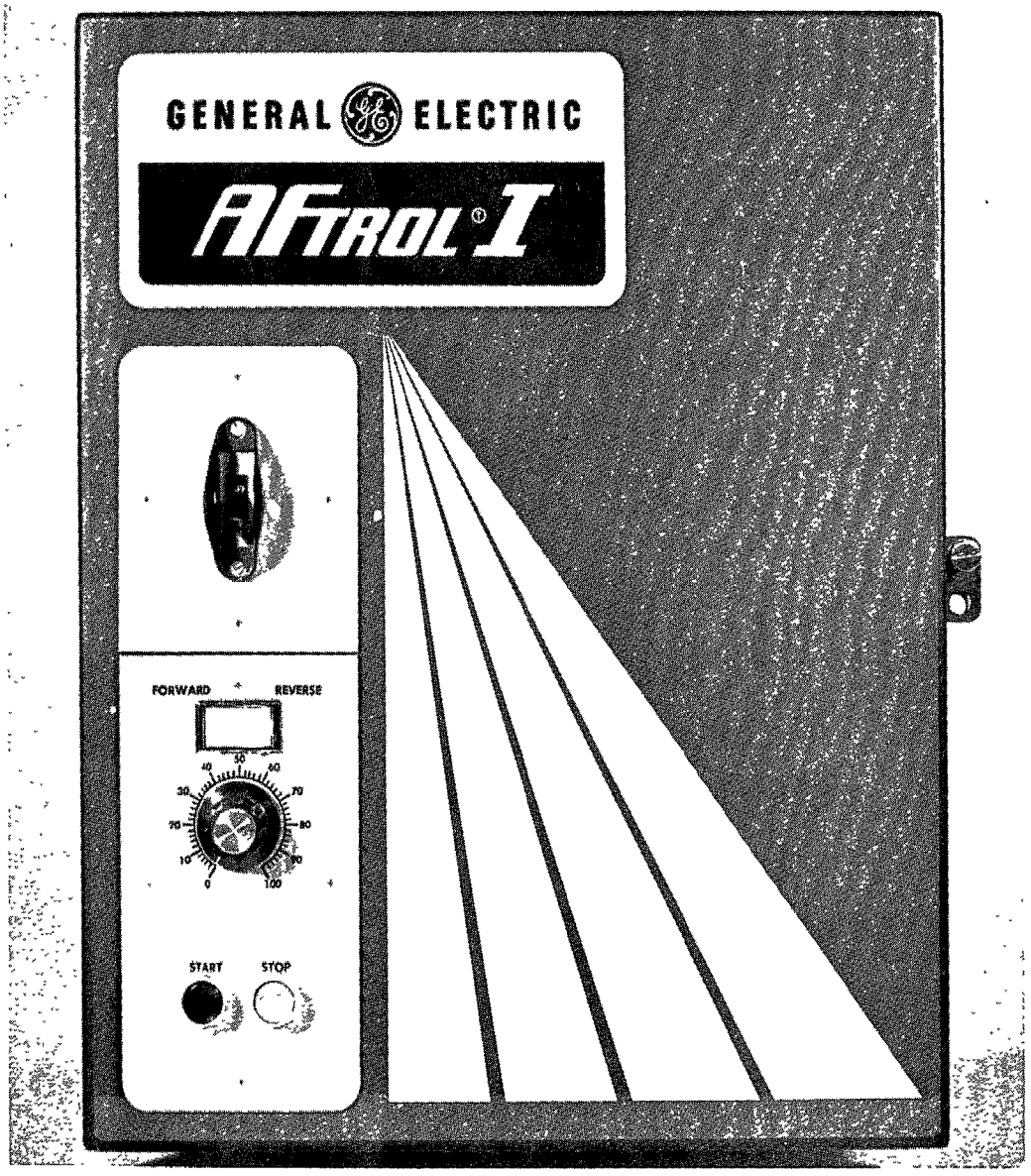
INSTRUCTIONS GEK-24997A

AFTROL* I

Adjustable Speed Drive Controller
1 to 7 1/2 HP Variable Voltage
Square Wave Inverter



(Photo MG-5603-1)

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

GENERAL ELECTRIC

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The operator's station is a NEMA 1 unit that can be remotely mounted and wired by the purchaser. (See Fig. 3).

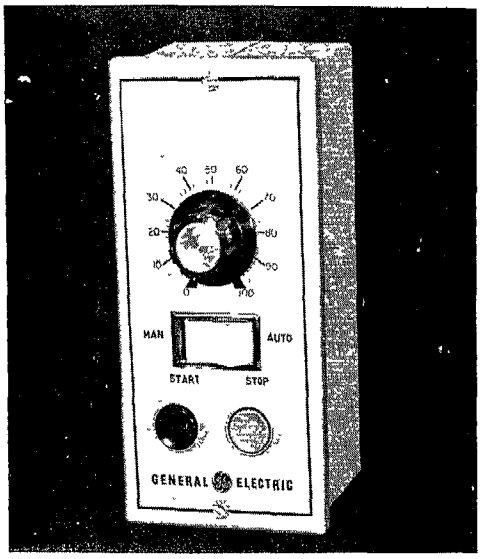


FIGURE 3
Operator's station with Man. Auto Selector Switch

As an optional feature, the operator's station can be an integral part of the controller, mounted and wired at the General Electric factory. It is also available in a kit that can be mounted and wired in the field by the purchaser. (See Fig. 1 and Fig. 7)

Standard features of the AFtrol I drive system include motor speed control, adjustable protective current limit, undervoltage protection and potentiometer adjustments for IR compensation, volts per hertz, linear timing, minimum frequency and maximum speed.

Optional features of the AFtrol I *drive system include* a Reversing card and a Follower card (for signals from a process instrument or tachometer). The Follower card permits the selection of the Speed Reference potentiometer in the manual mode or either an external analog or digital reference signal in the automatic mode. (See Fig. 4 and Fig. 5)

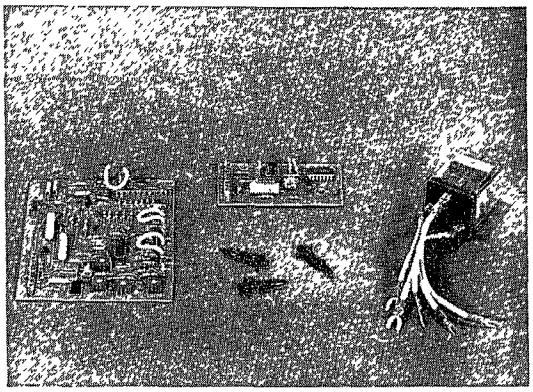


FIGURE 4
AFtrol I modification kits left to right:
Follower card
Reversing card
Auxiliary RUN relay

An Auxiliary RUN relay is available as an optional modification kit that can be installed and wired at the General Electric factory or in the field by the purchaser. Mounting hardware is built into the upper right hand corner of all standard AFtrol® I controllers. (See Fig. 4 and Fig. 5)

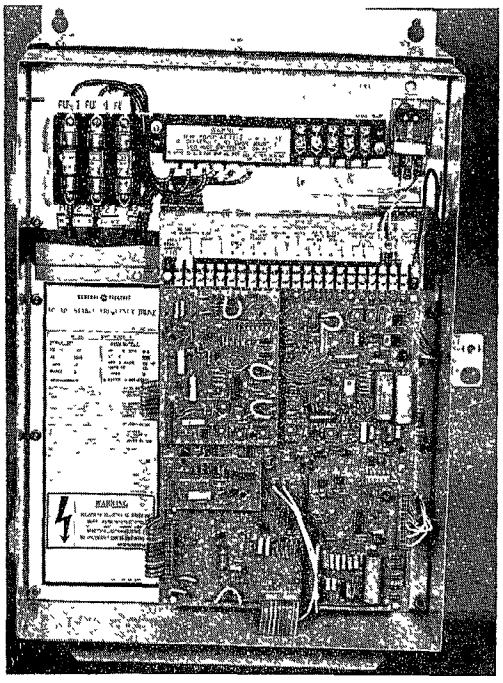


FIGURE 5
AFtrol I controller, with Follower Card, Reversing Card and Auxiliary RUN relay modification kits installed

A speed indicator is also available as an optional modification (See Fig. 6)

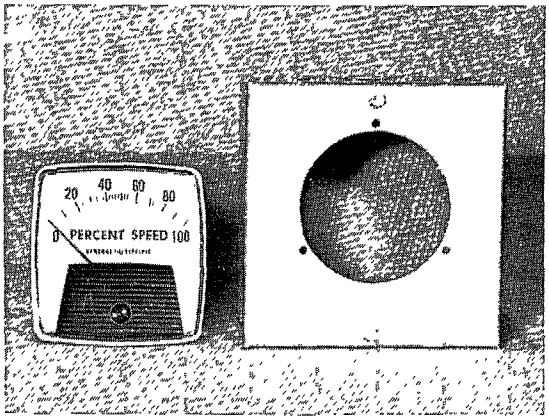


FIGURE 6
AFtrol I Optional Modification Kit
Speed Indicator and Enclosure

The AFtrol I controller is available as an "open" unit suitable for panel mounting inside a larger enclosure that may contain other electrical apparatus furnished by General Electric Company or by the purchaser (See Fig. 7A)

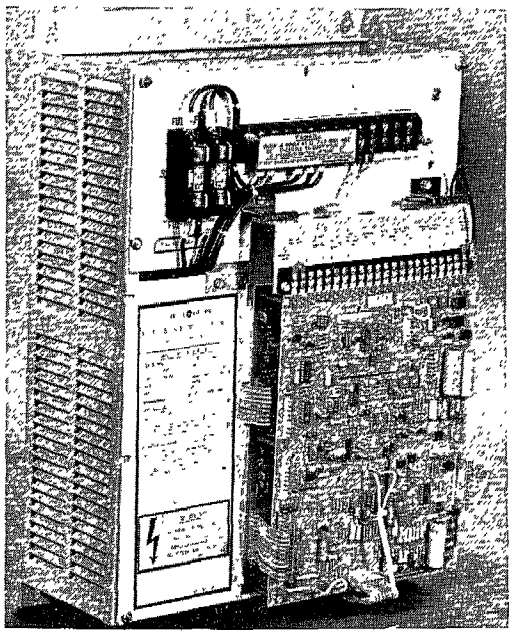


FIGURE 7A
AFtrol I, controller, suitable for "open" panel mounting

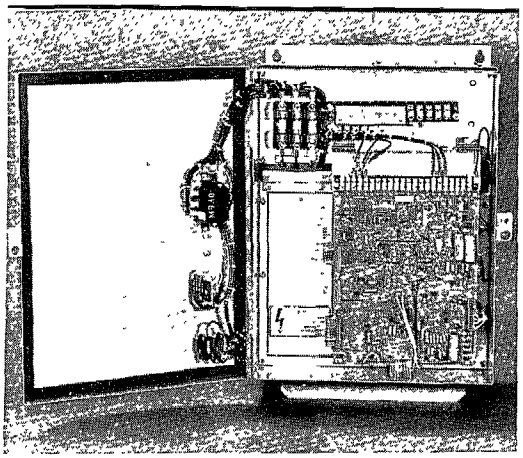


FIGURE 7
AFtrol I, wall mounted (enclosed) version)

ADDITIONAL FUNCTIONS

INPUT/OUTPUT TRANSFORMERS

Input voltage requirements for AFtrol I controllers are 230V AC in all cases, single or three phase, 60 or 50 hertz. When 230V AC is not available a voltage transformation is needed. Transformer KVA requirements are as follows:

	230V AC Single Phase				230V AC Three Phase			
HP	1	1 1/2	2	3	2	3	5	7 1/2
Input KVA	1.6	2.3	3.2	4.6	3.0	4.4	6.8	8.8
Input Amps	7	10	14	20	7.5	11	17	22

If 230V AC motors are not available, an output voltage transformation is required.

Refer to General Electric Company, Application Manual, GET-6659 or you nearest General Electric Company representative for assistance in the selection of the proper input or output transformers.

INPUT/OUTPUT AC CONTACTORS

An AC line contactor is not furnished with AFtrol I controllers, If an Ac contactor is desired in the line ahead of the controller or between the controllera nd the motor, of the purchased may add such a contactor (s) but should be guided by the information in the application Manual GET-6659.

SECTION 2.0

DESCRIPTION

AFtrol I drive system consists of the AFtrol I controller, suitable operator's devices, and an AC motor. The controller consists of several modules and assemblies in an enclosure. All of these parts of a representative drive system including available options are shown in block diagram form in Figure 8 (36D87008AB).

CONTROLLER

The AFtrol I controller is a variable voltage, square wave inverter, which converts a constant voltage and frequency AC supply to an adjustable voltage and frequency, three-phase AC output. The speed of the connected AC motor will be dependent on the output frequency of the controller and the motor torque will be dependent on the output voltage level. The controller adjusts the output voltage and frequency together to provide constant volts per hertz, over most of the operating range, for optimum motor performance.

The various parts of the controller are described below.

INPUT PROTECTIONS

The AC supply input consists of a two wire single phase input for 1 thru 3 HP single phase input controllers and a three wire three phase input for 2 thru 7 1/2 HP three phase input controllers. Standard 230 volt fuses are provided for short circuit protection. A ferrite choke is included in each AC supply line to protect the controller from voltage transients that may occur in the power system.

DC LINK FILTER

The DC link filter consists of 1 or 2 iron core reactors (LF) and 1 or 2 electrolytic capacitor (CF), depending on the controller horsepower rating. Their function is to filter the output of the converter before it is applied to the inverter. The CF capacitor also acts to supply reactive power through the inverter to the AC motor.

POWER MODULE

The power module assembly consists of 1 or 2 SCR converter modules, power transistors, power module card and control transformer all mounted on a single heatsink. The single phase input controllers have 1 SCR converter module and the three phase input controllers have 2 SCR converter modules (see Figs. 9,10,10A and 11). The SCR converter modules and power transistors have their base plates insulated from the power circuit so that they can be mounted on a common heatsink. The external connections to the power module are shown in Fig. 8.

The power module can be functionally broken down into two sections, the converter section and the inverter section. The converter section consists of the SCR converter modules and the following protective components on the power module card:

1. A metal oxide variator (MOV) is connected across each AC supply phase pair to clip transient voltages to a level which will not damage the converter SCRs.

2. Resistor — capacitor circuits are provided across each AC supply phase pair, and across the converter DC output, to suppress transient voltages and limit dv/dt in conjunction with the incoming line ferrite chokes.

3. A power resistor is connected across the converter DC output to discharge the DC link filter capacitor. This resistor is rated to cause the DC link capacitor to discharge from maximum voltage to 50 volts in one minute.

The function of the converter section SCR modules is to convert the AC supply power to adjustable voltage DC power at point P1 to N1 (see Figs. 9,10,10A and 11).

The DC output voltage of the converter can be adjusted from zero to maximum output by adjusting the firing point of each SCR relative to its AC supply voltage. This firing control is contained on the Regulator card, and is transmitted to the Power Module through ribbon cable 4CN. This same cable also transmits the DC link voltage feedback signal back to the Regulator card where it is used to regulate the converter output voltage to vary directly with the inverter output frequency.

The converter output voltage contains appreciable ripple voltage which must be filtered by the DC link filter.

The inverter section consists of the six power transistors which form a three phase bridge and the following components on the power module card:

1. Resistor - capacitor circuits are provided across each leg of the inverter to assist transistor switching operation.

2. Transistor base resistors and printed circuit runs to the 5CN and 6CN connectors.

The function of the Inverter Module power transistor switches is to convert the adjustable voltage DC link power at points P2 to N2 (see Figs. 9,10,10A and 11) to adjustable frequency and voltage AC power to drive an AC motor. The AC output of the inverter can be adjusted from approximately 2 Hz, depending upon adjustments on the Regulator card. The three-phase transistor base driver control is contained on the Inverter Control card, and is transmitted to the Power Module through ribbon cables 5CN and 6CN. Cable 6CN also transmits back DC link current and voltage signals to the Inverter Control card.

The power module card is a printed circuit card mounted on the power module heatsink. In addition to the items specified under the converter and inverter section, the power module card provides the following components and terminations:

1. Terminates the connections to the converter modules and power transistors.

2. Provides 3 AC input connections for 3 phase input controllers or 2 AC input connections for single phase input controllers and 3 AC output power terminations.

3. Provides 2 AC connections for the primary of the control transformer and 3 connection points for the DC Link Filter.

4. Provides connection points for the 4CN, 5CN and 6CN ribbon cables.

5. Mounts the DC link shunt connected between negative DC link terminals N1 and N2, and transmits the shunt voltage signal thru connector 6CN.

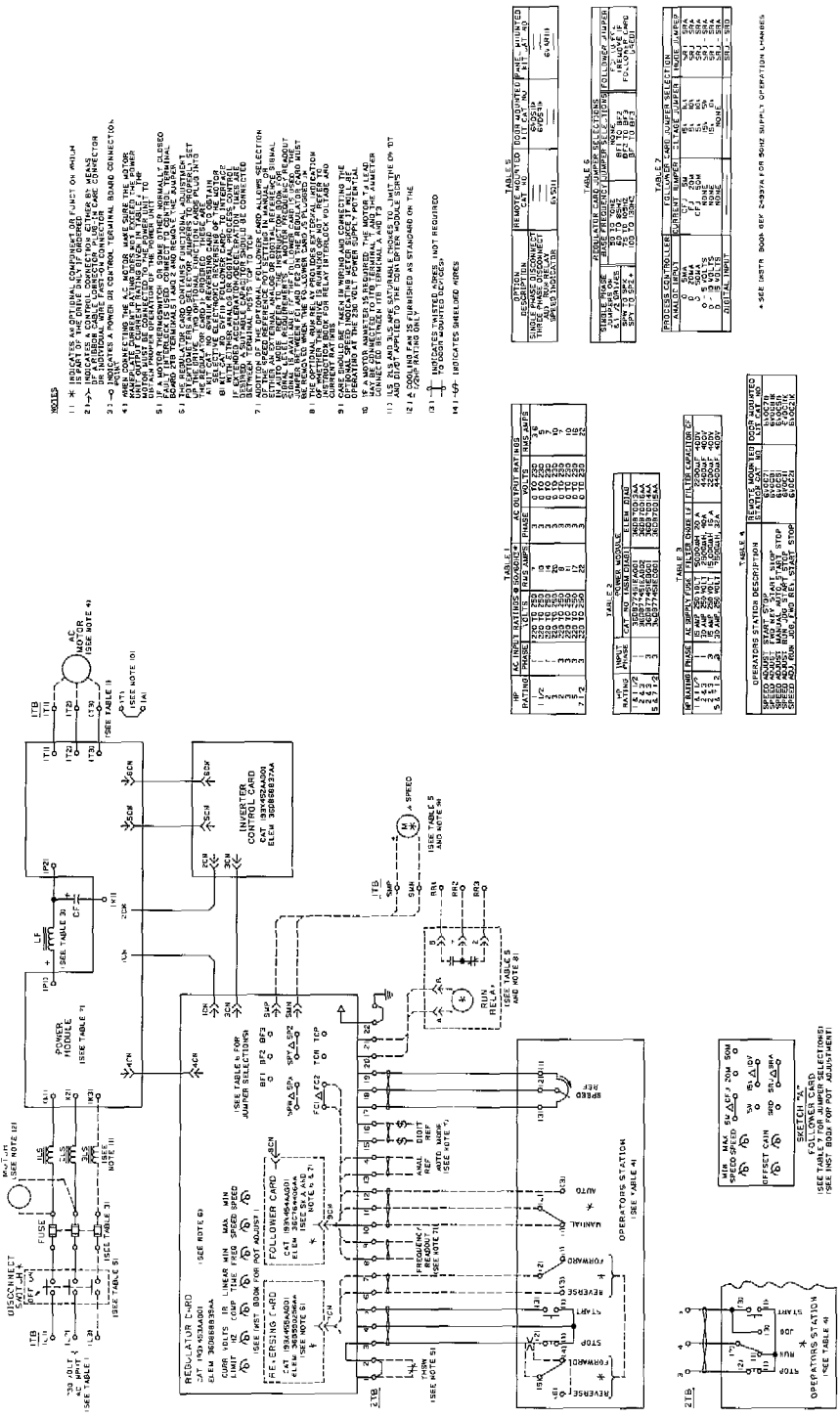


FIGURE 8
AFtrol I System Diagram
(36D870008AB)

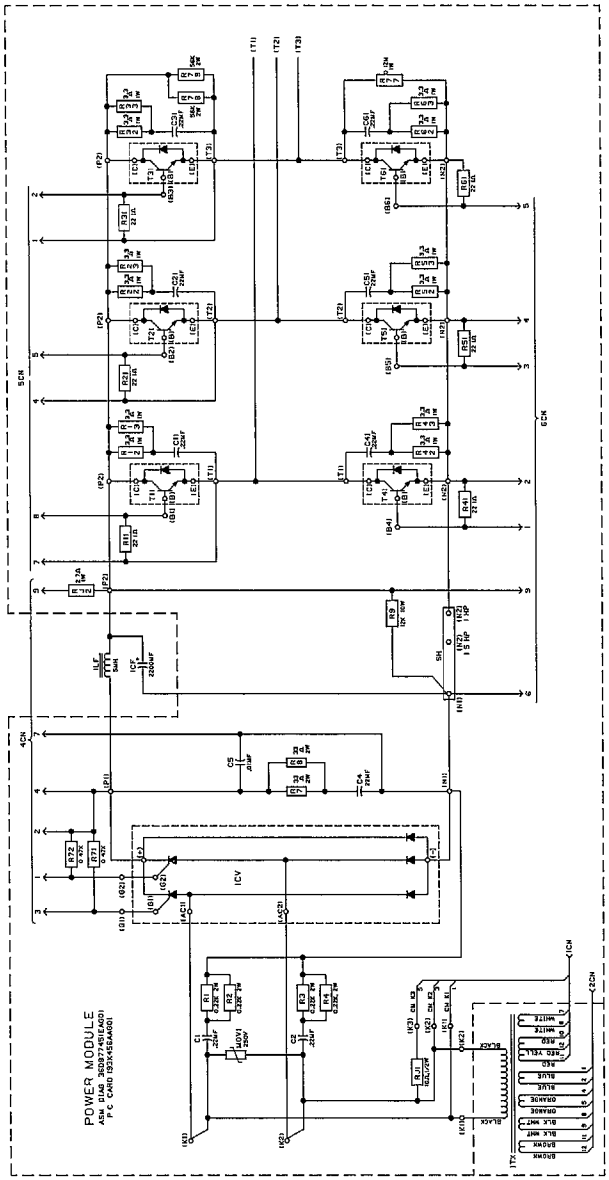


FIGURE 9
Power Module & DC Filter Elementary Diagram
1 & 1 1/2 HP Single Phase input
(36D870013AA)

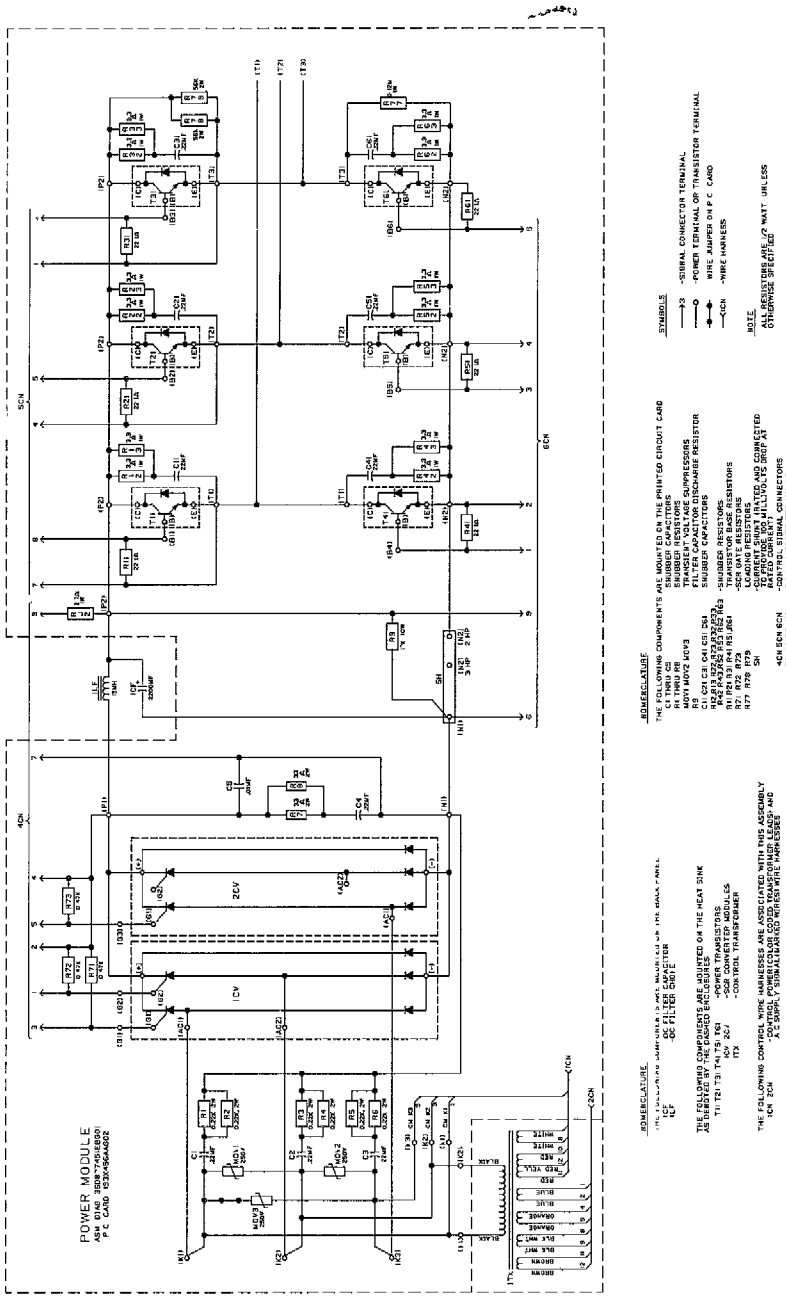


FIGURE 10
Power Module & DC filter Elementary Diagram
2 & 3 HP Three phase input
(36D870014AA)

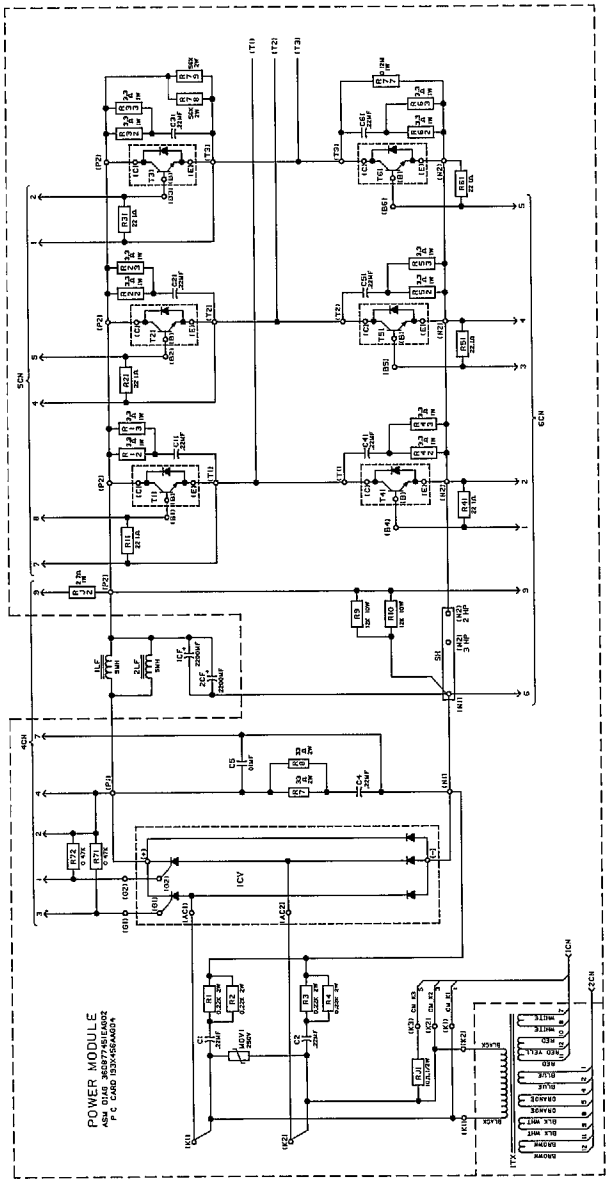


FIGURE 10A
Power Module & DC Filter Elementary Diagram
2 & 3 HP Single Phase input
(36D870016AA)

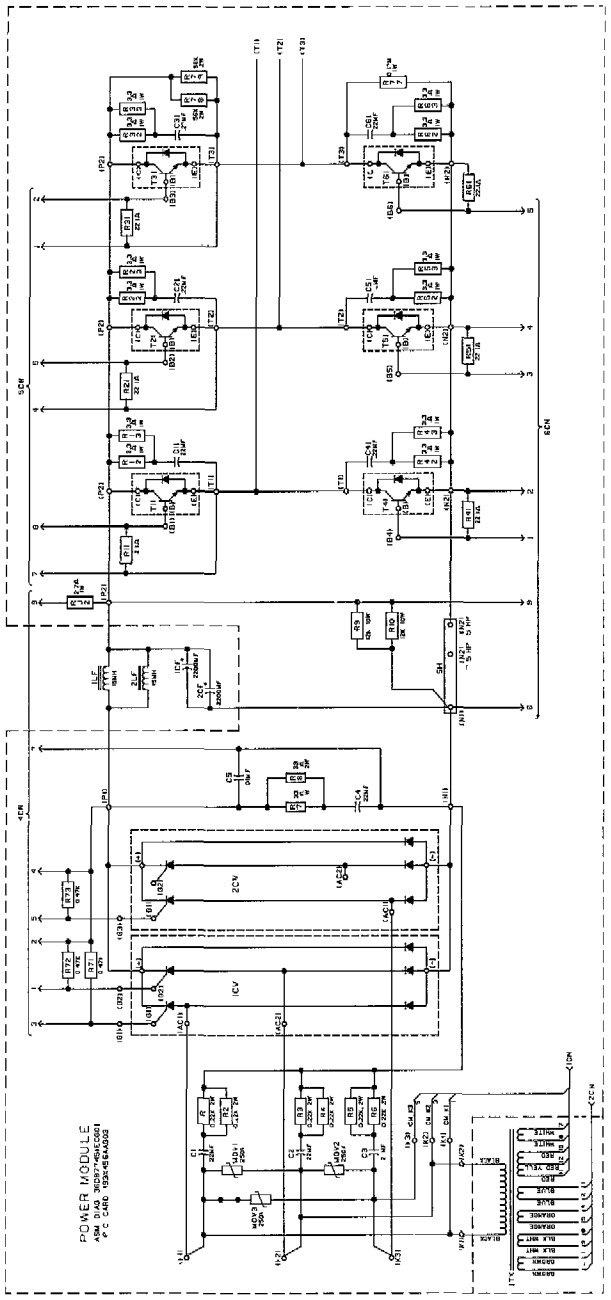


FIGURE 11
Power Module & DC Filter Elementary Diagram
5 & 7 1/2 HP Three phase input
(36D870015AA)

CONTROL CARD ASSEMBLY

This an assembly of the Regulator card (on top) and the Inverter Control card (on bottom), which is mounted in the controller front compartment. These two cards are electrically connected through ribbon cable 3CN.

REGULATOR CARD (see Fig. 19, Page 39)

The Regulator card contains 22 card fingers which connect to the 2TB control terminal board, and are the control interface between the operator's devices and the controller. The upper half of this card, adjacent to the card fingers, contains operator's control logic and regulating circuitry, and its common is connected to case ground through card finger 22. The lower half of this card contains the converter control, which operates at the positive DC link (P1) power potential. Signal isolation between the converter control and the regulator control is provided by optical couplers. The control power to both halves of the Regulator card is obtained from two isolated secondary windings of th 1TX control transformer through cable 1CN.

The operator's control and regulator portion of the Regulator card provides the following functions:

1. Power Supply

   Contains a regulated +12 volt and -12 volt dual power supply relative to the common bus connected to card finger 22.

2. Start-Stop Control

   Operator's start-stop control of motor operation is provided by logic circuitry. The 24 volt DC control power to the Start-Stop pushbuttons (see Fig. 15) (or to a run interlock) is provided for the +12 volt and -12 volt card power supply. This same control power is also provided to the Reversing and Manual-Auto option switches when provided. The start-stop logic allows starting the motor only at minimum frequency and voltage. When the Stop pushbutton is pressed, or the run interlock opens, the start-stop logic clamps the reference to zero, producing a timed deceleration down to minimum frequency and voltage, at which point the controller is stopped. In the stopped condition, the converter is turned off and the inverter is at zero frequency

3. Fault Logic

   Contains a fault latch which is set by a fault signal transmitted from the Inverter Control card through an optical isolator, or from a control undervoltage on the Regulator card. If a fault sets this latch, it turns off the converter and the inverter, applies the reference clamp to reset the control to zero and drops out the optional Run relay, if provided. The fault latch cannot be reset until the fault condition is removed, and the DC link voltage is near its minimum. To reset the fault latch, the Stop pushbutton must be pressed, or the run interlock opened, after which the controller may be restarted. (On single-phase input controllers, the SPW to SPX card posts must be jumpered to prevent the undervoltage fault circuit on the Inverter Control card from detecting a loss on one phase. This jumper is factory installed.

4. Run Readout

   A green "Run" light indicates when the controller is operating and is off when the controller is stopped. When operating, it blinks at the inverter minimum frequency. The Regulator card output to 2TB terminals 20 (pos.) and 21 (neg.) may be used to pick up the 24-volt coil of the optional Run relay to indicate when the controller is operating.

5. Speed Reference Adjustment

   The operator's speed reference potentiometer (5000 ohms, 1 to 2 watt) is connected to the Regulator card at 2TB terminals 17, 18 and 19, with terminal 18 being the reference input. The ***MINS*** potentiometer on the Regulator card is used to adjust the minimum operating speed (at zero setting of the operator's speed pot) of the motor from zero to approximately 40% if rated. The ***MAXS*** potentiometer on the Regulator card is used to adjust the maximum operating speed (at maximum setting of the operator's speed pot) based on the rated motor frequency selection

6. Timed Acceleration and Deceleration

The reference timing circuit translates a step change in reference input at terminal 18 into a linear ramp change of reference to the controller, resulting in a linear ramp change in motor speed, both accelerating and decelerating. The timing is adjustable, by means of ***LTIM*** potentiometer on the Regulator card, from a minimum of approximately 2 seconds to a maximum of 20 to 30 seconds. A "soft start" feature provides a slower initial rate of acceleration when fast timing rates are selected. Longer acceleration/deceleration times can be obtained by soldering an electrolytic capacitor across card posts TCP (pos.) and TCN (neg.). The following formulae for calculating the minimum and maximum ***LTIM*** pot setting times can be used to select the amount of capacitance needed:

$$T_{min.} = \frac{(25 + C) \times V_{ref}}{125} + .5 \text{ seconds } (\pm 25\%)$$

$$T_{max} = \frac{(25 + C) \times V_{ref}}{6} \text{ seconds } (+100\%, -30\%)$$

where C = capacitance in MFD (25VDC rating)
Vref = max. reference voltage at terminals 18 to 22 (COM) (5 to 8.5 volts)

7. Voltage to Frequency Oscillator (VCO)

The VCO changes the reference voltage from the timing circuit into a 6 times motor frequency signal, which is then sent to the Inverter Control card via an optical isolator. The ***MINF*** potentiometer on the Regulator card is used to adjust the minimum oscillator operating frequency from a minimum of 6 Hz to a maximum of approximately 60 Hz (equivalent to a motor frequency of 1 to 10 Hz, when a 60 Hz rated motor frequency is selected). The base frequency selection posts BF1,BF2 and BF3 on the Regulator card allow rough selection of higher than standard 60 Hz motor frequency. (The ***MAXS*** potentiometer gives fine adjustment of base frequency.) The four selections of base frequency are given in the following table

Base Frequency	Jumper Selection
50 to 70 Hz	None
60 to 85 Hz	BF1 to BF2
75 to 105 Hz	BF2 to BF3
100 to 130 Hz	BF1 to BF3

Remove the spare jumper that is connected to card posts LMN and LMP to make the above jumper selections. The above selections should be dependent on trying to keep the card terminal 18 to 22 (COM) reference voltage, at maximum operator's speed potentiometer setting as close to 7.5 volts as possible, and within the range of 5.0 to 8.5 volts.

8. Voltage Regulator

The voltage regulator compares the DC link voltage feedback signal from an impedance isolator circuit, to the voltage reference from the timing circuit and produces a converter reference signal. This signal is sent to the converter control through an optical isolator. The voltage feedback signal is modified by the setting of the ***V/Hz*** potentiometer on the Regulator card, dependent on the required volts per hertz for the AC motor being used. The range of adjustment of ***V/Hz*** is calculated as follows:

Vac = 20 x Vref (±1%) for min. V/Hz setting
Vac = 52 x Vref (±10%) for max V/Hz setting
where Vac = AC motor rms voltage
Vref = reference voltage at terminals 18 to 22

9 IR Compensation

The ***COMP*** potentiometer on the Regulator card can be used to increase the motor voltage as a function of motor load, to compensate for IR Drop in the motor windings. This is used to maintain proper motor excitation under loaded conditions and thus obtain optimum motor torque, especially at low speeds or for starting the motor from rest. An isolated motor load current (from the DC link shunt) is applied to the ***COMP*** potentiometer. Adjustment of the ***COMP*** pot applies the desired amount of this signal to change the voltage regulator output to the converter. The amount of AC voltage boost at rated load can be adjusted from zero up to from 15 to 30 volts, or approximately 10% of rated motor voltage.

10. Current Limit

If motor load exceeds the level set on the ***CLIM*** potentiometer (on the Regulator card), the current limit function reduces the controller output voltage and frequency to reduce the motor speed. The isolated motor load current signal from the DC link shunt is applied to the current limit circuit. The ***CLIM*** pot is adjustable to limit motor load current from a minimum of approximately 50% of rated to a maximum of over 150% of rated. The rate of motor speed decrease, when in current limit, is partially determined by the setting of the ***LTIM*** potentiometer, in order to stabilize current limit operation. The most stable operation is obtained with low time settings of ***LTIM*** for low load inertia drives and higher time settings for higher connected load inertias.

11. Motor Slowdown Control

The slowdown control limits the motor deceleration time to rate no faster than the coast time, irrespective of the setting of the ***LTIM*** potentiometer. This prevents a fault shutdown which could be caused by ***LTIM*** setting which is faster than the load inertia would allow. Higher inertial load will decelerate more slowly than lower ones.

12. Motor Stabilizing

The frequency control is also affected by the voltage feedback, in addition to the normal reference setting, to provide stable operation of the motor, especially in a low speed, light load condition, or when in current limit.

The converter control portion, on the bottom half of the Regulator card, provides SCR firing signals out of ribbon cable connector 4CN to control the Power Module Converter Section SCR bridges, and thus the DC link voltage. This control is designed to be insensitive to AC supply phase sequence, and to control either a single-phase converter or three-phase converter. The SCR phase control is synchronized to the AC supply by means of AC phase voltage signals coming in on ribbon cable 1CN.

The converter control is locked out during standby and produces SCR firing signals only during motor operation. The converter control reference signal comes from the regulator circuitry through an optical isolator, since the converter control is at the positive DC link power potential

For controllers with single-phase input, a jumper is placed across card posts SPY ans SPZ to bias the control differently than for three-phase input controllers. This control is designed to operate properly to 60 Hz AC supply frequency. Refer to page 36 for 50 Hz AC supply operation.

The SCR firing signal outputs each consist of a train of pulses to converter SCRs. This prevents misoperation of the converter when operating from an AC supply containing transients or notches caused by other equipment.

The Regulator card also contains several card posts and connectors for use with controller options or for diagnostic use, as listed below:

1. Connector 7CN for Reversing option card connections and mounting
2. Connectors 8CN and 9CN for Follower card connections and mounting.
3. Connectors 10CN and 12CN for diagnostic troubleshooting usage.
4. Card posts FC1 and FC2 are normally jumpered; the jumper is removed when th Follower card is used with a Manual-Auto operator's switch.
5. Card posts SMP and SMN (connected to 1TB terminals SMP and SMN) for percent Speed Meter option.
6. Card posts LMP and LMN for monitoring the DC link shunt voltage — presently used for storage of a spare jumper wire.
7. Card terminals 1 and 2, normally jumpered at 2TB, are for inserting a motor thermoswitch, thermal overload relay or other normally closed fault interlock, or auxiliary stop interlock. (See Fig. 8).
8. Card terminals 6 and 7 for use with the Reversing option operator's switch (See Fig. 8)
9. Card terminals 8 through 16 for use with the Follower option (See Fig. 8).

INVERTER CONTROL CARD

The Inverter Control card contains inverter control and fault detection circuitry. It receives signals from and transmits signals back to the Regulator card through ribbon cable 3CN. The circuitry on this card is at four different power potentials, and requires control power from four isolated secondary windings of the ITX control transformer, through cable 2CN. The Inverter Control card provides the following functions.

1. Power Supplies

   Four isolated unregulated power supplies for the four different power potentials are provided. Three of the power supplies are for the three transistor driver circuits operating at the T1, T2 and T3 motor terminal power potentials. The fourth power supply is for the three transistor driver circuits operating at the negative DC link (N2) power potential. A portion of this fourth power supply control power is regulated for the control and detection logic at this potential.

2. Phase Frequency Generator

   This control accepts the 6 times motor frequency signal from the Regulator card (through an optical isolator) and generates six square wave output signals, each 60° apart, at the desired motor frequency. These six signals control the six transistor driver circuits. A separate output signal from this generator is fed back to the Regulator card to operate the Run light and for a frequency readout.

3. Phase Sequence Reversal

   The phase sequence of the three-phase generator can be reversed by means of a signal from the Reversing option card mounted on the Regulator card, when provided. This provides electronic reversing of motor rotation.

4. Inverter Transistor Driver Circuits

   There are six transistor driver circuits for the six legs of the inverter bridge. Three of these drivers are at the negative DC link (N2) potential and obtain their signals directly from the three-phase generator. The other three drivers, at the T1, T2 and T3 motor lead potentials receive their signals from the three-phase generator through optical isolators. The outputs of the three isolated drivers are connected to the Power Module through ribbon cable 5CN, and the other three drivers through ribbon cable 6CN. Each transistor driver circuit amplifies its signal from the three-phase generator to provide transistor base current up to approximately 1.5 amps. In order to conserve base drive power, a base drive regulating circuit provides only the amount of base current necessary to keep the transistor switched on at all operating load currents. If an excessive overload occurs which would cause transistor failure, a protective circuit switches the transistor off to prevent failure. This same circuit prevents switching the transistor on if there is more than approximately 10 volts across its collector to emitter terminals.

5. Transistor Fault Detector

   This detects if any of the inverter transistor driver circuits have turned themselves off, to protect against overloads or due to a failure of another power transistor. Detection of a turn-off of any transistor produces a fault signal, which turns off all six transistor drivers. This fault signal is also transmitted to the Regulator card fault latch.

6. DC Link Overvoltage Detector

   This circuit monitors the DC link voltage and produces a fault signal when this voltage reaches approximately 370 volts peak, to protect the power circuit components. This fault signal is transmitted to the Regulator card in addition to turning off the inverter.

7. AC Supply Undervoltage Detector

   This circuit monitors the AC supply to the controller for undervoltage or loss of one phase condition, in addition to monitoring the Inverter Control power supply level. A fault signal is produced if the AC supply voltage level falls to 55 to 65% of rated, or if one of the three phases is opened. (A jumper on the Regulator card locks out the loss of phase detection for single phase input controllers.) This fault signal is transmitted to the Regulator card in addition to turning off the inverter.

8. Current Feedback Circuit

This circuit amplifies the signal from the DC link shunt and translates it into a pulse train signal which is transmitted to the Regulator card through an optical isolator. (After processing on the Regulator card, this current signal is used for IR compensation and current limit control.)

OPERATOR'S DEVICES

The devices to operate the controller may be mounted in one of the remote operator's stations or door mounted operator's stations listed in the Options section, or may be furnished by the user. These devices are described as follows:

1. Speed Reference Potentiometer

   This must be a 5000 ohm, 1 to 2 watt potentiometer, to give ***MAXS*** and ***MINS*** adjustments the correct control range, which is connected to the controller 2TB terminals 17, 18 and 19 as shown on Fig. 8.

2. Start-Stop Pushbuttons

   These are connected to the controller 2TB terminals 3, 4 and 5 as shown in Fig. 15A.

3. Run Interlock/Toggle Switch

   If a run interlock (open for stop, closed for run), or toggle switch is desired instead of pushbuttons, connect to the controller as shown in Fig. 15B.

4. Jog - Run Switch

   If jogging at the Speed pot setting is desired, a Jog-Run switch is inserted between the Start-Stop pushbuttons and the controller as shown in Fig. 15C.

5. Reversing Option Forward - Reverse Switch

   The reversing switch is connected as shown in Fig. 15D. When the reversing switch is operated, it will automatically produce a controlled stop, at which time the phase sequence reversal is accomplished electronically in the controller. It is then necessary to restart the drive by pressing the Start pushbutton.

6. Follower Option Manual - Auto Switch

   This switch is connected as shown in Fig. 8. It allows selection of either the Speed potentiometer (in the Manual position) or an external analog or digital signal (in the Auto position) as the speed reference to the controller Regulator card.

AC MOTOR

AFtrol I controller is designed to drive any standard three-phase, 230 volt, Nema B induction motor whose nameplate current rating does not exceed the controller current rating. The new Energy Saver® motor designs make an especially desirable drive motor due to their high efficiency, and their capability of operating at low speeds and rated load without overheating.

Multiple motors can be operated from a single controller as long as the sum of all the motor nameplate current ratings does not exceed the controller current rating.

Standard induction motors have approximately 3% speed regulation from no load to full load, due to motor slip.

Synchronous reluctance motors provide zero percent speed regulation since they operate in synchronism with the inverter frequency. They are particularly suited for applications requiring precise speed control or for multiple motor applications where identical motor shaft speeds are required. However, the rated current is higher and the power factor is less than for a comparable horsepower rating induction motor. It is, therefore necessary to multiply the nameplate current rating of a synchronous reluctance motor by a factor of 1.4, and this current should not exceed the controller nameplate current rating.

The result is that a synchronous reluctance motor HP rating must be substantially smaller than the controller HP rating. Since synchronous reluctance motors pull into synchronism with the controller frequency, it is recommended that the ***MINF*** potentiometer on the controller Regulator card be set for approximately 6 Hz minimum frequency for optimum motor pull-in.

Permanent magnet synchronous motors may also be operated from an AFtrol I controller, and offer zero percent speed regulation and synchronous operation.

The AFtrol I controller is designed to prevent motor single-phasing and will not operate unless a motor of at least 1/4 HP rating is connected. If the driven motor has a thermal overload protector, the normally closed interlock should be connected between controller 2TB terminal 1 and 2, after removing the metal jumper.

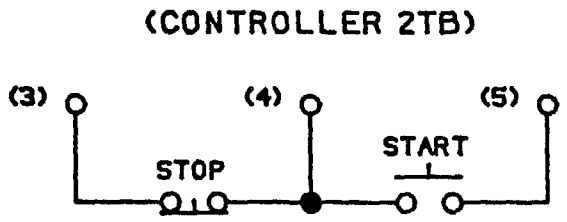
DERATING DATA

Standard AC motors must be derated if rated load is applied over a wide speed range to prevent overheating at low speeds where the motor cooling fan is not very effective. Derating is usually not necessary for fan or pump type loads where load torque decreases with decreasing speed. The high efficiency Energy Saver® motors normally do not have to be derated for any type of load because of their lower losses.

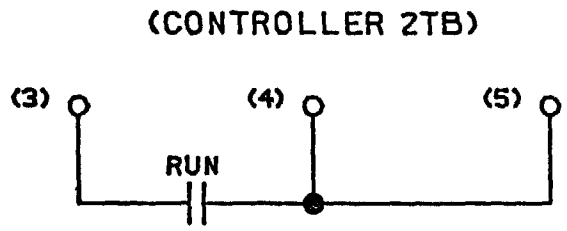
AC motors may also need to be derated for high ambient or high altitude conditions. Refer to General Electric Application Manual, GET-6659 or contact your nearest General Electric Company representative for motor derating recommendations.

POWER FACTOR IMPROVEMENT

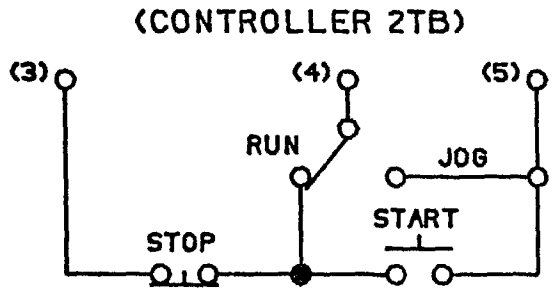
Small drives such as AFtrol I will seldom create concern over power factor; however, constant torque loads draw approximately constant KVA from the line over the speed range, so as power factor decreases at low speeds, the required reactive power increases. No single value of capacitance can be correct over the entire speed range, so power factor improvement should not be attempted on a drive-by-drive basis. Instead, the subject should be approached on a plant or area basis. See application data contained in GET-6659 or GET-6468A



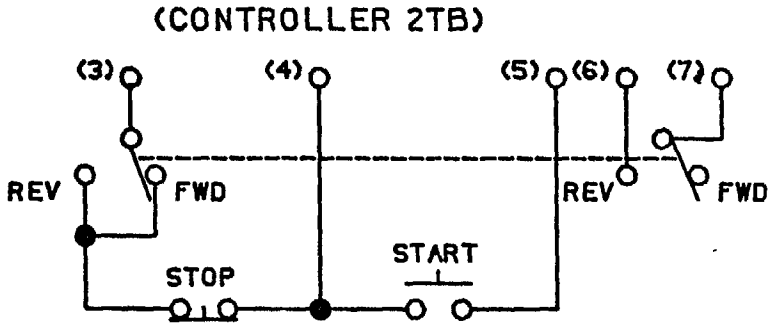
START - STOP PUSHBUTTON CONTROL **A**



RUN INTERLOCK CONTROL (CLOSE TO RUN) **B**



START -STOP PUSHBUTTON WITH RUN/JOG SELECTOR SWITCH **C**



START -STOP PUSHBUTTON WITH REVERSING SELECTOR SWITCH **D**

FIGURE 15
Operator's Start-Stop Control Options

SECTION 3.0

RECEIVING, HANDLING AND STORAGE

RECEIVING

The equipment should be placed under adequate cover immediately upon receipt. Packing cases are not suitable for outdoor or unprotected storage. Each shipment should be carefully examined upon arrival and checked with the packing list. Any shortage or damage should be reported promptly to the carrier. If required, assistance may be obtained from the General Electric Company, Speed Variator Products Operation, Erie, PA. When seeking assistance, please use the drive serial number to identify the equipment. Telephone: 814-455-0521.

HANDLING

Wall mounted controllers can be transported by lift trucks with the forks completely under the base, care being taken that the controller does not tip.

STORAGE

If the equipment is not to be installed immediately, it should be stored in a clean, dry location at ambient temperatures from -20°C (-4°F) to 55°C (131°F). The surrounding air must be free of chemical and electrically conductive or corrosive contaminants

Precautions should be taken to prevent condensation from forming within the equipment enclosure. If storage environment exceeds a 15°C (27°F) drop in temperature at 50 percent relative humidity, over a 4-hour period, a source of heat should be made available in the near vacinity of the controller. Higher humidities with smaller temperature changes will also cause condensation

SAFETY FOR PERSONNEL AND EQUIPMENT TYPES OF LABELS

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 A 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

NOTE

DENOTES AN OPERATING PROCEDURE OR CONDITION WHICH SHOULD BE HIGHLIGHTED.

COLOR — BLACK LETTERING ON WHITE FIELD.

INSTALLATION AND OPERATING LABELS

WARNING

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

WARNING: HIGH VOLTAGE

ELECTRIC SHOCK CAN CAUSE PERSONAL INJURY OR LOSS OF LIFE. WHETHER THE AC VOLTAGE SUPPLY IS GROUNDED OR NOT, HIGH VOLTAGE TO GROUND WILL BE PRESENT AT MANY POINTS WHEN INSTRUMENTS SUCH AS OSCILLOSCOPES ARE USED TO WORK ON LIVE EQUIPMENT, GREAT CAUTION MUST BE USED WHEN ONE OF THE INSTRUMENT LEADS IS CONNECTED TO THE CASE OR OTHER METAL PARTS OF THE INSTRUMENT, THIS LEAD SHOULD NOT BE CONNECTED TO AN UNGROUNDED PART OF THE SYSTEM UNLESS THE INSTRUMENT IS INSULATED FROM GROUND AND ITS METAL PARTS TREATED AS LIVE EQUIPMENT USE OF AN INSTRUMENT HAVING BOTH LEADS ISOLATED FROM THE CASE PERMIT GROUNDING OF THE CASE, EVEN WHEN MEASUREMENTS MUST BE MADE BETWEEN LIVE PARTS.

WARNING

DO NOT SERVICE THE EQUIPMENT WHEN POWER IS APPLIED.

NOTE

ALWAYS READ THE COMPLETE INSTRUCTIONS PRIOR TO APPLYING POWER OR TROUBLESHOOTING THE EQUIPMENT. FOLLOW THE START—UP PROCEDURES STEP BY STEP. READ AND HEED ALL WARNING, CAUTION AND NOTE LABELS POSTED ON THE EQUIPMENT.

SECTION 4.0

INSTALLATION GUIDELINES

The AFtrol I controller is suitable for most factory areas where other industrial equipment is installed. It should be installed in well-ventilated areas with ambient temperatures ranging from 0°C (32° F) to 40°C (104°F) and relative humidities up to 90%. It should be recognized; however, that since life expectancy of an electronic component decreases with increased ambient temperature, the 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 corrosive vapors.
4. Temperature excursions outside specified limits.
5. Caustic fumes.
6. Power line fluctuations.
7. Electromagnetic interference (electrical noise).

The totally enclosed (NEMA 12) portion of the controller should be positioned to permit heat radiation from all surfaces. The NEMA 1 ventilated part of the wall mounted controller may be placed next to another enclosure provided a clearance between them is maintained equal to the width of the controller. Clearance at least equal to the width of then enclosure should also be available in front so that the door may fully open for easy access. (see Fig. 16).

WARNING

EXPLOSION OR FIRES MAY RESULT FROM MOUNTING THE CONTROLLER IN HAZARDOUS AREAS SUCH AS LOCATIONS WHERE INFLAMABLE OR COMBUSTIBLE VAPORS OR DUSTS ARE PRESENT. AFTROL I CONTROLLERS MUST BE INSTALLED AWAY FROM HAZARDOUS AREAS EVEN IF USED WITH AC MOTORS SUITABLE FOR USE IN SUCH LOCATIONS.

MOUNTING

The controller enclosure may be mounted on any firm, reasonably flat, vertical surface. Four mounting holes are located in the top and bottom exterior flanges attached to the rear panel of the enclosure. See outline drawings Figs. 16 and 17 for mounting dimensions and enclosure weights.

CONNECTIONS

All internal connections between components and sub-assemblies in the AFtrol I controller are made at General Electric Company optional additions may be factory or field installed at the purchaser's option.

CAUTION

BE SURE TO PROTECT THE INTERNAL PRINTED CIRCUIT CARD AND OTHER COMPONENTS FROM METAL PARTICLES WHEN CUTTING OR DRILLING ENTRANCES FOR INTERCONNECTION WIRING AND CABLES.

IT IS RECOMMENDED THAT A GREENLEE PUNCH BE USED FOR CUTTING CABLE OPENINGS IN THE ENCLOSURE.

WARNING

ALL MOTOR BASES AND CONTROLLER ENCLOSURE HOUSINGS SHOULD BE CONNECTED TO THE INSTALLATION EARTH GROUNDING SYSTEM. AN EXTERNAL COPPER CONNECTOR IS LOCATED AT THE BOTTOM LEFT SIDE OF THE CONTROLLER AND IS SUITABLE FOR CONNECTING A GROUND WIRE BY MEANS OF A COPPER LUG (SEE FIG. 16).

NOTE

IT IS RECOMMENDED THAT THE CONTROL COMMON CIRCUIT BE GROUNDED AT ONLY ONE POINT WHICH IS(2TB-22). IF THE SPEED REFERENCE IS SUPPLIED BY A PROCESS INSTRUMENT, THERE SHOULD BE NO MORE THAN 15 VOLTS BETWEEN ITS SIGNAL OUTPUT AND GROUND.(SEE FIG. 18)

CAUTION

CARE SHOULD BE TAKEN TO SEE THAT ALL INTERCONNECTION WIRING IS SIZED AND INSTALLED IN ACCORDANCE WITH THE LATEST EDITION OF THE NATIONAL ELECTRICAL CODE (NEC) OR THE CANADIAN ELECTRICAL CODE (CEC) AND BE CONSISTENT WITH ALL OTHER APPLICABLE LOCAL CODES.

NOTE

IF THE CONTROLLER CANNOT BE STOPPED BY THE NORMAL STOP FUNCTIONS (STOP PUSHBUTTON, ZERO SPEED SETTING, ETC.) REMOVE POWER FROM THE CONTROLLER.

WARNING

THE NORMAL STOP FUNCTIONS OF THE CONTROLLER (STOP PUSHBUTTON, ZERO SPEED SETTING, ETC.) ARE NOT INTENDED TO BE USED AS A POWER DISCONNECT FOR THE CONTROLLER OUTPUT.

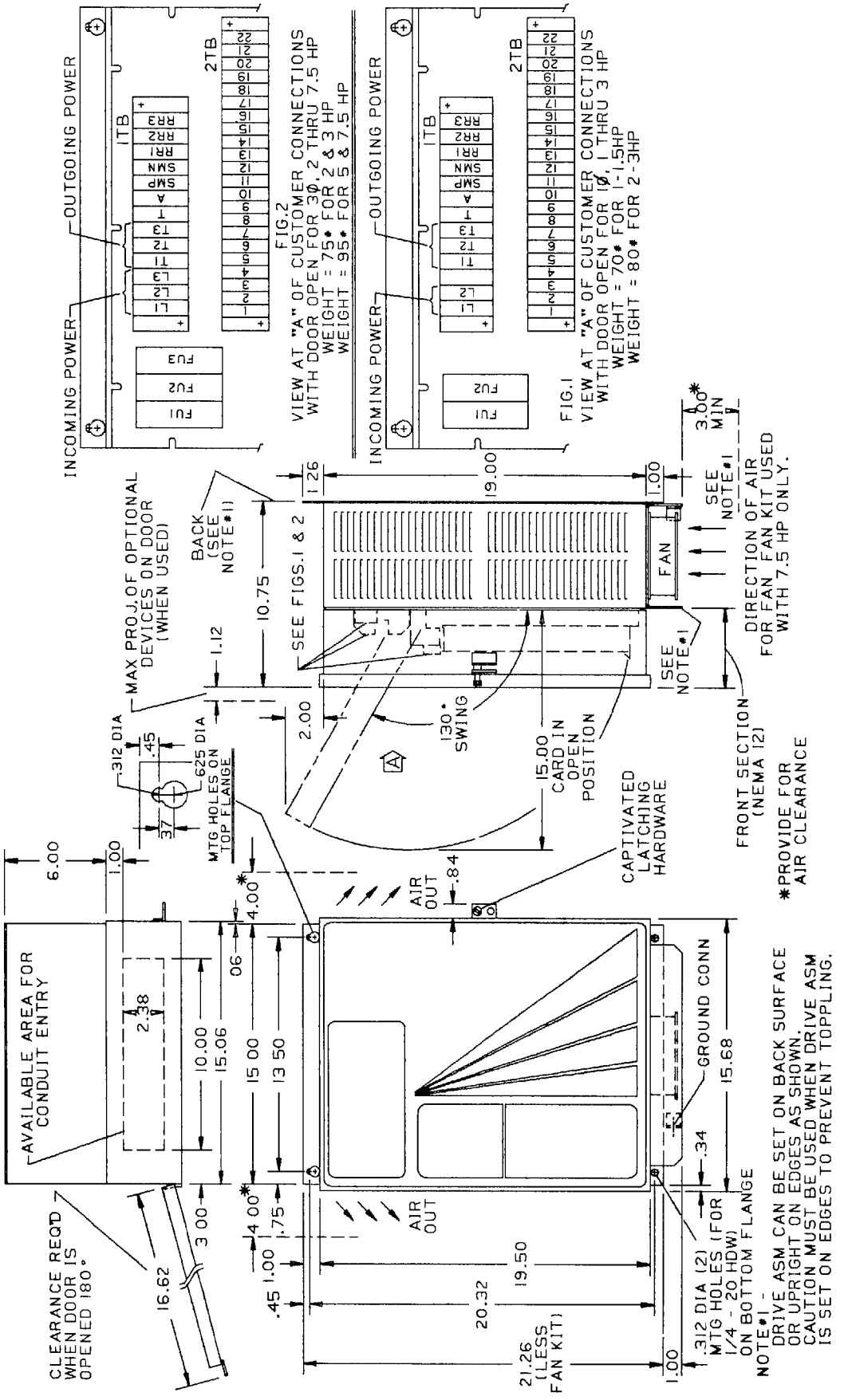


FIGURE 16
Outline Drawing AFtrol I wall mounted
(36B605405EB)

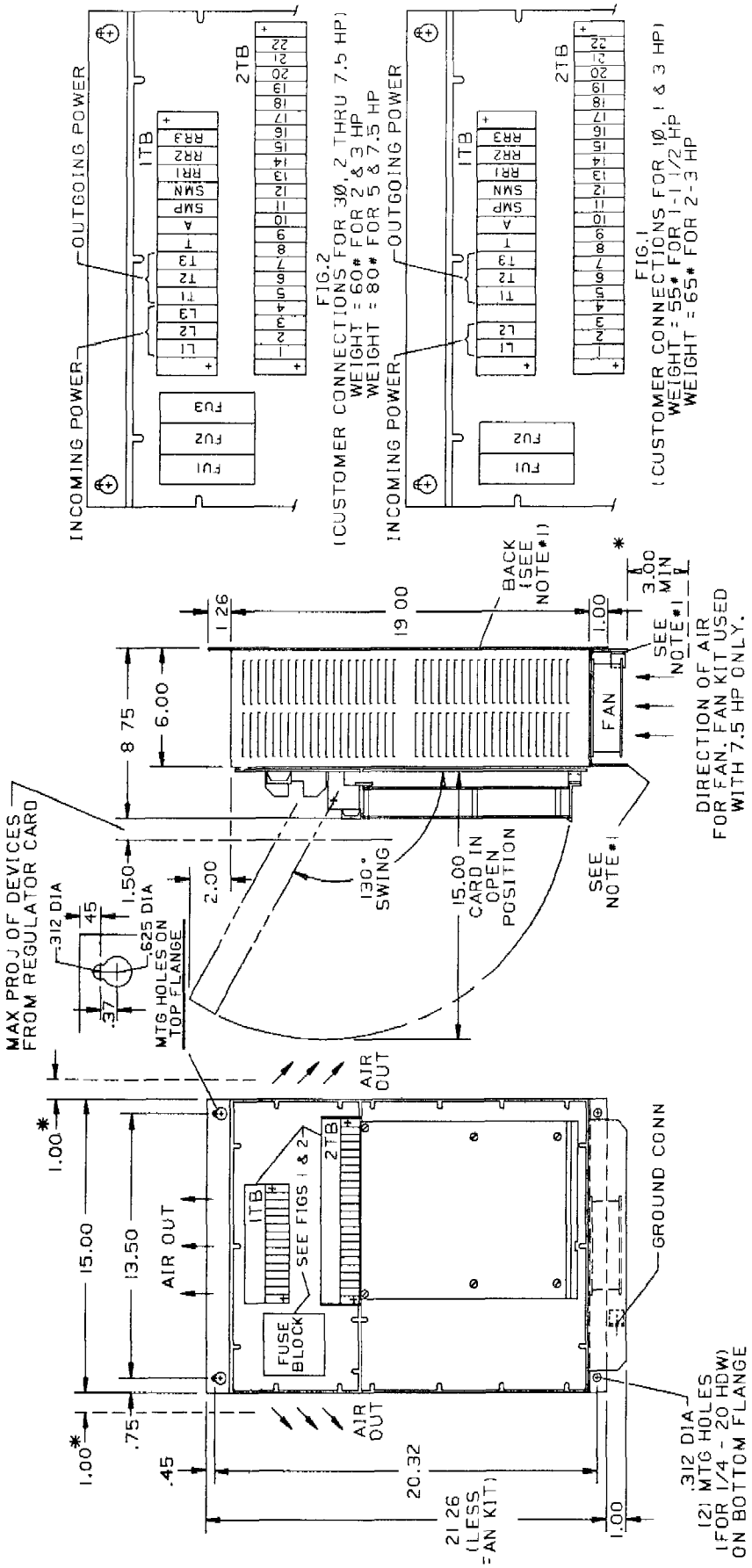


FIGURE 17
Outline Drawing, AFtrol I chassis mounted
(36B506405EA)

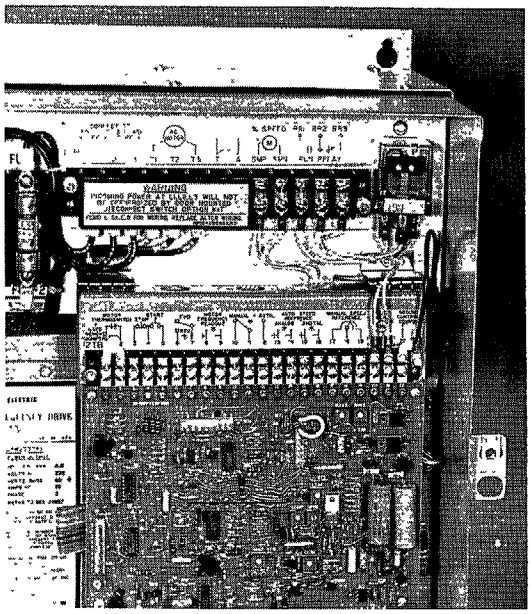


FIGURE 18
AFtrol I controller, door open showing close up to 2TB terminal board point 22 and ground connection

CAUTION

MEGGERING CAN DAMAGE ELECTRONIC COMPONETS. **DO NOT MEGGER** OR **HI POT** WITHOUT CONSULTING THE SPEED VARIATOR PRODUCTS OPERATION, GENERAL ELECTRIC COMPANY.

CAUTION

DO NOT USE POWER FACTOR IMPROVEMENT CAPACITORS WITH THIS EQUIPMENT WITHOUT CONSULTING THE SPEED VARIATOR PRODUCTS OPERATION, GENERAL ELECTRIC COMPANY. DAMAGE MAY RESULT FROM HIGH VOLTAGES GENERATED WHEN CAPACITORS ARE SWITCHED.

THE THREE (3) MAJOR COMPONENTS: (1) THE CONTROLLER, (2) THE OPERATOR'S STATION (IF REMOTE MOUNTED) AND (3) THE MOTOR SHOULD BE CONNECTED IN ACCORDANCE WITH THE SYSTEMS DIAGRAM, 36D87008AB (SEE FIG. 8).

POWER WIRING

Single phase, 230 VAC input is required for the 1 thru 3 HP single phase input AFtrol I contollers and three phase 230 VAC input is required for the 2 thru 7 1/2 HP three phase input AFtrol I controllers.

A power input disconnect mounted a reasonably short distance from the controller is required. A suitable disconnect switch kit for mounting on the controller front door (by factory or the purchased) is available as an optional modification. A line disconnect switch is a requirement of NEC or CEC and all codes.

Power wiring must be selected according to all applicable codes. The maximum contoller input currents are listed below. Power wiring should be sized to handle 150 percent of the amounts listed.

HP	No of Input Phases	Max. Input Amps (RMS)
1	1	7
1-1/2	1	10
2	1	14
3	1	20
2	3	8
3	3	11
5	3	17
7 1/2	3	22

The motor power leads should be sized in accordance with the motor nameplate current ratings. Wire size should be selected in accordance with NEC or CEC and all local codes.

A thermal overload protective device should be used to protect the motor windings from overheating and resulting damage to the motor. These overloads (or motor thermostats) should be selected based on the motor nameplate data and must comply with the NEC or CEC and all local codes. These overload devices are not provided; however, they can be connected to 2TB terminal board, points 1 and 2 after removing the metal jumper that is normally shipped with the controller.

CONTROL WIRING

The control signal interconnecting wire must be twisted, two conductor or three conductor wire having at least two twists per inch. This signal wire must be run in separate magnetic conduit from power wires to eliminate the possibility of electrical noise pick up The conduit can be rigid steel or flexible armoured steel. The signal wire should not be routed through junction or terminal boxes that contain non-signal wires. For signal wire distances of less than 100 feet use a minumum of No. 22 AWG. For distances of more than 100 feet and less than 500 feet use a minimum of No 16 AWG.

If shielded wire is used for the twisted signal wire, each shield should be grounded at only one point, preferably at the controller end.

Nearby relays, solenoids or brake coils can produce erratic drive behavior due to electrical noise transients. To eleminate this possibility, an RC suppressor should be added across the coils of these devices. A 220 ohm, 2 watt resistor in series with 0.5 mfd,600 volt capacitor can be used in 115 AC and 230V AC circuits.

AC MOTORS

The AC motor must be installed in accordance with separate instructions included with the motor. Care should be taken to assure that the motor is properly aligned with the driven machine to minimize unecessary motor loading due to shaft misalignment.

OPERATOR'S STATION

The operator's station must be mounted in a location that is convient to the operator but not more than 500 feet away from the controller. As an optional modification, all forms of the operator's station can be located on the front door of the controller, either factory mounted or field mounted by the purchaser

SECTION 5.0

INSPECTION, START UP AND ADJUSTMENT

Every AFtrol I controller has been tested and adjusted in the factory and is ready to operate. However, before applying power and starting the motor, the following inspection steps should be taken to prevent damage to the equipment and to ensure a successful start up.

INSPECTION

1. Inspect the controller for any shipping or installation damage. Inspect for loose or broken control cards or plug-in option cards. Check for loose connections where the Regulator card connects to 2TB terminal board and the wires connecting to both 2TB and 1TB terminal boards and to the fuse block. If a door mounted disconnect switch or operator's station is provided, check that all of the wire connections are tight. Finally, check that all of the ribbon cable connections to the control card assembly are tight.

2. Inspect all of the external wiring to see if it is properly installed and connected according to the terminal board sticker instructions and the system diagram, Fig. 8 (36D870008AB). Make a point to check of all interconnecting wiring between the controller and its operator's devices, AC motor, AC supply disconnect switch, etc., with an ohmmeter. Check the resistance to ground of all terminal board 1TB wiring connections with an ohmmeter to check that the power wiring is not grounded. Check that 2TB terminal 22 measures zero ohms to ground. If not, check whether the controller enclosure is grounded at the grounding terminal (on the outside of the bottom cover).

3. Check that the proper rating of AC motor is connected to the controller T1, T2 and T3 terminals. The motor nameplate current rating (or sum of multiple motor current ratings) should not exceed the controller current rating. If the motor is a synchronous reluctance motor (instead of an induction motor), the controller current rating should be 1.4 times the motor current rating to allow for higher peak and pull in currents.

   The AC motor voltage and frequency nameplate ratings must also agree with the controller rating. If a standard 230/460 volt, 60 hertz motor is used, it should be connected for 230 volt operation as shown on the connection diagram (low voltage connection) usually provided on the motor terminal box cover.

   If a non-standard voltage and/or frequency motor is used, refer to the Base Frequency jumper selection Table A (page 35) and the volts per hertz instructions later in this section. These will have to be checked and readjusted since the controller has been factory tested with a standard 60 hertz motor, unless specially ordered.

   It is recommended that the motor be disconnected from the driven machinery at the initial start-up to prevent possible damage if misoperation occurs. Check that the motor shaft can be rotated and is free from binding

NOTE

THE AFTROL I CONTROLLER **WILL NOT** OPERATE UNLESS THE AC MOTOR IS ELECTRICALLY CONNECTED. DISCONNNECTION OF ANY ONE MOTOR PHASE , WILL PRODUCE A FAULT SHUTDOWN.

4. Check for presence or absence of the following terminal board or card jumpers (Refer to page 36 for 50 Hz input jumpers.

   (a) 1TB terminals T and A should be jumpered if a motor ammeter is connected between terminal T3 and A, and the AC motor T3 lead is connected to 1TB terminal T.

   (b) 2TB terminals 1 and 2 should be jumpered unless a motor thermoswitch, thermal overload relay or other normally closed interlock is connected across these terminals. If any of these are connected the jumper should be removed, but check that the external interlock is closed

   (c) Regulator card posts SPW should be jumpered to SPX and SPY jumpered to SPZ if the AC input is single-phase and not jumpered for three-phase input controllers.

   (d) Regulator card posts FC1 and FC2 should normally be jumpered normally, but this jumper should be removed if the 6VF11K Follower option card is mounted on the Regulator card

   (e) Regulator card posts BF1, BF2 or BF3 should be jumpered according to Table A, if higher than 60 hertz motor frequency is desired.

5. Use a voltmeter to check that the AC supply voltage on the incoming is 230 volts AC +10 percent -5 percent.

START-UP PROCEDURE

1. Set the operator's speed potentiometer to zero (completely counter-clockwise). If the Follower option is included, set the operator's Manual/Auto selector switch in the Manual position.

2. Close the disconnect switch to supply 230 volts AC power to the controller. Check for 230 volts across the load side of the controller fuses. If no voltage is present, refer to the Troubleshooting section part A-1 "No power to controller."

3. Press the operator's start pushbutton, (or close the RUN switch) and observe the green RUN light on the regulator card. It should be blinking at a frequency of 2 to 3 hertz. If the light is off, refer to the Troubleshooting section, Part A-2 "Can apply power to controller, but cannot start."

4. Slowly increase the operator's speed potentiometer. The RUN light should increase its blinking frequency and the motor should begin to rotate. If the motor rotation is backwards and the Reversing option is not provided, press the operator's STOP pushbutton to stop the motor. Disconnect AC power, reverse the connections to any two motor leads and restart the controller.

5. Check the AC motor current with a clamp on ammeter. If the motor shaft is disconnected from the driven machinery, the current reading should be approximately 1/3 of the motor nameplate current rating for standard induction motors.

6. Slowly increase the speed potentiometer up to the maximum speed setting while observing motor current and motor operation. The motor should run smoothly up to its rated speed and the current of the disconnected motor should remain fairly constant over its entire speed range. If the motor does not operate properly, refer to the Troubleshooting section.

7. Press the operator's STOP pushbutton. The motor speed should decelerate smoothly down to a slow speed as can be seen by the RUN light blinking frequency. The RUN light should then go out and the motor should stop.

8. If different adjustments of minimum speed, minimum frequency, maximum speed, volts per hertz or linear time are desired, they should be made and tested while the motor shaft is still disconnected from its load. Refer to the ADJUSTMENT part of this section for adjustment recommendations and to the DESCRIPTION, section 2.0, for an explanation under REGULATOR card.

9. Connect the motor shaft to the driven machinery and repeat the above start-up steps. The motor current will be dependent on the driven load, but should not exceed the motor or controller nameplate rating. If the controller cannot start the motor or if motor current is excessive at low speeds, increase the ***COMP*** potentiometer setting as explained under adjustments.

NOTE

IF THE CONTROLLER HAS BEEN STORED FOR OVER 6 MONTHS, THE ELECTROLYTIC FILTER CAPACITORS SHOULD BE "FORMED" BEFORE OPERATING THE CONTROLLER ABOVE 150V AC TO THE MOTOR. FORMING IS ACCOMPLISHED BY OPERATING THE CONTROLLER AT 150V AC OUTPUT FOR 5 MINUTES AND THEN INCREASING THE OUTPUT TO 200 VOLTS AC AND OPERATING FOR 5 MORE MINUTES. AFTER THIS PROCEDURE, THE CONTROLLER MAY BE OPERATED OVER ITS ENTIRE RANGE.

ADJUSTMENTS — REGULATOR CARD (See Fig. 19)

If it is desired to change the Regulator card adjustments, the following procedures are suggested. Refer to the DESCRIPTION, Section 2.0 for information on adjustment ranges and operation.

MINS (Minimum Speed)

Normally, the ***MINS*** potentiometer is set fully CCW and must be in the fully CCW position for proper adjustment of the ***MINF***, Minimum Frequency potentiometer. If a higher than zero minimum speed is a requirement, it should be set after the adjustment of ***MINF***.

MINF (Minimum Frequency)

With the Speed Reference potentiometer set at zero (fully CCW) and both the ***MINS*** and ***COMP*** potentiometers on the Regulator card set fully CCW, start the controller. The DC link voltage (SMP to SMN) should be no greater than 8 volts. Normally, the ***MINF*** potentiometer should be adjusted to obtain an inverter output frequency of approximately 2 to 3 hertz. The RUN light should be blinking at this frequency and it should be possible to check minimum inverter frequency by observing the RUN light blinking frequency. If a synchronous reluctance motor is being used, it is recommended that ***MINF*** be set for a 6 hertz minimum frequency.

MAXS (Maximum Speed — Base Frequency)

With the Speed Reference potentiometer set at 100 percent (fully CW), adjust the ***MAXS*** potentiometer to obtain rated motor nameplate speed and frequency (normally 60 hertz). If this requires a reference voltage of greater than 8.5 volts as measured at terminal board 2TB terminals 18-22, install a jumper between Regulator Control card posts BF1 and BF2 to increase the base frequency setting. Readjust the ***MAXS*** potentiometer to rated motor speed and frequency. Also, readjust the minimum frequency as set by the ***MINF*** potentiometer, since this will also change. If higher than 60 hertz frequency is required, use Table A as a guide in selecting the proper base frequency jumper. It is possible that the next higher or lower base frequency jumper than the one indicated in Table A may be necessary to ensure that the voltage between 2TB terminals 18-22 is between 5 and 8.5 volts when the controller output is at the desired base frequency.

TABLE A
Base Frequency Jumpers

Base Frequency	Base Frequency Jumper
50 to 70 Hz	None
60 to 85 Hz	BF1 to BF2
75 to 105 Hz	BF2 to BF3
100 to 130 Hz	BF1 to BF3

V/Hz (Volts per Hertz Adjustment)

Set the Speed Adjust potentiometer at the maximum (fully CW) to obtain rated motor nameplate frequency (normally 60 Hz) and speed. If the AC motor is disconnected from the driven machinery so that it is at no load, adjust the ***V/Hz*** potentiometer to obtain 210V AC across the motor terminals or approximately 90 percent of rated motor voltage, if different than 230 volts.

After the motor shaft has been connected to its load and the ***COMP*** potentiometer has been adjusted for best low speed operation, return the Speed Adjust potentiometer to its maximum setting and recheck the motor terminal voltage. Before readjusting the ***V/Hz*** potentiometer, mark the original setting point. Slightly adjust ***V/Hz*** in either direction to try to achieve the following:

1. Minimum motor current at the loaded operating condition.

2. Motor terminal voltage no greater than 230V AC for 3-phase input controllers.

3. For single-phase input controllers, it may not be possible to obtain more than 210 to 220 volts at rated load. It may be necessary to slightly reduce the ***V/Hz*** setting or increase the ***MAXS*** potentiometer setting to obtain rated motor speed at full load.

4. If rated motor voltage is less than 230 volts, adjust ***V/Hz*** to obtain rated motor voltage.

LTIM (Linear Time Adjustment)

Adjust the ***LTIM*** potentiometer to obtain an acceleration time from zero to base speed equal to the time desired for the application. Ten seconds is a good average acceleration for many industrial applications. The deceleration time from base to zero speed should be approximately the same as the acceleration time, but may be longer for fast ***LTIM*** settings. If the controller trips out during acceleration or deceleration, try setting the ***LTIM*** potentiometer for a longer time.

COMP (IR Compensation Adjustment)

The amount of IR compensation required is dependent on the amount of motor torque required to start the driven machinery and to run at low speeds. Too little compensation will not produce enough motor torque and result in excessive motor current. Too much compensation can produce excessive motor "cogging" and excessive no load current.

Set the Speed Adjust potentiometer to operate the motor at approximately 10 percent of rated speed with the motor connected to its load. Adjust the ***COMP*** potentiometer to obtain the minimum motor current at normal load. Slowly turn the Speed Adjust potentiometer from its minimum to its maximum setting while observing motor current. Motor current should not exceed the motor or controller nameplate current rating at any operating point. Readjust the ***V/Hz*** setting as explained under ***V/Hz*** and recheck motor current over the motor speed range.

CLIM (Current Limit Adjustment)

The ***CLIM*** current limit potentiometer has been set at the factory to limit at 150 percent of controller nameplate rated current. Turning ***CLIM*** CCW will decrease current limit. Current limit can be increased by moving ***CLIM*** in the clockwise direction. Under normal circumstances, there should be no need to adjust the ***CLIM*** potentiometer.

FOLLOWER CARD (optional)

If the 6VF11K, Follower card option is furnished, refer to Follower card in SECTION 9.0 for specific instructions on adjustments and jumper connections.

ADJUSTMENT RECORDS

It is suggested that a record of all adjustments be made with the controller operating successfully under normal conditions. This will be useful in the event it becomes necessary to trouble shoot the controller at a later date.

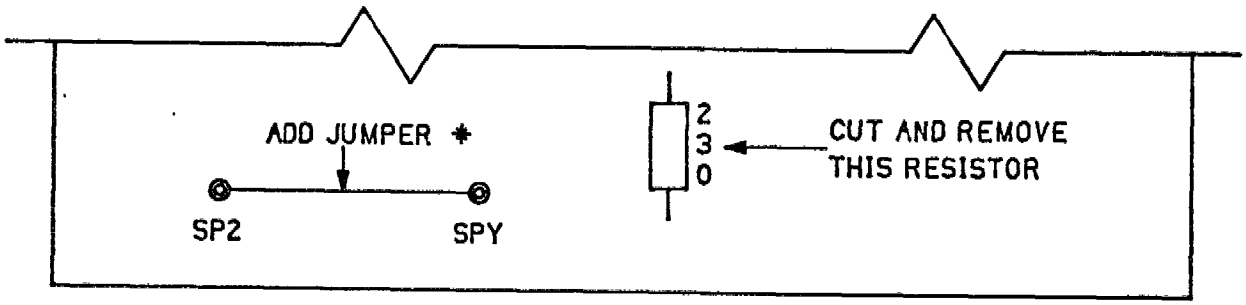
50 HZ AC SUPPLY OPERATION

Standard AFtrol I controllers are adjusted and tested on 60 Hz AC supply power. For operation on 50 Hz AC supply power, the following change should be made before start-up.

1. Single-phase input controllers - Remove the SPY to SPZ jumper on the Regulator card.

2. Three-phase input controllers — Add a jumper across Regulator card posts SPY and SPZ, and cut out resistor 230 adjacent to post SPY, as shown in the sketch below.

* Use the spare jumper connected across posts LMP and LMN, or solder a jumper wire across posts SPY and SPZ



***Use the spare jumper connected across posts LMP and LMN, or solder a jumper wire across posts SPY and SPZ.**

SECTION 6.0

TROUBLESHOOTING PROCEDURES

A systematic approach to troubleshooting will reduce the time required to find the problem. This approach consists of trying to identify the symptoms of the problem, taking a number of meter readings depending on these symptoms, and localizing the problem to some module or a printed circuit card as a result of these readings.

TEST EQUIPMENT REQUIRED

These troubleshooting notes are written so that all readings may be taken with any good quality multimeter or voltohmmeter. A digital multimeter, such as a Fluke Model 8020A, having high input impedance will provide accurate readings with minimum loading of the circuit being read. A clamp-on AC ammeter is also useful in reading controller input and output currents. Never use a megger to check for control or power circuit grounds inside the controller, as this may damage the equipment.

TESTING SAFETY PRECAUTIONS

Because troubleshooting involves taking readings of both control and power circuit voltages, it is a potentially hazardous procedure for both the person doing the troubleshooting and for the equipoment. By following recommended saftey precautions and observing good testing practices, these hazards can be reduced.

Whenever possible, disconnect AC supply power from the controller before inspecting the unit or taking troubleshooting readings. Where operating voltages must be read, proceed as if the circuit being read is at power potential. Although the control circuitry associated with the operator's control is at ground potential, most of the control circuitry and all of the power circuits are at power potentials.

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 IN BOTH THE POWER AND CONTROL CIRCUITS. AFTER AC SUPPLY POWER IS DISCONNECTED, WAIT AT LEAST ONE MINUTE FOR THE DC LINK CAPACITOR TO DISCHARGE BEFORE TOUCHING ANY PART OF THE CONTROLLER CIRCUITRY.

WARNING: HIGH VOLTAGE

ELECTRIC SHOCK CAN CAUSE PERSONAL INJURY OR LOSS OF LIFE. WHETHER THE AC VOLTAGE SUPPLY IS GROUNDED OR NOT, HIGH VOLTAGE TO GROUND WILL BE PRESENT AT MANY POINTS WHEN INSTRUMENTS SUCH AS OSCILLOSCOPES ARE USED TO WORK ON LIVE EQUIPMENT, GREAT CAUTION MUST BE USED. WHEN ONE OF THE INSTRUMENT LEADS IS CONNECTED TO THE CASE OR OTHER METAL PARTS OF THE INSTRUMENT, THIS LEAD SHOULD NOT BE CONNECTED TO AN UNGROUNDED PART OF THE SYSTEM UNLESS THE INSTRUMENT IS INSULATED FROM GROUND AND ITS METAL PARTS TREATED AS LIVE EQUIPMENT USE OF AN INSTRUMENT HAVING BOTH LEADS ISOLATED FROM THE CASE PERMIT GROUNDING OF THE CASE. EVEN WHEN MEASUREMENTS MUST BE MADE BETWEEN LIVE PARTS

WARNING

DO NOT SERVICE THE EQUIPMENT WHEN POWER IS APPLIED

When testing in the power area, 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 turned off again, prior to disconnecting the test equipment

CAUTION

WHEN TAKING READINGS WHILE THE CONTOLLER IS OPERATING, TAKE CARE NOT TO SHORT BETWEEN CIRCUITS WITH THE METER PROBES. USE INSULATING SLEEVES BETWEEN PRINTED CIRCUIT CARD CONNECTION POINTS AS A MEANS TO PREVENT SHORTING

NOTE

ALWAYS READ THE COMPLETE INSTRUCTIONS PRIOR TO APPLYING POWER OR TROUBLE-SHOOTING THE EQUIPMENT.

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

GENERAL TROUBLESHOOTING

Controller problems can usually be separated into two general areas:

A. Controller shuts down or cannot be started

B. Controller operates improperly.

The following troubleshooting notes are presented under two general headings. The notes are further subdivided under trouble symptoms to save time in the troubleshooting process. These notes refer to the Trouble Shooting Chart which gives normal readings of resistances and voltages at various test points, and comments on possible problems and recommended action. When the source of the problem is determined, refer to further instructions under the specific heading, such as Control Card Troubleshooting, Power Module Converter or Inverter Section Troubleshooting, or DC Link Filter troubleshooting. Some further things to check are included under Miscellaneous Troubleshooting Checks, beginning on page 49.

If a fault shutdown occurs, the following sequence should be used to restart the drive:

1. Wait several minutes for the drive link capacitor to discharge down to 15 volts or below (as measured between Regulator card test posts SMP and SMN)

2. Press the Stop pushbutton and then press the Start pushbutton.

3. If the DC link voltage does not discharge below 15 volts, disconnect the AC supply power to allow capacitor discharge, reapply AC power and repeat step 2. above

A. Controller shuts down or cannot be started

1. No power to controller.

a) Open the controller door and check the voltages between terminals FU1-1, FU2-1 and FU3-1 at the top of the fuse block with an AC voltmeter. These voltages should all read from 218 to 253 volts (230 volts, +10 -5%) If no voltage or incorrect voltage is obtained, the source of the problem is the incoming power to the controller. Check that the AC power disconnect switch to the controller (can be a door mounted option) is closed before investigating further.

b) If incoming power is correct, check the voltages between terminals FU1-2, FU2-2 and FU3-2 at the bottom of the fuse block. If no voltage is present, one or more fuses are blown. Disconnect AC power from the controller and check the fuses with an ohmmeter to determine which ones need to be replaced. Replace any blown fuses with ones of the same type and ampere rating.

c) Before applying AC power, check for shorted components in the controller by going through the step A readings contained in the Trouble Shooting Chart (page 39). If faulty readings are obtained, go to the Power Module Converter Section or DC Link Filter Troubleshooting for further instructions.

d) If Trouble Shooting Chart step A readings are all good, go through the step B readings. If faulty readings are obtained, go to the Power Module Inverter Section or to DC Link Filter Troubleshooting for further instructions.

2. Can apply power to controller, but cannot start.

a) Set the operator's speed potentiometer at zero, press the Stop pushbutton to reset the fault latch, and press the Start pushbutton. If the RUN light on the Regulator card starts blinking at a low frequency, proceed to step 3 (controller can be started but shuts down when operator's speed potentiometer is increased) or to step 3 (cannot control motor speed with speed potentiometer) under part B (controller operates improperly).

b) If the RUN light does not indicate, check all the control card power supply voltages listed in step C of the Trouble Shooting Chart (page 40). If any power supply readings are incorrect, check for open connections, defective control cards, or failed control transformer as recommended in step C. Refer to Section 7.0 for Removal/Repair and Replacement instructions

c) If Trouble Shooting Chart step C readings are all satisfactory, go through the step D readings. If faulty readings are obtained, go to the Control Card Troubleshooting (page 45) for further instructions.

d) If Trouble Shooting Chart step D readings are all satisfactory, go through the step E readings, (page 41) and follow the applicable comments.

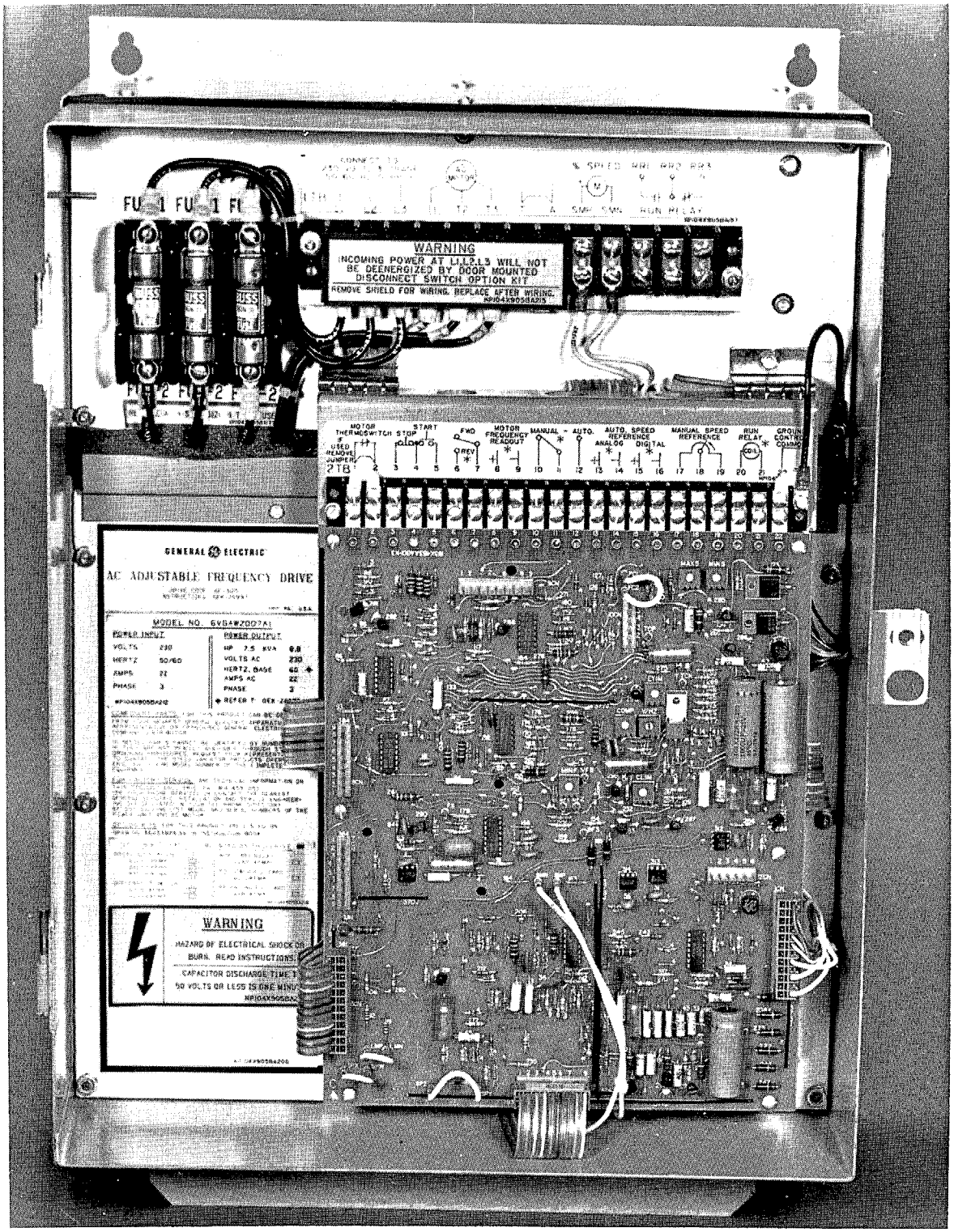


FIGURE 19
AFtrol I controller, front panel details

TROUBLE SHOOTING CHART

Trouble Shooting Step	Location of Terminal To Be Measured	Connect Meter Lead To Connector - Terminal		Meter Selector	Meter Reading in Ohms		Comments on Readings, Possible Problems and Recommended Action	
		Pos. Lead	Neg. Lead		Good	Bad		
A-1	Regulator Card (Top Card)	1CN — 1	1CN — 3	1K or 2K Range	25 to 60 Ω	0	Also measures control transformer winding	If zero ohms, check for shorted converter components Refer to Power Module Converter Section Troubleshooting
A-2		1CN — 1	1CN — 5		500 to inf	0	Not applicable for single-phase inputs	
A-3		1CN — 3	1CN — 5		500 to inf	0	Not applicable for single-phase inputs	
A-4		1CN — 1	4CN — 2		Infinity	0	Power Module SCR resistance	If zero ohms, check for shorted converter circuits Refer to Power Module Converter Section Troubleshooting
A-5		1CN — 3	4CN — 2		Infinity	0		
A-6		1CN — 5	4CN — 2		Infinity	0	(Good reading is 10 Ω for single phase input)	
A-7		1CN — 1	4CN — 7		Infinity	0	Power Module diode resistance	If zero ohms, check for shorted converter circuits Refer to Power Module Converter Section Troubleshooting
A-8		1CN — 3	4CN — 7		Infinity	0		
A-9		1CN — 5	4CN — 7		Infinity	0	(Not applicable to single - phase input)	
A-10		4CN — 2	4CN — 1		40 to 120 Ω	0 or inf	Power Module SCR gate resistance	If bad reading, check for bad converter circuits Refer to Power Module Converter Section Troubleshooting
A-11		4CN — 2	4CN — 3		40 to 120 Ω	0 or inf		
A-12		4CN — 2	4CN — 5		40 to 120 Ω	0 or inf	(Not applicable to single-phase input)	
A-13		4CN — 9	4CN — 7		Incr to inf. as capacitor charges up	0	DC Link Filter resistance	If zero ohms, refer to Power Module Inverter Section Troubleshooting and DC link Filter Troubleshooting
B-1	Inverter Control Card (Bottom Card)	5CN — 7	6CN — 2		Incr to inf	0	Power Module Transistor resistance	If zero ohm, check for shorted transistors in Power Module Refer to Power Module Inverter Section Troubleshooting
B-2		5CN — 4	6CN — 2		Incr to inf	0		
B-3		5CN — 1	6CN — 2		Incr. to inf	0		
B-4		6CN — 9	5CN — 7		Incr to inf	0		
B-5		6CN — 9	5CN — 4		Incr to inf	0		
B-6		6CN — 9	5CN — 1		Incr to inf.	0		
B-7		5CN — 8	5CN — 7		10 to 30 Ω	0 to 2 or inf	Power Module Transistor base resistance	If bad readings check for failed transistors in Power Module Refer to Power Inverter Section Troubleshooting Also, check connections between Power Module and Inverter Control card
B-8		5CN — 5	5CN — 4		10 to 30 Ω	0 to 2 or inf		
B-9		5CN — 2	5CN — 1		10 to 30 Ω	0 to 2 or inf		
B-10		6CN — 1	6CN — 2		10 to 30 Ω	0 to 2 or inf		
B-11		6CN — 3	6CN — 4		10 to 30 Ω	0 to 2 or inf		
B-12		6CN — 5	6CN — 4		10 to 30 Ω	0 to 2 or inf		
B-13		6CN — 9	6CN — 2		Incr to inf. as capacitor charges up	0	DC Link Filter resistance	If zero ohms, refer to Power Module Inverter Section Troubleshooting and DC Link Filter Troubleshooting
B-14		6CN — 6	6CN — 2	10 to 200 Ω Range	0	0 1Ω & higher	DC Link Shunt resistance	If over 0 1Ω, check for open connections to DC link shunt

TROUBLE SHOOTING CHART

Trouble Shooting Step	Location of Terminal To Be Measured	Connect Meter Lead To Connector - Terminal Pos. Lead	Neg Lead	Meter Selector	Normal Meter Reading In Volts When: Stopped (0 REF)	Operating	Comments on Readings, Possible Problems, and Recommended Action	
C-1	Regulator Card (Top Card)	1CN — 1	1CN — 3	AC	218 to 253	218 to 253	AC supply voltage	If reading is off, check AC supply voltage and connections between Regulator card and Power Module
C-2		1CN — 1	1CN — 5		218 to 253	218 to 253	Applicable only for three-phase input	
C-3		1CN — 3	1CN — 5		218 to 253	218 to 253	Applicable only for three-phase input	
C-4	Inverter Control Card (Bottom Card)	1CN — 7	1CN — 8		11 to 14 5	11 to 14 5	Control transformer secondary voltage supplies to card power supplies	If reading is off, check connections between control cards and control transformer and where transformer primary connects to Power Module
C-5		1CN — 10	1CN — 12		13 to 16 5	13 to 16 5		
C-6		1CN — 11	1CN — 12		13 to 16 5	13 to 16 5		
C-7		2CN — 1	2CN — 2		11 to 14 5	11 to 14 5		
C-8		2CN — 4	2CN — 5		11 to 14 5	11 to 14 5		
C-9		2CN — 8	2CN — 9		11 to 14 5	11 to 14 5		
C-10		2CN — 11	2CN — 12		11 to 14 5	11 to 14 5		
C-11		TP — 1P	TP — IN	DC	+14 to +18	+13 to +17	Inverter ϕ1 pos power supply	If low voltage or zero, check steps C-7 through 10 If these readings are OK, then Inverter Control card is probably defective and should be replaced
C-12		TP — 2P	TP — 2N		+14 to +18	+13 to +17	Inverter ϕ2 pos. power supply	
C-13		TP — 3P	TP — 3N		+14 to +18	+13 to +17	Inverter ϕ3 pos power supply	
C-14		11CN — 1	11CN — 2		+13 5 to +17 5	+12 5 to +16 5	Inverter 1, 2, 3 neg power supply	
C-15		TP — RPS	11CN — 2		+10 5 to +12 5	+10 5 to +12 5	Inverter Control power supply	
C-16	Regulator Card (Top Card)	8CN — 7	8CN — 5		+11 5 to +12 5	+11 5 to +12 5	Regulator power supply	If low voltage or zero, check steps C-4 through 6 If these readings OK, then Regulator Card is defective and should be replaced
C-17		8CN — 6	8CN — 5		-11 5 to -12 5	-11 5 to -12 5	Regulator power supply	
C-18		12CN — 3	12CN — 2		+14 to +18	+14 to +18	Converter power supply	
D-1	Inverter Control Card (Bottom Card)	11CN — 3	11CN — 2		+10 to +20	+10 to +20	Inverter fault trip detector	If zero, check steps G1 through 3 and G-11
D-2		11CN — 4	11CN — 2		+10 to +20	+10 to +20	DC link overvoltage detector	If zero, check steps E-9 through 11 and E11
D-3		11CN — 5	11CN — 2		+10 to +20	+10 to +20	AC supply undervoltage detector	If zero, check steps C-1 through 3 and D-12
D-4		11CN — 6	11CN — 2		+10 to +20	+10 to +20	Overcurrent detector	If zero, check steps G-10 and B-14
D-5	Regulator Card (Top Card)	10CN — 1	2TB — 22		+10 to +11	-4 to +5	Motor frequency control signal	Dependent on step D-8 voltage, except when stopped
D-6		10CN — 2	2TB—22		0 to 0 1	0 to -8	Motor voltage feedback signal	0 to -8V comparable to 0 to 300V of steps E-9
D-7		10CN — 3	2TB—22		-9 to -12	-9 to 12/+9 to 12	Min ref and voltage signal	Should be negative at min level, positive above min
D-8		10CN — 4	2TB—22		0 to ± 05	0 to +8	Timed reference signal	0 to +8V should be identical to step E-6 reading
D-9		10CN — 5	2TB—22		+9 to +12	+6 to -6	Motor voltage control signal	Dependent on step D-8 voltage, except when stopped
D-10		10CN — 6	2TB—22		+9 to +12	+9 to +12	Control undervoltage signal	If zero or negative, check steps C-16 and C-17
D-11		3CN — 6	3CN — 7		0	0	Fault signal (if not zero)	If approx 1 volt, check steps D1 through 4
D-12		3CN — 12	3CN — 7		+13 to +18	+13 to +18	AC supply voltage signal	Undervoltage trip occurs at less than 10 volts
D-13		3CN — 4	3CN — 5		0 to +0 1	+0 1 to +3 0	Current feedback signal to Regulator	If different, check step G-10 reading
D-14		3CN — 1	3CN — 2		0	+0 4 to +0 8	Frequency oscillator output	If different, check steps F-1 and D-5
E-1	Regulator Card Terminal Board	2TB — 1	2TB — 22		-11 5 to -12 5	+9 5 to +11	Stop-Start input signals	If readings are wrong, check for open interlock or jumper between 2TB—1 and 2TB—2, or for bad connections to operator's pushbuttons
E-2		2TB — 2,3	2TB — 22		-11 5 to -12 5	+9 5 to +11		
E-3		2TB — 4	2TB — 22		-11 5 to -12 5	+9 5 to +11		
E-4		2TB — 5	2TB — 22		+11 5 to +12 5	(See Comments)	(Open circuit when D-7 pos)	
E-5		2TB — 17	2TB — 22		+5 to +8	+5 to +8	Dependent on Max speed setting	If readings are wrong, check settings of Max and Min Speed pots on Regulator card and connections to Reference pot on operator's station
E-6		2TB — 18	2TB — 22		0 to +4	0 to +8	Dependent on Ref Pot setting	
E-7		2TB — 19	2TB — 22		0 to +4	0 to +5	Dependent on Min Speed setting	
E-8		2TB — 20	2TB — 21		0	+19 to +22	Applicable if Relay Option is installed	
E-9		4CN — 9	4CN — 7		0 to +2 5	0 to +300	DC link voltage feedback to Regulator	
E-10		TP — SMP	TP — SMN		0 to +2 5	0 to +300	DC link voltage (without speed meter)	
E-11		TP — SMP	TP — SMN		0 to +1 5	0 to +150	Reading with % Speed Meter option	If different, check F-1, D-9, D-11 and E-1

TROUBLE SHOOTING CHART

Trouble Shooting Step	Location of Terminal To Be Measured	Connect Meter Lead To Connector - Terminal Pos. Lead	Neg. Lead	Meter Selector	Normal Meter Reading in Volts When: Stopped (0 REF)	Operating	Comments on Readings, Possible Problems, and Recommended Action	
F-1	Regulator Card (Top Card)	12CN — 1	12CN — 2	DC	0 to +1	+13 to +18	Converter stop-start signal	If different, check steps E-1, D-7, and D-11
F-2		12CN — 4	12CN — 2		+6 to +9	+6 to +9	Reading for single-phase input	If readings are different, check voltage in steps C-1 through 4 and C-18 If these readings are OK, Regulator card is probably defective and should be replaced
F-3		12CN — 4	12CN — 2		+8 to +11	+8 to +11	Reading for three-phase input	
F-4		12CN — 5	12CN — 2		+6 to +9	+6 to +9	Reading for single-phase input	
F-5		12CN — 5	12CN — 2		+8 to +11	+8 to +11	Reading for three-phase input	
F-6		12CN — 6	12CN — 2		+8 to +11	+8 to +11	Reading for three-phase input	
F-7		4CN — 1	12CN — 2		0	+0 1 to +0 7	*Converter firing signal (average)*	If different, check steps F-1, D-9 and A-10 through 12 If readings OK, Regulator card may be defective and should be replaced
F-8		4CN — 3	12CN — 2		0	+0 1 to +0 7		
F-9		4CN — 5	12CN — 2		0	+0 1 to +0.7	(Applicable only to three-phase input)	
G-1	Inverter Control Card (Bottom Card)	11CN — 7	11CN — 2		(See Comments)	+5 to +6 5	At the Stopped condition, two readings will be 0 **and the other 10 5 to +12 5, or two readings will be 10 5 to +12.5 and the other 0.**	If different, check step D-14 If this reading OK, *then Inverter Control card may be defective and should* be replaced
G-2		11CN — 8	11CN — 2			+5 to +6 5		
G-3		11CN — 9	11CN — 2			+5 to +6 5		
G-4		5CN — 8	5CN — 7		(See Comments)	+0 3 to +1 5	Inverter driving signal (average) At the Stopped condition, three readings should be zero and three readings should be +0 6 to +1 5 volts, depending on the stopping point	If different, check step D-11 since a fault signal locks out all inverter driving signals Also, check steps G-1 through 3 and B-7 through 12. If these readings OK, Inverter Control card may be defective and should be replaced
G-5		5CN — 5	5CN — 4			+0 3 to +1 5		
G-6		5CN — 2	5CN — 1			+0 3 to +1 5		
G-7		6CN — 1	6CN — 2			+0 3 to +1 5		
G-8		6CN — 3	6CN — 2			+0 3 to +1 5		
G-9		6CN — 5	6CN — 2			+0 3 to +1 5		
G-10		6CN — 6	6CN — 2		0	0 to -0 12	Load indication (100MV = FL full load)	If different, check motor load and step B-14
G-11		6CN — 9	6CN — 2		0 to +2 5	0 to +300	DC link voltage	If different, check E-9 and E-10
H-1	Regulator Card (Top Card)	2TB — 7	2TB — 22		-11 5 to -12 5	-11 5 to -12 5	Operator's switch selected — Forward	If different, check connections between 2TB and operator's station Reversing switch
H-2		2TB — 7	2TB — 22		+9 5 to +11	+9 5 to +11	Operator's switch selected — Reverse	
H-3		7CN — 6	7CN — 7		0 to +2	+11 5 to +12 5	Reversing enable in Stopped condition.	If different, check E-1 and D-7
H-4		3CN — 8	3CN — 7		0	0	Inverter phase sequence — Forward	**If different than steps H-1 & 2 when H-3 is 0 to +2V, Reversing card may be defective.**
H-5		3CN — 8	3CN — 7		+10 to +15	+10 to +15	Inverter phase sequence — Reverse	
J-1	Regulator Card Terminal Board	2TB — 13	2TB — 14		(See Comments)	(See Comments)	Dependent on analog signal level	If different, check connections between controller unit and external signal
J-2		2TB — 15	2TB — 16				Dependent on digital signal level	
J-3		2TB — 10	2TB — 22		-8 5 to -11	-8 5 to -11	Operator's switch selected — Manual	If different, check connections between 2TB and operator's station Manual/Auto switch Also, check Follower card mounting
J-4		2TB — 10	2TB — 22		+11 5 to +12 5	+11 5 to +12 5	Operator's switch selected — Auto	
J-5		2TB — 12	2TB — 22		+11 5 to +12 5	+11 5 to +12 5	Operator's switch selected — Manual	
J-6		2TB — 12	2TB — 22		-8 5 to -11	-8 5 to -11	Operator's switch selected — Auto	
J-7	Follower Option Card	9CN — 9	9CN — 8		0	0	Operator's switch selected — Manual	If not zero, check that FC1 to FC2 jumper on Regulator card is removed
J-8		TP — SRJ	9CN — 8		0	0	Operator's switch selected — Auto	
J-9		8CN — 1	8CN — 2		0	+2 5 to +3 5	*Inverter frequency input*	If readout does not agree with input, Follower card may be defective
J-10		9CN — 1	9CN — 2		0	+4 to +6	Readout frequency signal	
J-11	Regulator Card	TP — FS	2TB — 22		(Variable)	(See Comments)	Reading is +11 to +12 5 volts when inverter frequency synched to reference frequency and variable when not in synchronism	Check steps J-2 through 8 and D-4 through 9 Also, check for jumper on Follower card posts SRD to SRJ

3. Controller can be started, but shuts down when operator's speed potentiometer is increased.

   a) If the RUN light on the Regulator card blinks at a low frequency when the Start pushbutton is pressed, with the speed pot at zero, the controller is in an operating condition. If it shuts down as soon as the speed pot is increased up to 10%, disconnect AC supply power and go through Trouble Shooting Chart step B (page 42). If faulty readings are obtained, go to Power Module Inverter Section or DC Link Filter Troubleshooting for further instructions.

   b) If Trouble Shooting Chart step B readings are all satisfactory, go through step G. If faulty readings are obtained, go to Control Card Troubleshooting.

   c) If Trouble Shooting Chart step G (page 42) readings are all satisfactory, or if the controller shuts down at a higher speed pot setting, go through step D (page 41). If faulty readings are obtained, go to the Control Card Troubleshooting (page 45) for further instructions.

4. Controller shuts down occasionally when running, but can be restarted and runs properly.

   a) Disconnect AC power and check for loose connections at controller terminal boards 1TB and 2TB Also, check for loose or shorted connections to the motor and in the operator's control station.

   b) Check for possibility of intermittent grounds in the motor or motor wiring. Disconnect the controller from the motor wiring before meggering the motor or motor wiring for grounds.

   c) Check for any source of electrical noise on the AC supply lines or in wiring in the same conduit as AFtrol I controller wiring. Suppress the coils of relays, contactors, solenoids, brakes, etc., if in close proximity. Use an RC circuit (0.5 MF capacitor in series with 220 ohm resistor) across the coil terminals for suppression.

   d) Refer to Miscellaneous Troubleshooting Checks. (page 49).

B. Controller Operates Improperly

1. Cannot obtain rated frequency and speed (check controller and motor nameplate ratings)

   a) Check reference voltage by going through Trouble Shooting Chart steps E-6 and D-8. If the D-8 voltage is less than the E-6 voltage, check step D-13 and G-10 for an overload condition. Check the motor current with a clamp-on ammeter and compare with the controller output current rating and motor current rating. If the motor current is less than rated, try increasing (turning CW) the ***CLIM*** (current limit) pot on the Regulator card to see if this adjustment is keeping the speed below the reference setting. If the motor current is higher than rated, investigate the reason for the overload.

   b) If the D-8 voltage is the same as the E-6 voltage, as measured in step A, but is less than 8.5 volts, try increasing (turning CW) the ***MAXS*** (max speed) pot on the Regulator card. If the speed increases, adjust ***MAXS*** to obtain the desired speed as long as D-8 and E-6 voltages do not exceed 8.5 volts. See Regulator Card Adjustments in Section 5.0 for more instructions. If the speed does not increase, return the ***MAXS*** pot to its original setting and proceed to the next step.

   c) Check the voltage control signal of step D-9 in the Trouble Shooting Chart. If this voltage is more negative than -9 volts, check the DC link voltage at step E-9 and the AC supply voltage at steps C-1 through 3. If the AC supply voltage is correct and the DC link voltage is over 30 volts higher than the AC supply voltage for single-phase input drives, or is over 60 volts higher for three-phase input drives, then reduce (turn CCW) the ***V/Hz*** (volts/hertz) pot on the Regulator card to obtain a step D-9 voltage less negative than -9 volts. If the AC supply voltage is less than 218 volts, this condition is out of specifications and must be corrected.

   d) If the problem cannot be found, The Regulator card may be defective and should be replaced. See Section 7.0 instructions.

2. Motor operation is rough or unstable

   a) Check setting of ***COMP*** (IR compensation) pot on the Regulator card. Too high a setting at low speed, light load operation will cause motor "cogging" and noisy opration, and may produce excessive current Try turning the ***COMP*** pot CCW to reduce the amount of IR compensation.

   b) If instability occurs in current limit (overload) operation, or occurs when using the Follower Option card to follow a digital reference signal, try increasing (turning CW) the ***LTIM*** (linear time) pot setting.

   c) Check for uneven motor loading, intermittent grounds or varying AC supply voltage.

3. Cannot control motor speed with speed potentiometer

   a) Check that the jumper between Regulator card posts FC1 and FC2 is in place. (This jumper must be removed if the 6VF11K Follower Option card is connected)

   b) Check reference voltage by going through Trouble Shooting Chart steps E-5 through E-8 and D-8. If the D-8 voltage is less than E-6 voltage, check steps D-13 and G-10 for overload condition. Check the motor current with a clamp-on ammeter and compare with the power unit output current rating and motor current rating. If the motor current is less than rated, try increasing (turning CW) the ***CLIM*** (current limit) pot on the Regulator card to see if this adjustment is keeping the speed below the reference setting.

   c) If steps E-6 and D-8 voltage are OK, but steps E-9 through E-11 readings are low, go through Trouble Shooting Chart step F to determine if there is a problem in the converter control. Also, refer to Control Card Troubleshooting.

4. Cannot stop motor

   Note: If motor cannot be stopped by the normal means interrupt AC supply power to the controller

   a) Check the Stop-Start input signals in steps E-1 through E-4 of the Trouble Shooting Chart. Pressing the Stop pushbutton should cause E-1 through E-3 to go to their negative, stopped readings immediately. If they don't, check wiring and connections between controller and operator's stations. If they do, proceed to step 4(b)

   b) Check Trouble Shooting Chart steps D-6 through D-9, D-6 and D-8 should go to zero and D-7 should switch to negative at the end of the deceleration time after the Stop pushbutton is operated. If D-7 remains positive, check the DC link voltage step E-9. If this voltage does not go below 8 volts, the Regulator card is probably defective and should be replaced. See Section 7.0 for instructions.

5. Motor rotation cannot be reversed (requires 6VRK11K Reversing Option card).

   a) Go through Trouble Shooting Chart step H readings. Reversing will occur only at the stopped condition when the H-3 reading is low (0 to 2 volts). If the Reversing card is defective and should be replaced, refer to Section 7.0 for instructions.

6. Controller will not follow external reference signal (when using 6VF11K Follower Option card).

   a) Check that the jumper between Regulator card post FC1 and FC2 has been removed.

   b) Check for proper jumper placement on the Follower card dependent on the desired operating mode and input signal level. Check adjustments of Follow card potentiometers (See ***Follower Card*** in Section 8.0 for jumper placement and potentiometer adjustment instructions)

   c) Go through Trouble Shooting Chart step J (page 42) readings. If it appears that the Follower card is defective and should be replaced, refer to Section 7.0 instructions.

CONTROL CARD TROUBLESHOOTING (see Fig. 19)

The two main control cards are mounted together to form the Control Card assembly in the front compartment of the controller. The Regulator card is the top card in the assembly and the Inverter Control card is the bottom card. The Reversing Option card and the Follower Option card (if furnished) are mounted to the Regulator card. Troubleshooting of all of these cards can normally be done without disconnecting or removing the cards.

The card assembly can be rotated and latched in an upright position for better access during troubleshooting as follows: (see Figures 24 & 24A)

1. Release the left and right card assembly latches located at the lower sides of the Inverter Control (bottom) card.

2. Swing the card upward until it stops (approximately 110°) and latch by extending the latch bar that is located on the bottom right side of the card assembly bracket.

If card removal or replacement becomes necessary refer to Section 7A.

CAUTION

IF THE REGULATOR CARD OR FOLLOWER OPTION CARD ARE REPLACED, THE NEW CARD SHOULD HAVE THE SAME POTENTIOMETER SETTINGS AND THE SAME JUMPER PLACEMENTS AS THE OLD CARD. NOTE THE PREVIOUS CARD SETTINGS PRIOR TO REMOVAL.

The control circuitry on the upper half of the Regulator card, adjacent to the control terminal board, is at case ground potential, as are all circuits connected to the control terminal board 2TB. The control circuitry on the lower half of the Regulator card and all the circuitry on the Inverter Control card, are at several different power potentials.

WARNING

GREAT CARE SHOULD BE USED IN TAKING CONTROL CIRCUIT READINGS SINCE MANY CIRCUITS ARE AT POWER POTENTIALS. AVOID PERSONAL CONTACT WITH THESE CIRCUITS AND TAKE CARE NOT TO SHORT BETWEEN CIRCUITS WHEN TAKING READINGS.

There are five fault detectors on the two control cards which are checked in Trouble Shooting Chart steps D-1 through D-4 and D-10. The DC link overvoltage detector (steps D-2), AC supply undervoltage detector (step D-3), overcurrent detector (step D-4), and control undervoltage detector (step D-10) should indicate a fault (by going to zero or negative) only during the time that the fault condition is actually present. Therefore, the additional checks called for in the Trouble Shooting Chart should be made immediately to determine if a fault condition actually exists, or if trouble is a result of misoperation of the fault detector. Normally, the actual fault condition disappears soon after the fault trip occurs, with the detector returning to its normal state after setting a fault latch on the Regulator card.

The Inverter Fault detector (step D-1) operates differently from the others. This detector indicates (by going to zero) when any transistor is turned off by its protective circuit. This is a part of each transistor driver circuit. This detector also indicates whenever the transistors are turned off by any other fault detector, and remains indicating for as long as the DC link voltage (steps G-11 or E-9) is above approximately 15 volts. This prevents restarting the controller after a fault shutdown until the DC link voltage has discharged to a low value.

The fault latch on the Regulator card is set whenever a fault occurs. To reset this latch and restart the controller DC link voltage must be below approximately 15 volts, and the Stop pushbutton must be pressed before pressing the Start pushbutton. If the DC link voltage does not go below 15 volts because of converter leakage current, disconnect AC power until the DC link voltage has been discharged. Reapply AC power and it should then be possible to start the controller. If the controller cannot be started due to the fault detector (steps D-1 through D-4) indicating even though no fault exists, the Inverter Control card is probably defective and should be replaced.

The diagnostic signals measured in steps D-5 through D-9 of the Trouble Shooting Chart indicate the operation of the Regulator card. The voltage readings given in the "operating" column for steps D-5, D-6, D-8 and D-9 will vary from approximately the first value at zero reference and speed, to approximately the second value at maximum reference and speed. The step D-7 reading should be negative at minimum reference and voltage, and should switch to positive at approximately 5% of rated reference and voltage. If any of these readings are appreciably different from normal, this should indicate the misoperation problem area. If the problem appears to be in the control rather than in the power circuits, the Regulator card is probably defective and should be replaced.

Trouble Shooting Chart step F checks the operation of the Converter Control on the Regulator card. If these readings indicate the Regulator card is defective, it should be replaced.

Trouble Shooting Chart step G checks the operation of the Inverter Control. If these readings indicate the Inverter Control card is defective, it should be replaced.

POWER MODULE TROUBLE SHOOTING

The power module assembly consists of 1 or 2 SCR converter modules, power transistors, power module card and control transformer all mounted on a single heatsink. The power module can be functionally broken down into two sections for troubleshooting as follows:

A. Converter Section

The power module converter section consists of the SCR converter modules with MOV and RC snubber protective circuits located on the power module card. To help in troubleshooting this section, refer to the Power Module elementary diagrams for the controller HP rating being checked (see Figures 9,10,10A and 11).

1. Checking SCR converter modules (with supply power disconnected). The SCR modules can be checked by removing the bottom plastic barrier (see instructions in Section 7B). If a faulty SCR bridge is suspected, disconnect the 4CN,5CN and 6CN ribbon cables from their connectors on the Power Module Card and push them to one side to gain access to the SCR bridges. Disconnect the wires to the six stab-on connectors of each SCR package (see Fig. 38), keeping a record of which wires go to which terminals. Using a multi-meter selected to 1K or 2K scale, check the resistance between terminals per the following table:

SCR MODULE CHECK LIST

Connect Meter Lead To		Meter Reading in Ohms	
Positive Lead	Negative Lead	Good	Bad
AC1	+	100K to inf.	0 to 1K
AC2	+	100K to inf.	0 to 1K
AC1	—	100K to inf.	0 to 1K
AC2	—	100K to inf.	0 to 1K
+	AC1	100K to inf.	0 to 1K
+	AC2	100K to inf.	0 to 1K
—	AC1	0.1K to 1K	0 to inf.
—	AC2	0.1K to 1K	0 to inf
—	+	0.1K to 1K	0 to inf.
+	—	100K to inf	0 to 1K
+	G1	40 to 120Ω	0 to inf
+	G2	40 to 120Ω	0 to inf.

If any bad readings are obtained, that SCR module should be replaced. Refer to Section 7D for instructions on SCR Module removal. After checking and/or replacement of any replacement of and components, make sure all disconnected wires are reconnected correctly.

2. Converter Section Operational Test

If converter section misoperation is suspected, but all converter section and DC link filter components appear to be good, the converter section and DC link filter portion of the controller may be operated alone, without operating the inverter section or motor. However, the Inverter Section must not have shorted components, since Dc link voltage will be applied to it even though it is not operating. The following procedure should be used to perform this operational test:

With the AC power supply disconnected, disconnect ribbon cables 3CN,5CN and 6CN from the Inverter Control card (bottom card of the control card assembly.) Apply AC power and start and operate the controller in the normal manner. If the Converter section and the Converter Control on the Regulator card is operating correctly, the DC link voltage as measured between test points SMP and SMN on the Regulator card, should be controllable over the whole operating range by the operator's speed potentiometer. However, the "deceleration" time will be much longer than normal because the DC link filter capacitor discharges only through the discharge resistor, which requires one minute to discharge down to 50 volts.

The minimum DC link voltage that can be obtained will depend on the leakage current in the SCR conversion bridges. If the minimum DC link voltage with controller in the stopped condition exceeds 60 volts, then one of the SCR modules has excessive leakage and should be replaced. If the minimum DC link voltage exceeds 60 volts only after the Start pushbutton is pressed at minimum reference setting and with the ***MINS*** pot on the Regulator card turned fully CCW, then there is a problem in the Regulator card. Refer to Control Card Troubleshooting and to Trouble Shooting Chart steps D-5 through D-10 and steps. F-1 through F-9.

If the DC link voltage cannot be controlled by the operator's speed potentiometer over its entire range up to at least 250 volts (dependent on the ***V/Hz*** pot setting on the Regulator card), a problem on the Regulator card probably exists Refer to Control Card Troubleshooting and to Trouble Shooting Chart steps D-5 through D-10 and steps F-1 through F-9.

B. Inverter Section

The power module inverter section consists of the power transistors with RC snubber circuits, base resistors, and loading resistors located on the power module card. To help in troubleshooting this section, refer to the Power Module elementary diagrams for the controller HP rating being checked (see Figures 9,10,10A and 11).

1. Checking inverter section power transistors and snubbers.

   If a defective transistor is suspected from going through Step B of the Trouble Shooting Chart, remove the lower plastic barrier as explained in Section 7B.
   Disconnect the motor leads at terminal board 1TB points T1,T2 and T3 (see Figures 16 and 17). Disconnect the 5CN and 6CN ribbon cables, the 2 power leads (from the link filter reactor and capacitor) on the stud connection point at P2, and the N2 connection at the shunt on the power module card. Using a multimeter selected to the 1K or 2K scale, check the resistance between terminals per the following table:

TRANSISTOR CHECK LIST

Connect Meter Lead To		Meter Reading in Ohms	
Positive Lead	Negative Lead	Good	Bad
P2	T11(E)	Infinity	0
P2	T21(E)	Infinity	0
P2	T31(E)	Infinity	0
T1	T41(E)	Infinity	0
T2	T51(E)	Infinity	0
T3	T61(E)	Infinity	0
T11(E)	P2	0.2k to 1K	0 or inf.
T21(E)	P2	0.2k to 1k	0 or inf.
T31(E)	P2	0.2K to 1K	0 or inf
T41(E)	T1	0.2K to 1K	0 or inf.
T51(E)	T2	0.2K to 1K	0 or inf.
T61(E)	T3	0.2k to 1K	0 or inf.
T11(B)	T11(E)	30 Ω to 200 Ω	0 or inf
T21(B)	T21(E)	30 Ω to 200 Ω	0 or inf.
T31(B)	T31(E)	30 Ω to 200 Ω	0 or inf.
T11(B)	T41(E)	30 Ω to 200 Ω	0 or inf
T51(B)	T51(E)	30 Ω to 200 Ω	0 or inf.
T61(B)	T61(E)	30 Ω to 200 Ω	0 or inf.

If any bad readings are obtained, disconnect the base (B) and emitter (E) leads from their terminations and recheck the resistance readings. If they are the same as before, the transistor should be replaced. Refer to Section 7E for instructions on replacement of failed transistors. Refer to Section 9.0 for spare parts listings.

If the disconnected transistor readings are good, then the original bad reading is caused by either another transistor or a failed snubber circuit

2. Inverter Section Operational Test

If inverter misoperation is suspected, but all inverter section components appear to be good, the inverter section of the power module may be operated alone, without power from the converter section. However, the converter section must not have shorted components since power will be applied to it. Operating the inverter section with no voltage in the DC link allows checking the inverter control card operation and inverter section power transistor base drive and switching operation without being concerned about fault trips if misoperation occurs. The following procedure should be used to perform the operational test:
With AC power supply disconnected, disconnect ribbon cable 4CN from Regulator Control card. Apply AC power and start and operate the controller in the normal manner. The Converter Section will not be operated, so the link voltage will be less than 2 volts (unless the AC motor is disconnected). It should be possible to operate the inverter from its minimum frequency up to about one-half maximum frequency, the upper frequency being limited by the DC link voltage being essentially zero. If the inverter trips out or cannot be started, go through steps D-1 through D-4 and D-10 and D-11 of the Trouble Shooting Chart. If the inverter can be started but operates incorrectly, go theough steps D-5 through D-8 and G-1 through G-9 on the Trouble Shooting Chart. Also, refer to Control Card Troubleshooting.

DC LINK FILTER TROUBLESHOOTING

The DC link filter consists of the filter choke(s) and the filter capacitors. Always disconnect AC power and wait for several minutes before checking the DC link filter components.

1. Filter Capacitors (see Figures 35 & 37)

This consists of either one (1CF) or two (1CF & 2CF) electrolytic capacitors connected in parallel between P2 and N1. When the controller has not been operated fro six months or more, the filter capacitors may start to degrade and their leakage current increase A procedure called "forming" may be necessary to return the electro-lytic capacitors to their rated operating capability. Refer to Section 5.0 for forming instructions.

Electolytic 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" of excessive current and/or temperature.

The filter capacitors can be checked by removing the bottom plastic barrier (see instruction in Section 7B). If a shorted capacitor is suspected disconnect the wires to one terminal of each capacitor. Check across the terminals of each capacitor with multimeter, selected to the 1K or 2K scale. A shorted capacitor will read zero or a low resistance while a good capacitor will charge up to infinite impedance (on that scale). Any shorted or leaky capacitors should be replaced The remaining capacitors should be checked for ruptured or missing vent plugs. These are round plugs, approximately 3/16" in diameter, between the terminals. If a plug is ruptured, it does not cause an immediate capacitor failure, but will result in gradual loss of capacitance Any capacitor with ruptured plugs should be replaced as soon as possible.

2. Filter Choke(s) (see Fig. 42)

This consists of either one (1 LF) or two (1LF & 2LF) in parallel) chokes connected between P1 and P2. These chokes are mounted in the rear compartment near the top of the case. The DC resistance of the filter choke (s), from P1 to P2, will be between .015 to .09 ohms depending on the rating. However, the resistance between the terminals to case ground should be infinite If a faulty choke is suspected, see Section 7I for removal instructions.

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 sufficent air flow through power unit.
2. Check if intake air is below 40°C.
3. Check for adjacent heat sources.
4. Check if room ventilation is adequate to remove the heat being produces.

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 occured due to lightning or ground faults or power factor capacitor switching?
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?
9. Are there excessive switching transients or "notching" observable on the AC supply lines (with an oscilloscope)?

C. Systems 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 for bent terminals shorting to one another on control cards.
6. Check for broken card components due to physical damage.

E. Electrical Noise

1. Check that all external relays, solenoids, brakes, etc., interfacing with or adjacent to the power unit have RC suppression on their coils.
2. Check for other external sources of electrical noise including possible pick up in control leads.

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.

SECTION 7.0

REMOVAL/REPAIR AND REPLACEMENT

GENERAL

This section is supported by a series of photographs (see Figs. 20 through 43) which have been arranged in the column next to the text, to be of assistance during the complete assembly of the AFtrol I contoller.

A. The Regulator Card/Inverter Control Card Assembly is best removed as follows:

1. Disconnect the single-phase (or three phase) AC input power.

2. Remove ribbon cable connectors 1CN and 4CN from the Regulator (top) Card (see Fig. 20).

3. Remove ribbon cable connectors 2CN,5CN and 6CN from the Inverter Control (bottom) card.

NOTE

CABLE CONNECTOR 3CN CONNECTS THE REGULATOR CARD TO THE INVERTER CONTROL CARD AND SHOULD ONLY BE REMOVED WHENEVER IT BECOMES NECESSARY TO SEPARATE THE TWO CARDS.

4. Remove stab-on connectors SMP and SMN. These leads are connected to SMP and SMN on 1TB terminal board for the optional speed indicator.

5. Loosen all 22 bottom screws on terminal board 2TB. (see Fig. 21)

6. Release the left and right (bottom) card assembly latches (Fig. 22) and swing the card assembly up to its latched up position (see Figures 23,24 and 24B).

7. Loosen the left and right nuts on the slotted plastic wire support. Lift off the wire support. (see Fig. 25).

   Release the cable harness 1CN from the plastic wire clamp on the back of the Inverter Control card (see Fig. 25)

8. Carefully withdraw the complete Regulator/Inverter Control card assembly from 2TB terminal board and the slotted card assembly bracket holes. Be careful not do damage the loose ribbon cables. (see (Fig. 26)

9. If it becomes necessary to replace either card, they can be separated as follows:

   (a) Remove the ribbon cable connector 3CN from the Regulator and Invertor Control Cards.

   (b) Remove the six plastic stand offs that separate these two cards.

   (c) Carefully remove the plastic sheet on the back of the Inverter Control Card. (see Fig. 25)

10. To reassemble, reverse the above procedure.

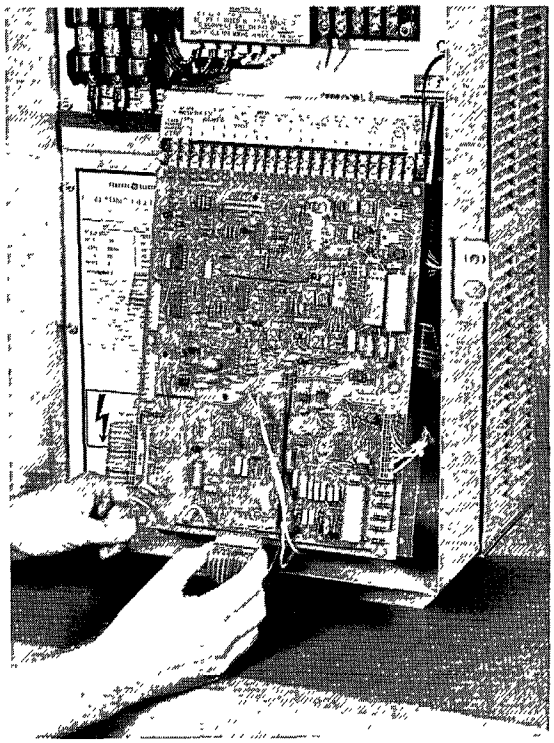


FIGURE 20
AFtrol I controller — Regulator/Inverter Control Cards showing removal of ribbon cable connectors.

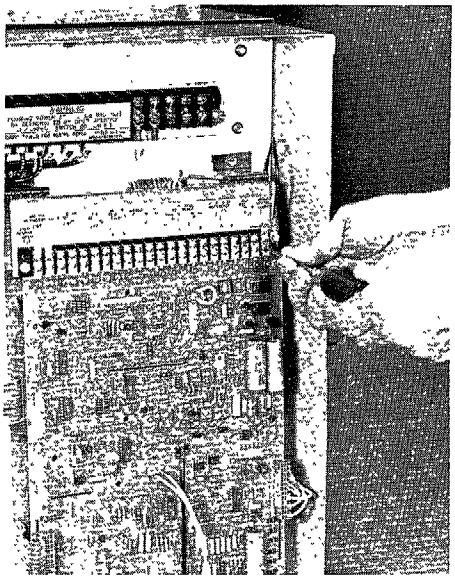


FIGURE 21
AFtrol I controller, showing the loosening of 2TB terminal screws that hold the Regulator/Inverter control cards in place.

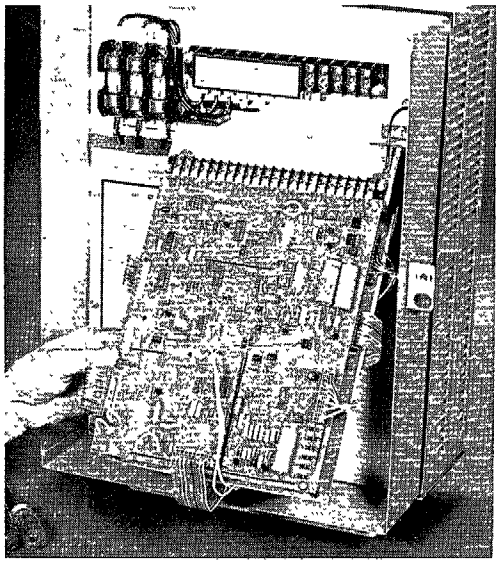


FIGURE 23
AFtrol I controller, showing the Regulator/ Inverter Control Card being lifted up.Note connector 3CN that connects the two cards together.

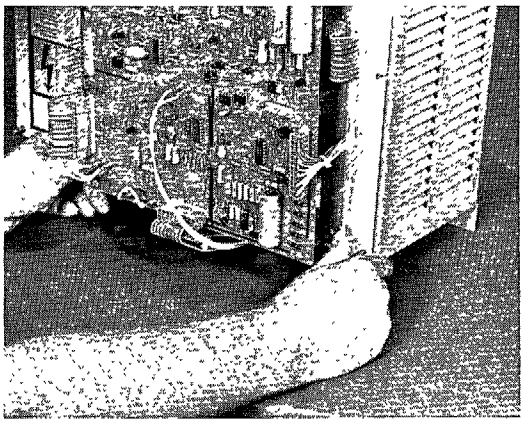


FIGURE 22
AFtrol I controller, showing the release of lower latches on the Regulator/Inverter Control Card Assembly

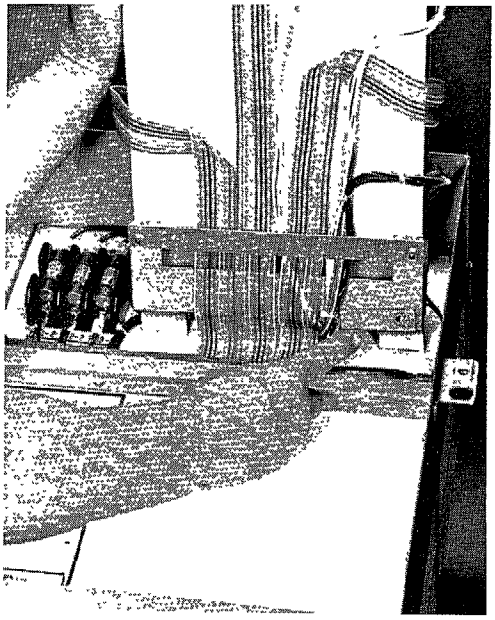


FIGURE 24
AFtrol I controller, showing the latch bar in retracted positon.

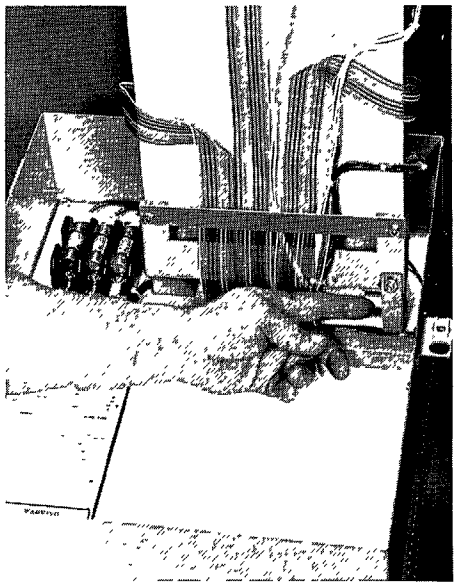


FIGURE 24A
AFtrol I Controller, showing the Regulator/Inverter Card Assembly in latched up position.

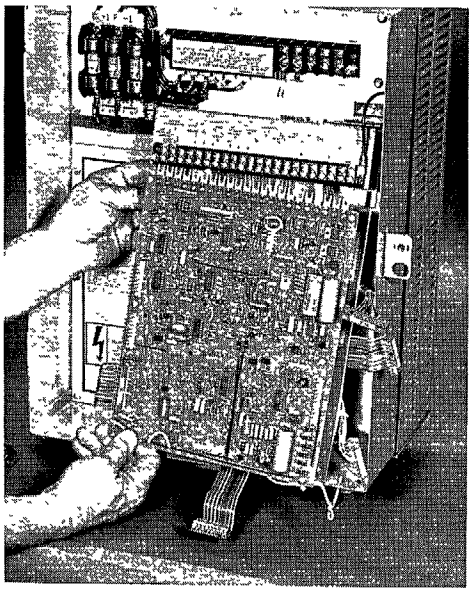


FIGURE 26
AFtrol I controller, showing withdrawal of Regulator/Inverter Control Card Assembly from 2TB terminal board and slotted hinge holes

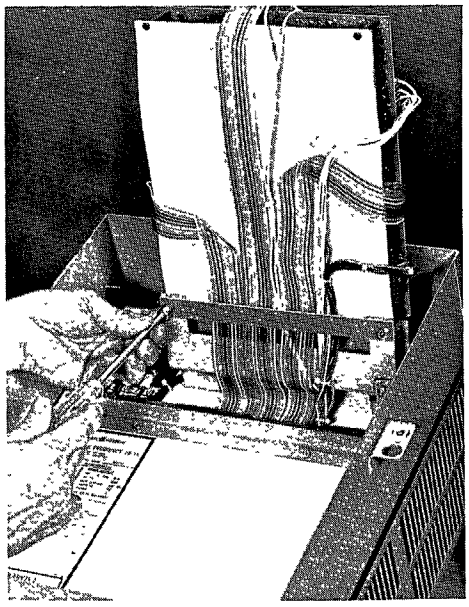


FIGURE 25
AFtrol I controller, showing removal of plastic wire support on Regulator/Inverter control card assembly.

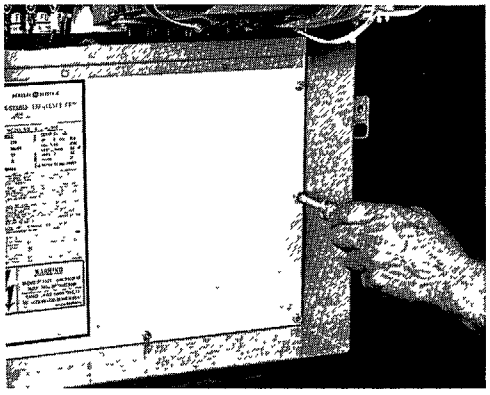


FIGURE 28
AFtrol I controller, showing removal of nuts holding the lower plastic barrier in place.

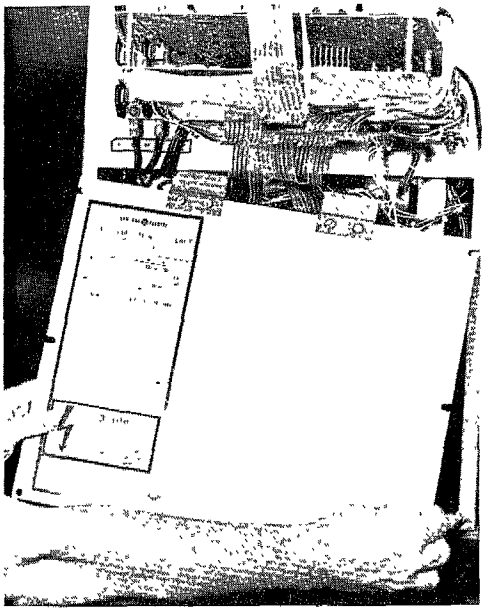


FIGURE 28A
AFtrol I controller, showing removal of lower barrier on chassis mounted unit

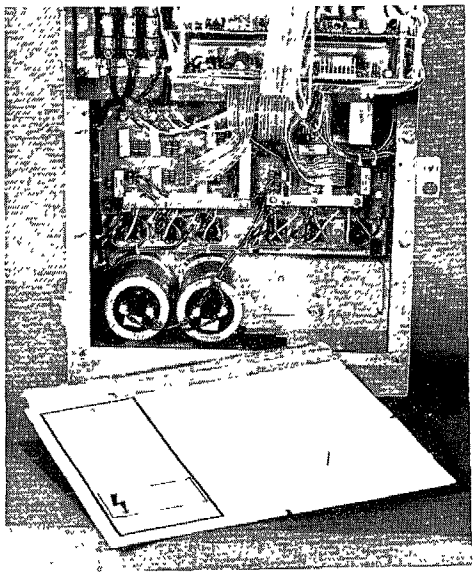


FIGURE 29
AFtrol I controller, showing the lower plastic barrier removed

B. Lower Barrier Removal:

1. Wall mounted (enclosed) controllers:

   a. Raise the control card assembly and latch in that position (see Figures 24 and 24A).

   b. Remove the seven nuts with captive washers that hold the lower barrier in place (see Figures 28 and 29) and remove the lower barrier.

   c. To reassemble the lower barrier, line up the mounting holes and studs and replace the nuts being careful to spread out the ribbon cables and wires under the gasket seal.

2. Chassis mounted (open) controllers:

   a. Raise the control card assembly and latch in that position. (see Figures 24 and 24A)

   b. Remove the two nuts with captive washers in the lower right and left corners.

   c. Remove the lower barrier by pulling out the bottom edge until it clears the two mounting studs, then pull down until the two clips at the top of the lower barrier clear the top barrier. (see Figure 28A)

   d. To reassemble the lower barrier, hook the two clips at the top of the lower barrier under the edge of the upper barrier being careful not to damage the ribbon cables or wires. Then push the bottom edge in while lining up the mounting holes and studs and replace the two mounting nuts.

C. Capacitor Assembly.

NOTE

The assembly is composed of 2200 MFD, 400 Volt capacitors clamped to a mounting plate.
The number of capacitors provided are as follows:

Aftrol Drive, HP	Number of Capacitors Provided
1 and 1-1/2 HP (1 ph. input)	1
2 and 3 HP (1 ph. input)	2
2 and 3 HP (3 ph. input)	1
5 and 7-1/2 HP (3 ph. input)	2

The capacitor assembly is best removed as follows:

1. Disconnect the single-phase (or three-phase) AC input power.

2. Remove the screws, lock washers and ring terminals (P2 and N1) on capacitor 1CF. (see Figures 35 and 36)

NOTE

THE POSITION OF P2 AND N1 RING TERMINALS IS ALWAYS IN THE SAME PHYSICAL LOCATION REGARDLESS OF HORSEPOWER SIZE.

3. Remove the four nuts and captive washers that secure the capacitor assembly to the controller.

4. Carefully lift the assembly from the fixed studs and rotate to the right in order to remove the assembly. (see Figures 36 and 37)

5. Remove fault capacitors by loosening the clamps that secure them to the assembly.

6. To reassemble the capacitor assembly, reverse the above procedure.

NOTE

IN EVENT ANY OF THESE ELECTROLYTIC CAPACITORS NEED TO BE REPLACED, IT WILL BE NECESSARY TO "FORM" THEM. REFER TO THE INSTRUCTIONS IN THE START-UP SECTION 5.0 FOR CAPACITOR FORMING.

D. **The Power Module** SCR bridge is best removed as follows:

1. Disconnect the single-phase (or three-phase) AC input power.

2. Remove the 6 stab connectors located on each molded plastic SCR bridge. These are located on the top front of the power module heat sink. One bridge for single-phase units and two bridges three-phase units. (see Fig. 38)

3. To replace the SCR bridge packages, remove the two machine screws, with lock washers and flat washers. Lift out the packages. (see Fig. 38)

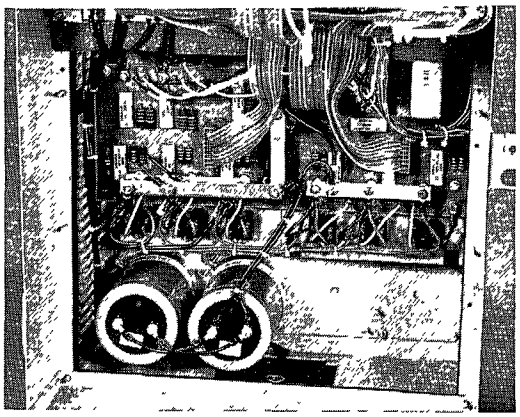


FIGURE 35
Aftrol I controller, showing capacitor assembly with two capacitors.

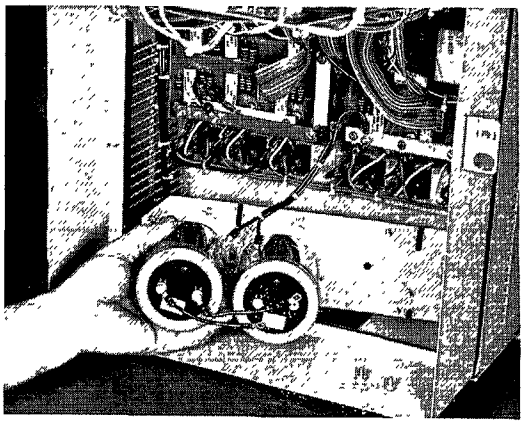


FIGURE 36
AFtrol I controller, showing capacitor removal.

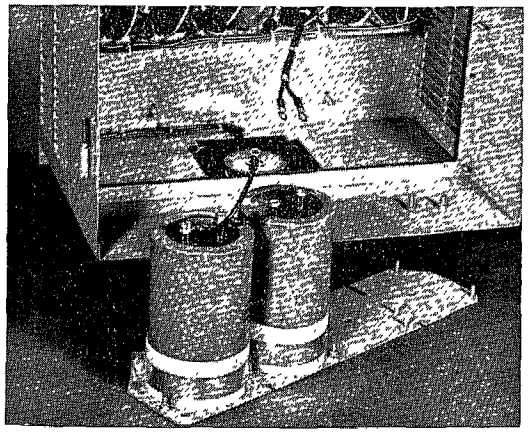


FIGURE 37
AFtrol I controller, showing the capacitor assembly removed

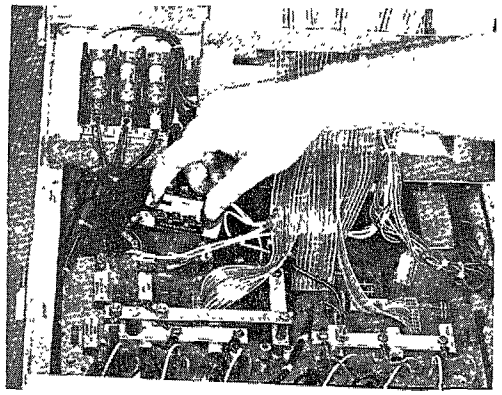


FIGURE 38
AFtrol I controller, showing the removal of the SCR bridges from the Power Module.

NOTE

JUST BEFORE ASSEMBLING THE SCR BRIDGE MODULE(S) REMOVE ANY FOREIGN MATERIAL BY WIPING WITH A LINT-FREE CLOTH. APPLY A THIN COAT OF THERMAL GREASE, GENERAL ELECTRIC, G3221, VERSILUBE PLUS (OR EQUIVALENT) TO THE BACK OF THE SCR BRIDGE MODULE(S). WHEN THE MODULE(S) IS TIGHTENED DOWN, THE EXCESS THERMAL GREASE MUST BE REMOVED FROM THE HEAT SINK AROUND THE SCR BRIDGE PACKAGE(S).

E Power Transistor Removal:

1. Disconnect the AC input power.
2. Remove the bottom plastic barrier (see Item B)
3. Remove the 3 stab connectors on the transistor. (Black wire is collector, red wire is emitter and the white wire is base)
4. Remove the two machine screws with flat and lock washers that hold the transitor. Lift out the transistor. (see Fig. 38A)
5. To install the transistor, repeat the above procedure.

NOTE

PRIOR TO REASSEMBLING, INSPECT THE FLAT SURFACES OF THE POWER TRANSISTORS(S) AND THEIR RESPECTIVE HEAT SINK(S). THESE SURFACES SHOULD BE WIPED CLEAN WITH A LINT FREE CLOTH. APPLY A THIN COAT OF THERMAL GREASE, GENERAL ELECTRIC G322L, VERSILUBE PLUS (OR EQUIVALENT) TO THE HEAT SINK SURFACE(S) WHEN THE TRANSISTORS ARE TIGHTENED DOWN, THE EXCESS THERMAL GREASE MUST BE REMOVED FROM IN BACK OF THE HEAT SINK(S).

F Power Module Card Removal:

1. Disconnect the AC input power.

2. Remove the bottom plastic barrier (see Section 7B).

3. Disconnect the following wires and ribbon cables:

   a. The 4CN,5CN and 6CN ribbon cable connectors at the card.

   b. The base, emitter and collector wires on each of the power transistors (T11 thru T61).

   c. The six wires to the 1CV SCR module and the three wires to the 2CV SCR module on three phase input controllers.

   d. The power input wires at K1,K2 and K3 screw type binding posts for three phase input controllers or at K1 and K2 for single phase input controllers.

   e. The two wires from the link filter chokes connected at P1 and P2.

   f. The two wires from the link filter capacitors connected at N1 and P2.

   g. The three output wires at T1,T2 and T3.

   h. The three wires from the 1CN harness connected at the K1,K2 and K3 terminal posts.

   i. The two contol power transformer primary leads (black) connected at the K1,K2 terminal posts.

4. Remove the five screws with flat and lock washers that hold the card in place.

5. Lift out the card. If replacing the old card with a new one, save the wires left on the old card as required to install the new one. (see Fig. 38B)

6. To install the card reverse the above procedure. When tightening the screw terminals on the card, be careful not to exert too much force, as this may damage the solder connection of the threaded insert to the printed circuit card. Also, when installing the push-on terminal connections on the board, be careful to support the board from the bottom to prevent it from bending.

G. ITX Control Power Transformer Removal:

1. Disconnect the AC input power.

2. Remove the bottom plastic barrier (see Section 7B).

3. Disconnect the following wires and ribbon cables.:

   a. The 1CN and 2CN ribbon cable connectors at the regulator and inverter control cards and release the cables from the wire support and clamp per section 7A7.

   b. The three wires from the 1CN harness connected at the K1,K2 and K3 terminal posts on the power module card.

   c. The two ITX control power transformer primary leads (black) connected at the K1 and K2 terminal posts on the power module card.

4. Remove the two machine screws with flat and lock washers that fasten the transformer to the heatsink and remove the transformer (Note: For easier access to the top screw, remove the hardware holding the top plastic barrier per section 7J1 and move the barrier just far enough to allow access to the screw, being careful not to damage any of the wires connected to the devices on the barrier.)

   In event ITX control transformer needs to be replaced, the spare transformer is available from General Electric Company with wire harnesses and connectors (pre-wired) and stab-on connectors K1,K2 and K3 along with an instruction sheet.(see Figure 38C)

H. Power Module Assembly Removal:

1. Disconnect the AC input power.

2. Remove the bottom plastic barrier (see Section 7B).

3. Disconnect the following wires and ribbon cables:

   a. The 4CN,5CN and 6CN ribbon cable connectors at the power module card.

   b. The two wires from the link filter capacitors connected at N1 and P2 on the power module card.

   c. The three output wires at T1,T2 and T3 on the power module card.

d. The power input wires at K1,K2 and K3 screw type binding posts on the power module card for three phase input controllers or at K1 and K2 for single phase controllers.

e. The two wires from the link filter chokes at P1 and P2 on the power module card.

f. The 1CN and 2CN ribbon cable connectors at the regulator and inverter control card and release the cables from the wire support and clamp per section 7A7.

Remove the hardware holding the heatsink as follows:

a. For 1 thru 3 HP controllers (plate heatsink), remove the four nuts with captive washers that fasten the plate to the mounting brackets and pull out the plate heatsink (It is not necessary to remove the mounting brackets that are fastened to the rear case.) See Figure 38D

b. For 5 and 7 1/2 HP Controllers (extruded heatsink), remove the six nuts with captive washers that fasten the heatsink to the rear case and pull out the heatsink. Slots are provided in the top part of the heatsink for access to the nuts. See Figure 38E

Note: For easier access to the top nuts, remove the hardware holding the top plastic barrier per section 7J4 and move the barrier just enough to allow access to the nuts, being careful not to damage any of the wires connected to the devices on the barrier.

5. To Reassemble, reverse the above procedure.

I Choke Assembly Removal

1. Disconnect the AC input power.

2. Remove the hardware holding the top plastic barrier per section 7J4 and carefully fold the barrier out and down exposing the choke assembly.

3. Disconnect the two wires from the choke assembly at the P1 and P2 connection points on the power module card

4. The chokes are fastened to a plate that is fastened to the back case on four studs with nuts and washers. The choke assembly has one choke on the 1-1 1/2 HP single phase and 2-3 HP three phase controllers. The 2-3 HP single phase and 5-7 1/2 HP three phase controllers have two chokes mounted on the assembly. To remove the choke assembly, remove the four nuts and washers that fasten the assembly to the back case and lift out the choke assembly. (see Figures 38F and 38G)

CAUTION: The choke assembly should be supported while the mounting nuts are being removed since each of the chokes weighs approximately 17 pounds.

5. The individual chokes may be removed from the assembly mounting plate by disconnecting the wires and removing the four nuts with lock washers that fasten the chokes to the plate, being careful to mark the wires that were removed to facilitate reconnection.

6 To reassemble, reverse the above procedure

J. Top Barrier Removal:

1. Disconnect the AC input power.

2 Remove the Regulator Card and Inverter Control Card as shown in section 7A.

3. Remove the following wires:

a All outgoing wires from terminal board 1TB.

b. The wires from door mounted disconnect switch to 1TB and the fuse block if present

c. All outgoing wires from terminal board 2TB.

d. The three wires from 1TB going to T1,T2 and T3 terminals on the power module card.

e The wires from the ferrite core reactors connected at the K1,K2 and K3 terminal points on the power module card for three phase input controllers or at K1 and K2 for single phase input controllers.

4. Remove the five nuts with captive washers holding the top barrier in place on the enclosed controllers or the two nuts and two screws on the chassis type controllers and remove the top barrier. (see Figure 41)

CAUTION: The two nuts in the top corners of the enclosed controllers also hold the front case in place along with the two nuts in the bottom corners of the front case. If the controller is in a vertical position, the two nuts in the bottom corners of the case must be in place and the front case should be supported while the top barrier is removed. Install the two top nuts in the corners after removing the barrier to hold the front case in position until the top barrier is replaced.

5. To Install the top barrier, reverse the above procedure.

K. Ferrite Core Reactors

Located on the back of the upper plastic barrier are 3 ferrite core reactors. The two or (three) phase wires from the load side of the AC supply fuses FU1-2, FU2-2 and FU3-2 (if three-phase) each take five turns through these ferrite cores. These ferrite cores reduce AC voltage spikes that can be present on supply lines.

After the ferrite cores, these wires terminate at K1, K2 and K3 (three-phase) on the power module card.

To remove the ferrite core reactors:

1. Disconnect the AC input power.

2. Remove the top barrier per section J.

3. Disconnect the wires from the reactors connected at FU1-2, FU2-2 and FU3-2 (if three phase).

4. Remove the hardware (screws, nuts and washers) that fasten the reactor to the panel. Note that the screw holding the reactor may also hold the fuse block on the front of the panel. Remove the reactor assembly being careful to note the position that it was mounted in. (see Figure 42)

5. To reassemble, reverse the above procedure.

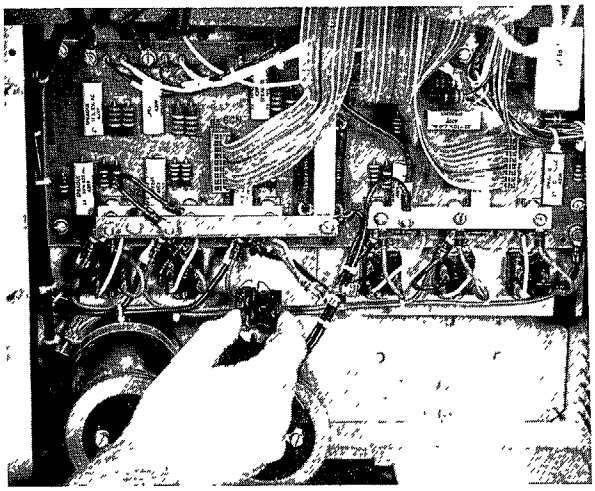


FIGURE 38A
AFtrol I, controller, showing the removal of the power transistors from the Power Module

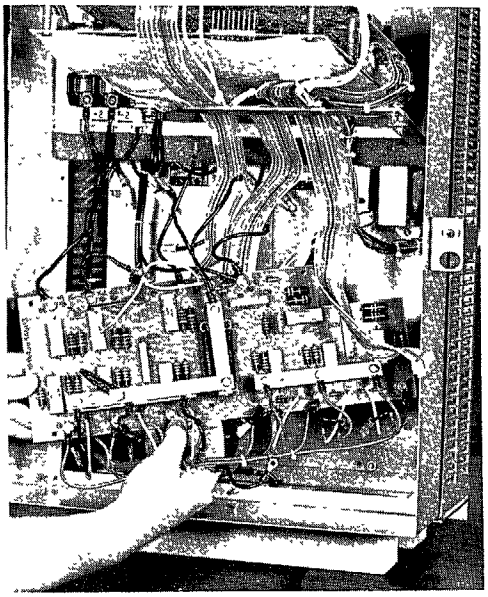


FIGURE 38B
AFtrol I controller, showing the removal of the Power Module Card.

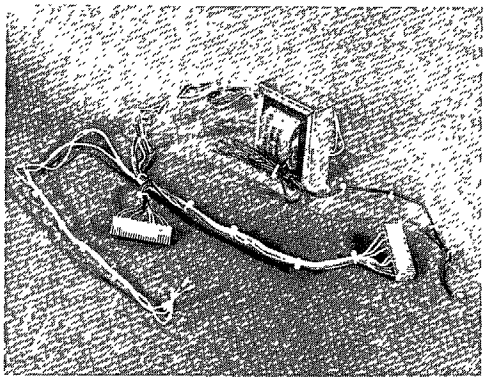


FIGURE 38C
AFtrol I controller, showing the Control Power Transformer removed from the Power Module

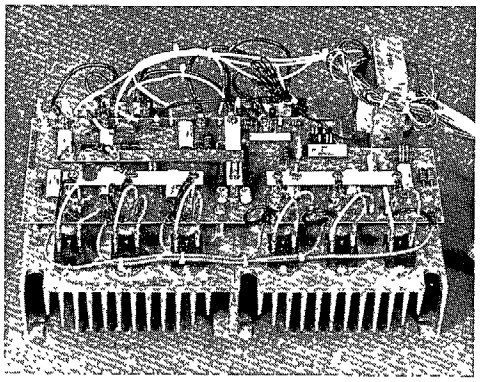


FIGURE 38E
AFtrol I controller, showing Power Module with extruded heatsink (5-7 1/2 HP)

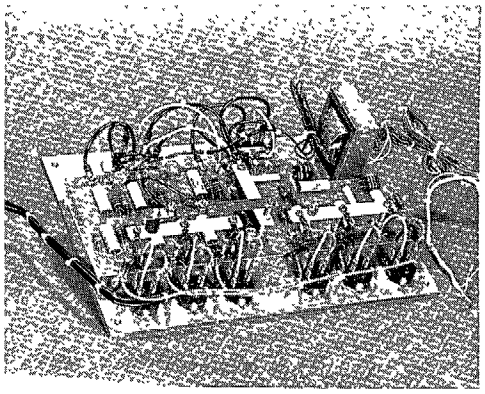


FIGURE 38D
AFtrol I controller, showing Power Module with plate heatsink (1 thru 3 HP)

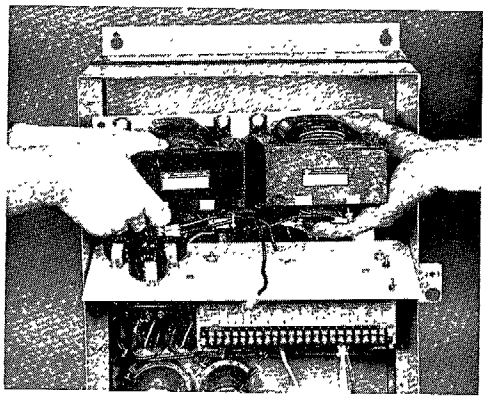


FIGURE 38F
AFtrol I controller, showing removal of the choke assembly

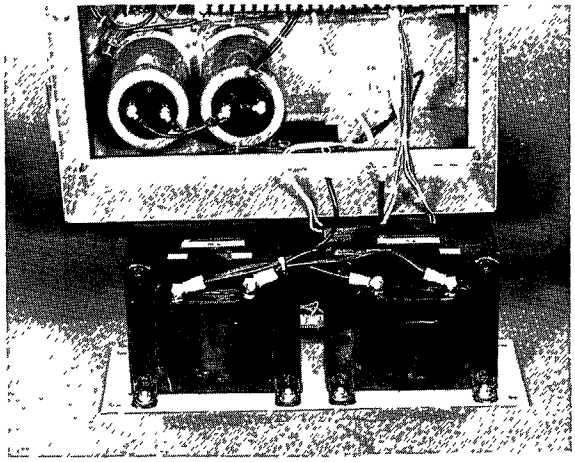


FIGURE 38G
AFtrol I controller, showing the choke assembly removed from the controller.

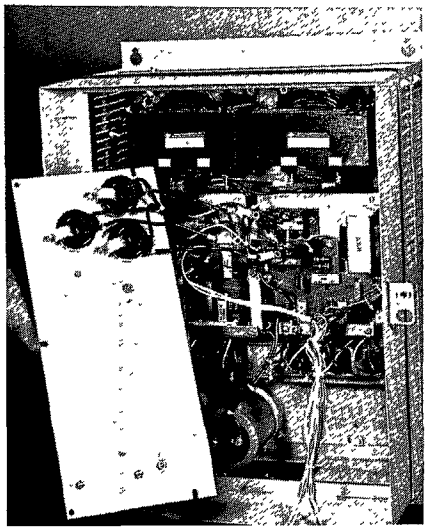


FIGURE 42
AFtrol I controller, with upper plastic barriers removed, exposing the choke assembly and ferrite core reactors.

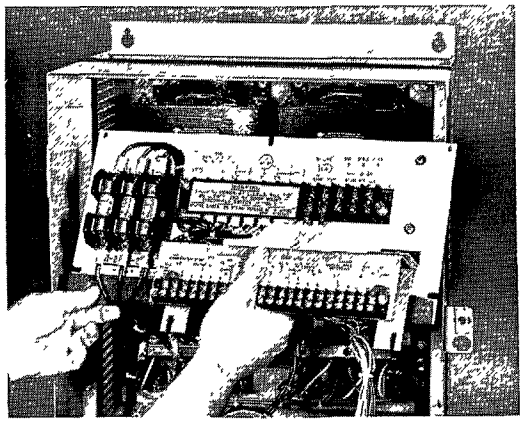


FIGURE 41
AFtrol I controller, showing the removal of the upper plastic barrier.

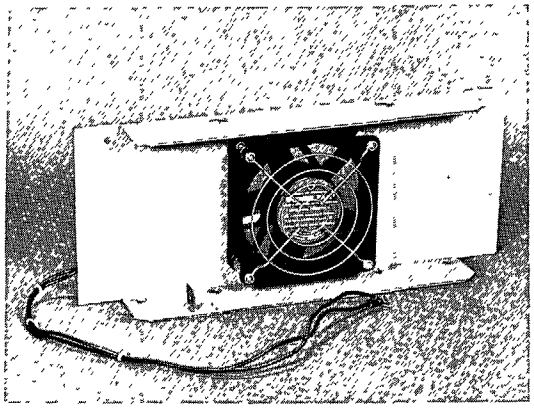


FIGURE 43
Ventilating Fan Assembly for 7 1/2 HP Controller, Note the copper case grounding connection

L. Fan Assembly (7 1/2 HP only)

1. Disconnect the AC input power.

2. Disconnect the two wires from the fan connected at the FU1-2 and FU2-2 fuse block terminals.

3. Remove four nuts, flat washers and washers and two machine screws from the bottom of AFtrol I controller, thereby, releasing the fan assembly.

4. Carefully lift off the fan assembly along with the two wires that were connected at the fuse block.

M. Optional Reversing and Follower Cards

These cards are best removed as follows:

1. Disconnect the AC power supply

2. Use needle nose pliers to release the locking of each snap-in mounting post, so that the card can be pulled away from the post. Carefully pull the card away from the Regulator card connector(s), taking care not to bend the connector posts.

3. If the snap-in mounting posts are damaged, they should be replaced with posts furnished in the replacement option kit(s). Using the needle nose pliers, press the two prongs of the mounting posts together (on the back side of the Regulator card) to release the post, so that it can be pulled from the top side of the Regulator card

4. Follow the mounting directions furnished with the option kit to install the new card

5. For Follower cards, make the same jumper connections and potentiometer settings on the new card, as on the card being replaced

SECTION 8.0

STANDARD SPECIFICATIONS, OPTIONS AND OPERATORS STATIONS

RATINGS

Horsepower — 1 to 7 1/2 HP

Power Supply
Voltage — 1 to 3 HP single phase, 230V + 10%, -5%
— 2 to 7 1/2 HP, three phase, 230V +10%, -5%
Frequency — 60 or 50 Hertz ±2%

Power Output — 3 phase, 0 to 230 volts
Base Frequency at 230 volts can be adjusted from 50 to 120 Hertz (3 ranges)

HP	No. of Input Phases	Full Load Amps RMS Input	Full Load Amps RMS Output
1	1	7	3.6
1.5	1	10	5
2	1	14	7
3	1	20	10
2	3	8	7
3	3	11	10
5	3	17	16
7.5	3	22	22

Overload Capability
Service Factor — 1.0
1 Minute Overload — 150%
Breakaway Torque — 125%
(NEMA B Induction Motor)

Speed Range — 10 to 1 within frequency range selected.
i.e., 6 to 60 Hz, 12 to 120 Hz

Service Conditions — Ambient temperature — 0 to 40°C
Altitude — 0 to 3300 feet
— (0 to 1005 meters)

Functions of Basic Controller
Drive start and stop
Speed control (by potentiometer)
Unidirectional operation
Adjustable linear timed acceleration and, deceleration (2 to 20 sec. single adjustment)

Speed Regulation — 3% with induction motor
(Due to motor slip)
0% with sync. reluctance motor
Service deviation — 1%

Current Limit — 50 to 150% (adjustable)

Adjustments — Current limit
Accel/Decel time
IR compensation
Volts per hertz
Minimum frequency
Maximum speed
Minimum speed

Protective Features —
AC line, fuses
AC line, surge protection
AC line, undervoltage shut down and loss of phase on three-phase drives
Phase insensitive on three-phase drives
DC link overvoltage trip
Control undervoltage trip
Motor slow down limit
(Maintains inverter-motor synchronism during stopping)
Motor stabilization circuit
Motor overtemperature (when used — see 2TB terminal board, points 1 and 2)
Isolation between power and operator's control circuits
Indication
"RUN" light on Regulator Card
(Located above ribbon cable connector 3 CN)

Operator's Station
Start-Stop pushbuttons (control voltage — 24 volts DC)
Speed adjust potentiometer
NEMA 1 Enclosure (See Fig 3)

OPTIONS

The AFtrol® I controller has a number of options which may be added to produce a custom drive system. Some of these options are mounted remote from the controller while others are mounted in the controller. The controller mounted options may be ordered in kit form for user mounting and connection, or may be ordered factory mounted in the controller. The 6V ordering number contains a KA1 suffix if the option is in kit form and contains KFMA1 suffix if the kit is to be factory mounted.

A listing of available options and option kits is given in 36A319231AA shown in Fig. 14. The assembly drawing showing location of these options kits is 36B605432AA in Fig. 15. This assembly drawing is furnished with each option kit, together with an instruction sheet, as listed below:

36A319230AD — Disconnect Switch kits
36A349230AF — Auxiliary Run Relay kit
36A319230AB — Speed Indicator kit
36A349230AC — Enclosure for Speed Indicator
36A349230AE — Reversing and Follower Card kits

The various options are described as follows:

OPTIONS KITS FOR USE WITH AFTROL I INVERTER DRIVE TYPES 6VGAC2/6VGAW2

Catalog No.	Kit Name	Where Mounted	Mounted by
6VOC51A1	Operator Station	Remote	Field
6VOC71A1	Operator Station	Remote	Field
6VOC81A1	Operator Station	Remote	Field
6VOC51KA1	Operator Station	Door	Field
6VOC71KA1	Operator Station	Door	Field
6VOC81KA1	Operator Station	Door	Field
6VOC51KFMA1	Operator Station	Door	Factory
6VOC71KFMA1	Operator Station	Door	Factory
6VOC81KDMA1	Operator Station	Door	Factory
6VDS11KA1	Disconnect Switch	Door	Field
6VDS31KA1	Disconnect Switch	Door	Field
6VDS11KFMA1	Disconnect Switch	Door	Factory
6VDS31KFMA1	Disconnect Switch	Door	Factory
6VAR11KA1	Auxiliary Relay	Drive Panel	Field
6VAR11KFMA1	Auxiliary Relay	Drive Panel	Factory
6VR11KA1	Reversing PC Card	Control Card	Field
6VR11KFMA1	Reversing PC Card	Control Card	Factory
6VF11KA1	Follower PC Card	Control Card	Field
6VF11KFMA1	Follower PC Card	Control Card	Factory
6VSI11A1	Speed Indicator	Remote	Field
6VIE11A1	Instr. Enclosure	Remote	Field
6VOC11A1	Operator Station	Remote	Field
6VOC21A1	Operator Station	Remote	Field
6VOC11KA1	Operator Station	Door	Field
6VOC21KA1	Operator Station	Door	Field
6VOC11KFMA1	Operator Station	Door	Factory
6VOC21KFMA1	Operator Station	Door	Factory
6VFN11KA1	Fan Kit	Case Bottom	Field

FIGURE 44
Option Kits
(36A349231AA)

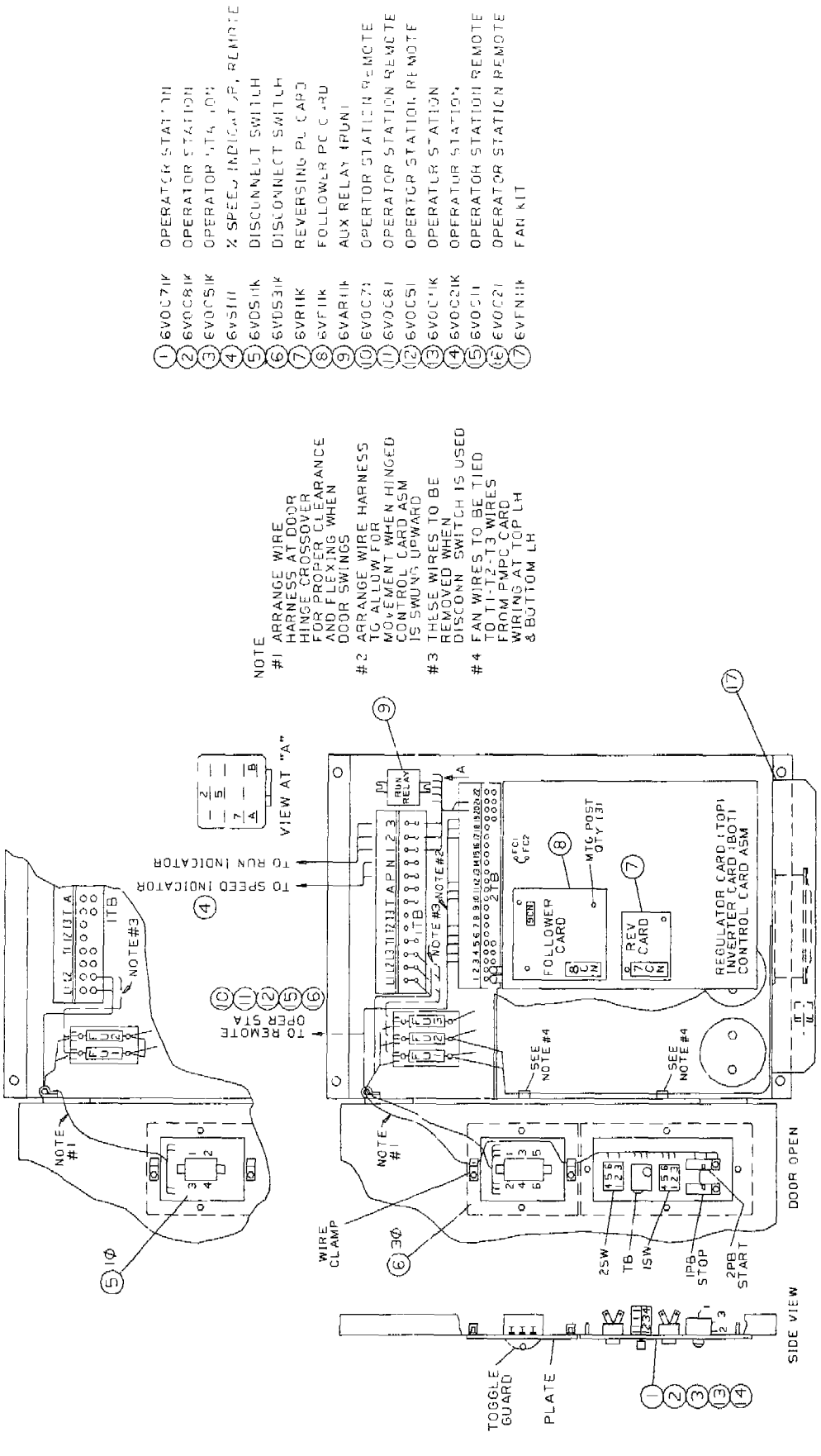


FIGURE 45
Location of Option Kits
(36B605432AA)

Disconnect Switch — 6VDS11KA1 or 6VDS11KFMA1 for single-phase inputs and 6VDS31KA1 or 6VDS31KFMA1 for three-phase inputs.

The disconnect switch comes in either a two-pole form for single-phase input controllers, or a three-pole form for three-phase input controllers. This kit also includes a guard, mounting plate, wires and instructions for mounting and connection. The disconnect switch is mounted on the controller door, with the toggle operable from the front with the door closed (see Fig. 1). It is connected between the controller 1TB terminals L1,L2 & L3 and the AC. supply fuse block (see Fig. 8).

Auxiliary Run Relay - 6VAR11KA1 or 6VAR11KFMA1

This relay, with connected wire harness, is mounted in the upper right hand corner of the controller front compartment, and is connected between 2TB and 1TB terminal boards (see Figs. 5 & 8). The 24 volt DC coil of the relay is energized by the run control on the Regulator card so that the relay is picked up only when the controller is operating to run the AC motor. The SPST contacts connected to controller 1TB terminals RR1, RR2 and RR3, are rated for 100,000 operations under either of the following operating conditions:

1. High current level — 5 amps resistive at 28 volts DC or 5 amps at 115/230 volt AC, 50/60, 0.8 power factor, steady state. Contacts to make and break 5 amps AC.

2 Low current level — 3 milliamps resistive at 20 volts DC or 2 millamps at 115/230 volt AC 50/60 Hz, 0.8 power factor.

Speed Indicator — 6VSI11A1
Indicator Enclosure — 6VIE11A1

This meter is mounted remote from the controller, either in the 6VIE11A1 enclosure, or in the user's panel. The meter is connected to controller 1TB terminals SMP and SMN as shown in Fig. 8. It has an internal calibration potentiometer which is adjusted by means of a screw on the back of the meter. The meter scale is marked 0 to 100 to read percent speed, although it actually reads the controller DC link voltage fed back to the Regulator card. The DC link voltage varies directly with the frequency and motor speed, so that the meter reads speed within ±5%. After the controller has been completely checked out and adjusted, the meter should be calibrated to read 100% at the desired maximum operating speed. It will be necessary to readjust the calibration if the ***MAXS***, ***MINS***, ***V/Hz*** or ***COMP*** potentiometers on the AFtrol I Regulator card are changed

WARNING

THE SIGNALS GOING TO THE SPEED INDICATOR ARE AT POWER POTENTIAL. TAKE CARE NOT TO COME INTO PERSONAL CONTACT WITH THE CONNECTIONS, AND PREVENT SHORTING BETWEEN TERMINALS AND GROUND

Cooling Fan — 6VFN11

This fan can be mounted to the bottom of all 1 through 5 HP controllers to provide additional cooling. This allows operation of the controller in ambient temperatures up to 55°C or at altitudes above 3300 feet (Maximum ambient temperature is 40°C for standard connection cooled 1 through 5 HP controllers and fan cooled 7 1/2 HP controller). This kit includes wiring and mounting instructions.

Motor Ammeter — User Furnished

An ammeter can be remotely mounted to measure motor current and connected to the controller terminal board 1TB. The motor T3 is connected to 1TB terminal T and the ammeter is connected between 1TB terminals A and T3. Following is a listing of meters which are recommended for the different horsepower ratings. These are 3 1/2 inch meters of the same size and type as the Speed Indicator, and will fit in the 6VIE11A1 enclosure.

VFtrol® 1	Controller	Motor Ammeter	
HP Rating	Amp Rating	Amp Scale	General Electric Cat. No
1	3.6	8	50-250 340 MJMJ
1 1/2	5	8	50-250 340 MJMJ
2	7	15	50-250 340 NDND
3	10	15	50-250 340 NDND
5	16	30	50-250 340 NLNL
7 1/2	22	30	50-250 340 NLNL

Reversing Card -- 6VR11KA1 or 6VR11KFMA1

This printed circuit card provides the additional control required for electronically reversing the motor rotation. It is used in conjunction with a Forward-Reverse operator's switch, which is part of the 6VOC81 series of operator's stations, or can be user furnished. The Reversing card is mounted in a designated location (see Fig. 46) on the Regulator card, using a plug-in connector and two snap-in mounting posts. Instructions are furnished with this kit to explain the mounting procedure.

The Reversing card control allows reversing of the inverter output phase sequence only when the controller is stopped. The connection of the operator's reversing switch (see Fig. 8), causes the controller to stop when the reversing switch is operated. At this point, the Reversing card puts out a signal which causes the Inverter Control card to reverse the phase sequence of the inverter. When the controller is started (by pressing the Start pushbutton), the motor will rotate in the opposite direction.

Follower Card — (6VF11KA1 or 6VF11KFMA1)

This printed circuit card provides the capability and flexibility for the controller to follow a number of different kinds and levels of speed reference signals. It is used in conjunction with a Manual-Auto operator's switch, which is part of the 6VOC51 series of operator's stations, or can be user furnished. This switch allows operation of the controller from the operator's Speed Reference potentiometer in the Manual selection, and from the external speed reference signal in the Auto selection. Operation in Manual allows checking out and setting up the drive independent of the external speed signal. If only external reference signal operation is desired, the Speed Reference potentiometer and Manual-Auto switch can be omitted, but controller 2TB terminals 11 and 12 must be jumpered to maintain the Auto mode of operation at all times.

The Follower card is mounted in a designated location (see Fig. 47) on the Regulator card, using two plug-in connectors and three snap-in mounting posts. Instructions are furnished with this kit to explain the mounting procedure. When the Follower card is mounted, the jumper between Regulator card posts FC1 and FC2 must be removed for proper operation.

The Follower card provides the flexibility for following various types and levels of external reference signals, either analog or digital, from a process controller, master oscillator or other source. Three groups of jumper selections are used to set up the card for the desired operation, as shown in Table B.

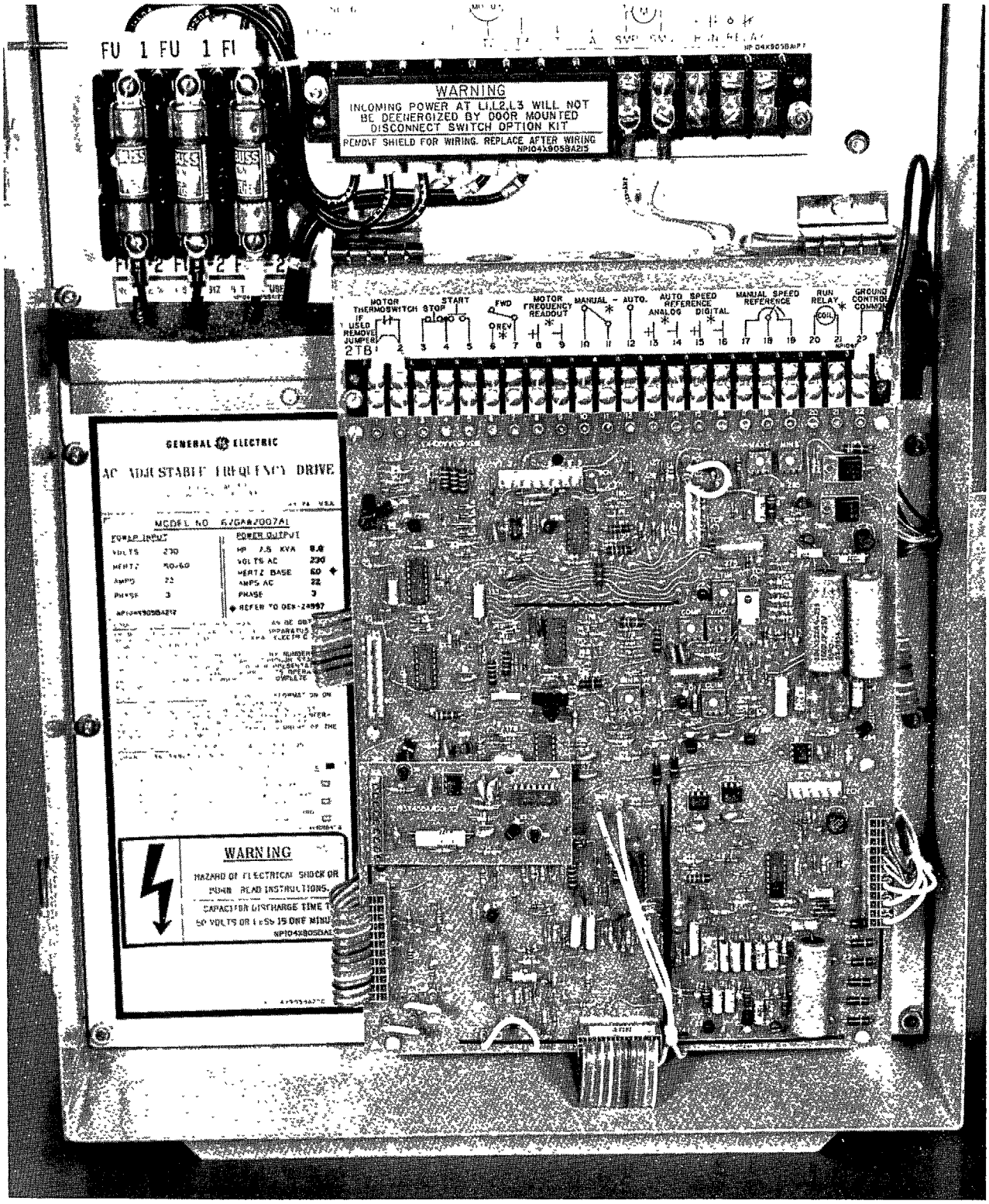


FIGURE 46
AFtrol® I controller, showing Reversing card option mounted on Regulator card

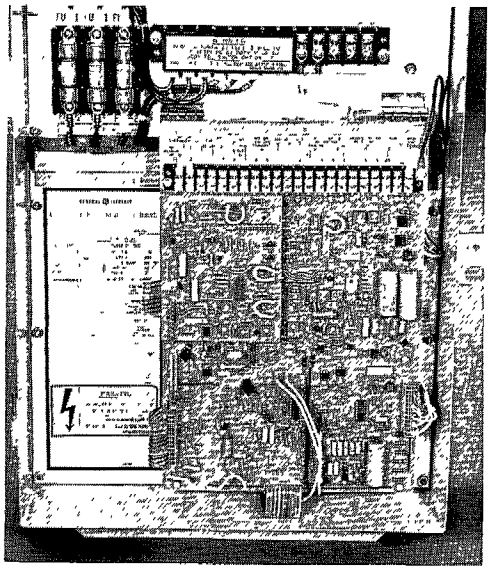


FIGURE 47
AFtrol® I controller, showing Follower card option on Regulator Card.

(These loading resistances require approximately 9 to 10 volts out of the process instrument to produce the maximum current signal, with the voltage jumper connected between card posts 15V and 10V).

When the Follower card is used to follow a voltage signal, the CFJ card post should be left open, and the voltage jumper is selected as shown in Table B. This provides a rough adjustment of circuit gain with the fine adjustment being accomplished with the ***GAIN*** potentiometer on the Follower card.

The ***GAIN*** and ***OFFSET*** potentiometers may be adjusted to provide a wide range of Follower card output signal versus input signal characteristics, as shown in Fig. 48, with the output signal being the reference input to the Regulator card, and finally the speed of the AC motor. The input signal can be either positive or negative, increasing from zero or some minimum up to a maximum level, or decreasing from a maximum level to a minimum or zero level, to produce the desired increasing output signal. The input signal connection rule that must be followed is that

TABLE B

Process Controller	Jumper Selection		
Analog Input	Current Jumper	Voltage Jumper	Mode Jumper
1 — 5MA	CFJ — 5M	15V — 10V	SRJ — SRA
0 — 20MA	CFJ — 20M	15V — 10V	SRJ — SRA
0 — 50MA	CFJ — 50M	15V — 10V	SRJ — SRA
0 — 5 Volts	None	15V — 5V	SRJ — SRA
0 — 10 Volts	None	15V — 10V	SRJ — SRA
0 — 15 Volts	None	None	SRJ — SRA
Digital Input			SRJ — SRD

Analog signals are connected to controller 2TB terminals 13 and 14, with terminal 13 normally positive. Neither of these inputs need to be at ground potential, but both should be within ±45 volts of ground for proper operation. The loading of either input to ground is 45,000 ohms with the CFJ card post open.

The CFJ card post is jumpered to one of the three current loading posts for different process instruments as follows:

1 — 5 ma: jumper posts CFJ to 5M, R_1 =1 1734 ohms
4 — 20 ma. jumper posts CFJ to 20M. R_1 = 469 ohms
10 — 50 ma: jumper posts CFJ to 50M. R_1 = 199 ohms

controller 2TB terminal 13 always be increasing in positive potential with respect to 2TB terminal 14, either from zero to some positive voltage or from some negative voltage toward zero. The differential input of the Follower card allows connection according to this rule, no matter which input signal lead might be at ground potential.

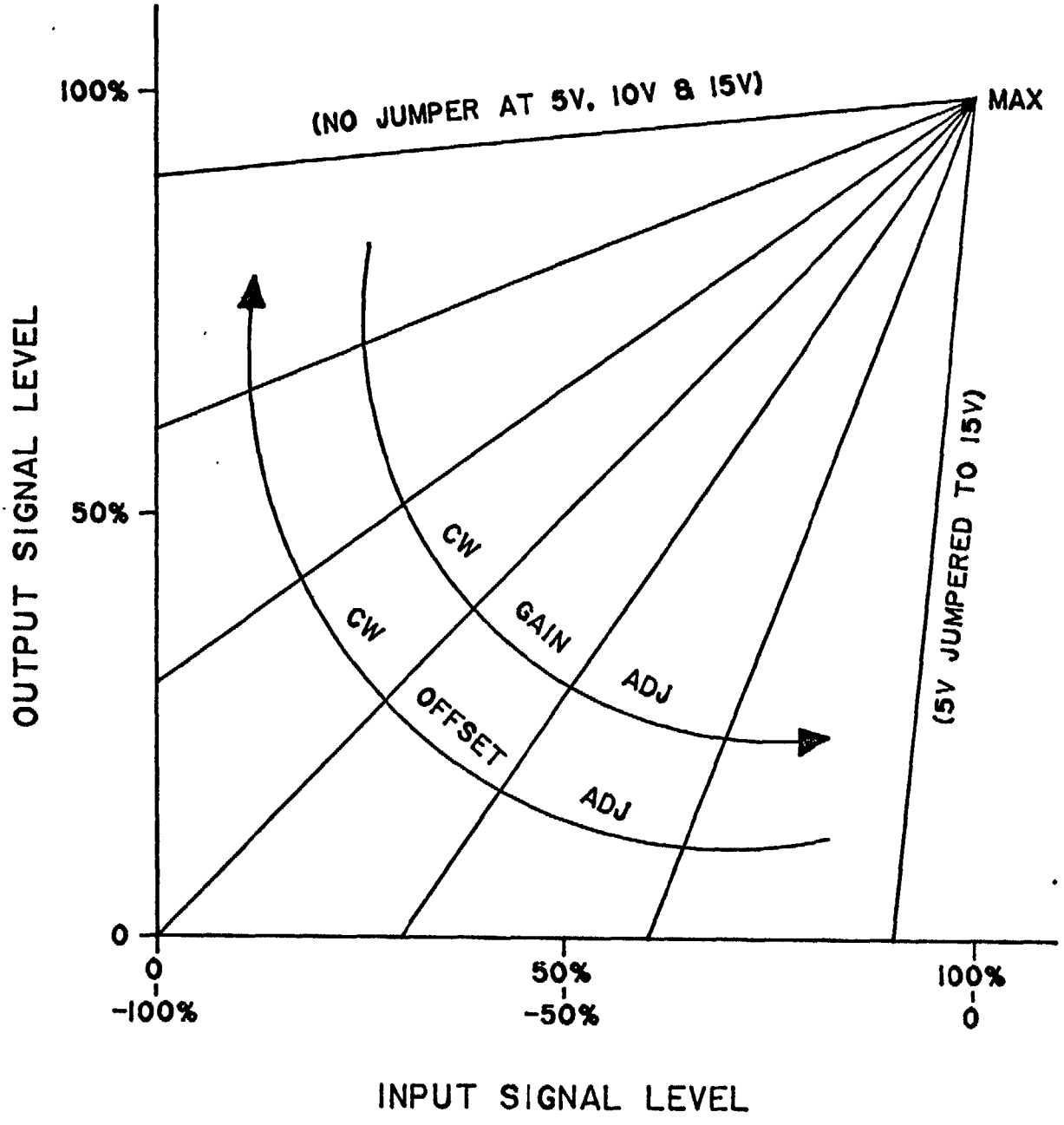


FIGURE 48
AFtrol® I Follower Card, Gain and Offset Characteristics

The adjustment directions of the ***GAIN*** and ***OFFSET*** potentiometers to achieve the desired output versus input characteristics are shown in Fig. 48, with the arrows indicating the results of adjustment in the clockwise (CW) directions. In order to achieve the maximum or minimum gains possible, the 5V to 15V card posts are jumpered for maximum gain, and none of the 5V, 10V and 15V posts are jumpered for minimum gain. The lines shown in Fig. 48 are representative of the different output versus input characteristics which can be achieved between the two limit lines

If a digital (frequency) signal is to be followed instead of an analog signal, it is connected to controller 2TB terminals 15 and 16, with terminal 15 positive. Terminal 16 is connected through a 1000 ohm resistor to controller common, which is grounded. This digital signal must operate at a frequency which is 6 times the desired motor frequency. The signal shape may be either a square wave or pulse, since only the positive going leading edges are used by the phase-locked loop control. The pulse magnitude should be 12 volts, ±3 volts, and the transition time should preferably be less than 10 microseconds. Signal loading is 100,000 ohms

The mode jumper is used to select whether an analog or digital reference signal is to be followed As shown in Table B, connection of card posts SRJ to SRA is used for analog inputs and connection of SRJ to SRD is used for digital inputs. The signal is then fed through one of a pair of FET switches which are controlled by the Manual-Auto selector switch.

The ***MINSP*** and ***MAXSP*** potentiometers can be adjusted to override either an analog or digital reference signal in order to set a minimum and maximum speed of the motor. The range of adjustment of the ***MINSP*** potentiometer is from 0 up to approximately 70% of rated, while the ***MAXSP*** adjustment range is from approximately 50% of rated to over 100%

It should be noted that the output of the Follower card is the reference signal to the Regulator card This means that the signal goes through the Regulator card timed acceleration and deceleration circuit, and is subject to all Regulator card potentiometer adjustments, except the ***MAXS*** and ***MINS*** potentiometers.

The Follower card also contains an optical isolator and amplifying circuit which takes the motor frequency signal from the Regulator card, isolates it, and feeds it to controller 2TB terminals 8 and 9 This signal is a square wave, alternating between zero and 10 volts when loaded to 1.5 milliamps, with terminal 8 positive. It is suitable for driving a frequency counter to accurately measure motor frequency.

OPERATOR'S STATION

There are five different models of operator's stations for basic drives and drives with jog option, reversing option, reversing with jog option, and follower option. Each operator's station model can be ordered in three different configurations, as denoted by the catalog suffix number:

A1 — Remote mounted in own enclosure
KA1 — Kit for user mounting in controller door
KFMA1 — Factory mounted kit in controller door

Aftron I operator's stations are furnished with mounting and wiring instructions 36A349230AA Sh. 1 & 2 for either mounting in the controller door (see Fig. 45) or mounting remote. These operator's stations are listed and described below.

Speed Pot, Start PB, Stop PB — 6VOC71A1, 6VOC71KA1 or 6VOC71KFMA1

This is the standard operator's station. It is connected to the controller as shown in Fig. 8.

Speed Pot., Start PB, Stop PB, Forward-Reverse Switch — 6VOC81A1, 6VOC81KA1 or 6VOC81KFMA1

This operator's station should be used when the 6VR11KA1 or 6VR11KFMA1 Reversing PC card option is added to the controller to provide the motor reversing (selective rotation) function. It is connected to the controller as shown in Fig. 8.

Speed Pot., Start PB, Stop PB, Manual-Auto Switch — 6VOC51A1, 6VOC51KA1 or 6VOC51KFMA1.

This operator's station should be used when the 6VF11KA1 or 6VF11KFMA1 Follower PC Card option is added to the controller, to provide the capability of following either an external analog or digital reference signal (Auto selection) or the Speed potentiometer reference setting (Manual selection). It is connected to the controller as shown in Fig. 8

Speed Pot., Start PB, Stop PB, Run-Jog Switch — 6VOC11A1, 6VOC11KA1 or 6VOC11KFMA11.

This operator's station allows selection of either a Run mode or Jog mode when the Start PB is operated. It is connected to the controller as shown in Fig. 8.

Speed Pot , Start PB, Stop PB, Run-Job Switch, Forward-Reverse switch — 6VOC21A1, 6VOC21KA1, 6VOC21KFMA1.

This operator's station combines the Run-Job and Forward-Reverse options It is connected to the controller as shown in Fig. 8.

SECTION 9.0

SPARE AND RENEWAL PARTS

AFtrol I controller — 1 & 3 HP 230 V, single-phase, 50/60 Hz
2 — 7 1/2 HP 230V, three-phase 50/60 Hz

PRINTED CIRCUIT CARDS

Catalog Number	Description		
193X456AAG01	Power Module Card	1 & 1 1/2 HP	(1 phase input)
193X456AAG04	Power Module Card	2 & 3 HP	(1 phase input)
193X456AAG02	Power Module Card	2 & 3 HP	(3 phase input)
193X456AAG03	Power Module Card	5 & 7 1/2 HP	(3 phase input)
193X452AAG01	Inverter Control Card		
193X453AAG01	Regulator Card		
193X454AAG01	Follower Card		
193X455AAG01	Reversing Card		

SUB ASSEMBLIES AND COMPONENTS (Not HP related)

Catalog Number	Description
36C774235EAG1	Control Transformer with connected wire harness
104X156CA011	Control Transformer only
36B605400ABG2	Ventilating Fan 7 1/2 HP only with connected wire harness
104X215CAP1	Ventilating Fan only — 7 1/2 HP only

SPARE AND RENEWAL PARTS (HP RELATED)

AFirol I Controller — 1—3 HP 230V, Single Phase, 50 60 Hz
2--7 1/2 HP 230V, Three Phase, 50 60 Hz

(Quantities used per drive are indicated under respective drive rating)		Drive Rating & Number of Input Phases							
Part Name	**Cat. Number**	1 (1 ph)	1-1/2 (1 ph)	2 (1 ph)	3 (1 ph)	2 (3 ph)	3 (3 ph)	5 (3 ph)	7 1/2 (3 ph)
AC Power Fuses (15 Amp)	104X109AA004	2	2			3	3		
AC Power Fuses (30 Amp)	104X109AA005			2	2			3	3
Power Module	36D877151EAG01	1	1						
Power Module	36D877151EAG02			1	1				
Power Module	36D877151EBG01					1	1		
Power Module	36D877151ECG01							1	1
SCR Bridge Module	104X125DC006	1	1			2	2		
SCR Bridge Module	104X125DC007			1	1			2	2
Power Transistors	104X170CB006	6	6						
Power Transistors	104X170CB007			6	6	6	6		
Power Transistors	104X170CB008							6	6
Filter Choke	104X220AA012	1	1	2	2				
Filter Choke	104X220AA013					1	1	2	2
Filter Capacitors	104X122AA355	1	1	2	2	1	1	2	2

SPARE AND RENEWAL PARTS

AFtrol I controller — 1 — 3 HP 230V, single phase, 50/60 Hz
2 — 7 1/2 HP 230 V, three-phase 50/60 Hz

FIELD MODIFICATION KITS

Catalog Number	Description
6VOC71A1	Start, Stop, Speed Adjust, Operator's Station Remote Mounted Kit. Has own enclosure.
6VOC71KA1	Start, Stop, Speed Adjust, Operator's Station Kit mounts in cut out of controller door.
6VO81A1	Start, Stop, Forward, Reverse, Speed Adjust Operator's Station Remote Mounted Kit. Has own enclosure.
6VOC81KA1	Start, Stop, Forward, Reverse Speed Adjust Operator's Station Kit mounts in cut out of controller door.
6VOC51A1	Start, Stop, Manual, Auto, Speed Adjust Operator's Staion Remote Mounted Kit. Has own enclosure.
6VOC51AK1	Start, Stop, Manual Auto, Speed Adjust Operator's Station Kit mounts in cut out of controller door.
6VOC11A1	Start, Stop, Run, Jog, Speed Adjust Operator's Station Remote Mounted Kit. Has own enclosure.
6VOC11KA1	Start, Stop, Run, Jog, Speed Adjust Operator's Station Kit mounts in cut out of contoller door.
6VOC21A1	Start, Stop, Forward, Reverse, Run, Jog, Speed Adjust Operator's Station Remoted Mounted Kit. Has own enclosure.
6VOC21KA1	Start, Stop, Forward, Reverse, Run, Jog, Speed Adjust Operator's Station Kit mounts in cut out of controller door.
6VDS11KA1	Single-Phase, 2 pole disconnect switch 1 & 1 1/2 HP. Kit mounts in cut out of controller door.
6VDS31KA1	Three-Phase, 3 pole disconnect switch 2 & 7 1/2 HP Kit mounts in cut out of controller door.
6VAR11KA1	Aux. Run Relay. Includes wire harness. Mounts in upper right hand corner of controller using screws already in place.
6VR11KA1	Reversing printed circuit card assembly*
6VF11KA1	Follower printed circuit card assembly*
6VS111A1	Speed Indicator — Remote mounted
6V1E11A1	Insrument Enclosure — Remote mounted
6VFN11KA1	Cooling Fan Kit mounts on bottom of controller

*Kit includes snap in plastic mounting posts

HOT LINE TELEPHONE NUMBER

The Contract Warranty for AFtrol* I 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 AFtrol I drive user regarding warranty administration and how to obtain assistance on out-of-warranty failures.

AFtrol I CONTROLLERS (1 to 7 1/2 HP)

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

1. In the event of failure or misapplication during "in warranty" refer to the instruction book to identify the defective part or subassembly.

2. When the defective part has been identified (or for assistance in identification) call:

General Electric Company
Erie, Pennsylvania
(814) 455-0521
(24-Hour Phone Service)

Before calling, list catalog numbers of the controller, motor, operator's station and any modification kits for ready reference.

AFtrol I DRIVE MOTORS

AFtrol I drive motor repairs are generally handled by General Electric Small Motor Service Centers or Apparatus Service shops. For specific instructions on your motor, call General Electric at the number listed above and furnish complete nameplate data.

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GLOSSARY OF TERMS

BF1, BF2, BF3 — Base Frequency Jumpers

CF — Filter Capacitors
CFJ — 5M, CFJ-20M, CFJ-50M — Follower Card milliampere jumpers
CLIM — Current Limit Adjustment
1CN, 2CN, 3CN, 4CN, 5CN, 6CN, — Ribbon Cable Connectors
7CN — Reversing Card Connector
8CN — 9CN — Follower Card Connectors
10CN, 11CN, 12CN — Diagnostic Test Point Connectors
COM — Regulator Common
COMP — IR Compensation Adjustment

DS — Disconnect Switch

FC1 — FC2 — Follower Card Jumpers
FU1, FU2, FU3 — AC Power Fuses

GAIN — Follower Card Adjustment

K1, K2, K3 — Power Module Input Power Connections

LF — Filter Choke
L1, L2, L3 — AC Power Connections
1LS, 2LS, 3LS — Ferrite Core Reactors
LTIM — Linear Time Adjustment

MAXSP — Follower Card Adjustment
MAXS — Maximum Speed Adjustment (Base Frequency)
MINF — Minimum Frequency Adjustment
MINS — Minimum Speed Adjustment
MINSP — Follower Card Adjustment
MOV — Metal Oxide Varistor

N1 — Negative Converter Output
N2 — Negative Inverter Input

OFFSET — Follower Card Adjustment

P1 — Positive Converter Output
P2 — Positive Inverter Input

RC — Resistor Capacitor Suppressor Circuit
RR1 — Auxiliary Relay, N.O. Interlock
RR2 — Auxiliary Relay, Common
RR3 — Auxiliary Relay, N.C. Interlock
RUN — Indicating Light

SCR — Silicon Controlled Rectifier (Thyristor)
SMN — Speed Meter Negative
SMP — Speed Meter Positive
SPW, SPX, SPY, SPZ — Single Phase Jumpers
SRA, SRD, SRJ — Follower Card Mode Jumpers

GLOSSARY OF TERMS
(continued)

T1, T2, T3 — AC Motor Connections
1TB — Terminal Board — Power
2TB — Terminal Board — Control
TCN — Capacitor Terminal Points for
TCP — Extended Accelerating Time
THSW — Motor Thermal Switch
1TX — Control Power Transformer

V/Hz — Volts per Hertz Adjustment
Voltage Jumpers — Follower Card 5V, 10V, 15V

GENERAL ELECTRIC COMPANY
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GENERAL ELECTRIC

GEK-24997A (11/81) 2M (P)