INSTRUCTIONS

GEK-22944

DC-1021

SCR POWER UNIT ASSEMBLY

1-5 HP, SINGLE PHASE

USED WITH

ADJUSTABLE SPEED DRIVES

SPEED VARIATOR PRODUCTS DEPARTMENT
ERIE, PENNSYLVANIA

GENERAL ELECTRIC

WARNING

SINCE HIGH VOLTAGES ARE PRESENT IN MANY LOCATIONS WITHIN THE SCR DRIVE, EXTREME CARE MUST BE EXERCISED IN THE SELECTION AND USE OF TEST INSTRUMENTS, WHETHER THE A-C SUPPLY IS GROUNDED OR NOT, HIGH VOLTAGES TO GROUND WILL BE PRESENT AT MANY POINTS. OPERATORS SHOULD NOT STAND ON GROUNDED SURFACES OR BE IN CONTACT WITH GROUND WHEN APPLYING TEST INSTRUMENTS TO TEST POINTS. EXTREME CARE SHOULD BE TAKEN WHILE ATTEMPTING TO ADJUST, TROUBLESHOOT OR MAINTAIN ANY DRIVE SYSTEM DESCRIBED HEREIN.

CONTENTS

		Page
	RECEIVING AND STORAGE	1
	INTRODUCTION	2
PART I -	INSTALLATION AND SETUP INSTRUCTIONS	
	Installation	3
	Interconnection Wiring	5
	Typical Setup and Adjustment	8
	Operation	11
	Maintenance	12
	Troubleshooting	12
Part II -	GENERAL DESCRIPTION	
	Description	16
	Specification	16
	How the SCR Power Unit Works	18
	Spare and Renewal Parts	23
	Typical SCR Power Unit	24

LIST OF ILLUSTRATIONS

Figure		Page
1	Power Unit Assembly	1
2	Power Units – Basic and Reversing	2
3	Power Conversion Module	4
4	Identification of Component Connection Points	6
5	Voltage Follower Modification	7
6	Typical Waveforms	19
7	Regulator Block Diagram	21
8	Typical SCR Power Unit	24

LIST OF TABLES

Table		Page
I	Power Unit Rating Data	5
II	Voltage Check List	12
III	Troubleshooting Chart	13
IV	Spare and Renewal Parts List	23

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 the General Electric Company.

RECEIVING AND STORAGE

RECEIVING

Place the equipment under adequate cover immediately upon receipt. The packing cases are NOT suitable for out-of-doors or unprotected storage Examine each shipment carefully on its arrival and check it against the packing list. Promptly report any shortage or damage incurred in shipping to the carrier and to the nearest Industrial Equipment sales office of the General Electric Company.

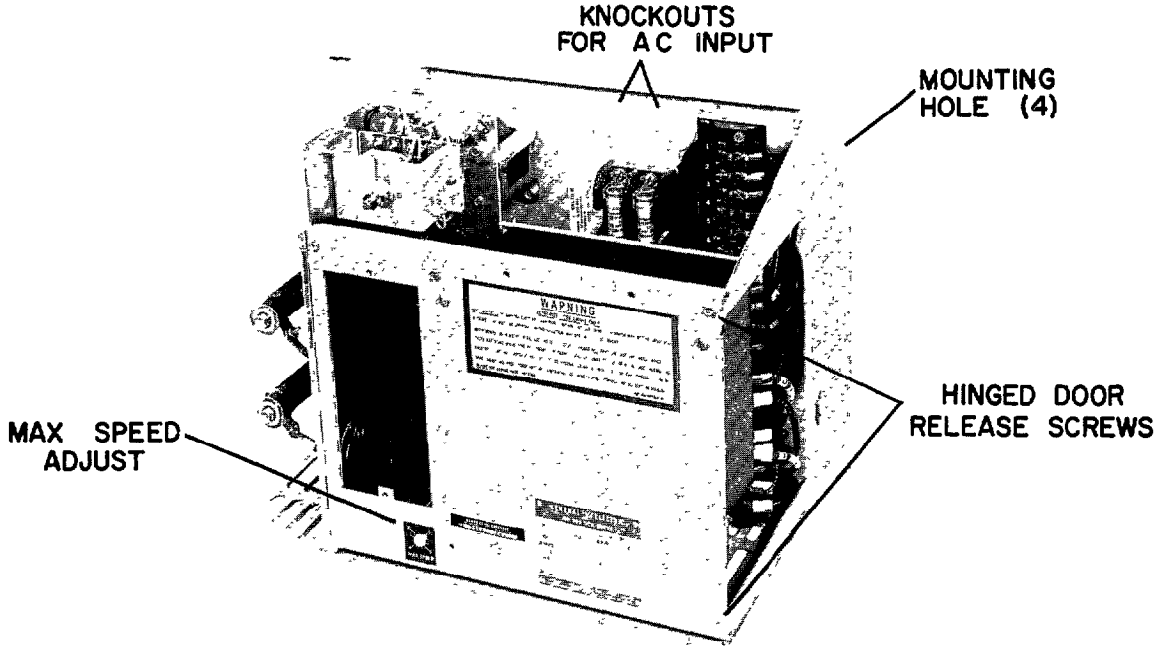
STORAGE

If the equipment is not to be installed immediately, store it under cover in a clean, dry location away from any area where construction work is in progress, and protect the equipment from low temperatures and rapid or extreme variations in temperature or humidity. The minimum storage temperature is −20C. Take care to prevent the accumulation of moisture, dust, or dirt in the equipment during storage or installation, since these contaminants are detrimental to the equipment insulation. The warranty is voided if conditions are not complied with.

ENVIRONMENTAL REQUIREMENTS:

(See page 21 for service conditions.)

This equipment may be stored at ambient temperature of −20C to 70C for a period of up to one year. Air must be free of chemical and electrically conductive contaminants, and other conditions must be such that no moisture condensation occurs in or on the equipment. In addition, when a control that has been in operation will be shut down for either a short or extended period of time, it is recommended the environmental conditions be maintained the same as when in operation Power supplies, ventilation or heating, and air conditioning (if used) should be left on during the downtime to prevent changes in temperature and possible moisture condensation.



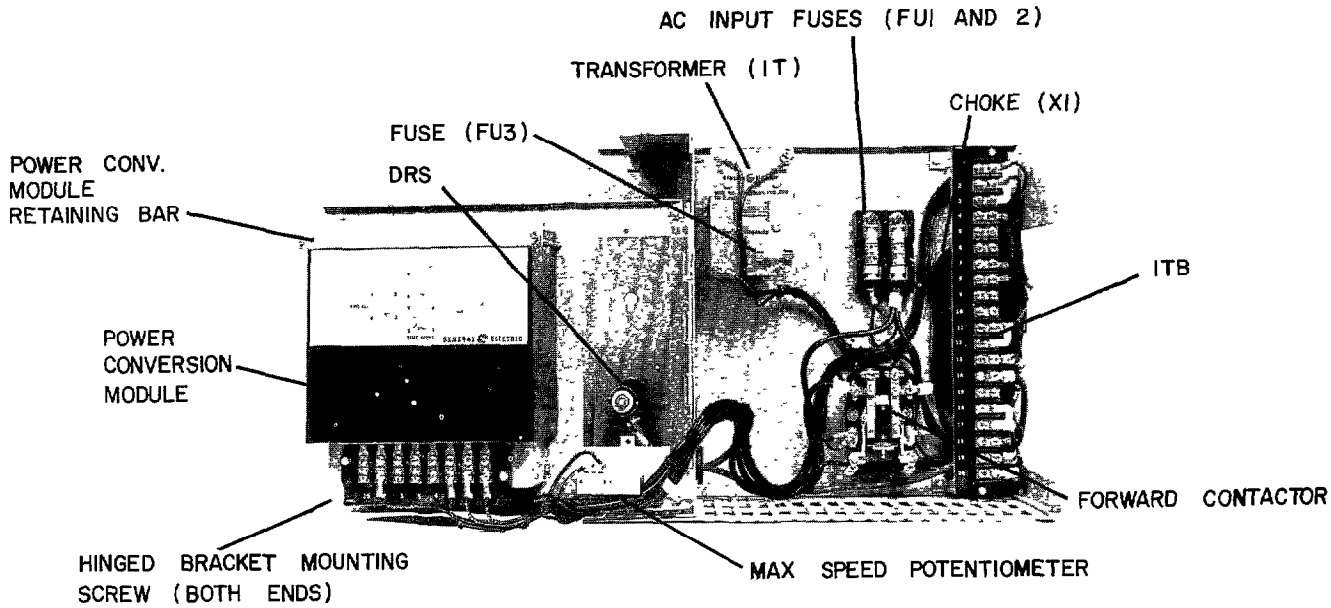
POWER UNIT ASSEMBLY – LESS ENCLOSURE
Figure 1

INTRODUCTION

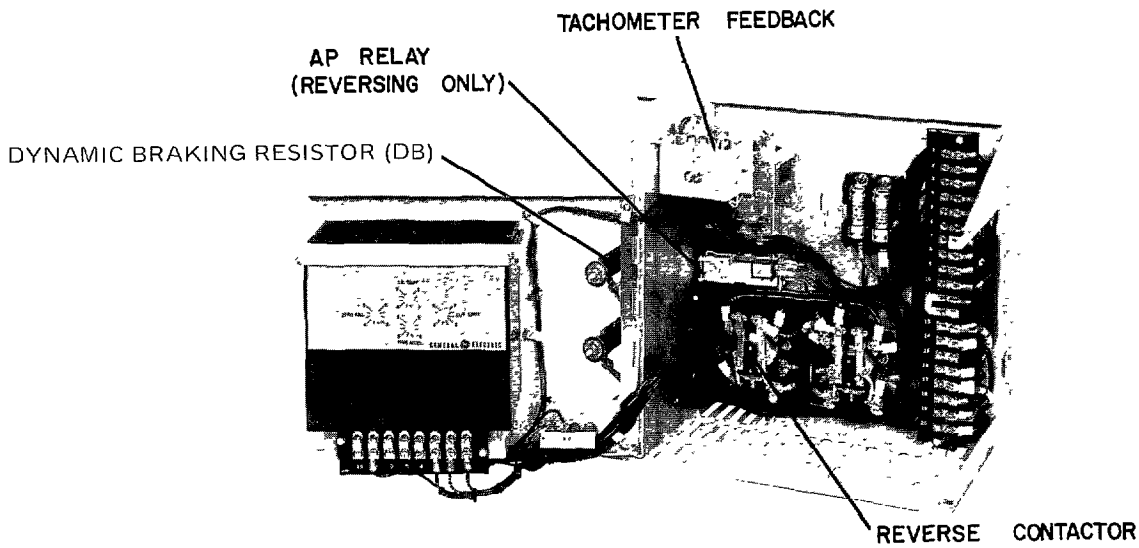
This instruction manual is a guide to the installation, setup, operation, maintenance and troubleshooting for the SCR power unit assembly.

If any modifications or special applications are required other than those covered in this instruction book, and elementary drawings, please contact the General Electric Company prior to implementation to preclude faulty operation or misapplication of the equipment. Failure to do so could nulify your warranty

This equipment has been factory tested and adjusted so as to require only minor adjustment during installation and set-up. Should further information be desired or should a particular problem arise which is not covered sufficiently for the purchasers purpose, the matter should be referred to General Electric Company.



POWER UNIT ASSEMBLY – BASIC, NON-REVERSING, HINGED PANEL OPEN



POWER UNIT ASSEMBLY – REVERSING, WITH SEVERAL MODIFICATION OPTIONS IDENTIFIED

Figure 2

PART I
INSTALLATION AND SETUP INSTRUCTIONS

INSTALLATION
OPERATION
MAINTENANCE
INTERCONNECTION WIRING
SETUP AND ADJUSTMENT
TROUBLESHOOTING

INSTALLATION

GENERAL

When the equipment is installed, check all screw terminal connections for tightness, since connections may loosen during shipment.

WARNING

EXCESSIVE SPEED CAN CAUSE DAMAGE TO MOTORS AND SERIOUS INJURY TO PERSONNEL. BEFORE ATTEMPTING TO OPERATE THE DRIVE,

1. THE FEEDBACK OF ARMATURE VOLTAGE SHOULD BE CHECKED TO MAKE SURE IT IS CONNECTED (JUMPER BETWEEN TERMINALS 1 AND 16 ON 3TB.)
2. THE MOTOR FIELD SHOULD BE CHECKED TO MAKE SURE IT IS CONNECTED, AT THE MOTOR AND AT THE TERMINAL BOARD 1TB. (MOTOR F2 to F3, TERMINAL 19 TO MOTOR LEAD F4, AND TERMINAL 18 TO LEAD F1).

NOTE

OTHER FIELD CONNECTION COMBINATIONS ARE POSSIBLE DEPENDING ON APPLICATION – CHECK THE DIAGRAMS SUPPLIED FOR THE EXACT CONNECTIONS REQUIRED.

DC MOTOR

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

Do not couple the motor to the load until after preliminary setup instructions have been completed.

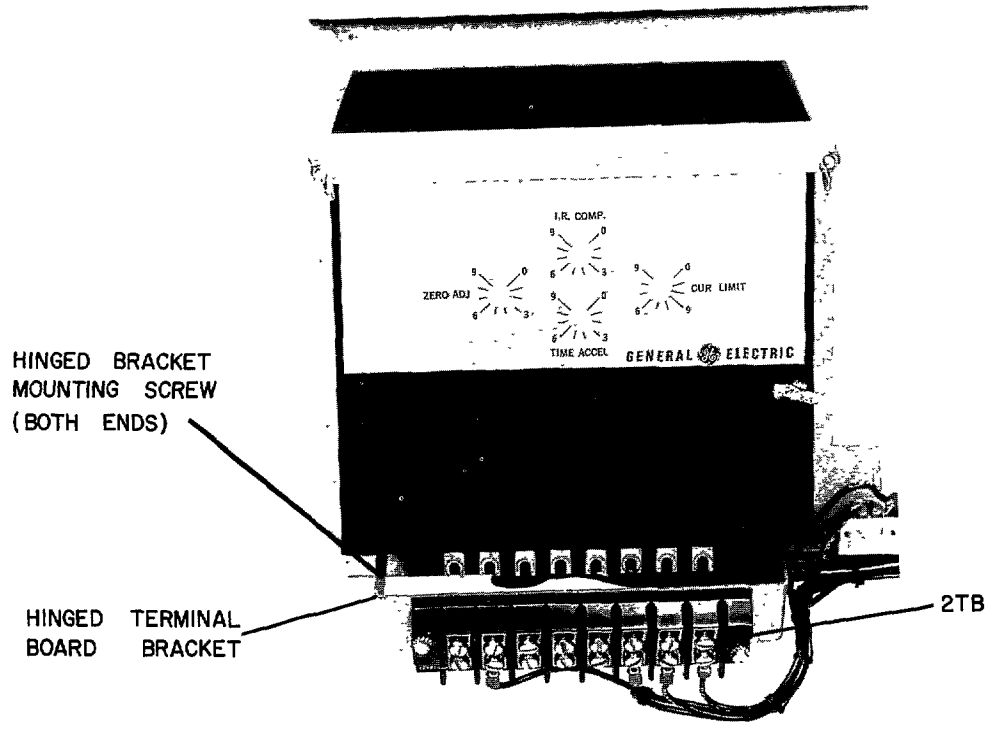
LOCATION

The DC 1021 SCR power unit assembly is suitable for use in most factory areas where other industrial equipment is installed. However, avoid locations subject to steam vapors, oil vapors, chemical fumes, excessive moisture, or excessive dirt, dust, or lint.

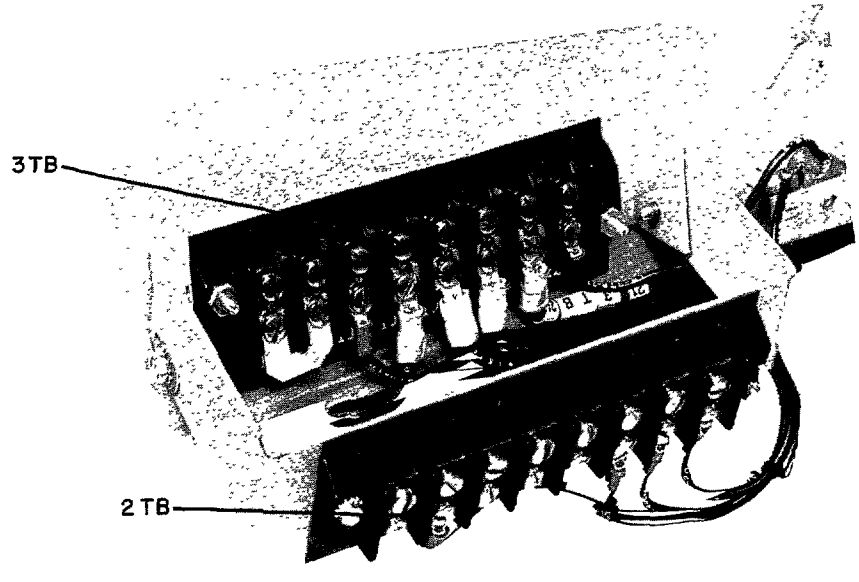
WARNING

NEVER INSTALL THE UNITS WHERE HAZARDOUS INFLAMMABLE, OR COMBUSTIBLE VAPORS OR DUSTS ARE PRESENT.

The power unit assembly is normally supplied convection cooled. Air enters through the bottom and exits through the upper part of the front and sides. Make sure that there is clearance around the assembly to allow a normal flow of cooling air. Certain applications will have a cooling fan mounted over the power conversion module.



POWER CONVERSION MODULE – 2TB HINGED BRACKET LOWERED



POWER CONVERSION MODULE REMOVED – 2TB HINGED DOWN POSITION

Figure 3

INTERCONNECTION WIRING

GENERAL

All internal electrical connections between devices in the power unit have been made at the factory. For exact connection and wiring information of the control devices and motor, refer to the elementary and interconnection diagrams supplied with the equipment.

PRECAUTIONS (VOLTAGE TRANSIENT)

The DC 1021 SCR Power Unit Assembly includes voltage transient protection which is adequate for most drive applications. However, since the exact nature of voltage transients present in any location cannot be anticipated, certain precautions should be followed to insure maximum reliability and life.

When silicon rectifiers (diodes) and silicon controlled rectifiers (SCR's) are subjected to voltage transients (spikes) in excess of their maximum rating, even for extremely short periods of time, they are apt to be permanently damaged. Destructive voltage transients (in excess of those for which the drive is protected) may be produced by interrupting relay coils, transformer primaries and other inductive electrical devices.

To insure maximum protection of the SCR Power Unit the following practices are suggested.

1. Always stop the SCR Drive by opening the d-c armature loop first (drive stop pushbutton) before disconnecting the drive from the a-c line.

2. Do not switch associated power or control transformer primaries when the SCR Power Unit is operating (See No 1 above).

3. Avoid switching transformers and other heavy loads on the a-c line, while the SCR Power Unit is operating (See No. 1 above).

4. Do not run the SCR Power Unit inter-connecting power wires in the same conduit runs or in close proximity to other control equipment wires.

5 Use a control transformer to supply a-c power to auxiliary relays and devices.

6. For a particular application some of the steps listed above may not be necessary. Also, where extensive auxiliary relaying is proposed, additional problems may be encountered, therefore, it is suggested that a sketch or drawing of the proposed circuits be sent to the General Electric Company for recommendations.

TABLE 1

POWER UNIT RATING DATA

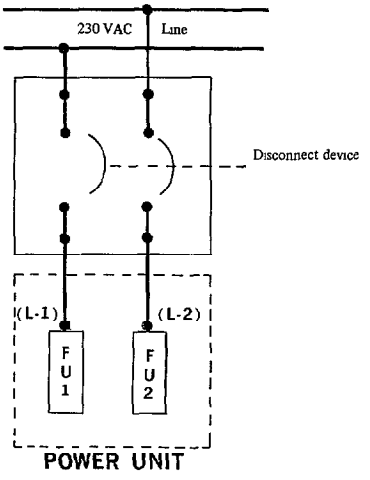
HP	Rated AC Line Amps 230V	Rated DC Line Amps	Motor Shunt Field Amps
1	10.6	5.6	0.9
1-1/2	13.5	8.5	0.9
2	16.0	10.5	1.1
3	22.0	15.0	1.3
5	34.0	24.0	2.1

AC POWER CONNECTION

1. Make certain that the input voltage and frequency of the available power supply agree with the rating on the power-unit nameplate located on the inside back of the power-unit enclosure.

2. Electrical codes generally require the use of a fused disconnecting switch or circuit breaker in the a-c power line ahead of the SCR drive. This disconnecting device also provides a convenient method of removing field excitation from the d-c motor when the drive is not in use, and allows complete removal of power for routine maintenance and inspection

3. A-c power connection from the disconnecting device to the power unit should be made in accordance with the connection diagram.



GROUNDING

No part of the a-c or d-c electrical circuit of the SCR drive may be grounded unless a line isolating transformer is used on the a-c input, and then only at one point. SCR drives are designed to operate on normal a-c power systems which are normally grounded. If a follower voltage signal is used and is not isolated from the a-c line, the SCR drive must be equipped with a line isolating transformer.

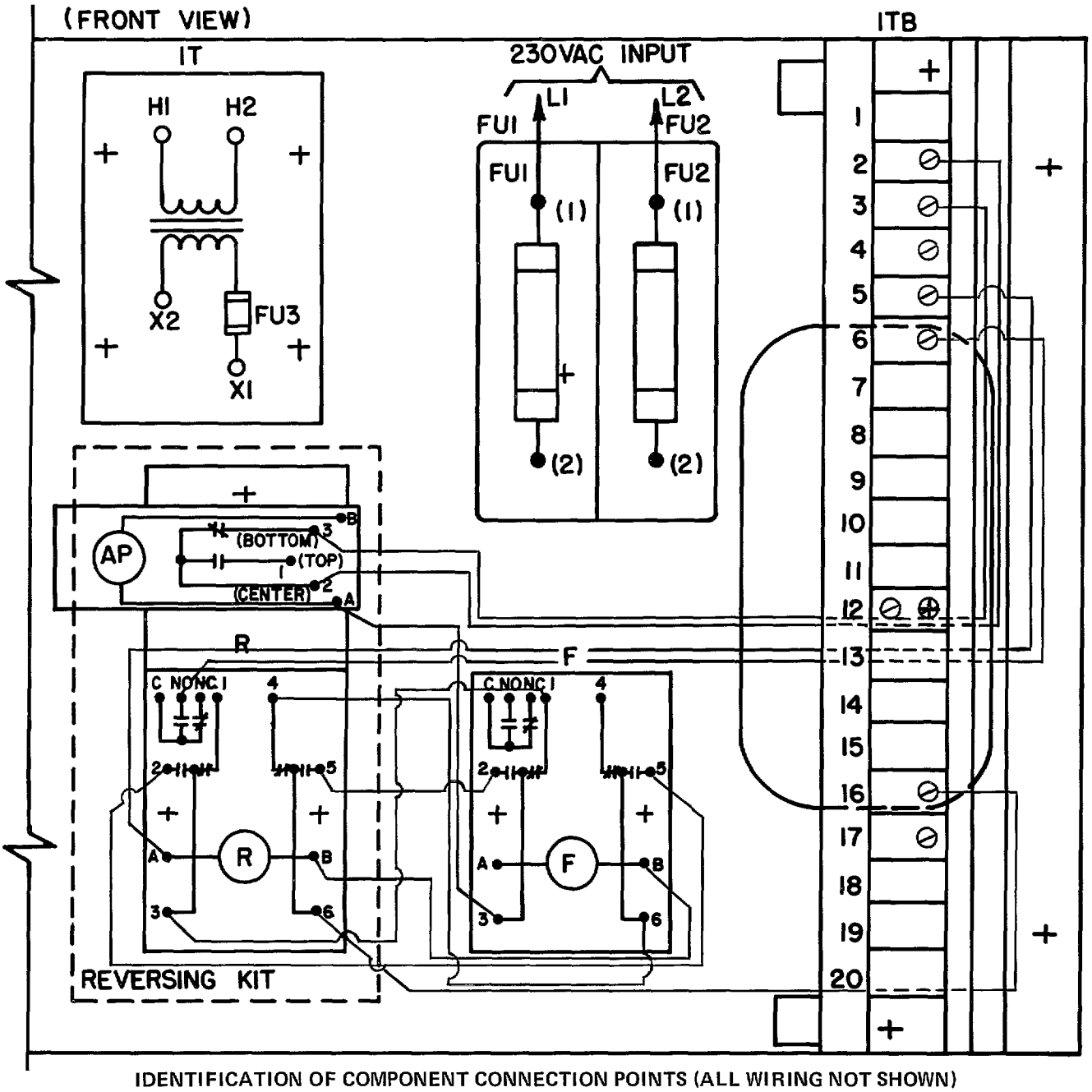
It is recommended that the equipment be grounded in accordance with NEC or local code requirements.

FINAL CHECK

After all electrical connections have been made, complete the installation as follows.

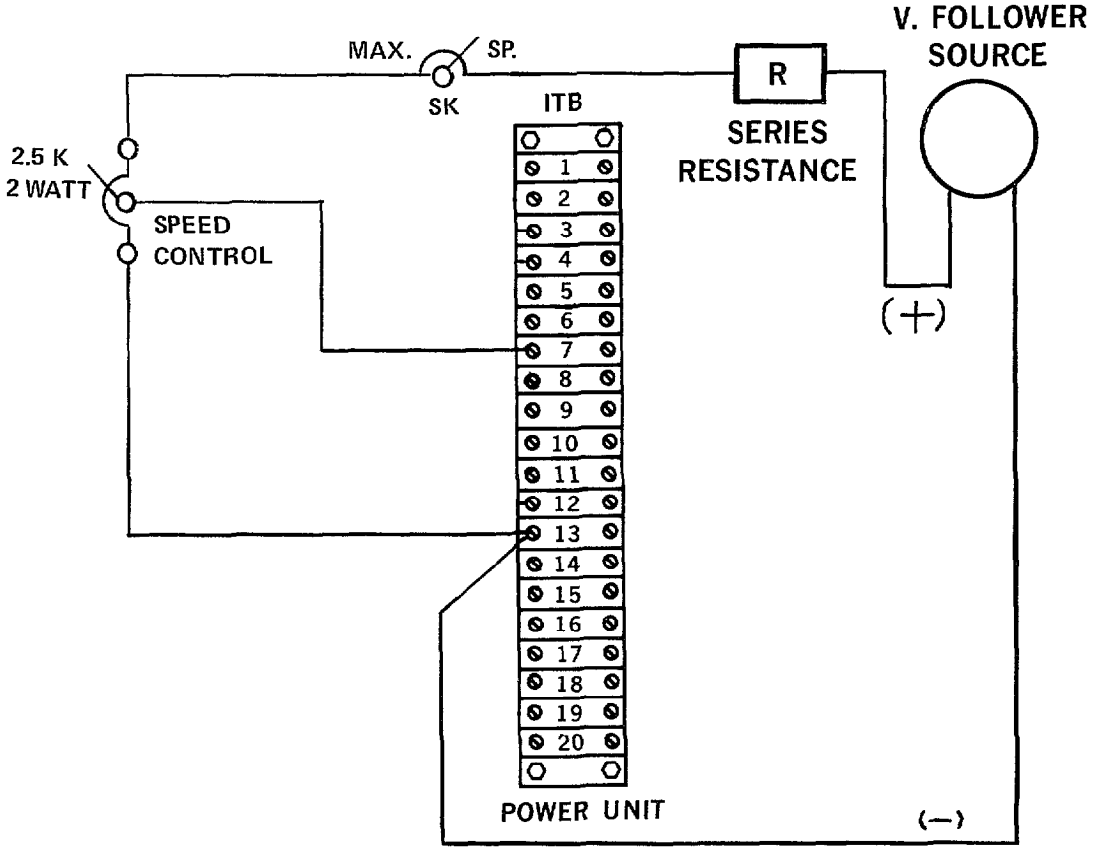
1. Recheck all connections using the system interconnection diagram.

2. Install protective fuses in the a-c disconnect (if used).



IDENTIFICATION OF COMPONENT CONNECTION POINTS (ALL WIRING NOT SHOWN)

Figure 4



VOLTAGE FOLLOWER MODIFICATION
Figure 5

VOLTAGE FOLLOWER MODIFICATION

A. Voltage Follower Signal

On the SCR Power Unit Assembly, locate and check to insure connections are as in Fig. 5.

The voltage follower signal required is 5 ma at 20 volts d-c maximum. If the available signal voltage is higher than 20v, a 2-watt series resistor must be added and separately mounted by the purchaser. The value of this resistance, R, may be determined as follows:

Series Resistance, R (Ohms)=(Signal Voltage−20) x 200.

The maximum follower signal voltage permissible is 250 volts d-c. This signal must have less than 1.0 percent a-c rms ripple. An armature voltage signal from a rectifier drive is not an acceptable follower signal without adequate filtering and isolation.

The follower signal must be isolated from the a-c line or, alternately, the SCR Drive must be equipped with a line isolating transformer.

B. Removal of Timed Acceleration

Since timed acceleration is generally not desirable on follower drives, it can be disabled by inserting a 1500 ohm, 1 watt resistor between points 7 and 4 on the power conversion module terminal board 2TB.

TYPICAL SETUP AND ADJUSTMENT

SETUP INSTRUMENTS AND TOOLS
PRELIMINARY
SPEED RANGE
TIMED ACCELERATION
CURRENT LIMIT
IR COMPENSATION
MODIFICATIONS
Dynamic Braking
Tachometer Feedback

SETUP INSTRUMENTS AND TOOLS

A 250-volt voltmeter and screwdriver will suffice to set up and adjust an SCR Drive. However, if optimum drive performance is required, it is recommended that a hand tachometer and a d-c ammeter of appropriate rating also be available. The required ammeter rating may be determined from the tabulation of d-c motor current in Table 1, Page 5.

PRELIMINARY

1. Check to see that motor is not coupled to the load and is free to rotate.

2. Connect the voltmeter across the d-c armature at 1TB points 15 and 20. Point 15 is positive in the non-reversing drive and in the "forward mode."

3. Connect the ammeter (if used) by removing the wire from point 20 on the terminal board and connecting the ammeter in series with the d-c motor armature. Point 20 is negative.

4. Close the incoming line to the power unit.

WARNING

HIGH VOLTAGE. ELECTRIC SHOCK CAN CAUSE SERIOUS OR FATAL INJURY. THIS EQUIPMENT IS AT LINE VOLTAGE ANY TIME THE INCOMING LINE IS CLOSED WHETHER THE UNIT IS IN OPERATION OR NOT IN OPERATION. A-C POWER MUST BE DISCONNECTED (BOTH A-C LINES) FROM THE POWER UNIT BEFORE IT IS SAFE TO TOUCH ANY INTERNAL PARTS OF THIS EQUIPMENT.

SPEED RANGE (MOTOR NOT COUPLED TO MACHINE)

NOTE

IF THE TACHOMETER FEEDBACK MODIFICATION HAS BEEN ORDERED, OMIT THIS PROCEDURE AND SUBSTITUTE "TACHOMETER FEEDBACK" ON PAGE 11.

WARNING

EXCESSIVE SPEED CAN CAUSE DAMAGE TO MOTORS AND SERIOUS INJURY TO PERSONNEL.

BEFORE ATTEMPTING TO OPERATE THE DRIVE,

1. THE FEEDBACK OF ARMATURE VOLTAGE SHOULD BE CHECKED TO MAKE SURE IT IS CONNECTED (JUMPER BETWEEN TERMINALS 1 AND 16).

2. THE MOTOR FIELD SHOULD BE CHECKED TO MAKE SURE IT IS CONNECTED, AT THE MOTOR AND AT THE TERMINAL BOARD AS INDICATED BY THE SYSTEM ELEMENTARY DIAGRAM.

3. ANY OVERSPEED OR FIELD LOSS PROTECTION, WHEN PROVIDED SHOULD BE CONNECTED.

To adjust the speed range of the drive, complete the following steps (If a pre-amplifier card has been added to the input its settings may affect all of the following adjustments)

1. Set the "Speed" potentiometer to zero.

2. Depress and release the "Start" push-button or energize the "start" function.

3. Adjust the minimum speed (by means of the ZERO ADJ. potentiometer on the power unit) so that the motor just turns over.

4. Back off the ZERO ADJ. setting until the motor just stops.

5. Turn the "Speed" potentiometer to 100 percent (full CW) and observe the d-c armature voltage on the voltmeter. This voltage should be approximately 175 to 180 volts d-c with no load on the motor.

6. If this voltage is not correct, adjust the MAX SPEED rheostat until the d-c armature voltage is within the required limits. Turning the rheostat shaft clockwise increases armature voltage and speed.

TYPICAL SETUP AND ADJUSTMENT (CONT'D)

7. Depress and release the "Stop" push button or energize the "stop" function.

8. If the direction of motor rotation is **not** correct remove a-c power, and then interchange **motor field** leads at the power-unit terminal board points 18 and 19 on 1TB.

TIMED ACCELERATION (MOTOR NOT COUPLED TO MACHINE)

An adjustable timed acceleration circuit is provided as standard equipment on all SCR drives The time required to accelerate from standstill to top rated speed is continuously adjustable from approximately 2.5 to 10 seconds.

Set the desired acceleration time by adjusting the TIME ACCEL potentiometer located on the front of the power unit. Turning this potentiometer clockwise increases the acceleration time.

The SCR drive also provides fixed time deceleration. With the drive running at rated (pre-set) speed, if the operator's speed-control potentiometer is quickly turned to a lower speed (or to zero), the drive will decelerate to this new speed in three seconds, assuming that the coasting time of the drive (and load) is less than three seconds. It follows that if the load has high inertia and long coasting time, the decelerating time will be longer than three seconds as determined by the load inertia.

If timed acceleration is **not** desired for any reason, disable the timed acceleration circuit by connecting a resistor, 1500 ohms 1 watt or greater, between terminal board points 7 and 4 on the terminal board 2TB.

CURRENT LIMIT (MOTOR COUPLED TO LOAD)

A current-limit circuit is standard on all SCR drives. This circuit provides protection against excessive armature current and overload during acceleration and normal operation. The current limit is adjustable from approximately 60 percent of the rated armature current by means of the CUR LIMIT potentiometer located on the front of the conversion unit.

CAUTION

UNDER NO CONDITIONS SHOULD THIS EQUIPMENT BE OPERATED IN EXCESS OF 150 PERCENT RATED ARMATURE CURRENT. FAILURE TO OBSERVE THIS LIMIT MAY RESULT IN OPENING OF THE LINE FUSE OR PERMANENT DAMAGE, TO THE SCR'S AND POWER RECTIFIERS. IF 150 PERCENT IS REACHED, AND MAINTAINED FOR ONE MINUTE THE DRIVE SHOULD BE SHUT DOWN AND ALLOWED TO COOL FOR AT LEAST 20 MINUTES.

Normally the current limit is set at 150-percent rated current. However, current limit can also be used to control acceleration of the motor and maximum acceleration torque can be adjusted between 60 and 150-percent rated. Adjust the current limit to the desired value by means of the CUR LIMIT potentiometer located on the front of the conversion unit. Turning this potentiometer clockwise increases the current limit setting from approximately 60 to 150-percent of the rated armature current.

IR COMPENSATION (MOTOR COUPLED TO LOAD)

NOTE

IF TACHOMETER FEEDBACK HAS BEEN ORDERED, OMIT THIS PROCEDURE.

Simplified Adjustment

The simplified adjustment of IR compensation is recommended where any one or more of the following conditions may exist.

1. It is difficult or impossible to change the driven machine load during the set-up procedure.

2. Where machine load does not change significantly.

3. Where speed regulation (due to load change) of 5-10 percent is acceptable.

The simplified adjustment of IR compensation is made by setting the IR COMP potentiometer on the unit at Position 1.0 or less.

If optimized adjustment of the IR compensation is required, set as indicated and proceed to the next step.

Optimized Adjustment

1. Start the drive by momentarily depressing the "START" button.

2. Turn the "Speed" potentiometer so that the motor is rotating at the middle speed expected for your application. This speed should not be lower than 1/30 rated motor speed.

3. Adjust the driven machine for minimum load conditions. The value should not be less than 5 percent of rated current for smooth operation.

4. Read and record motor speed using a hand tachometer.

TYPICAL SETUP ADJUSTMENT (CONT'D)

Motor speed may be conveniently read by removing the dust cap on the commutator-end motor bearing.

5. Adjust the driven machine for maximum load (not exceeding the 100-percent rated torque) and again read motor speed using the hand tachometer.

6. If the "maximum-load" speed is less than the "minimum-load" speed, turn the IR COMP potentiometer on the unit clockwise until they are equal.

7. Repeat steps 3, 4, 5 and 6.

8. Turn the "Speed" potentiometer so that the motor is running at the maximum speed required for the application, but not in excess of the rated speed on the motor nameplate. (Motor voltage should not exceed 180 VDC).

MODIFICATIONS

Dynamic Braking.

No adjustment required.

Tachometer Feedback (Motor Not Coupled to Load)

NOTE

FOLLOW THIS PROCEDURE ONLY IF THE IMPROVED SPEED REGULATION MODIFICATION (TACHOMETER FEEDBACK) HAS BEEN ORDERED

WARNING

EXCESSIVE SPEED CAN CAUSE DAMAGE TO MOTORS AND SERIOUS INJURY TO PERSONNEL.

BEFORE ATTEMPTING TO OPERATE THE DRIVE,

1 THE CONNECTIONS OF THE TACHOMETER FEEDBACK MODIFICATION SHOULD BE CHECKED AT THE TERMINAL BOARD, KIT, AND TACHOMETER TO MAKE SURE THEY ARE CONNECTED.

2. THE MOTOR FIELD SHOULD BE CHECKED TO MAKE SURE IT IS CONNECTED, AT THE MOTOR AND AT THE TERMINAL BOARD.

3. ANY OVERSPEED OR FIELD LOSS PROTECTION WHEN PROVIDED, SHOULD BE CONNECTED.

1. Turn the IR COMP potentiometer on the front of the unit to the extreme counterclockwise position (zero).

2. Turn the MAX SPEED rheostat clockwise to the midpoint of its travel.

3. Turn the TACH FEEDBACK potentiometer on the tachometer feedback unit to the extreme counterclockwise position.

4 Set the "Speed" potentiometer to zero.

5. Depress and release the start pushbutton.

6. Adjust the ZERO ADJ. potentiometer (located on the unit) so that the motor begins to rotate, then "back off" adjustment until the motor just turns over.

7. Turn the "Speed" potentiometer clockwise until the drive is running at the maximum speed required for the application. Drive speed may be measured directly using a hand tachometer, or the d-c volt-meter may be connected across points 9 and 10 in the power unit to obtain an indication of speed.

8. Turn the TACH FEEDBACK potentiometer clockwise until the drive is running at the maximum speed required for the application. Drive speed may be measured directly using a hand tachometer, or the d-c volt-meter may be connected across points 9 and 10 in the power unit to obtain an indication of speed.

9. Depress and release the "STOP" push button.

Proceed with the setup procedure on time acceleration and current limit shown on Page 10. IR compensation procedure is not required since the IR COMP signal is not used with tachometer feedback.

VOLTAGE FOLLOWER DRIVES

NOTE

FOLLOW THIS PROCEDURE ONLY IF THE SCR DRIVE IS TO BE USED AS A VOLTAGE FOLLOWER (FOLLOWING AND EXTERNAL VOLTAGE SIGNAL).

1. Apply the voltage follower signal as indicated under INSTALLATION, to the drive. This signal is connected to terminal-board point 3 on operator speed control and 13 on 1TB. (See Figure 5, Page 8).

2. If timed acceleration has been disabled, turn the TIME ACCEL potentiometer fully clockwise.

3. Follow the setup and adjustment procedure previously specified for either voltage regulated or tachometer feedback drives as appropriate. This procedure is summarized below.

TYPICAL SETUP AND ADJUSTMENT (CONT'D)

Voltage Regulated	Tachometer Feedback
Speed Range	(If ordered)
Current Limit	Current Limit
IR comp	

4. Tracking Adjustment.

If the drive is to closely follow the signal voltage, the following adjustments must be made for tracking.

a Apply the maximum voltage follower signal voltage that will be encountered on this application.

b Turn the "Speed" control potentiometer to the zero speed position.

c. Depress and release the "Start" push button.

d. Turn the "Speed" control potentiometer slowly to the 100-percent speed position.

e. Cause the voltage follower signal voltage to be reduced to the minimum operating value expected on this application This signal level should not require the SCR drive to operate below 1/30 rated speed.

f. Adjust the ZERO ADJ. potentiometer on the unit to establish the same speed ratio between the master (follower signal) and the SCR drive as existed with "full" voltage follower signal.

g. Repeat steps (d) through (g) until satisfactory tracking is obtained.

OPERATION

NON-REVERSING DRIVES

REVERSING DRIVES

NON-REVERSING DRIVES

Apply a-c power to the SCR drive by closing the a-c line disconnecting device (if used) Set the desired preset speed on the "Speed" potentiometer Depress and release the "Start" push button and the drive will accelerate to preset speed, either linearly with respect to time or under current limit, depending upon adjustments. Alternately, the "Speed" potentiometer may be set initally at zero, the "Start" button depressed and released, and the drive speed controlled manually by the "Speed" potentiometer during acceleration

Depress and release the "Stop" push button and the drive will coast to rest at a rate determined by the friction and inertia present in the drive system. If the dynamic-braking modification has been added, operation of the "Stop" push button will cause the drive to rapidly brake to a stop.

Sudden, excessive overloads (300 percent) or d-c faults (shorts) will cause the static IOC circuit to stop the drive. Reset by pressing the "Stop" push button; remove the condition causing the overload and restart.

REVERSING DRIVES

Apply a-c power to the SCR drive by closing the a-c line disconnecting the device (if used). Select the required direction of rotation with the "Forward-Reverse" selector switch. Set the desired preset speed on the "Speed" potentiometer. Depress and release the "Start" push button and the drive will accelerate to preset speed, either linearly with respect to time or under current limit, depending upon adjustments. Alternately, the "Speed" potentiometer may be set initally at zero, the "Start" button depressed and released, and the drive speed controlled manually by the "Speed" potentiometer during acceleration.

If the "Forward-Reverse" selector switch is operated with the drive running at preset speed, the drive will coast to rest, or dynamic brake to rest if this modification has been ordered. Depressing and releasing the "Start" button will now cause the drive to accelerate to preset speed in the reverse direction.

If the "Start" push button is held depressed while operating the "Forward-Reverse" selector, the drive will stop and immediately accelerate in the reverse direction.

Sudden, excessive overloads (300 percent) or d-c faults (shorts) will cause the static IOC circuit to stop the drive. Reset by pressing the "Stop" push button, remove the condition causing the overload and restart.

MAINTENANCE

Maintenance of the SCR drive is primarily a matter of periodic inspection and cleaning of the power unit.

After removing the a-c power, clean the exterior and interior of the power unit by vacuuming or blowing accumulated dust and dirt. Do not use a highpressure air hose as this may damage the electrical components.

Check all electrical connections for tightness and examine the electrical contacts on the contactors. Both copper and silver contacts discolor and become roughened during normal operation. Generally contacts will not require attention but, if prominent beads form, due to severe arcing, dress the contact face with a fine file. Do not use sandpaper or emery cloth, and never oil any part of the power unit.

TROUBLESHOOTING

GENERAL

Nearly all of the problems encountered in initial startup of adjustable-speed-drive equipment are caused by improper interconnection wiring. If difficulty is encountered, the first step should be a careful recheck of all interconnection wiring in accordance with the connection diagram.

In the event that this check does not disclose the problem, proceed to the Troubleshooting Chart,Table III, performing each step in the sequence indicated.

WARNING

HIGH VOLTAGE, ELECTRIC SHOCK CAN CAUSE SERIOUS OR FATAL INJURY. THIS EQUIPMENT IS AT LINE VOLTAGE ANY TIME THE AC POWER IS CONNECTED TO THE POWER UNIT WHETHER THE EQUIPMENT IS IN OPERATION OR NOT IN OPERATION. BOTH SIDES OF THE AC POWER LINE MUST BE DISCONNECTED FROM THE POWER UNIT BEFORE IT IS SAFE TO TOUCH ANY INTERNAL PARTS OF THIS EQUIPMENT.

If the equipment operates, but operates improperly, refer to that portion of the Troubleshooting Chart titled "Operational Problems".

NOTE

DO NOT CHANGE ANY OF THE SETUP ADJUSTMENTS WITHOUT FIRST MAKING A NOTE OF THE SETTING SO THAT YOU CAN RETURN THE CONTROL TO THIS SETTING. THIS PROCEDURE WILL MINIMIZE TIME IN CORRECTING THE DIFFICULTY.

TABLE II

VOLTAGE CHECK LIST

Direct Current

Circuit	Terminal Board Points	1/8 Speed DC Volts	Rated Speed DC Volts
Motor Armature	1TB-15-20	25	180
Motor Shunt Field	1TB-18-19	100	100
Reference	1TB- 7-13	1-2	12-15
Ref. Supply	2TB- 2-13	17-20	17-20
TG Out	3TB- 1-18	2-3	20-25
AP Coil	R-6,1TB20	25	180

Alternating Current

Circuit	Voltage	Measure At
AC Input	230‡	FU1 to FU2
CR Coil	115‡	2TB points, 20,8
F Coil	115‡	1T-X1, 1TB-1 (when contactor is is energized)
R Coil	115‡	1T-X1, 1TB-5 (when contactor is is energized)

‡ Minus 5%, Plus 10%

TROUBLESHOOTING (CONT'D)

TABLE III
TROUBLESHOOTING CHART

DRIVE DOES NOT OPERATE

Difficulty	Possible Cause	Remedy
1. No a-c power to power unit. Bottom of FU1-FU2.	Open disconnect, breaker or fuse in a-c supply.	Locate and correct.
2. Blown fuses in power unit.*	Shorts or grounds in wiring, open motor field circuit.	Correct wiring and replace fuses.
3. No 115vac control power. Points X1-X2.	FU3 fuse blown, faulty 1T transformer, shorts or grounds in control wiring.	Replace fuse, correct wiring or replace 1T transformer.
	Open motor thermostat.	Check for cause of malfunction.
4. No d-c output from power units (Points 1TB–15+,20–).	D-c fault operating 10C circuit.	Remove fault and reset by pressing "Stop" button
	No power supply voltage (1TB-13, 2TB-2). No reference (1TB-7,13)	Replace conversion unit (see footnote). Check wiring to speed pot and pot itself. If a-c supply and reference are present, conversion unit is defective (see footnote).*
5. No d-c output to motor (1TB-15,20).	F or R relay inoperative	Check for coil voltage at relay. If voltage is present, replace defective contractor.
	CR relay inoperative	Check for relay coil voltage 2TB-20 & 8. If voltage is present and relay inoperative, replace conversion unit. If no voltage, check wiring to "Start" "Stop" push buttons.
6. Motor does not run.	Incorrect or defective Wiring.	Check armature and shunt field connections between power unit and motor. Be sure field coils have been properly connected in series. Check field circuitry for continuity
	No field supply (1TB-18,19).	Replace conversion unit* (see footnote).
	Motor brushes not seated.	Free brushes in holder - see motor instructions.
	Defective motor.	Repair.
	Blown Fuses	Check for grounds in external connections.

* No attempt should be made to open or repair the sealed conversion unit. The conversion unit warranty becomes void if the unit has been opened or tampered with in any way (see WARRANTY). Defective conversion units or those which fail within the warranty period should be returned to the Company as indicated in the warranty instructions.

TROUBLINGSHOOTING (CONT'D)

TABLE III
TROUBLESHOOTING CHART

OPERATIONAL PROBLEMS

Difficulty	Possible Cause	Remedy
7. Motor will not reach top speed.	Improper setup.	Recheck.
	Low line voltage.	Correct.
	Motor overloaded.	Reduce load.
	Low reference voltage (1TB-7,13)	Should be approximately 15 volts with speed pot full CW. If low, check for grounds and shorts.
	High tachometer voltage (if used)	Check tachometer nameplate and setup procedure. Voltage from tachometer must not exceed 250 V d-c.
8. Motor runs at top speed. Does not respond to speed pot or has limited response.	Improper setup.	Recheck
	Motor wired incorrectly.	Recheck wiring. Check response of reference (1TB,-7,13) to speed pot position.
	Tachometer signal (if used) is too low	Check tachometer nameplate and review setup procedure.
	Defective conversion unit.	Replace. *(see footnote).
9. Motor jumps upon starting will not run at low speed.	Improper setup.	Recheck. Recheck wiring. Check response of reference (1TB-7,13) to speed pot position.
	High breakaway torque required.	Reduce if possible.
	Defective conversion unit.	Replace. *(see footnote).

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TROUBLESHOOTING (CONT'D)

TABLE III
TROUBLESHOOTING CHART

Difficulty	Possible Cause	Remedy
10. Motor speed changes excessively when load is applied.	Improper setup.	Recheck current limit (normal dial setting 7) and IR Comp. (normal dial setting (1.0 or less)
	Low line volts or excessive voltage regulation in a-c line.	Correct wire or transformer size.
	Motor overloaded.	Reduce load.
	Defective conversion unit.	Replace. *(see footnote)
11. Motor speed unstable.	Improper setup.	Check for too high IR Comp (set at zero if TG is used).
	Excessive inertia	See specifications (page 16) and reduce inertia.
12. Motor overheats.	Motor overloaded.	See specifications (page 16) and reduce load.
	Ambient temperature above 40C (104F).	Reduce temperature or improve ventilation.
	Motor ventilation restricted.	Remove restrictions.
	Defective motor.	Repair.
13 Motor noise excessive.	Loose motor mounting or coupling.	Tighten.
	Damaged bearing.	Replace bearing.
	Defective conversion unit (half-wave).	Replace. *(see footnote)
14. Motor sparks exessively (some sparking is normal)	Motor overloaded.	Reduce load.
	Brushes worn too short.	Replace.
	Rough commutator.	Repair.
	Defective conversion unit (half-wave)	Replace. *(see footnote)
15. Motor stops for no apparent reason	Sudden extreme overload or intermittent d-c fault.	Remove cause of overload or fault and reset by pressing "Stop" button.

* No attempt should be made to open or repair the sealed conversion unit. The conversion unit warranty becomes void if the unit has been opened or tampered with in any way (see WARRANTY). Defective conversion units or those which fail within the warranty period should be returned to the Company as indicated in the warranty instructions.

PART II

GENERAL DESCRIPTION

POWER UNIT SPECIFICATIONS
HOW THE SCR POWER UNIT WORKS
SPARE AND RENEWAL PARTS

DESCRIPTION

BASIC POWER UNIT

The SCR adjustable-speed drive is a packaged, all-electric drive operated from a-c power. The drive consists of:

1. A power unit which contains the power conversion unit, necessary magnetic contractors, control power transformers and fuses. The power conversion unit provides conversion of incoming a-c power to d-c power, as well as necessary regulator functions.

The power unit consists of terminal-board assemblies, the conversion unit, line contractor(s), fuses, control power transformer and associated wiring. These components are mounted in a convection-cooled enclosure.

The power conversion unit is the control center of the drive. It is mounted on two terminal-board assemblies, one of which is hinged at the bottom to allow it to be swung out approximately 90 degrees, providing easy access to the rear terminals. This unit contains two heat sinks on which are mounted the SCRs and diode rectifiers. The heat sinks support two printed circuit boards containing the firing and regulating circuits which control the SCRs (which in turn control the speed of the d-c motor). The unit is enclosed in a protective cover, which is open at the bottom and louvered at the top to allow proper ventilation. The warranty is void if the enclosure is removed or if the unit tampered with in any way (see WARRANTY). Four potentiometers which control the setting of zero speed, IR compensation, acceleration time and current limit are mounted in the unit. The control knobs for these potentiometers are located on the front of the unit so they can be adjusted while the unit is in the operating position. These potentiometers are labeled ZERO ADJ, IR COMP, TIME ACCEL, and CUR LIMIT.

Reversing (Selective Rotation)

Antiplugging protection and forward-reverse selector are provided.

Direction may be selected before starting. Rapid reversing may be accomplished by operating selector and holding start button depressed until motor has changed direction of rotation complete.

Dynamic Braking

Provides fast braking action when drive "Stop" button is pressed.

Tachometer Feedback Unit

If improved speed regulation is ordered, the tachometer feedback unit will be shipped with the power unit. Connection of only two leads is done at time of installation. Complete instructions are included under INSTALLATION.

SPECIFICATIONS

BASIC POWER UNIT AND MODIFICATIONS

BASIC POWER UNIT ASSEMBLY

Power Supply

Voltage–230v, 1 phase, –5 + 10%
Frequency–20/60 hertz – ± 1 hz

Voltage Regulation

Voltage regulation of 1% of rated output voltage due to 95% load change over a 30/1 controlled voltage range.

Steady-state output voltage may also be affected by changes in line voltage, frequency and ambient temperature. These variables (other than load) are referred to as "service conditions."

SPECIFICATIONS (CONT'D)

Variable	Range	Voltage Change (Percent of Rated)
Voltage Frequency Ambient Temp	10% 2% 15C	15%

Specified performance does not apply to transient changes in load or ambient conditions, nor when connected load inertia is in excess of twice motor inertia (referred to the motor shaft). See the motor dimension sheet for inertias.

Acceleration Control

(If used - see elementary drawings)

Linear Timed

Total accelerating time (to full speed) is continuously adjustable from 2.5-10 seconds This complete time range is, of course, only available when 150-percent rated torque is sufficient to accelerate the drive and load to rated speed in 2.5 seconds or less. Modifications by adding special capacitors will extend this time.

Decelerating time (when preset speed is reduced) is at a fixed rate of 3 seconds If normal coast time exceeds 3 seconds, the load characteristics determine deceleration time.

Current Limit

Adjustable from 60-150-percent rated current. Timing may be set at minimum (or disabled) and current limit used to control accelerating (and running) torque – or the current-limit may be used with timed acceleration providing a maximum current (torque) limit. (Normal dial setting of 7 corresponds to approximately 150 percent.) Power Unit output current must not exceed 150% for longer than 1 minute.

Protection

Fused 115vac Control-Power Transformer

CLF Fuses - Provides protection for the power unit

Static IOC - An internal circuit providing d-c fault current protection for the motor and power unit.

Current Limit - Limits operating overloads to 150-percent rated (or less as adjusted) for protection of motor and power unit.

Undervoltage - A-c operated d-c line contractor protects against automatic restarting following a-c power interruption.

Efficiency

The conversion efficiency (a-c to d-c) of the SCR Power Unit Assembly is approximately 95 percent at full load, full speed and is high even at light load, low speed. The over-all drive efficiency is the product of the conversion and motor efficiency.

Power Factor

The SCR Power Unit Assembly power factor is approximately 65 percent at full load, full speed and is reduced with speed.

Service Factor – 1.0 (unless otherwise noted)

Minimum Load

5 percent power unit current.

SCR Power Units will generally operate satisfactorily without load coupled to the motor if motor losses approximate 5 percent current.

Service Conditions

Ambient temperature (of air supply for cooling the Power Unit) – 10C to 40C (50 to 104F). 10°C to 60°C with fan kit.

Altitude – Sea level to 3300 Ft.

MODIFICATIONS

(If supplied – see elementary drawings).

Dynamic Braking

When dynamic braking is provided, the drive system shall be capable of braking a load (whose inertia equals that of the motor) at an initial current of 150 percent of rated armature current from full speed to standstill three times in rapid succession with the dynamic braking resistor initially at ambient temperature.

Improved Speed Regulation (Tachometer Feedback)

When this modification is ordered providing a tachometer feedback unit for the power unit, speed regulation may be improved as follows:

Speed regulation of 1 percent of motor base speed for a 95-percent load change over a 50/1 speed range. Speed change due to "service conditions" is improved to 3 percent.

SPECIFICATIONS (CONT'D)

Variable	Range	Speed Change (Percent of Rated)
Voltage	10%	
Frequency	2%	3%
Ambient Temp	15C	

Reversing (Selective Rotation

Antiplugging protection and forward-reverse selector are provided Direction may be selected before starting. Reversing is accomplished by contractor switching in the armature circuit.

HOW THE SCR POWER UNIT WORKS

AC TO DC POWER CONVERSION
SCR FIRING CIRCUIT
MOTOR SHUNT FIELD EXCITATION REGULATOR
TIMED ACCELERATION
CURRENT LIMIT
STATIC 10C CIRCUIT
MAGNETIC FUNCTIONS
TACHOMETER FEEDBACK MODIFICATION

AC TO DC POWER CONVERSION

The power conversion circuit of the SCR Power Unit consists of a single-phase, full-wave rectifier bridge (see Fig. 6). The negative legs of the rectifier bridge contain silicon-controlled rectifiers, while the positive legs contain diodes or uncontrolled rectifiers. The SCR conversion unit has a two-fold function, to rectify the a-c voltage to d-c voltage, and to control the d-c voltage level.

A diode rectifier will conduct current in only one direction, blocking the voltage in the opposite direction. A rectifier bridge consisting of only diode rectifiers will convert an a-c voltage into a d-c voltage having an average value of 0.9 (for a single-phase bridge) times the rms value of the a-c voltage. The rectifiers block current flow in the reverse direction such that it is impossible to regenerate power back into the a-c line.

The function of controlling the d-c voltage level is obtained by using silicon-controlled rectifier bridge An SCR is a solid-state, semi-conductor which is basically a rectifier, but can also block voltage in the forward direction (anode positive with respect to cathode) until "fired" by a gate signal It then switches to a highly conductive state having a very low forward voltage drop. The SCR remains in the conductive state even after the gate signal is removed, until the forward voltage is removed It then reverts to a blocking state in the forward direction The sinusoidal a-c voltage waveform satisfies these conditions in that each alternate half cycle causes the anode to swing positive with respect to the cathode to permit conduction, and the other half cycle reverses this voltage to turn the SCR off A positive firing signal is applied to the gate of the SCR at the proper point in time to turn the SCR on Controlling the point in time (with respect to the a-c supply voltage) when this gate signal is applied to the SCR, controls the output voltage which can be obtained.

Fig. 6 shows the output voltage and current wave-form of a single-phase SCR conversion unit It can be seen that as the firing pulses are advanced toward the zero time point, the average output voltage of the SCR conversion unit is increased

HOW THE SCR POWER UNIT WORKS (CONT'D)

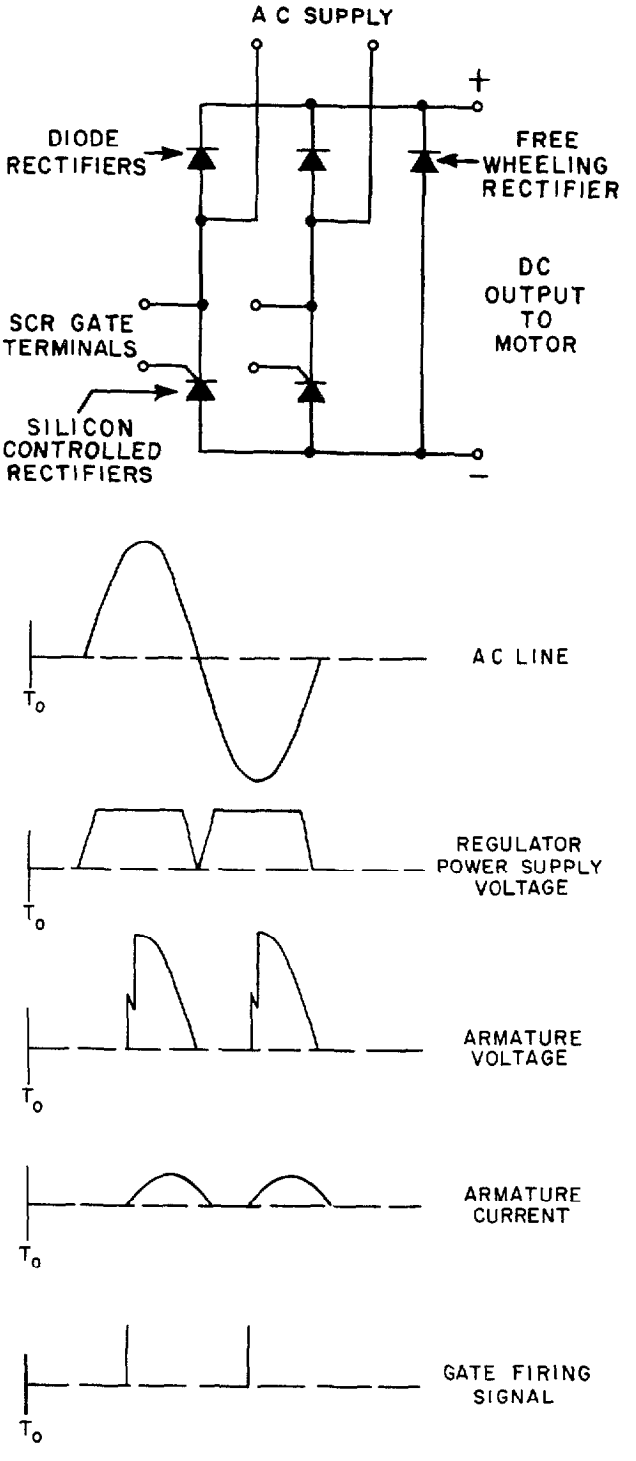

Figure 6 Typical Waveforms

HOW THE SCR POWER UNITS WORKS (CONT'D)

An SCR has a minimum forward current, which is required for the SCR to stay in a conducting state This means that the SCR conversion unit cannot be controlled if its output is open-circuited.

A diode rectifier, called a commutating or free-wheeling rectifier, is connected across the d-c terminals of the power-conversion bridge. This diode provides, a free-wheeling path for current produced by the induced voltages in the d-c motor armature during phased-back operation. It prevents this free-wheeling current from flowing through a controlled-rectifier leg. If this were allowed, the SCR would fail to turn off when the supply voltage goes negative and control would be lost. The free-wheeling rectifiers also acts to reduce motor-armature ripple current.

The unit contains the silicon-controlled rectifiers and diode rectifiers, together with transient-voltage protective circuits. The SCRs and diodes are mounted on aluminum cooling fins. These fins serve to transmit the heat produced inside the rectifiers to the surrounding air. The unit is convection cooled.

Two standard CLF fuses are placed in the a-c supply line to the rectifier bridge. These fuses are mounted in the upper right corner of the power unit.

A Thyrector* and other transient-voltage protective components are contained within the unit. A Thyrector is a special selenium rectifier which breaks down to limit high voltage transients, similar to but more sharply than a Thyrite* resistor. It "passes" the energy of the transient and then reheals itself. The Thyrector is selected with a voltage breakdown less than the transient-voltage rating of the SCRs and diodes. Series resistor-capacitor networks are connected in shunt across each SCR and the d-c output. These provide a low-impedance path parallel to the rectifier to further limit transient voltage spikes. Their effectiveness is increased through use of the series choke under 1TB.

Noise-suppression capacitors are connected across the gate to cathode of each SCR to prevent misfiring from extraneous signals.

SCR FIRING CIRCUIT

The firing circuit provides pulses to the gate circuits of the two controlled rectifiers to "fire" them at the correct phase angle, as determined by the signal from the amplifier

The firing circuit consists of a pulse transformer, unijunction transistor, a capacitor and a constant current supply. The firing circuit is controlled by the unijunction transistor.

*Trademark of General Electric

A unijunction is a special type of transistor that behaves similar to a switch; it is either full "on" or full "off." The unijunction transistor can be turned "on" by applying a voltage signal of sufficient magnitude to its input.

Operation is as follows the amplifier determines the level of a constant current supply. The constant current linearly charges the capacitor, which is connected to the input of the unijunction transistor. When the voltage across the capacitor is large enough, the unijunction transistor turns "on". The capacitor discharges through the unijunction transistor into the primary of the pulse transformer The pulse of power is passed on to the secondary windings of the transformer which are coupled directly to the gate circuits of both SCRs.

If the amplifier output is decreased, the magnitude of the constant current supply is reduced; the capacitor takes a longer time to charge, and the unijunction transistor turns on later in the cycle. Hence, the SCRs fire closer to the end of the cycle and the average d-c output voltage is decreased.

The firing circuit fires each half cycle of line frequency. Only that SCR which is forward biased (anode plus with respect to cathode) is turned "on". The SCR will remain in the conducting mode after the signal is removed, until the anode to cathode voltage is reversed

The firing circuit is synchronized with the a-c line by the power supply. The power supply provides a full-wave pulsating d-c voltages. Each half cycle the voltage goes to zero (see Fig. 6 Page 19). The capacitor is fully discharged at the end of each half cycle, assuring that it will start charging from zero volts.

MOTOR SHUNT FIELD EXCITATION

Excitation for the motor shunt field is normally obtained from a part of the full-wave rectifier bridge used to control the motor armature circuit.

The motor shunt field is connected between one a-c line and the positive side of the full-wave rectifier bridge. The positive side of this bridge contains two diode rectifiers. One diode rectifier furnishes half-wave power to the motor shunt field, while the other diode rectifier acts as a commutating or free-wheeling diode. This diode provides a free-wheeling path for the current produced by the induced voltages in the motor shunt field.

On SP and CD drives, special application may result in shunt field being excited from separate source.

HOW THE SCR POWER UNIT WORKS (CONT'D)

REGULATOR

Figure 7 is a block diagram of the SCR Power Unit regulator. They are two feedback signals used in this regulator. The primary signal is from the d-c output voltage of the SCR conversion unit, and the second is an IR compensation signal. This IR compensation signal is obtained from the voltage drop across the DRS resistor and is proportional to armature current. The magnitude of the compensation signal is established by the IR COMP potentiometer.

When these two feedback signals are combined, their difference is a measure of motor CEMF, which is very closely related to motor speed. Thus the combination of these two signals provides a feedback which is a good approximation of motor speed.

When this "net" feedback signal is compared to the regulator reference voltage, the resulting signal is called the error signal. The level of the error signal is very small and requires amplification (by the amplifier) before it can be used to control the firing circuit.

The output of the amplifier controls the value of current delivered by the constant current source in the firing circuit. As the error signal increases, the magnitude of the capacitor constant charging current increases. With a rapid charging rate, the capacitor is charged quickly and the firing pulse occurs early in the cycle. This results in turning the SCRs "on" at an earlier point in the a-c wave, increasing the average d-c output voltage.

TIME ACCELERATION

The timed acceleration function is inserted between the preset reference voltage and the regulator reference as shown in Fig. 7. This function is inoperative except during acceleration or deceleration of the drive. When the "Start" button is pressed, the CR relay applies the preset reference to the timed acceleration circuit This circuit allows the regulator reference voltage to increase smoothly at a rate (2 5-10 seconds) established by the setting of the TIME ACCEL potentiometer.

The time acceleration circuit consists essentially of a constant current source and a capacitor When this current source is used to charge the capacitor, its voltage will increase approximately linearly with time. The voltage appearing on this capacitor is the regulator reference.

The total accelerating time is thus the charging time for the capacitor and is determined by the setting of the TIME ACCEL potentiometer, which controls the value of charging current. The ultimate value of capacitor voltage (regulator reference) is determined by the setting of the operator's "Speed" potentiometer.

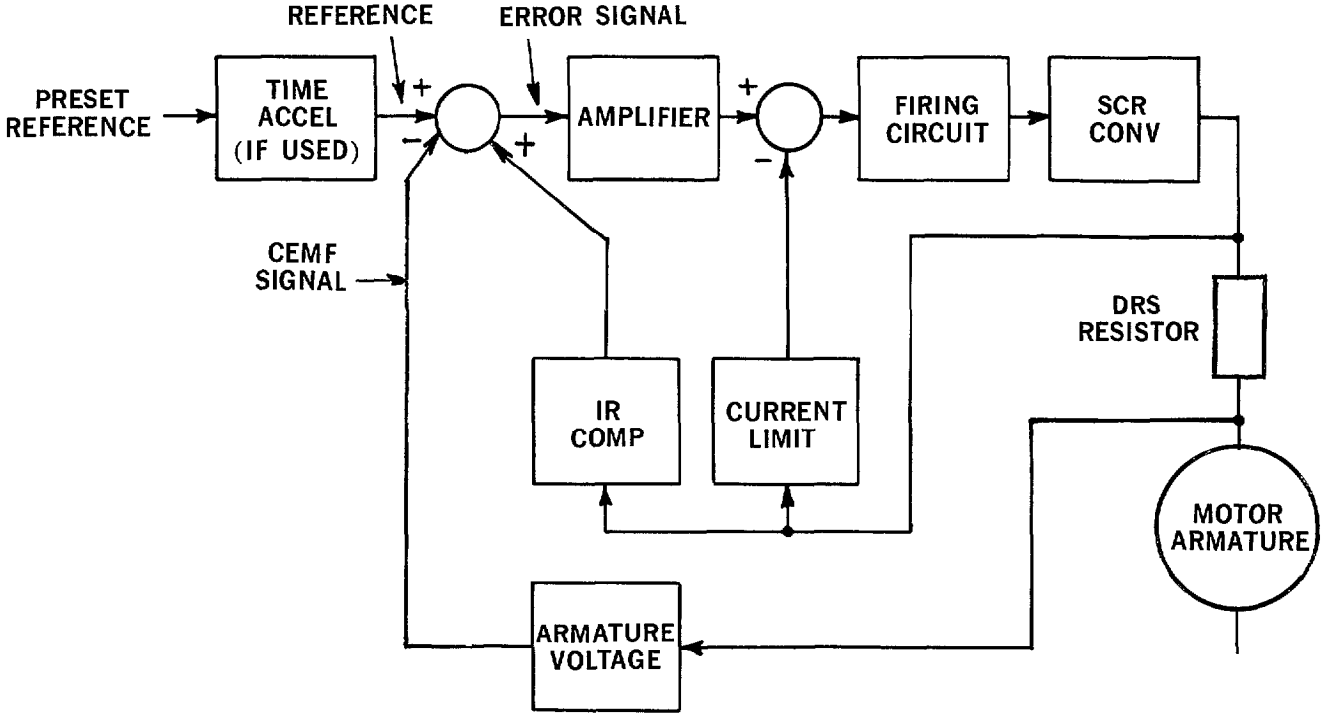

Figure 7 Regulator Block Diagram

HOW THE SCR POWER UNIT WORKS (CONT'D)

Whenever the preset reference is at a higher value than the regulator reference, the timing circuit becomes operative. If the value of preset reference is reduced below the regulator reference voltage (by turning the "Speed" potentiometer down), the capacitor in the TIME ACCEL circuit will discharge at a fixed exponential rate, reducing the regulator reference voltage.

Under these conditions, the drive will decelerate to the new preset speed at this rate, assuming that this rate is slower than the normal coasting time of the drive and its connected load.

When the "Stop" button is pressed, the CR relay is deenergized and will discharge the capacitor in the TIME ACCEL circuit. This "resets" the circuit, assuring that the next start will find the reference voltage at zero. The above assumes the time acceleration circuit has not been bypassed.

CURRENT LIMIT

The current-limit signal is obtained from the voltage across the DRS Resistor. This voltage is proportional to the motor armature current. The magnitude of the current-limit feedback signal is adjusted by the "CUR LIMIT" potentiometer.

When the armature-current feedback signal increases to the limit setting, it acts to retard the charging rate of the capacitor in the firing circuit. The unijunction transistor fires later and the SCRs are phased back (turn on later in the cycle) until the armature current is reduced to the level determined by the setting of the CUR LIMIT potentiometer.

STATIC IOC CIRCUIT

A static instantaneous overcurrent circuit senses armature current. When current exceeds approximately 300 percent, this circuit prevents the SCRs from firing and so reduces output voltage to zero in 1/2 cycle.

The circuit is reset by pressing the "Stop" button.

MAGNETIC FUNCTIONS

Depressing the "Start" push button energizes the CR relay. Relay CR applies preset reference voltage and initiates the timed acceleration circuit (if not disabled by jumper 7-4). Also, relay CR seals in an energizes the F (or R) contactor connects the motor armature circuit to the conversion unit.

Depressing the "Stop" push button drops out relay CR and the F (or R) contactor. Relay CR removes the preset reference voltage and resets the timed acceleration circuit. The F (or R) contactor disconnects the motor armature circuit from the conversion unit.

When dynamic braking is furnished, the F (or R) contactor, when de-energized, connects the dynamic-braking resistor to the motor armature.

On reversing drives, an antiplugging relay, AP, is connected across the motor armature. Relay AP locks out the start circuit to relay CR as long as the armature voltage is is above approximately 20 volts.

TACHOMETER FEEDBACK MODIFICATION

The tachometer generator provides a voltage-feedback signal proportional to motor speed. This voltage-feedback signal is fed into a full-wave rectifier bridge which makes the feedback signal insensitive to the polarity of the tachometer-generator output voltage.

A resistor bridge located immediately after the full-wave rectifier bridge reduces the tachometer-generator output voltage to a suitable value. The output of the resistor bridge is then fed to the regulator at points 1 and 18 on 3TB.

The armature-voltage feedback is modified by a jumper removal (1-16), thus permitting the tachometer generator to control the drive. Since the tachometer generator provides an accurate speed signal, the IR comp circuit is not required and "IR COMP" is set to zero (CCW).

SPARE AND RENEWAL PARTS NOTES

TABLE IV
SPARE AND RENEWAL PARTS LIST

1-5 HP SINGLE-PHASE SCR POWER UNIT

Part Name	Qty. Used	Drive Horsepower				
		1	1-1/2	2	3	5
Basic Non-reversing Power Unit						
*Power Conversion Unit	1	331X210 AAG01	331X210 AAG02	331X210 AAG02	331X210 AAG03	331X210 AAG04
**Fuses CLF 250V	2	15 Amp 104X109 AB002	20 Amp 104X109 AB003	20 Amp 104X109 AB003	30 Amp 104X109 AB004	40 Amp 104X109 AB005
F Relay	1	104X131 AB014	104X131 AB014	104X131 AB014	104X131 AB014	104X131 AB014
XI Choke	1	104X220 AA009	104X220 AA009	104X220 AA009	104X220 AA009	104X220 AA009
Control Power Trans.	1	104X156 AA115	104X156 AA115	104X156 AA115	104X156 AA115	104X156 AA115
Fuse	1	104X109 AD004	104X109 AD004	104X109 AD004	104X109 AD004	104X109 AD004
DRS Resistor	1	104X136 AD014	104X136 AD013	104X136 AD012	104X136 AD011	104X136 AD010
Power Unit Modifications						
R Relay	1	104X131 AB014	104X131 AB014	104X131 AB014	104X131 AB014	104X131 AB014
Anti-plugging Relay	1	104X131 AB003	104X131 AB003	104X131 AB003	104X131 AB003	104X131 AB003
Dynamic Braking Kit	1	331X207 AAG01	331X207 AAG02	331X207 AAG03	331X207 AAG04	331X207 AAG05
Tachometer Feedback Unit	1	331X200 AAG01	331X200 AAG01	331X200 AAG01	331X207 AAG01	331X200 AAG01

Order spare or renewal parts from your drive supplier or nearest General Electric sales office giving complete power-unit name-plate data, parts quantity and catalog number from the above tabulation.

*See SCR Warranty for replacing "in-warranty" failure of power conversion units.

**Fuses not included in warranty (See warranty statement).

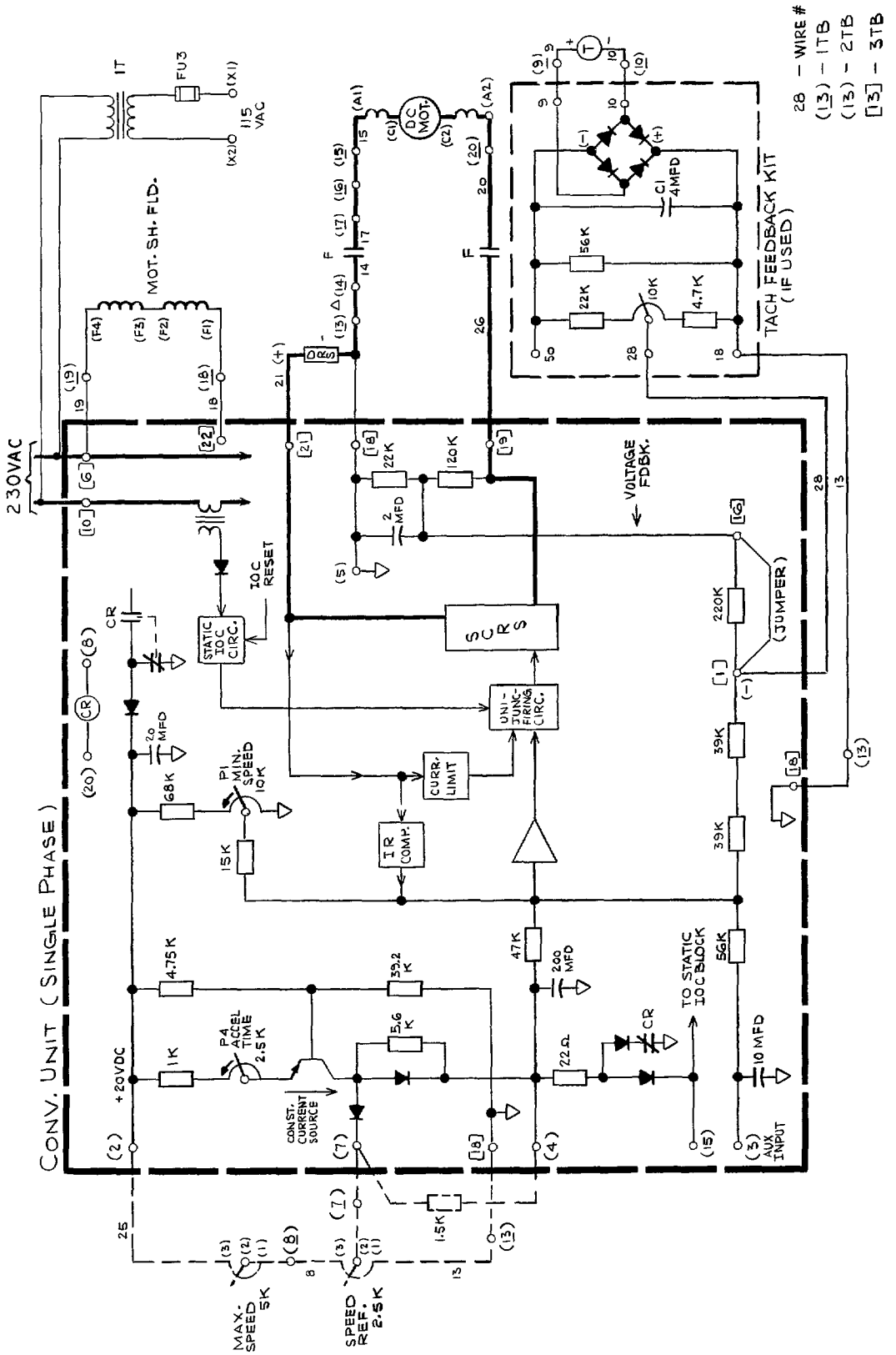

Figure 8 TYPICAL SCR POWER UNIT DIAGRAM

NOTES

GENERAL ELECTRIC

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