates a series of actions. The command functions of the system are as follows: Start, Stop, No. 1 Pump Auto, No. 2 Pump, Foreign Circuit ON-OFF, and the Manual Speed Control.

The logic is a series of actions that occur from a command of the system; i.e., the logic behind the start command (pressing the start button) tirggers the following series of actions: the start button picks up the run relay. A normally open (N.O.) interlock on the run relay closes around the start button, thereby sealing the circuit closed, when the start button is released. These contacts also supply the voltage to the Power On indicator.

If a fault or trouble exists in the system neither starter "MA1" nor "MA2" will be allowed to energize. If the KXA motor thermal switch or the conversion module thermal switch operate the "MA1"

9.1.2 Command and Logic Circuits (Cont'd.)

starter will not energize. Operation of the K motor overloads will keep starter "MA2" from energizing. If no faults are present the drive may be started and operated in accordance with the position of the mode selection switch. If the #1 position is selected the KXA motor may be operated in the manual mode. In the AUTO position both motors will operate as called for by the system pressure sensor. In the #2 position the constant speed K motor will operate in the emergency mode at rated speed.

9.1.3 Regulator

The next portion of the system to be covered is the regulator which is the heart of the system. The regulator consists of six printed circuit cards. The power supply has no adjustments but the inputs of each supply are fused. The Coordination Card receives a very low voltage signal input from either the automatic sensor or manual speed control pot. This signal must be amplified and conditioned for the driver coordination card. This card has three adjustments. Their purpose is explained in Table 2-1. The input of this card is normally a negative voltage which can be monitored on regulator TB terminal seven. The output of this card can be monitored on regulator TB terminal twenty.

A subcircuit card mounted on the coordination card is the oscillator circuit which produces a continuous pulse train that is sent to each of the three gate pulse generator cards. The three adjustments on the coordination card are stability, range and response.

The input from the coordination card to the driver coordination card is fed into an amplifier. The amplifier's function is to take the signal input from the coordination card and amplify it. The output of the amplifier is in turn fed into a straight amplifier for amplification. At this amplifier, the signal is summed with the output of the current limit amplifier. The summation of the two input signals will be of different polarities. The current limit amplifier's input is to protect from an overcurrent condition in the power conversion module. This amplifier will turn on at a point determined by the current limit adjustment and cause the output of the driver coordination card to decrease until a safe limit of current is maintained at the power conversion unit. The current limit signal input to the driver coordination card is obtained from the power conversion unit. The output of the driver coordination card may be monitored on regulator TB terminal 14.

The output from the driver coordination card is then fed to three identical gate pulse generator cards. The gate pulse generator card's function is to tell the power conversion module's SCR when to fire (conduct). Each gate pulse generator card consists of two identical circuits which in turn produce two outputs. Therefore,

9.1.3 Regulator (Cont'd.)

from the three gate pulse generator cards there will be obtained a total of six outputs which in turn are fed into the power conversion module which contains six SCR's. As previously stated, the regulator must be able to turn the six SCR's on at the proper time and in the proper sequence to insure the exact amount of power to pass through the motor which in turn will supply the motor speed needed to maintain the pressure required. There are four separate types of inputs to the gate pulse generator cards. The first input is from the STA assembly which synchronizes (proper time relationship) the outputs of the three cards for proper firing of the SCR's in relationship to each other. The oscillator input (second input) from the coordination card is combined with the ramp voltage input from the driver coordination card, and the synchronizing voltage from the STA to produce pulse trains that vary in width depending upon how long the SCR's must conduct to supply the proper amount of voltage to the motor. The fourth input to the pulse generator cards is the lockout circuit. Whenever a fault is detected in the system, through the system logic, the run relay is de-energized and the ground path is supplied to the input signal of the gate pulse generator cards which stops their operation; i.e., lockout signal means the stopping of operation of the gate pulse generator cards which in turn will not allow the power conversion module SCR's to conduct to the motor.

9.1.4 Transfer Function (TRFUNC)

The transfer function assembly is the heart of the logic for the operation of the K motor in the automatic mode.

The Transfer Function is made up of 2 amplifiers which are used as switches. Around the amplifiers are time delay circuits and gain change circuits which prevent the constant speed motor from cycling on and off. These delay circuits are factory set to give the minimum necessary deadband in output regulation.

The Balance Adjust Pot (P322) adjusts the point at which the constant speed motor is started. The constant speed motor should start after the variable speed motor has reached top speed and a slight loss in regulation is noticed. Pot P-322 is adjusted clockwise (CW) to start the constant speed motor earlier.

9.1.5 Power Conversion Module

The power conversion module consists of three pulse amplifier cards and six SCR's and associated resistive and filter networks plus a feedback network. Each pulse amplifier card contains two identical circuits which control two SCR's per card. These circuits are used for amplification and isolation. The signals from these pulse amplifier cards are used to turn the SCR's on at the proper time in re-

9.1.5 Power Conversion Module (Cont'd.)

spect to each other. Three SCR's will conduct on the positive portion of each cycle of three phase input. The other three will conduct on the negative portion of each cycle of the input.

The opposite half of the cycle for the conducting SCR's will cause them to stop conduction (turn them off). The SCR heatsinks also have a thermal protection device to sense an over temperature condition, which, if reached, will de-energize FR1 relay, shutting the drive down.

9.1.6 AC Motor

The KXA motor reacts to the amount of conduction that the SCR's have allowed, and provides the proper amount of voltage that provides the required torque and speed to maintain the pressure level command from the sensor. The motor is equipped with thermal protective devices which will shut off the AC power by opening starter MA1 if an overload condition exists which would cause motor overheating.

The K motor is protected by overload heaters which will open starter MA2 if an overload condition exists.

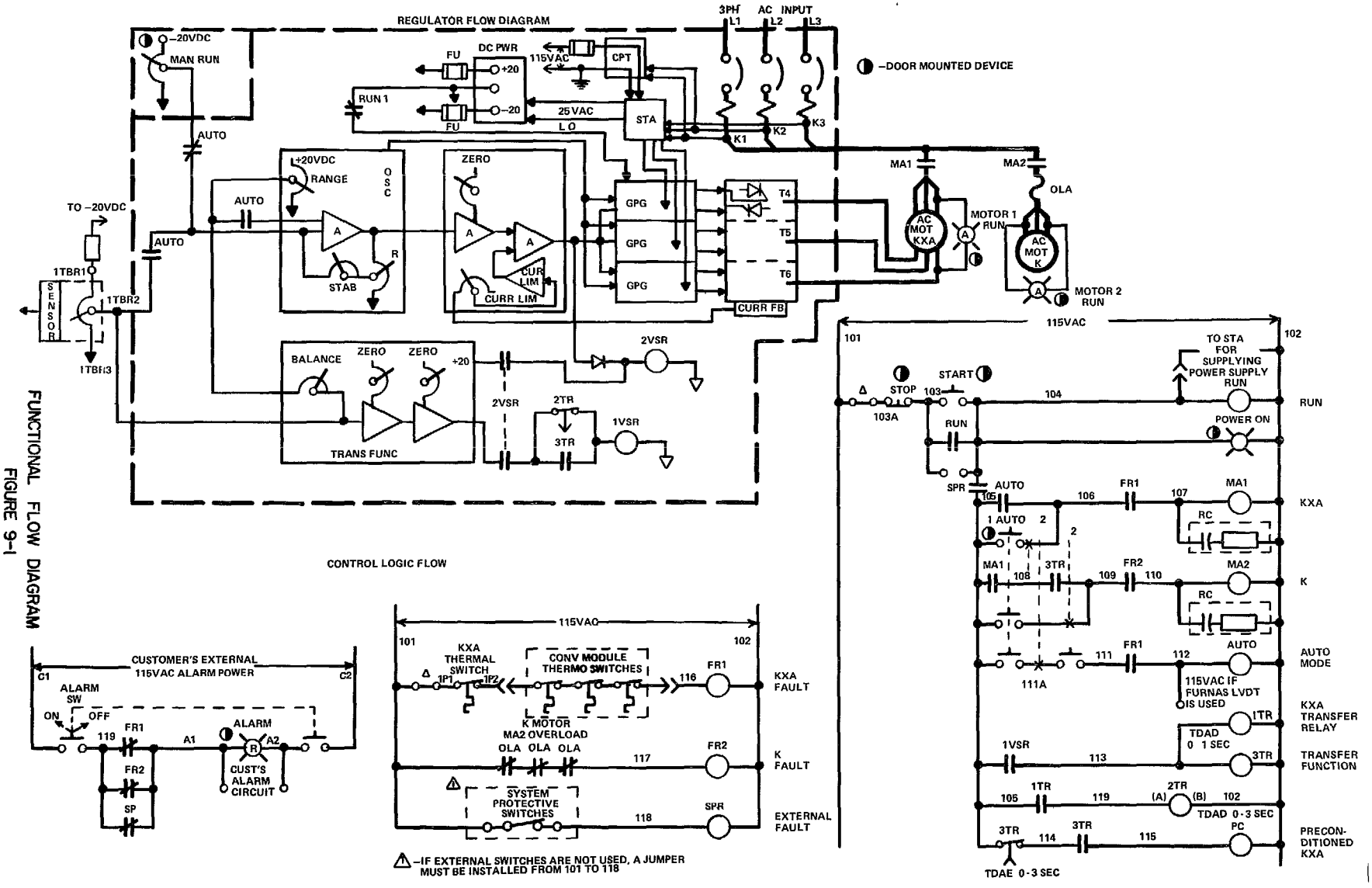
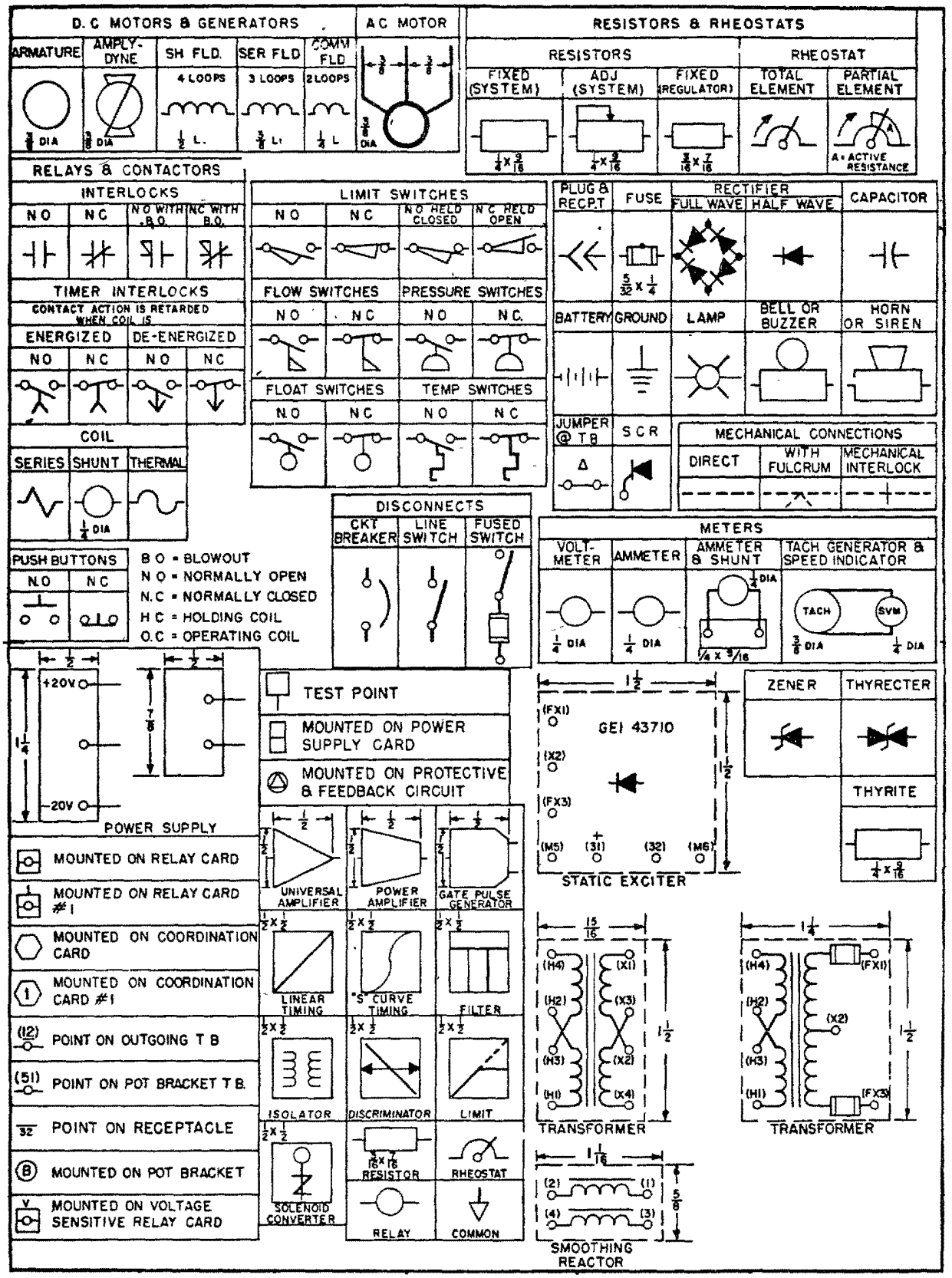


FIGURE 9-1 FUNCTIONAL FLOW DIAGRAM

STANDARD SYMBOLS



NOTES

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