INSTRUCTIONS

Preliminary GEK-24975

REVERSING GENERATOR FIELD REGULATOR AND EXCITER

INSTALLATION - OPERATION - MAINTENANCE

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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INTRODUCTION

The Reversing Generator Field Regulator and Exciter assembly is a static SCR controlled power supply for bidirectional excitation of a highly inductive load. It is primarily used for exciting the shunt field of a DC generator and controlling the generator armature voltage through a system regulator. The controller also has provision for an adjustable unidirectional DC motor shunt field supply.

The operator and maintenance man should have access to a copy of this instruction book.

Additional instructions are included in the supplementary instruction publications and diagrams included in the instruction folder with the equipment.

RECEIVING, HANDLING AND STORAGE

RECEIVING

The equipment should be placed under adequate cover immediately upon receipt as packing cases are not suitable for out-door 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 requested from General Electric Company Speed Variator Products Operation, Erie, PA. When seeking assistance, please use requisition number and model and serial numbers to identify the equipment. Telephone 814—455-3219.

HANDLING

Wall mounted power units can be transported by lift trucks with the forks completely under the base using care that the unit does not tip.

Floor mounted power units have lifting lugs, or holes for lifting bars, so that crane hooks may be used to pick up the unit. Spreader bars should be used as required.

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 the storage environment exceeds a 15°C (27°F) drop in temperature at 50% humidity over a 4-hour period, a space heater should be installed inside each enclosure to prevent condensation.

(A 100 watt lamp can sometimes serve as a substitute source of heat). Higher humidities with smaller temperature changes will also cause condensation.

Condensation occurs when air containing some moisture is cooled below its dew point. The dew point represents saturation of the air, and is the temperature at which the moisture starts to condense into water. It is not a fixed temperature but rather is related to the initial temperature of the air and its relative humidity at that temperature. The amount of moisture that can be held in the air is related to the air temperature. The following examples illustrate some of these relationships.

TABLE I
Relationship Between Air Temperature, Relative Humidity and Dew Point

AIR TEMP °F	AIR TEMP °C	RELATIVE HUMIDITY %	WGT. OF MOISTURE IN 1 LB OF DRY AIR. GRAINS	DEW POINT °F	DEW POINT °C
104	40	100	345	104	40
104	40	80	270	97	36
104	40	40	130	75	24
104	40	10	32	37	3
50	10	100	54	50	10
50	10	80	42	43	4
50	10	40	21	25	4

In industrial drives, condensation is a possibility in applications where air temperature changes are large and rapid and/or the air is moist. For example, an outdoor crane operating in sunshine on a winter day, which then is shut down and parked in the shade will experience a rapid drop in temperature. This can result in condensation inside the equipment. Adding heat to keep the air temperature above its dew point can prevent condensation.

If storage temperatures below —20°C (—4°F) are likely to be present then auxiliary heat should be added in each enclosure to maintain temperature at or above —20°C. For assistance in heater size selection contact General Electric Company.

When a drive that has been in operation is shut down for either a short or extended period of time, it is recommended the environmental conditions be maintained the same as when in operation. Power, ventilation or heating and air-conditioning (if used) should be left on during the down-time to prevent large changes in temperature and possible moisture condensation.

SAFETY FOR PERSONNEL AND EQUIPMENT

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

WARNING

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

COLOR — BLACK OR WHITE LETTERING ON RED FIELD.

CAUTION

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

COLOR — BLACK LETTERING ON AMBER FIELD.

NOTE

DENOTES AN OPERATING PROCEDURE OR CONDITION WHICH SHOULD BE HIGHLIGHTED.

COLOR — BLACK LETTERING ON A WHITE FIELD.

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. CIRCUIT BREAKERS, IF SUPPLIED AS PART OF THE TOTAL SYSTEM, MAY NOT DISCONNECT ALL POWER TO THE EQUIPMENT. SEE SYSTEM ELEMENTARY DIAGRAMS. 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 ISOLATED FROM GROUND AND ITS METAL PARTS TREATED AS LIVE EQUIPMENT. USE OF AN INSTRUMENT HAVING BOTH LEADS ISOLATED FROM THE CASE PERMITS GROUNDING OF THE CASE EVEN WHEN MEASUREMENTS MUST BE MADE BETWEEN TWO LIVE PARTS.

CAUTION

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

NOTE

ALWAYS READ THE COMPLETE INSTRUCTIONS PRIOR TO APPLYING POWER OR TROUBLE SHOOTING THE EQUIPMENT. FOLLOW THE START UP PROCEDURE STEP BY STEP.

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

CAUTION

DO NOT REMOVE INPUT POWER FROM THE DRIVE UNTIL IT HAS FULLY EXECUTED A STOP SEQUENCE, AS THIS CAN DAMAGE THE DRIVE SYSTEM.

INSTALLATION

LOCATION

Reversing Generator Field Regulator and Exciter assemblies are suitable for most factory areas where other industrial equipment is installed. They should be installed in well-ventilated areas with ambient temperatures ranging from 0°C (32°F) to 40°C (104°F) and relative humidities up to 90 percent. It should be recognized; however, that since the life expectancy of any electronic component decreases with increased ambient temperature, reduction of the ambient temperature will bring about extended component life. For example, longer component life should be expected if the ambient temperature is held between 20°C (68°F) and 30°C (87°F).

Proper performance and normal operational life can be expected by maintaining a proper environment for the drive system.

LATER

FIG. 1 CONTROL ASSEMBLY

Environments which include excessive amounts of one or more of the following characteristics should be considered hostile to assembly performance and life:

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

Totally enclosed power units should be positioned to permit heat radiation from all surfaces except the bottom; otherwise, the enclosure can be positioned as follows:

A wall mounted power unit enclosure (or floor mounted enclosure) may be placed side by side with another enclosure. Clearance at least equal to the width of the enclousre should be available in front so that the door may be fully opened for easy access.

WARNING

SOME ASSEMBLIES ARE FURNISHED WITH PARTIAL ENCLOSURES OPEN AT TOP AND BOTTOM. THESE ARE INTENDED ONLY FOR MOUNTING IN ANOTHER ENCLOSURE OR IN A CONTROL ROOM HAVING ACCESS BY QUALIFIED PERSONNEL ONLY. EXPLOSIONS OR FIRES MIGHT RESULT FROM MOUNTING THESE ASSEMBLIES IN HAZARDOUS AREAS SUCH AS LOCATIONS WHERE INFLAMMABLE OR COMBUSTIBLE VAPORS OR DUSTS ARE PRESENT. THESE ASSEMBLIES SHOULD BE INSTALLED AWAY FROM HAZARDOUS AREAS, EVEN IF USED WITH OTHER EQUIPMENT SUITABLE FOR USE IN SUCH LOCATIONS.

CONNECTIONS

All internal electrical connections between components in the assembly are made at the factory of General Electric Company.

Be sure to protect the interior panel mounted components and sub-assemblies from metal particles when cutting or drilling entrances for interconnecting wiring and cables.

If additional relays, contactors, or electrical solenoids are added in the proximity of the equipment enclosure, RC suppression networks should be added across the coils. A series combination of a 220 ohm resistor and a 0.5 mfd capacitor in parallel with the relay coils is recommended for 115VAC control circuits.

NOTE

SOME SYSTEM TRANSFORMERS AND OTHER APPARATUS MAY BE SHIPPED SEPARATELY AND MUST BE MOUNTED AND CONNECTED TO THE SYSTEM.

WARNING

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

NOTE

IT IS RECOMMENDED THAT THE ASSEMBLY COMMON CIRCUIT BE GROUNDED AT ONLY ONE POINT. THIS MEANS THAT IF THE DRIVE REFERENCE IS SUPPLIED BY A NUMERICAL CONTROL OR PROCESS INSTRUMENT WITH GROUNDED COMMON, THE DRIVE COMMON

SHOULD NOT BE GROUNDED. IF A SEPARATE POWER TRANSFORMER IS USED AND IF THE SECONDARY OF THE TRANSFORMER MUST BE GROUNDED, IT IS RECOMMENDED THAT HIGH RESISTANCE GROUNDING BE USED.

CAUTION

INSTALLATION WIRING MUST BE IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND BE CONSISTENT WITH ALL LOCAL CODES. SECONDARIES OF 115 VOLT CONTROL TRANSFORMERS TYPICALLY HAVE ONE SIDE FUSED AND THE OTHER GROUNDED OR AVAILABLE FOR GROUNDING BY THE USER.

CAUTION

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

CAUTION

DO NOT CONNECT ANY EXTERNAL CIRCUITS OTHER THAN SHOWN ON THE ELEMENTARY DIAGRAM, SUCH AS AMMETERS ON THE SHUNT OR VOLTMETERS ON THE TACHOMETER BECAUSE THE PERFORMANCE OF THE DRIVE SYSTEM MAY BE DEGRADED.

CAUTION

DO NOT USE POWER FACTOR CORRECTION 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.

Before power is applied to the drive system, checks should be made to see that all internal connections are tight, that plug in printed circuit cards in the optional regulator rack are fully seated and that all open relays and contactors operate freely by hand. Check that the equipment is clean and that no metal chips are present.

MAINTENANCE

Periodically inspect and maintain the equipment protective devices (particularly air filters when supplied) per instructions in this section. Check all electrical connections for tightness; look for signs of poor connections and over heating (arcing or discoloration).

FANS AND FILTERS

On force ventilated drives, the power unit contains a fan and perhaps an air filter in the intake of the enclosure and/or on equipment inside the enclosure.

Inspect the fan at regular intervals to see that it is operating properly. Check for excessive noise and vibration, loose fan blades and for over heating of the motors. Keep the fan blades clean.

If the fan does not operate, replace the fan and integral motor with a unit with the same catalog number.

Clean and/or replace air filters as appropriate depending on the accumulation of dirt for the type supplied.

To clean metal filters, flush only with warm water, dry and recoat lightly with RP® Super Filter Coat or equivalent (light oil) or replace the filter. Be sure to install filters with air flow direction as indicated on the filter.

DC MOTORS AND GENERATORS

Maintenance instructions covering brushes, commutator and lubrication are in GEK-2304 which is found elsewhere in the instruction book.

PRINTED CIRCUIT CARDS

Printed circuit cards normally do not require maintenance except to keep them clean and tightly secured to their respective terminal boards or tightly plugged in the optional modification rack receptacles. Clean as follows:

1. Dry Dust — Vacuum clean, then blow with dry filtered compressed air (low pressure supply).

2. Oily Dirt — Certain components (electrolytic capacitors, switches, meters, potentiometers and transformers can be damaged by solvent, so its use is not recommended. If absolutely necessary, use solvent sparingly on a small brush and avoid above components. Clean contact terminals with dry non-linting cloth after solvent has been used. Recommended solvents: Freon* RE or TF.

3. If the card is badly contaminated or corroded, replace.

*Trademark of E.I. DuPont Company.

SILICON CONTROLLED RECTIFIERS

Keep SCR's and heatsink free from dirt, oil or grease, since any accumulation of dirt may cause overheating. Clean as follows:

1. Dry Dust — Vacuum clean, then blow with dry, filtered compressed air (low pressure).

CAUTION

SOLVENT CAN HARM NON-METAL COMPONENTS.

2. Oil Dirt — Use dry or barely moist (with solvent) non-linting cloth. Repeat until cloth remains clean. All contact tips must be cleaned with dry non-linting cloth after solvent has been used. Recommended solvents: Freon* RE or TF.

CONTROL DEVICES

Inspect all relays and contactors at regular intervals and keep them free from dirt, oil or grease. Check for freedom of moving parts, corrosion, loose connections, worn or broken parts, charred insulation or odor, proper contact pressure and remaining wear allowance on contacts. Do not lubricate the contacts as lubrication shortens their life.

Both copper and silver contacts will become darkened and somewhat roughened in normal operation. This does not interfere with their performance, and does not indicate that the contacts should be filed. In general, contacts will not need attention during their normal life, but if prominent beads form on the surfaces due to severe arcing, the contact faces may be dressed with a fine file. **Do not** use sand paper or emery cloth.

Any contact that is worn to the point where contact wipe or pressure is lost should be replaced. Contactor shunts which are badly frayed or broken should also be replaced.

Cleaning procedure is the same as previously given for SCR and heatsink.

INSTRUCTION INFORMATION

The instruction folder furnished with the equipment includes detailed instructions and diagrams applicable for each specific drive system.

*Trademark of E.I. DuPont Company.

In addition to this general instruction, the folder includes instruction for the motor(s) and other components furnished. Start-up and troubleshooting guides are included. All instructions and the accompanying diagrams should be consulted before applying power to the system.

THE FOLLOWING INFORMATION IS OF PARTICULAR IMPORTANCE.

TYPES OF DIAGRAMS

Different types of control diagrams are provided for specific purposes. The type of control diagram is noted in the title block of each diagram sheet.

The two major types of diagrams are Elementary, (sometimes called schematic) and Layout or Connection.

The Elementary diagrams represent (in symbolic form) the fundamental operation and relationship of the electrical parts of a system. These diagrams are drawn so that the operation of the control system may be easily understood. Connections made between control devices and power devices within the enclosure are also shown in this type of diagram.

The Layout or Connection diagram, when supplied is one which shows the relative physical position of the devices as well as other electrical components located within the same enclosure.

The Elementary diagram also identifies adjustments, signals and test points. In this instruction book, adjustments are in special type. Example: ***FMAX*** (Maximum motor field adjustment).

Signals and test points are CAPITALIZED, Example: CFB (Current Feedback).

GENERAL DESCRIPTION

The simplified typical block diagram, Figure 2, shows the main subassemblies, components and the basic signal flow in the Reversing Generator Field Regulator and Exciter assembly.

This assembly is an addition to the VALUTROL® drive family and contains circuitry, subassemblies and components common to this line of DC drives.

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This assembly contains the following parts:

CPT	— Control power transformer, 230 V or 460V/115V, 50VCT
CFU1-3	— Control Fuses
RT1R, RT2R, RT3R	— 3φ Isolation Resistors for synchronizing
DCPR, DCNR	— Isolation Resistors for voltage feedback
TKPR, TKNR	— Isolation Resistors for tachometer feedback
RS1, RS2	— 1φ Isolation Resistors for synchronizing

(The Isolation Resistors are built into the wire harnesses)

FU1, FU2	— Incoming AC fuses for the reversing power module
PSC	— Power supply card, ±20V regulated, ±30V unregulated
IFC	— Interface Card
MFC	— Motor field control card (See GEK-24971)
DGC	— Diagnostic Card
MCC	— Main Control Card
MDR	— Card rack with custom wired S-22 cards
SCR	— Reversing field control power module
MAX	— Main control relay
FLT	— System fault relay
GPT	— Center tapped power transformer for the reversing field control power module (located externally)
SH	— 100 millivolt shunt for motor armature current signal (located externally)
MD	— DC loop contactor (located externally)
CB	— Circuit breaker or disconnect device (located externally)

The reversing field control system will always require an externally mounted center-tapped isolation power transformer (or transformer combination). Usually a system will also include other externally mounted devices such as a power disconnect or circuit breaker, a DC loop contactor and a 100 millivolt current shunt, etc.

Refer to the system elementary diagrams and instructions for a complete system description.

SYSTEM OPERATION

In the system, as shown in Fig. 2, 3φ AC power is applied to the three control fuses, CFU1-3 and to the MFC card. The 3φ AC signal is connected through isolator resistors, RT1R-3R, to the interface card to provide the synchronizing signal for the MFC card. Two of the phases connect to the control transformer, CPT, which provides an isolated 115V AC control signal and a 50V center-tapped signal which is rectified to ±30V DC and regulated to ±20V DC by the power supply card, PSC. Two phases of the main power connect to the input of the reversing field transformer, GPT. The GPT secondary connects through fuses to the reversing power module and through isolation resistors, RS1, RS2 to the synchronizing circuit on the main control card, MCC.

The output, GF, of the power module connects to one side of the generator field. The other side of the field connects to the center tap of GPT.

The current feedback from the 100 millivolt shunt connects directly to the interface card. The armature voltage signal connects through isolation resistors, DCPR-NR, and the tachometer signal, if used, connects through isolation resistors, TKPR-NR, to the interface card.

NOTE: If a motor field exciter, MFE, or a motor field control, MFC, is not used, the third AC power phase, X3, is not required. However, the loss of phase trip would have to be inhibited by connecting the φSEQ post on the IFC card to the COM post on the same card.

INTERNAL CONNECTIONS

NOTE: Since the core assembly may be used both for special purpose applications, like crane hoists, and for standard regulating systems, there are certain internal connections which must be completed prior to system operation.

STANDARD SYSTEM CONNECTIONS

The wire runs listed below must be completed. Refer to the Connection diagram for terminal board point locations.

MCC (DMAC) —	MCC (MAC)
5TB (DFDR) —	RTB (FDR)
5TB (DCRM) —	RTB (CRM)
MF (CEMF) —	IFC (CEMF) or MCC (CEMF)
MCC (TFB) —	5TB (TFB)

REGULATOR SYSTEMS

DC TACHOMETER REGULATOR

On the IFC card, make the two jumper connections corresponding to the tachometer voltage at maximum motor speed. For forward operation (SR negative) the positive side of the tach must connect to 2TB (29).

Max. Tach Voltage	IFC — Jumpers
18.5 — 49V DC	NT — NT1, PT—PT1
46 — 123V DC	NT — NT2, PT—PT2
85 — 232V DC	NT — NT3, PT—PT3

TABLE 2 IFC JUMPERS

CEMF REGULATOR

On the IFC card jumper NT—CEMF and CC—COM. Adjust ***COMP*** on the MCC card for desired IR compensation.

VOLTAGE REGULATOR

For armature voltage regulation delete the standard system connection MCC (TFB) — 5TB (TFB) and connect MCC (VFB) — MCC (TFB).

In this mode the ***MAX SPEED*** adjustment is inoperative. Rated voltage will result with 10 volts at MCC (TR).

CURRENT REGULATOR

Armature current regulation requires the use of a custom engineered regulator stage using amplifier cards in the MDR rack.

NOTE: Operation above motor base speed normally requires the use of a tachometer generator.

RATINGS

The basic reversing field control is available in sixteen combinations of voltage and current ratings. The control rating is determined from the generator field current and voltage, the three-phase AC input voltage and the generator armature volts. The rating of GPT is also dependent upon the generator field current and voltage. These ratings are shown in Table 3.

OUTPUT VOLTAGE

The output voltage wave shapes of the reversing bridge for continuous load currents are shown in Fig. 3.

The average output voltage, V_{CN}, applied to the load is found by averaging the instantaneous voltage applied by one-half of the transformer between two firing points.

The relationship between the output and the input voltage is $V_{CN} = .9V_{IN} \cos \alpha$ where V_{IN} is one-half the transformer secondary rms voltage and α is the SCR firing angle. The maximum voltage occurs for zero firing delay, $\alpha = 0$, resulting in:

$$V_{CN} \text{ max.} = .9V_{IN}$$

Figures 3b through 3e show the instantaneous load voltage V_{CN} superimposed on the voltage wave from each of the transformer windings.

In Figure 3b, SCR 1F is turned on at time t_{1F} and the V_{1N} voltage is applied to the load until SCR 2F is fired 180° later at time t_{2F}. This turns off SCR 1F and the voltage V_{2N} is now applied to the load.

Figure 3c shows the output voltage in the forward inverting mode which can only occur transiently. If the reference is reversed, the firing angle is restarted past 90° towards a maximum delay of 150° and the net output voltage goes negative. This forces the load current towards zero as the inductive load energy is pumped back into the AC supply. As the current goes discontinuous the firing of the forward SCRs is locked out and reverse firing is initiated.

Figure 3d shows the output voltage in the reverse operating mode. The average output voltage is negative and the load current is reversed. If the reference is again reversed the firing is phased back to produce a positive output voltage as shown in Fig. 3e. As the reverse current reaches zero firing will transfer to the forward SCRs.

Figure 3f shows the synchronizing voltage available at the SYNC post on the MCC card. The synchronizing pulses are fixed at 30° prior to each zero crossing of the transformer voltage and coincides with the maximum phaseback firing points.

PRINTED CIRCUIT CARDS

The printed circuit cards in the core assembly are terminal board mounted and interconnected by wire harnesses. Most of the correspondingly nomenclatured points are connected, i.e., IFC (VFB) connects to MCC (VFB), etc.

MDR RACK

The custom designed portion of the systems is located in the MDR rack containing S-22 type plug-in printed circuit cards interconnected by termi-point wiring. The rack has 20 space units available.

Core Asm. 36D877— 305DF Group No.	Generator Field				DC Motor		
		GPT		Shunt Field		Arm.
	Max. Field Amps	1 Ph. Sec. AC Volts	Field Volts	3 Ph AC Volts	Max. MFC Volts	Max. DC Volts
01	25	340	120	460	300	500
02	25	340	120	230	150	500
03	25	340	120	460	300	240
04	25	340	120	230	150	240
05	25	575	240	460	300	500
06	25	575	240	230	150	500
07	25	575	240	460	300	240
08	25	575	240	230	150	240
09	70	340	120	460	300	500
10	70	340	120	230	150	500
11	70	340	120	460	300	240
12	70	340	120	230	150	240
13	70	575	240	460	300	500
14	70	575	240	230	150	500
15	70	575	240	460	300	240
16	70	575	240	230	150	240

TABLE 3 ASSEMBLY RATINGS

NOTE: The Connection Diagram shows the wiring of a standard core assembly. Refer to the system diagrams for modifications and interfacing with the MDR rack, and to the section under internal connections.

Following, is a brief description of the basic printed circuit cards in the core assembly:

MAIN CONTROL CARD (MCC)

(Refer to GEK-45127 for the elementary diagram).

The main control card consists of two main sections, — the output field current regulator stage with the phase control and firing signals for the reversing power module, — and the input system regulator section. Both sections are controlled by the run and preconditioning logic circuits.

SYSTEM REGULATOR

Timed Reference: The maximum input voltage range at SR is ±5V to ±10V, or ±10V to ±20V with a jumper between SRH and COM.

With maximum reference applied at SR the voltage at TR is adjusted for ±10V with the ***REF SCALE*** potentiometer.

The timing range is .3 sec. to 7 sec., or 2 sec. to 60 sec. with 332 ohm connected between LT1 and COM. The timing is set by the ***LIN TIME*** potentiometer. If +20V is applied at ALT the ***LIN TIME*** potentiometer is disabled and the timing is set by the ***AUX TIME*** potentiometer.

Regulator: During normal operation the function of the regulator is to make the system feedback voltage, SFB, equal to the inverse of the timed reference voltage, TR (i.e., SFB = TR). The ***ZERO ADJ*** potentiometer is factory set to counteract any DC offset in the SFB and TR signals at low speeds. The gain in the feedback amplifier makes SFB = +10V for TFB = -5.6V.

The SFB voltage represents either tachometer voltage, motor counter — EMF or armature voltage, depending on the system connections. Refer to the Regulator Systems section.

NOTE: Only a DC tachometer can be used for speed feedback.

The regulator output, DR, is normally connected by a card jumper to the field current regulator input, GFR.

CEMF: The CEMF signal is generated by subtracting a portion of the current feedback, representing the motor IR drop, from a filtered voltage feedback. The amount of "IR Compensation" is set by the ***COMP*** potentiometer. This signal represents motor speed at base speed and below.

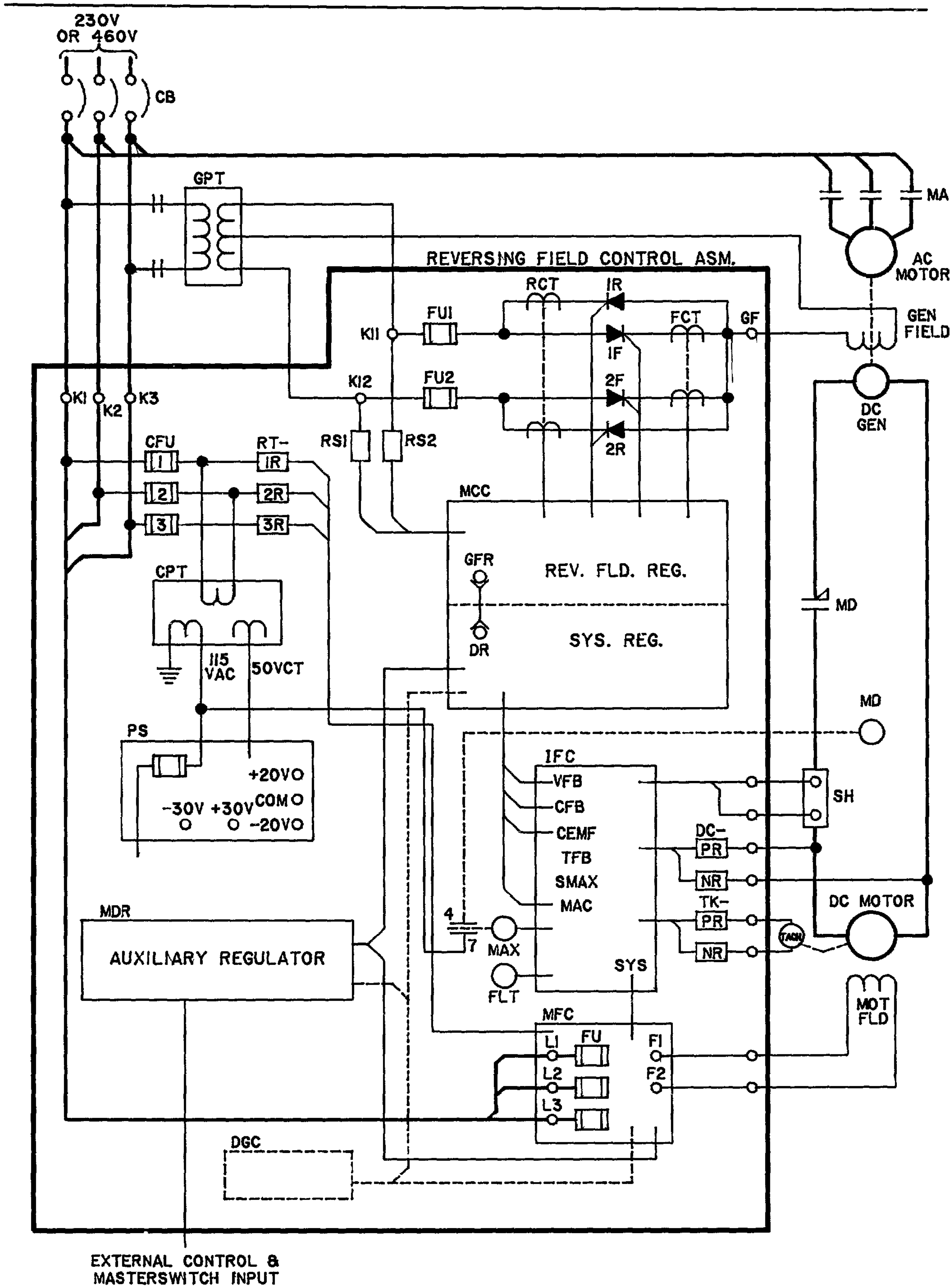
Current Limit: If the level of the armature current feedback signal, CFB, exceeds the setting of the current limit reference, the output of the current limit circuit will override the regulator. The voltage level at DR or the rate of change in the DR voltage is modified to keep the current at the set limit.

The current limit can be adjusted from 80% to 215% of a rated CFB level of 2.5 volts with the ***CUR LIM*** potentiometer.

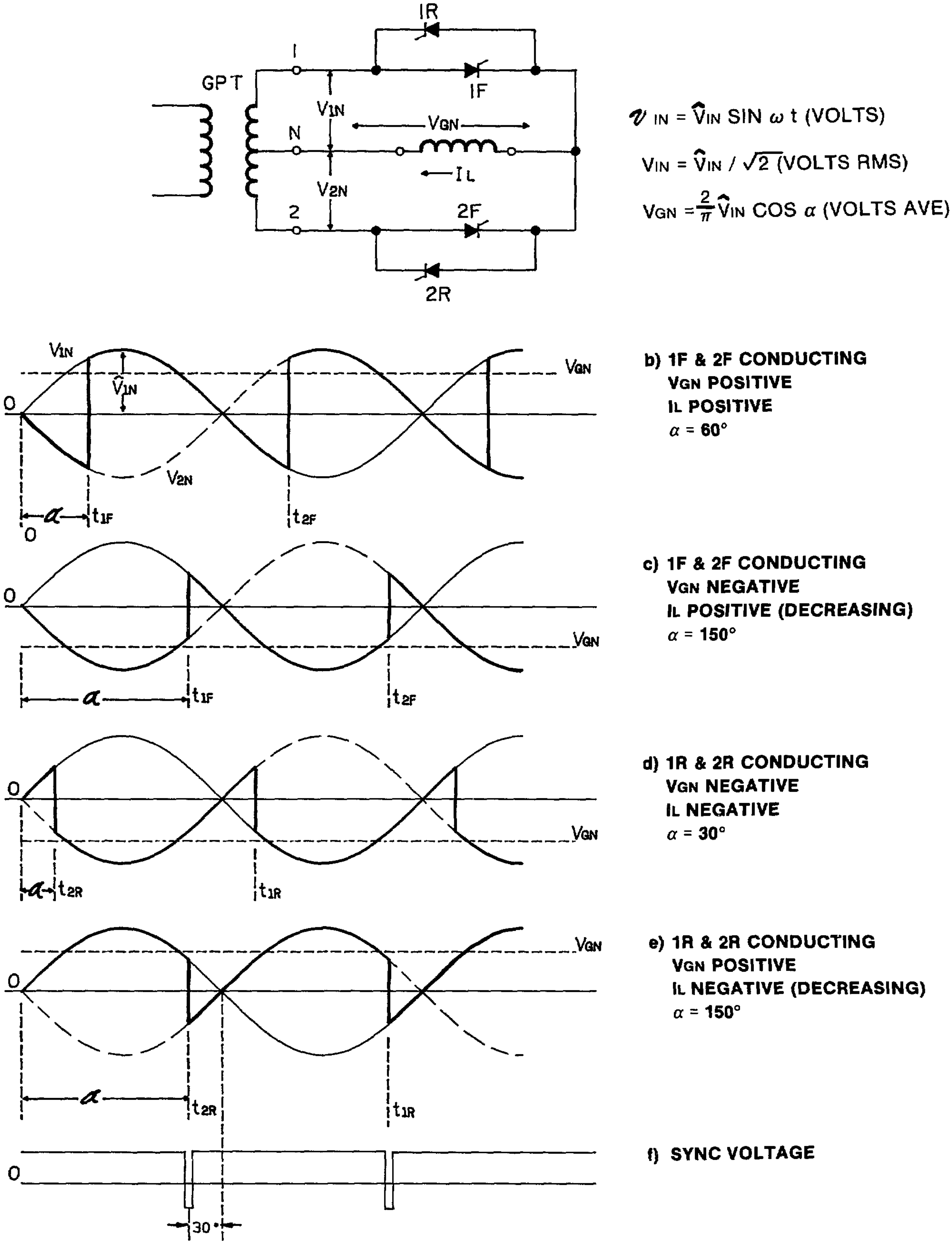
With +20V applied at ALM the current limit is set by the ***ALIM*** potentiometer which also has a range of 80% to 215%.

With +20V applied to BLM (with ALM open) the current limit is set by the ***BLIM*** potentiometer over a range from 20% to 110%.

NOTE: When operating in current limit the drive speed or voltage does not follow the timed reference, TR (i.e., SFB ≠ -TR).



© FIG.2 TYPICAL SYSTEM DIAGRAM



© FIG.3 VOLTAGE WAVESHAPES

RUN/Preconditioning: Starting of the drive is initiated by the application of —30V to RUN. This will apply —18V to MAC which provides the turn-on signal to the interface card for the MAX relay. If no fault conditions exist, the MAX relay is energized and the voltage at PRE goes to —3.5 volts. The FET switch, T6 around the timing integrator is opened. After a time delay of about 80 milliseconds, — the delayed firing power, DFP, is applied to the pulse transformer circuits, — the input switches T1 and T2 are opened to apply the SR signal to the timing circuit, — the T7 switch is opened to release the regulator preconditioning.

In the reversing field control circuit the T25 switch is opened to release the current regulator preconditioning, — and the T33 switch is opened to release the lockout of the firing signal.

A normal stop sequence is initiated by disconnecting —30V from RUN. The reference switches, T1 and T2, closes and the timed reference, TR, ramps down toward zero. The — 18V at MAC is removed, but the MAX relay stays picked up until the CEMF signal drops below the level set by ***RSTOP*** on the interface card. When the MAX relay is deenergized the voltage at PRE goes from —3.5 to 0 volts. The timed reference is immediately preconditioned by the closing of switch T6. After a time delay of .4 to .6 seconds the firing power, DFP, is disabled and switches T7, T25 and T33 close to precondition the regulating system.

GENERATOR FIELD CURRENT REGULATOR

Regulator: The reference, GFR, is compared to the field current feedback, FGC and RGC by the regulating amplifier to produce the phase-control reference, PCR. The current feedback is applied to FC1 and FC2 from the forward current transformer and to RC1 and RC2 from the reverse current transformer. Correct signal voltage is produced by making jumper connections to insert the proper loading resistors according to the level of the field current. The transformer signals are then rectified and any offsets are cancelled by the zero adjust potentiometers, ***FIZ*** and ***RIZ***.

The ***IMAX*** should be adjusted for rated field current with 10 volts at GFR, and the max. value of FGC and RGC should be from 4.5 to 10 volts.

The current transformer loading resistors should correspond to the field current ranges listed in Table IV.

TABLE IV
Reversing Field Current Ranges

Max. Field Amps	Jumper* Suffix	C.T. Prim. Connection
.8—1.7	None	2 turns
1.3—2.7	B-D	2 turns
2.6—5.5	A-B	2 turns
3.7—8.2	A-B, C-D	2 turns
7.4—15	A-C	2 turns
12.3—25	A-C, B-D	2 turns
23—49	A-E	1 turn
45—70	A-E, A-C, B-D	1 turn

*NOTE: B-D implies jumpers FB-FD and RB-RD, etc.

Fwd./Rev. Lockout: The lockout switching amplifiers are controlled from the regulator error signal, PCR, and the current feedback signals, FGC and RGC.

With PCR negative the forward lockout output, FLO, will switch positive provided the reverse current signal, RGC, is zero. As forward current is established, the negative FGC signal will keep the forward lockout released.

When PCR changes positive the forward SCR are phased back forcing the forward current and the FGC voltage to zero. As FGC reaches zero, the forward firing signals are locked out and the reverse lockout is released with RLO switching positive.

During transfer, both the forward and reverse gate signals will be locked out for about 8 milliseconds.

Synchronizing: The synchronizing for the phase control is generated from the transformer voltage applied to the SCR power module. The signal is isolated through external resistors to produce a 6.7V AC signal, phase shifted 150° at post SX. The voltage at SYNC will be at a positive level with negative going pulses at the zero crossings of the SX signal. The SYNC signal is applied to the unijunction oscillator circuit to reset the timing capacitor during each negative pulse.

Phase Control: The programmable unijunction transistor, T29, will turn on to produce an output pulse when the voltage on the timing capacitor, C29, exceeds 10 volts. With PCR equal to zero, the circuit is biased such that firing occurs at a phase lag of 150°.

The unijunction pulses are amplified and applied to the pulse transformer circuit inputs, FGP, in the forward mode, and RGP, in the reverse mode.

Each pulse transformer has two output windings applying pulses simultaneously to both forward SCRs in the forward mode and likewise to both reverse SCRs in the reverse mode.

For 50 Hz operation, the circuit should be rebiased by removing the jumper between posts X and Y.

Ready to Run: The green Ready to Run indicating light on the MCC card must be on before the drive can be started.

If a fault occurs the light is extinguished and the drive shuts down. After the fault condition is removed the drive can be reset by pushing the RESET button.

Miscellaneous: A spare, unity gain, inverting amplifier is available with input and output at connector posts X1 and XDR.

Regulator points available at connector posts can be connected to spare output terminal points by jumper connections to any of the eight "dummy" posts DM1 through DM8. This feature is primarily used for interfacing between the MCC card and the MDR rack.

In a speed regulated system a tachometer lead circuit can be added by connecting a resistor between posts RJ and TL and a capacitor between posts TL and SFB.

The rate feedback from DR to the current limit circuit can be strengthened by adding a capacitor between posts DR and CLI, and a resistor between posts CLI and CLJ for the purpose of reducing current limit overshoots.

The field current regulator response can be trimmed by adding a resistor from post PCJ to PCI or a capacitor between posts PCI and PCR.

By connecting +20V to post NRG, the system feedback, SFB, is inhibited and the regulator gain is reduced to unity. This makes DR = —TR (unless the drive is in current limit) such that the input to the field current regulator is set by the external reference. This modification can be used temporarily during troubleshooting or tune up.

The forward SCR gate pulses can be inhibited by connecting FGP to COM. The reverse SCR gate pulses can be inhibited by connecting RGP to COM.

INTERFACE CARD (IFC)

(Refer to GEK-45113 for the elementary diagram).

The primary purposes of the interface card are:

1. To provide low level isolated signals corresponding to the three-phase AC, DC armature voltage, armature current and tachometer feedback.
2. To control the start, stop and synchronizing of the drive while monitoring the system for abnormal operating conditions.
3. To provide one milliampere signals for external speed and current indication.

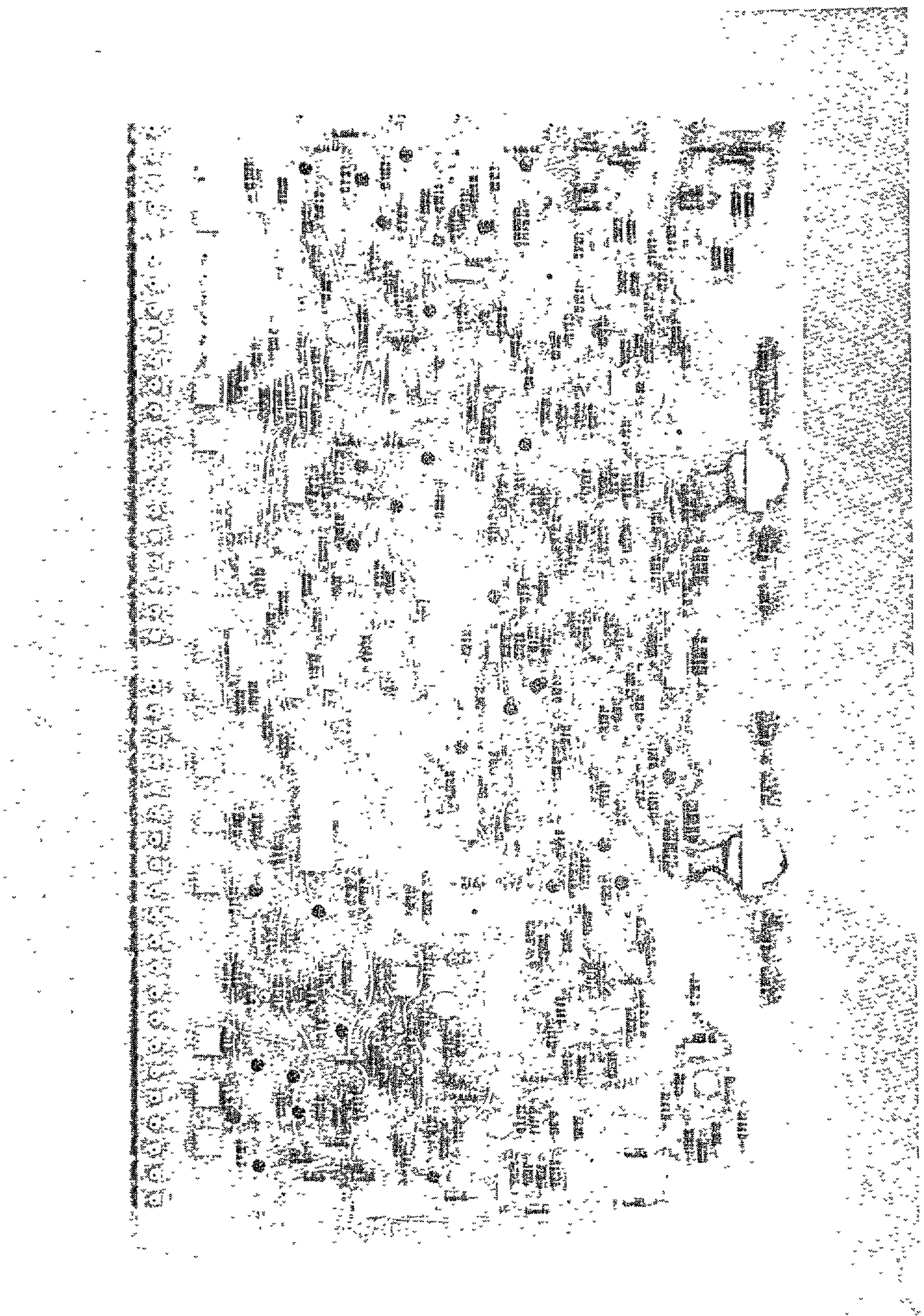
Other outputs provide:

1. A NO/NC contact indicating MA closure (MAX).
2. A NO contact indicating a fault condition (FLT).

There are (5) potentiometers on this card.

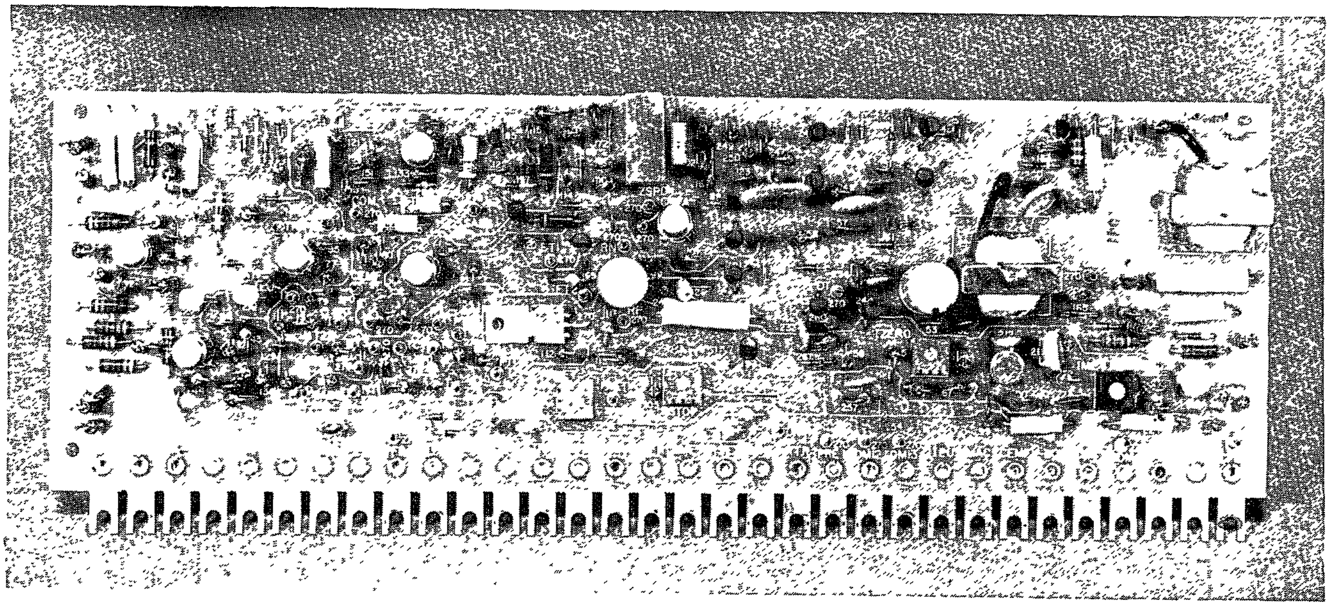
1. The ***IZERO*** is a bias adjustment for the current feedback output and is factory set. This control should not be disturbed.
2. ***ICAL*** is the calibration adjustment for CFB and is factory set. This control should not be disturbed.
3. ***R STOP*** is the drop out level of the regenerative stop sequencing circuit and is also factory set.
4. ***IMET*** is the calibration adjustment for the current indicator.
5. ***SMET*** is the calibration adjustment for the speed indicator.

Adjustment 4 and 5 will be factory set if the indicators are ordered with the drive and mounted in the power unit enclosure.



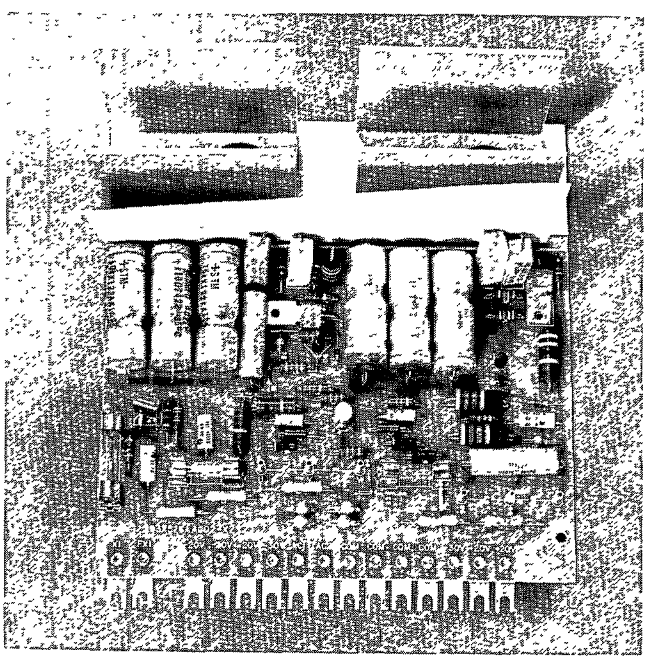
(Photo MG—5543-8)

FIG. 4 MAIN CONTROL CARD
(NOTE: TEST POSTS ALONG LARGE EDGE)



(Photo MG—5236-13)

FIG. 5 INTERFACE CARD



(Photo MG—5236-20)

FIG. 6 POWER SUPPLY CARD

POWER SUPPLY CARD (PSC)

(Refer to GEK-45111 for the elementary diagram).

The power supply card rectifies the AC input and provides regulated plus and minus 20 volts for the printed circuit cards. Unregulated plus and minus 30 volts DC is also provided to drive the static logic switches and the MAX relay. All of the DC outputs are fused to protect the power supply card against overloads. The regulated plus and minus 20V DC outputs are protected by a "crowbar" circuit which causes the card mounted fuses to blow if the voltage from +20V to —20V exceeds 47 volts. This card is also used for mounting the 1 ampere fuse for the 115VAC control power.

MOTOR FIELD CONTROL CARD (MFC)

(Refer to GEK-24971 for the elementary diagram).

This card provides a current regulated motor field supply for the DC motor.

The tachometer monitor circuit is used to monitor SFB and detect an overvoltage. Loss of motor field is also detected by this card. Any of these faults will shut down the drive. A field economy circuit is also included on this card, which automatically reduces the level of motor field excitation whenever the drive is shut down, thereby avoiding the possibility of excessive temperature (at stand still) and/or reduced insulation life.

The adjustments on the card are: ***FMAX*** is set for maximum field current with the voltage at WFR equal to zero, and with proper current range selected by the YA through YD card jumpers.

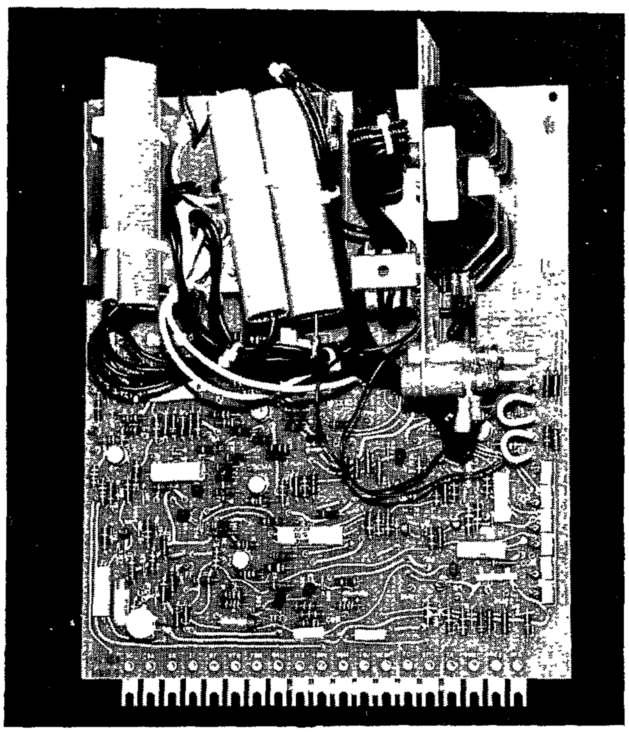
FMIN is set for minimum field current (normally 90% of minimum required operating field) with a negative voltage applied at CRM or FDR.

FLOSS is adjusted to initiate a system trip at a field current of about 70% of minimum operating field. A positive voltage applied at FDR reduces the field below the FMIN setting.

ALIGN — The ***ALIGN*** potentiometer is set for zero voltage at the TA post of the MFC card when operating below crossover.

CROSS — The crossover adjustment sets the point at which the CEMF voltage starts decreasing the maximum field current.

NOTE: If a fixed motor field excitation is required, the MFE card may be used instead of the MFC card. The MFE card contains a field loss circuitry which requires proper selection of the YA through YD jumpers and setting of the ***FLOSS*** potentiometer. Refer to Instruction Book GEK-24972.



(Photo SV—4951-005)

FIG. 7 MOTOR FIELD CONTROL CARD

DIAGNOSTIC CARD (DGC) (OPTIONAL)

(Refer to GEK-45118 for the elementary diagram).

The diagnostic card performs no function under normal operating conditions but will program the drive into a diagnostic run mode and diagnostic static mode for ease in initial start up and troubleshooting.

In "DIAG STATIC" +20V is applied to DP1 and DP2. The voltage at CFB is set by the ***CUR REF*** potentiometer and the voltage at LR and FDR is set by the ***LOC REF*** potentiometer.

In "DIAG RUN" +20V is applied to DP1, —20V is applied to MAC and +4.8V is applied to CRM. The voltage at LR is set by the ***LOC REF*** potentiometer.

NOTE: DGC (MAC) is not connected to the MCC (MAC) and IFC (MAC) such that the MAX relay will not pick up in "DIAG RUN."

MAX AND FLT RELAYS

MAX

The N.O./N.C. form C contacts wired to 2TB5, 6 and 7 have a resistive rating of 5A at 28V DC and 115V AC. The pilot duty rating is .7A holding and 6.1A inrush at 115V AC.

The N.O. contact at relay points 4 and 7 is a heavy duty version with a resistive rating of 12A at 28V DC and 115V AC. The pilot duty at 115V AC is 2.6A holding and 35A inrush.

FLT

The N.O. contact wired to 2TB3 and 4 has a resistive rating of 5A at 28V DC and 115V AC. The 115V AC pilot duty is .7A holding and 6.1A inrush.

ISOLATOR RESISTORS

Isolation between power and control signals is provided by high resistance differentially connected op amps. The input resistors are connected in the wires and protected by heat shrinkable sleeving. The resistance values listed below are produced by a series combination of two or three resistors.

Voltage	Resistor	Resistance (MEG Ohms)
3 Ph, 230V AC 3 Ph, 460V AC 3 Ph, 575V AC	RT1R, —2R, —3R " "	1.500 3.000 3.710*
1 Ph, 340V AC 1 Ph, 460V AC 1 Ph, 565V AC	RS1, RS2 " "	2.210 3.000*+ 3.710
VFB 240V DC VFB 500V DC	DCPR, —NR "	1.681 3.562
TACH	TKPR, —NR	.150

TABLE V ISOLATOR RESISTORS

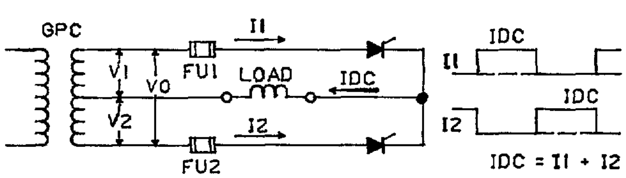
* Not included in the 16 groups of the core assembly listed in the Ratings section.

\+ A 340V rated core assembly can be used at 460V by connecting a 1 MEG ohm resistor from MCC (RS1) to MCC (RS2).

GPT TRANSFORMER

GPT TRANSFORMER RATING

The KVA rating of the GPT transformer secondary center tapped winding is twice the rating of each winding half. The rating of each half is the product of the rms voltage and the rms current. With an inductive load, a DC output current can be assumed, with each winding supplying the DC output for 180°.



© FIG.8 GPT TRANSFORMER CURRENTS

$$i_1\,RMS = i_2\,RMS = \frac{1}{\sqrt{2}} \cdot I_{DC}$$

$$V_1 = V_2 = \frac{1}{2} V_o$$

KVA rating per winding half:

$$KVA_1 = \frac{i_1\,RMS \cdot V_1}{1000} = \frac{I_{DC} \cdot V_1}{\sqrt{2} \cdot 1000}$$

Total secondary rating:

$$KVA_S = 2KVA_1 = \frac{I_{DC} \cdot 2V_1}{\sqrt{2} \cdot 1000} = \frac{I_{DC} \cdot V_o}{\sqrt{2} \cdot 1000}$$

For Vo = 340 volts:

$$KVA_S = \frac{340}{\sqrt{2} \cdot 1000} \cdot I_{DC} = .24\,I_{DC}$$

For Vo = 460 volts:

$$KVA_S = \frac{460}{\sqrt{2} \cdot 1000} \cdot I_{DC} = .33\,I_{DC}$$

For Vo = 575 volts:

$$KVA_S = \frac{575}{\sqrt{2} \cdot 1000} \cdot I_{DC} = .41\,I_{DC}$$

NOTE: The KVA load on the primary winding is less than the secondary rating. The primary rating is the same as if a single secondary winding was carrying the DC current 100% of the time such that the RMS current equals the DC output current.

Primary KVA load: $KVA_P = \frac{I_{DC} \cdot V_1}{1000} = \frac{I_{DC} \cdot V_o}{2 \cdot 1000}$

or: $KVA_P = \frac{1}{\sqrt{2}} \cdot KVA_S$

GPT TRANSFORMER AND SCR BRIDGE FUSING

The FU1 and FU2 fuses located in the controller provides protection both for the SCR module and for the external GPT transformer.

In order to comply with the NEC code, the current rating of these fuses should not exceed the rated secondary transformer current by more than 200%.

i.e., $I_{FUSE} \leq \frac{2 \cdot (\text{TRANSF. KVA}) \cdot 1000}{V_o}$

Since the relationship between transformer KVA rating and DC output current rating, I_{DC}, of the SCR bridge is:

$$KVA = \frac{I_{DC} \cdot V_o}{\sqrt{2} \cdot 1000},$$

it then follows that:

$$I_{FUSE} \leq \frac{2}{\sqrt{2}} \cdot I_{DC} = 1.4\,I_{DC}$$

The fuses must also be able to carry the rms current resulting from the actual load, i.e., the rated field current, I_F, which is less or equal to the rated output, I_{DC}.

i.e., $I_{FUSE} \geq \frac{1}{\sqrt{2}} \cdot I_F = .7\ I_F$

it then follows that:

$.7\ I_F \leq I_{FUSE} \leq 1.4\ I_{DC}$

TRANSFORMER CONNECTIONS

Some of the various GPT transformer connections are shown in Figure 9. Figure 9a shows the most common arrangement with a centertapped secondary and a reconnectable primary. The maximum output voltage is 150V DC, but mostly used for 120V DC fields.

In Figure 9b a centertapped output is provided from a reconnectable secondary winding.

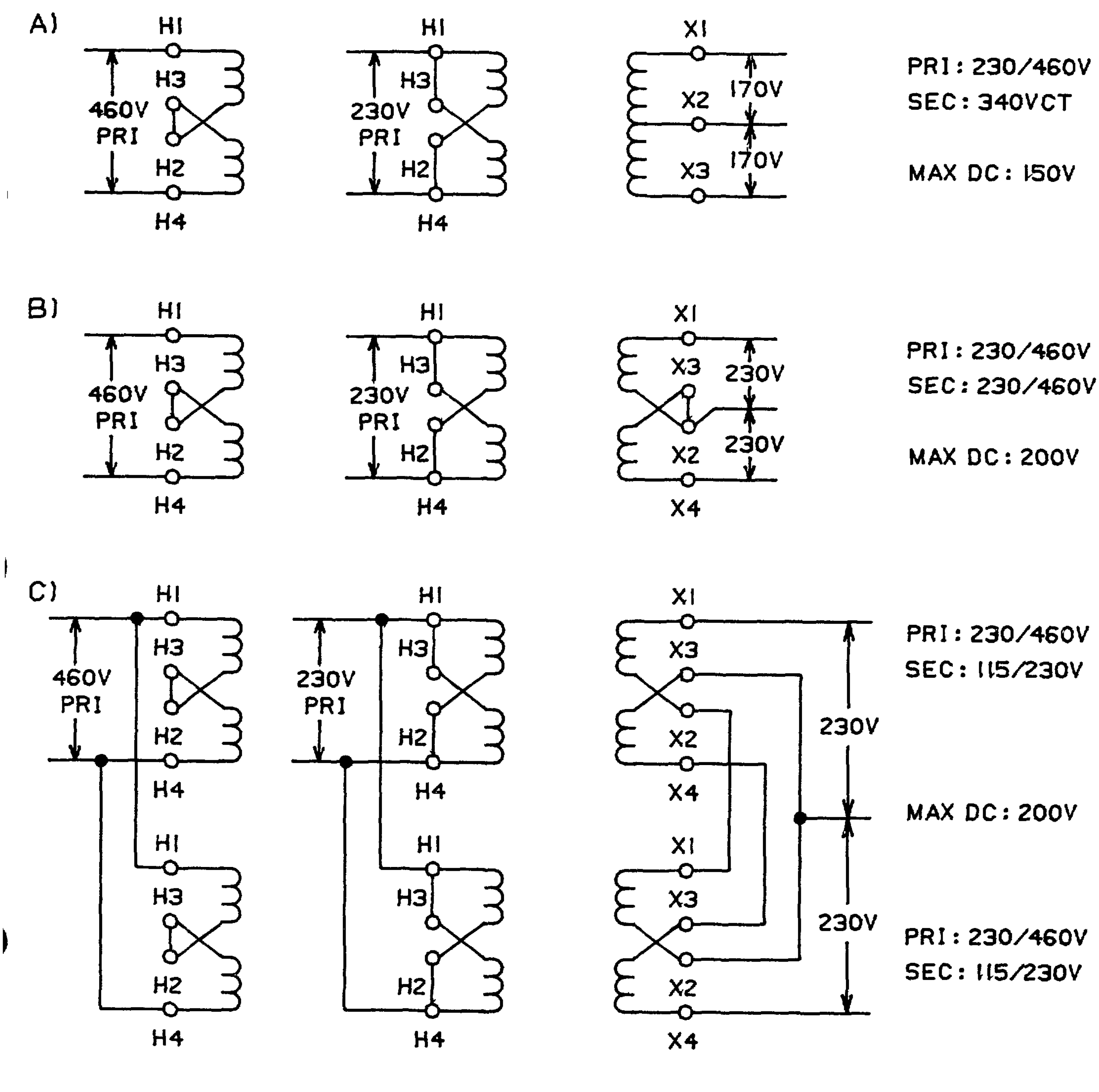
Figure 9c shows how two transformers can be used. In this arrangement, the secondary windings should be connected such that during each half cycle the output current flows through both transformers. This keeps the primary KVA loading less than the secondary KVA load as described before.

TABLE VI
JUMPER PROGRAMMING TABLE

FUNCTION	USE	LOC	JUMPERS
60 Hz		MFC	ZA-ZB
60 Hz		MCC	X-Y
50 Hz			None
IOC — 400%			None
— 500%		IFC	I-IHI
— 300%		IFC	I-ILO
SR 5-9V			None
9-20V		MCC	SRH-COM
L.T. .3-7 SEC			None
2-60 SEC		MCC	332 Ω, LT1—COM
CEMF REG.		IFC	NT-CEMF, CC-COM

TABLE VI
JUMPER PROGRAMMING TABLE
(continued)

FUNCTION	USE	LOC	JUMPERS
TACH 18-49V DC		IFC	NT-NT1, PT-PT1
VOLTS 46-123V DC		IFC	NT-NT2, PT-PT2
85-232V DC		IFC	NT-NT3, PT-PT3
MAX AMPS G1, 3, 4 / G2, 5, 6			MFC OR MFE
.8 / 1.7		MF	None
1.3 / 2.8		MF	YB—YD
2.4 / 5.0		MF	YA-YB
4.0 / 8.0		MF	YA-YB, YC—YD
7.0 / 13.0		MF	YA-YC
13.0 / 25.0		MF	YA-YC, YB—YD
L/R < .25 SEC		MFC	QA—QB
INHIBIT RUN		DGC	D1—D2
GEN. FIELD AMPS			
.8 — 1.7		MCC	None
1.3 — 2.7		MCC	B—D
2.6 — 5.5		MCC	A—B
3.7 — 8.2		MCC	A—B, C—D
7.4 — 15		MCC	A—C
13 — 25		MCC	A—C, B—D
23 — 49		MCC	A—E
45 — 70		MCC	A—E, A—C, B—D



Ⓒ FIG. 9 GPT TRANSFORMER CONNECTIONS

TABLE VII
TEST POINT VOLTAGES (MCC)

Test Point	Typical Voltages	Operating Mode
+20V	+19.9 to +20.1 VDC	
—20V	—19.9 to —20.1 VDC	
+30V	+30 to +40 VDC	
ALT	a) —20V	"LIN TIME" timing control
	b) +20V	"AUX TIME" timing control
ALM	+20V, (BLM —20V)	"A LIM" current limit control
BLM	+20V, (ALM —20V)	"B LIM" current limit control
	ALM —20V, BLM —20V	"CUR LIM" current limit control
CEMF	a) —5 to —5.8 VDC (PS)	Max. Fwd. Arm. Voltage
	b) +5 to +5.8 VDC (PS)	Max. Rev. Arm. Voltage
CFB	—2.5/+2.5V (PL)	100% Arm. Current — Fwd./Rev.
DP1	a) —20VDC	Normal Running
	b) +20 VDC	Diag. Static & Diag. Run
DP2	a) —20 VDC	Normal Running
	b) +20 VDC	Diag. Static
DR	+10/—10 VDC (PS)	100% Arm. Voltage — Fwd./Rev.
EAO	a) 0 to ±1V	Steady State
	b) +17/—17 VDC	Fwd. Accel./Rev. Accel.
FC	+4 to +10 VDC	Rated Motor Field Current
LR	0 to ±14 VDC	Diag. Static & Diag. Run
MAC	a) 0 to +4 VDC	Stopped, Diag. Static
	b) —17 to —20 VDC	Running, Diag. Run
PCR	—10/+10 VDC (PS)	Max. Gen. Field Voltage — Fwd./Rev.
PRE	a) 0 VDC	Stopped
	b) —3 to —4 VDC	Running & Diag. Run
RTR	a) +14 to +16 VDC	"READY TO RUN" Light On
	b) 0 to +1 VDC	Fault Condition
RUN	a) +30 to +40 VDC	Stopped
	b) —30 to —40 VDC	Running
FGC	—4 to —10V (PS)	100% Gen. Field Current — Fwd.
RGC	+4 to +10V (PS)	100% Gen. Field Current — Rev.
SFB	+10/—10 VDC (PS)	Max. Speed — Fwd./Rev.
SMAX	+2 to +5.7V/—2 to —5.7V (PS)	Max. Speed — Fwd./Rev.
SR	a) —5 to —9V/+5 to +9V (PS)	Max. Reference — Fwd./Rev.
	b) —9 to —20V/+9 to +20V (SRH-COM)	Max. Reference — Fwd./Rev.
SYS	a) 0 VDC	Normal Running
	b) +10 to +15 VDC	Fault Condition
TA	a) ±1/—17 VDC (MFC Card)	Fwd. — Below Base/Above Base Speed
	b)±1/+17 VDC (MFC Card)	Rev. — Below Base/Above Base Speed
TFB	—5.64/+5.64 VDC (PS)	Max. Speed — Fwd./Rev.
TR	—10/+10 VDC (PS)	Max. Reference — Fwd./Rev.
VFB	—5.5/+5.5 VDC (PS)	Max. Arm. Voltage — Fwd./Rev.
WFR	a) —.6 VDC	Running, Below Base Speed
	b) 0 to +7 VDC	Running, Above Base Speed

(PS) — Signal varies proportional to speed.

LATER

FIG. 10 COMPONENT AND SIGNAL CONNECTION LOCATION

TABLE VIII SIGNAL CONNECTIONS

ATB	NOMENCLATURE	DESCRIPTION
K1, K2, K3	K1, K2, K3	Three-phase power for motor field (MFC) and control transformer (CPT).
BTB NO.	**NOMENCLATURE**	**DESCRIPTION**
DCP, DCN	DCP, DCN	Voltage Feedback from DC generator armature. NOTE: DCP must be positive with SR negative.
IP, IN	IP, IN	Current Feedback signal from DC line, 100MV shunt. NOTE: IP must be positive for forward motoring current.
F1, F2	F1, F2	DC Motor Field connection from MFC.

TABLE VIII SIGNAL CONNECTIONS (continued)

2TB NO.	NOMENCLATURE	DESCRIPTION
1	30V	Unregulated negative DC voltage used as the return line for the CONTROL ON function and the static switch RUN and possible modifications.
2	CONTROL ON	If CONTROL ON is *not connected to* —30V the drive will not start. If CONTROL ON is opened with the drive operating, the contactor will open and the drive will coast.
3, 4	FLT	A normally open, held closed relay contact. Under normal conditions this contact is closed. If a fault condition is detected, this contact opens. Usually connected in the undervoltage circuit to remove control power.
5, 6, 7	MAX	A NO/NC relay contact which actuates when the contactor actuates.
8, 27	COM	Signal common. All signals are measured with respect to common, unless otherwise noted.
9	EST	External Fault Stop input. If EST is momentarily disconnected from common, the contactor will open and the motor will coast. The drive may not be restarted until the reset line is momentarily connected to COMMON. (See RESET below).
10, 11	FX1, X2	The internal 115V AC. FX1 is fused for external use.
12	RSET	Reset input. All fault shut downs inhibit the drive from starting until the fault has been cleared and the drive is reset. After the motor has come to a stop, the drive may be reset by momentarily connecting RSET to common. The drive will not restart until RSET is released from common. Momentarily connecting RSET to common or pushing the RESET BUTTON will initiate a coast stop shutdown.
13, 15, 16 17, 18, 19 24, 25	SP1, SP2, SP3 SP4, SP5, SP6 SP7, SP8	These are special purpose wires which are used to bring additional signals out of 2TB. Refer to the system elementary for details. Additional SP wires may be connected to 3TB and 4TB as required.
14	RUN	The drive will not start unless RUN is connected to —30V, either at 2TB or by special purpose logic in the MDR. When RUN is released from —30V, the drive will decelerate to a stop and open the MA contactor.

TABLE VIII SIGNAL CONNECTIONS (continued)

2TB NO.	NOMENCLATURE	DESCRIPTION
20, 21	+20V, —20V	Regulated power supply outputs.
22	***IMET***	Output to an optional 1ma load instrument. The instrument is calibrated with the ***IMET*** potentiometer on the Interface Card. ***IMET*** is an absolute (—) signal.
23	***SMET***	Output to a 1ma speed instrument. The instrument is calibrated with the ***SMET*** potentiometer on the Interface Card. ***SMET*** is an absolute (—) signal.
28	SR	Speed Reference input. (SR is negative for forward operation).
29, 30	TKP, TKN	Input connections for motor mounted D.C. tachometer or machine mounted D.C. tachometer. **NOTE:** TKP MUST BE POSITIVE WHEN SPEED REFERENCE IS NEGATIVE.

TABLE IX FAULT CONDITIONS

A fault has occurred if the fault relay contact (FLT) is open or if the "READY TO RUN" light is off. The conditions that can initiate a fault are as follows:

1. No three-phase power.
2. Loss of an incoming phase.
3. Incorrect phase rotation.
4. AC power fuse blown.
5. Control fuse is open.
6. Power supply plus or minus DC fuse is open.

** 7. Instantaneous overcurrent (IOC) level exceeded.

8. Motor thermo-switch (MTHSW). (If connected to fault circuitry).

* 9. Timed overcurrent (TOC) - electronic. (If connected to fault circuitry).

** 10. Loss of motor field.

11. External Fault Stop momentarily released from Common.

* 12. Other special functions to System Trip (SYS) or External Fault Stop inputs.

13. System Trip input (SYS) momentarily connected to +10 volts.
14. RESET button depressed or RSET input held connected to Common.
15. RESET button held depressed or RSET input held connected to Common.
16. Diagnostic mode selected with the motor rotating.
17. Oscillator (OSC) failed - "on."

* 18. Tachometer fault (loss of tachometer signal).

** 19. Overspeed.

* May not be provided. Refer to instructions on Motor Field Supply and System elementary diagram.

** Can be caused by ***LOC REF*** and ***CUR REF*** settings in Static Diagnostic mode.

After the fault condition has been cleared and the motor has come to standstill, the drive can be RESET by any of the following three methods:

1. Momentarily remove the three-phase power and re-apply.

2. Push the RESET button.

3. Momentarily connect RSET to common.

If all fault conditions have been cleared but the drive fails to RESET, the RSTOP adjustment may be set too low.

START-UP

This assembly is factory tested. It is ready to operate provided the external power and control connections have been properly made and the following step by step procedures are followed:

1. Verify that the terminal board screws are tight.

2. Verify that incoming power is the proper voltage and the incoming wiring is complete and correct.

3. If the diagnostic option is furnished, set the diagnostic switch to its NORMAL (center) position. Apply power to the drive. If the green "Ready to Run" light located on the lower left hand corner of the main control card (MCC) is not illuminated, press and release the RESET pushbutton on the panel below. If the light does not turn on, the most probable cause is incorrect incoming phase rotation. Remove power, reverse any two of the incoming AC power leads and repeat.

4. Verify that the reference voltage, SR, from 2TB(28) to 2TB(27) is variable with the external speed adjust controller.

5. With the generator rotating, set the local speed reference **LOC REF** potentiometer to its center position and switch into the diagnostic run **DIAG RUN** position. The MD contactor should not pick up. Slowly turn the **LOC REF** potentiometer away from the control until the motor starts to rotate. Verify that the system feedback signal on the SFB test point, located on the bottom of the main control card (MCC) has electrical polarity opposite to signal LR, and that VFB and CFB are the same polarity as LR. Turn the **LOC REF** potentiometer back to the center position and switch to **NORMAL**. If the feedback polarity was incorrect, remove power and interchange the motor field connections F1 and F2 on the BTB terminal board.

6. If no diagnostic card is available, set the external speed reference potentiometer to zero volts and press the START pushbutton. The MD contactor should pick up. Slowly turn the speed reference until the motor starts to rotate. Check motor rotation. If incorrect, remove power and interchange the motor field leads F1 and F2 on BTB terminal board.

7. Run the drive from the external speed reference up to top speed. Adjust **MAX SPEED** as may be required. DO NOT OVERSPEED.

8. Close and secure the doors of the power unit.

NOTE

ALWAYS READ THE COMPLETE INSTRUCTIONS PRIOR TO APPLYING POWER OR TROUBLESHOOT—ING THE EQUIPMENT. FOLLOW THE START-UP PROCEDURE STEP BY STEP.

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

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 ISOLATED FROM GROUND AND ITS METAL PARTS TREATED AS LIVE EQUIPMENT. USE OF AN INSTRUMENT HAVING BOTH LEADS ISOLATED FROM THE CASE PERMITS GROUNDING OF THE CASE, EVEN WHEN MEASUREMENTS MUST BE MADE BETWEEN TWO LIVE PARTS.

CAUTION

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

SEQUENCE OF OPERATION

POWER APPLIED

The control transformer (CPT) is energized through its primary fuses. The fans (if supplied) will come on.

The power supply card is energized and the DC output (±20 volt) are applied through their fuses to the rest of the cards. All readings carry a tolerance of ±10%.

The motor field supply is energized. Refer to the motor field supply instructions for details.

If no faults have been detected by the monitor section of the interface card, the fault relay, FLT, will close, and the "Ready to Run" indicator on the main control card will illuminate. Table IX tabulates the fault conditions which are monitored.

The oscillator will start, and the synchronizing signals SA, SB, SC will measure 8.5 volts RMS, (±10%).

SWITCH LOGIC

RUN will be connected to —30 volts by an internal relay interlock. The control line MAC from the main control card to the interface will be pulled down to —20 volts.

The interface card checks that no faults exist and that "control on" is connected to —30 volts before applying power to the coil of the pilot relay MAX.

MAX picks up, releasing the preconditioning signal PRE from common and applies power to the coil of the MD contactor.

When PRE is released from common, it switches to —3.5 volts which will release the main control card preconditioning after approximately 80 milliseconds.

Releasing preconditioning allows the drive to send firing pulses to the gates of the SCR's in the conversion module, and allows the normal signal flow to occur.

SIGNAL FLOW

If RUN is switched, the reference at SR is applied to the linear time section. The timed reference output, TR, will ramp to a voltage proportional to SR. The ***REF SCALE*** adjustment is used to set TR to 10.0 volts when the input at SR is set for top speed. The time for TR to ramp from 0 to 10 volts is adjustable from .3 to 60 seconds with the ***LIN TIME*** adjustment. See jumper table on system elementary. (Ranges: .3 to 7 sec. or 2 to 60 sec.).

The speed (or CEMF) feedback from the motor tachometer is scaled with a selectable resistor network on the interface card, and connected to TFB on the main control card. The output of the speed feedback section is SFB, and will be 10 volts at top speed. ***MAX SPEED*** is adjusted to make the actual top speed correspond to desired top speed.

The timed reference, TR, and the system feedback, SFB, are summed by the regulator error amplifier. The error amplifier output, EAO, will be a low voltage (nearly zero) when the drive is regulating voltage. EAO will not be low when the drive is in current limit. The gain of the error amplifier is set with the ***GAIN*** adjustment. The ***GAIN*** adjustment is used primarily to improve the response of the drive in the constant horsepower region when the motor field supply is a motor field control, MFC.

To maintain good load regulation, the error amplifier is fed into the regulator integrator. The output of the integrator is the reference, DR, to the driver. The response of the control below base speed is set with the ***RESPONSE*** adjustment.

There is a limit, however, to how responsive a drive may be set. Stability of the drive is decreased as its response is increased.

To protect the system, the current limit drives the regulator integrator and will override and the error amplifier. The current limit is set with the ***CUR LIMIT*** adjustment. Typically, the current limit is set at 150% of the motor nameplate current or 3.75 volts (±10%) of current feedback, CFB.

The counter EMF signal CEMF is developed on the main control card by subtracting a signal proportional to the IR drop of the motor from voltage feedback. This is set with the ***COMP*** adjustment.

The driver reference, DR, is connected by a card jumper to GFR, the generator field current reference. This signal is compared with the generator field current feedback to produce the field current regulator output, PCR.

PCR is the phase-control reference which causes the output pulse trains to phase shift in time with respect to the AC line. As PCR moves from zero to 10 volts (±10%), the output pulses will shift from full off to full on. PO is used to monitor the pulse outputs to the SCR's.

STOP

There are two stop sequences, normal stop and fault stop. With a normal stop the drive regenerates to near zero speed before opening the contactor. A fault stop opens the contactor and drive coasts to a stop.

Normal stop (disconnect RUN from —30 volts).

RUN will switch from —30 volts to +30 volts. MAC will switch to zero volts and the system reference input to the linear time section will be shunted to common.

The timed reference, TR, will begin to time down to zero and the drive speed will come down accordingly.

The regenerative stop circuit on the interface card will hold the contactor closed until the CEMF signal is almost zero, corresponding to zero speed. At this time, the preconditioning signal, PRE, goes to common, removing power from the MAX coil. MAX drops out removing power from MD, which then drops out. The CEMF level corresponding to zero speed is set by the ***RSTOP*** adjustment. If ***RSTOP*** is set too far CW, power is removed prematurely and the drive will coast into zero speed. If ***RSTOP*** is set too far CCW, the contactor will not open at all.

FAULT STOP — Fault detected (See Table IX) or CONTROL ON is open.

The preconditioning signal, PRE, is immediately applied to the main control card, forcing the TR into zero. After about 0.5 seconds, preconditioning is established throughout the card.

The MAX relay unconditionally drops out 100 milliseconds after the fault condition occurs.

The drive cannot be restarted until the motor has come to rest. If the STOP was initiated by a fault, this is taken care of automatically, but it is the purchaser's responsibility to not reclose "CONTROL ON" before the motor has come to rest. After the motor has stopped, push the RESET button.

DIAGNOSTIC STATIC (SWITCH TO LEFT)

LOGIC

The RUN input is inhibited. This prevents the reference, SR, from activating the drive and holds the contactor open.

The current reference potentiometer ***CUR REF*** controls the current feedback signal, CFB.

The local reference ***LOC REF*** potentiometer is connected into the input of the linear time section and into the system feedback section. The local reference is also connected to the field diagnostic reference, FDR. Refer to the motor field control instructions (GEK-24971) for details of operation.

To simplify tracing, the gain of the regulator and drive is reduced and the system feedback signal to the regulator error amplifier is removed.

SIGNAL FLOW

The local reference, LR, is applied directly to the input of the linear time section, by-passing the ***REF SCALE*** adjustment. The timed output, TR, will ramp to a voltage equal to LR in magnitude and polarity in a time determined by the setting of ***LIN TIME***.

The local reference, LR, is also applied to the input of the last stage of the system feedback section. The output, SFB, will be equal to LR in magnitude, but opposite in polarity. The tachometer scaling circuit and its output, TFB, are unaffected by the local reference and will remain at zero. The signal from SFB into the regulator error amplifier is inhibited. The primary purpose of exercising SFB is to check any special function circuits in the modification rack which are programmed from SFB, and/or SFB functions of an MFC.

A dummy feedback signal to replace the normal SFB signal is connected from the output of the regulator integrator output, DR, to the input of the regulator error amplifier. Under these conditions, DR is equal to the magnitude of TR but opposite in polarity as long as the current reference is zero. When the current reference is raised, the current feedback signal, CFB, will exceed the current limit level set by ***CUR LIM*** and force the DR output into negative saturation for forward current limit and positive saturation for reverse current limit.

The current reference will also program the CEMF output to a level proportional to the CFB level and the ***COMP*** adjustment.

The load instrument output, IMET, will also respond to the current reference.

The gain of the field current regulator is reduced so that the phase-control reference, PCR, is proportional to the magnitude of the driver reference, DR, and the setting of the ***IMAX*** potentiometer.

With an oscilloscope, the pulse output, PO, may be monitored to verify proper operation.

DIAGNOSTIC RUN (SWITCH RIGHT)

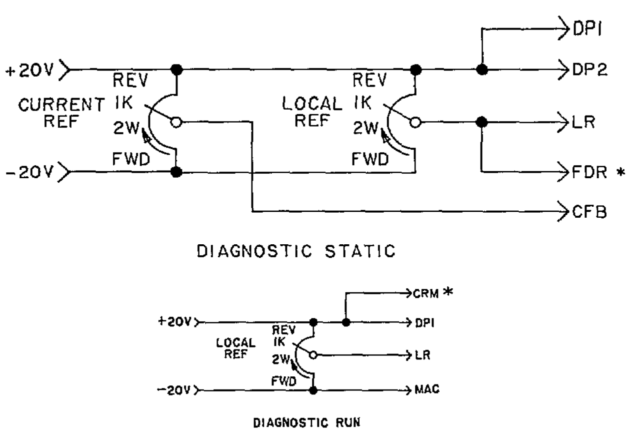
In diagnostic run, the local reference, LR, and the diagnostic switch are substituted for the reference, SR, and the RUN switch input just as in diagnostic static. The drive then runs normally with one important exception: system feedback is normal but the signal from system feedback to the regulator error amplifier is inhibited and the dummy feedback from DR is still in place. — i.e., the system regulator operates at unity gain. The net effect is that the drive operates as a generator field current regulator from the ***LOC REF*** potentiometer.

CALIBRATION PROCEDURE

The diagnostic card is used to generate the appropriate test signals and operating modes to calibrate the drive. If a diagnostic card has not been furnished, one may be ordered or the test circuit shown in Figure 11 may be used.

Make all connections prior to applying input power. To exit from the DIAGNOSTIC RUN mode, push the RESET button to initiate a fault shutdown, then remove input power.

*All connections may be made to the test posts on the front of the main control card except for CRM and FDR which are located on the RTB terminal board.



© FIG. 11 DIAGNOSTIC TEST CIRCUITS

To avoid confusion and possible interaction, the adjustments should be made in the following sequence. Two sequences are listed, one when a motor field exciter, MFE, is provided, and one when a motor field control, MFC, is provided. Refer to the system elementary to determine which has been furnished.

TABLE X
Recalibrating Adjustment Sequences

	WITH MOTOR FIELD CONTROL	WITH MOTOR FIELD EXCITER
DIAGNOSTIC STATIC MODE, ADJUST	***FIZ, RIZ***	***FIZ, RIZ***
	FMAX	
	FMIN*	
	FLOSS	***FLOSS***
	SLIM	
	CROSS*	
	LIN TIME	***LIN TIME***
	COMP	***COMP***
	CUR LIMIT	***CUR LIMIT***
	IMET (IF USED)	***IMET (IF USED)***
DIAGNOSTIC RUN MODE, ADJUST	***MAX SPEED***	***MAX SPEED***
	ALIGN	
	SMET (IF USED)	***SMET (IF USED)***
NORMAL MODE, ADJUST	***REF SCALE***	***REF SCALE***
	MAX SPEED (TRIM)	***MAX SPEED (TRIM)***
	IMAX	***IMAX***
	GAIN	***GAIN***
	RESPONSE	***RESPONSE***
	RSTOP	***RSTOP***

*NOTE: A motor field control card may be furnished on base speed drives (constant field) to provide field economy, tach monitor, or field current regulation. Set ***CROSS*** full CW and ***FMIN*** per test data sheet.

All of the high voltage inputs to the controller have been scaled down with the scale factors shown on the test data sheet.

For example: On a 240V motor voltage feedback VFB will be be 5 volts when the armature voltage is 216 volts. If VFB is 3.2 volts, then the armature voltage is 3.2 X 216/5 = 138 volts. If armature voltage is 67 volts, VFB will be 67 X 5/216 = 1.55 volts. All values have a tolerance of ±10%.

CALIBRATION WITH MOTOR FIELD CONTROL (MFC)

All readings can have a tolerance of ±10%.

Select Diagnostic static and set the ***CUR REF*** and ***LOC REF*** to the center positions.

FIZ, RIZ **(Forward and reverse current zero adjust)**

Adjust ***FIZ*** for FGC = 0 to —.05 volts.
Adjust ***RIZ*** for RGC = 0 to +.05 volts.

FMAX **(Maximum Field)**

Set the ***LOC REF*** potentiometer for —1 volt at LR. Adjust ***FMAX*** until FC corresponds to maximum field FC on the test data sheet.

FMIN **(Minimum Field — Limit)**

Set ***LOC REF*** potentiometer for —7 volts at LR. Adjust ***FMIN*** until FC corresponds to minimum field FC on the test data sheet.

FLOSS **(Field Loss — Fault)**

Set the ***LOC REF*** to center position and reset the drive. Adjust ***FLOSS*** full CCW.

Monitor FC and move the ***LOC REF*** potentiometer Rev until FC corresponds to the field loss value on the test data sheet. Slowly rotate ***FLOSS*** CW until the "Ready to Run" light turns off indicating a drive fault. Reset the drive.

SLIM **(Speed Limit — Overspeed Fault)**

Set the ***LOC REF*** to center position and reset the drive. Adjust ***SLIM*** full CW.

Monitor SFB and move the ***LOC REF*** potentiometer Fwd until SFB corresponds to the overspeed limit on the test data sheet. Slowly adjust ***SLIM*** CCW until the "Ready to Run" light turns off indicating a drive fault.

CROSS **(Cross Over — Field)**

Set ***CROSS*** full CCW. Turn the ***LOC REF*** potentiometer Fwd until LR corresponds to the cross over LR on the test data sheet.

Monitor FC and adjust ***CROSS*** CW until FC just starts to increase. ***CROSS*** may be checked when the drive is running in normal operation by verifying that CEMF reads the value on the test data sheet with the drive operating above base speed.

LIN TIME **(Linear Time)**

Monitor TR and set to —10V with the ***LOC REF*** potentiometer. Switch to NORMAL, then back to DIAGNOSTIC STATIC and measure the time for TR to ramp to —10 volts (±10%). Adjust ***LIN TIME*** until this time corresponds to the test data sheet linear time.

COMP **(Compensation — IR)**

Set the ***LOC REF*** potentiometer to center position. Adjust the ***CUR REF*** potentiometer Fwd or Rev until CFB is at 5 volts (±10%).

Monitor CEMF and adjust ***COMP*** until CEMF equals the value on the test data sheet.

CUR LIMIT **(Current Limit)**

Set ***CUR LIMIT*** full CW. Adjust the ***CUR REF*** potentiometer until CFB corresponds to the current limit level on the test data sheet. Monitor DR and turn ***CUR LIMIT*** CCW until DR just moves away from zero.

IMET **(Load Instrument Calibration)**

Adjust the ***CUR REF*** until CFB corresponds to full load current. Verify that the optional load instrument reads full load. If not, remove power; adjust ***IMET*** and repeat.

Set the ***LOC REF*** to the center position; reset the drive and switch to Diagnostic Run.

MAX SPEED/ALIGN **(Max Speed/Tachometer Loss Align-Fault)**

Turn ***MAX SPEED*** full CCW. Turn ***ALIGN*** full CW. Adjust the ***LOC REF*** potentiometer until CEMF reads 5 volts (±10%). Adjust ***MAX SPEED*** until SFB corresponds to the base speed feedback on the test data sheet.

Monitor TA and adjust ***ALIGN*** CCW until TA is approximately zero volts.

SMET (Speed Instrument Calibration)

Turn the ***LOC REF*** potentiometer until SFB is 3 volts (±10%). The optional speed indicator should indicate 30% top speed. If it does not, push the RESET button to initiate a shut down. Remove power, adjust ***SMET*** and repeat.

Return the Diagnostic Switch to Normal.

REF SCALE/MAX SPEED (Reference Scale/Max Speed)

Turn ***REF SCALE*** full CCW. Start the drive and apply top speed reference to SR. Adjust the ***REF SCALE*** potentiometer until SFB is 10 volts (±10%). This normalizes the timed reference, TR, and speed feedback, SFB for 10 volts (±10%) at top speed.

Now measure motor RPM and adjust ***MAX SPEED*** (if necessary) until the actual RPM corresponds to the desired top speed. If actual top RPM was off by more than 5% reset ***ALIGN*** as detailed above.

IMAX (Field Current Reference Calibration)

Adjust ***IMAX*** for DR = 10 volts with the generator operating at rated voltage.

RSTOP (Regenerative Stop)

With the monitor operating at some RPM, call for a drive stop by initiating the proper magnetics which will release 2TB-14 from —30 volts. The motor will decelerate to a low speed and the contactor will open. If the contactor opens before the drive comes down to a stop, ***RSTOP*** is set too far CW. If the contactor fails to open, ***RSTOP*** is set too far CCW. Push the RESET button to drop out the contactor prior to removing power. ***RSTOP*** should be readjusted with power removed.

GAIN, RESPONSE, and ***COMP*** (Stability Adjustments)

1. Place the Diagnostic switch in the static mode. Adjust ***CUR REF*** for 2.5 volts at test pin, CFB. This is equivalent to rated armature current.

2. Set ***COMP*** potentiometer by reading at the CEMF test pin a value equal to 0.0312 (240V — motor CEMF) for 240V drives. For 500V drives use .0148 (500V — motor CEMF).

   Typical values of motor counter EMF:

TABLE XI MOTOR COUNTER EMF's

MOTOR HORSEPOWER	MOTOR COUNTER EMF	
	240V	500V
5 to 15	215	455
20 to 40	225	470
50 to 125	230	480
150 to 250	——	490

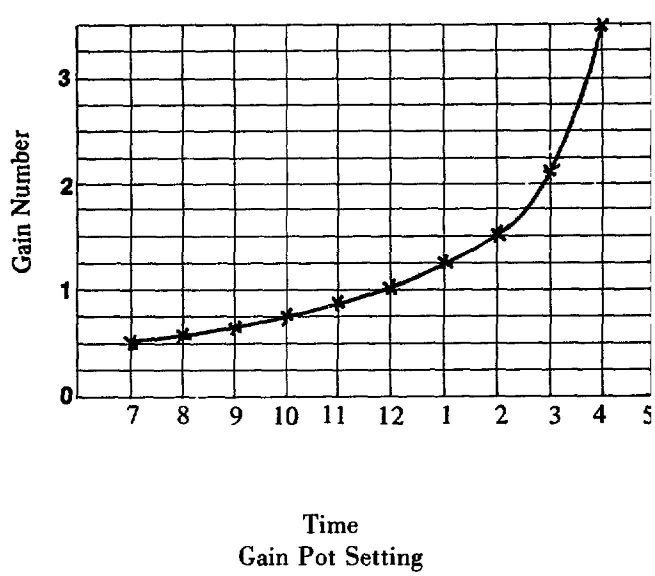
The reading at CEMF test pin is a voltage proportional to motor CEMF.

Example: 20 to 40 HP @ 240V
CEMF = 0.0312 (240 — 225)
= 0.468 volts

The ***COMP*** potentiometer is now set for proper operation. Regardless of overload range, IOC setting or motor field range this setting is correct and should not be changed.

4. Set the ***GAIN*** adjustment by calculating the Gain number and referring to the chart (Fig. 24).

$$\text{Gain No} = \frac{\text{Maximum Operating Speed}}{\text{Motor Base Speed}}$$



After this setting has been made, make no further adjustments to the Gain Pot.

FIG. 12 GAIN ADJUSTMENT

See motor nameplate under — Speed.

Motor Base Speed/Maximum Operating Speed.

Example: 1150/2000 RPM

5. Set ***LIN TIME*** potentiometer at minimum (7 o'clock).

6. Set ***RESPONSE*** potentiometer at minimum (7 o'clock).

   When the drive is functioning properly in all other respects, make small incremental step increases and decreases in speed below base speed. Observe armature current for bumping repeatedly before steady state speed is attained.

   Increase the ***RESPONSE*** setting (move CW) until bumpy current is observed. Then reduce the ***RESPONSE*** setting until no bumps (or only one) is observed. This is the maximum ***RESPONSE*** setting.

   In general, settings below 10 o'clock will show signs of increasing sluggishness. Settings greater than 2 o'clock may show signs of hard or even continuous bumping. Full ***RESPONSE*** setting (5 o'clock) will usually trip the IOC.

7. RESET ***LIN TIME*** to required setting.

CALIBRATION WITH MOTOR FIELD EXCITER (MFE)

Refer to motor field exciter instructions GEK-24972 for details of operation.

Select Diagnostic Static and set ***CUR REF*** and ***LOC REF*** to the center positions.

FIZ, RIZ (Forward and reverse current zero adjust)

Adjust ***FIZ*** for FGC = 0 to —.05 volts.
Adjust ***RIZ*** for RGC = 0 to +.05 volts.

FLOSS (Field Loss — Fault)

Adjust ***FLOSS*** full CCW and reset.

Monitor FC and move the ***LOC REF*** Rev until FC corresponds to the field loss value on the test data sheet. Slowly adjust ***FLOSS*** CW until the "Ready to Run" light turns off indicating a drive fault. Reset the drive.

COMP (Compensation — IR)

Adjust the ***LOC REF*** potentiometer to the center position. Adjust the ***CUR REF*** potentiometer Fwd or Rev until CFB is at 5 volts (±10%).

Monitor CEMF and adjust ***COMP*** until CEMF equals the value on the test data sheet.

CUR LIMIT (Current Limit)

Adjust ***CUR LIMIT*** full CW. Turn the ***CUR REF*** potentiometer until CFB corresponds to the current limit value on the test data sheet.

Monitor DR and turn ***CUR LIMIT*** CCW until DR just moves away from zero.

IMET (Load Instrument Calibration)

Turn the ***CUR REF*** until CFB corresponds to full load current. Verify that the optional load instrument reads full load. If not, remove power, adjust ***IMET*** and repeat.

LIN TIME (Linear Time)

Monitor TR and set to —10V with the ***LOC REF.*** Switch to NORMAL, then back to DIAGNOSTIC STATIC and measure the time for TR to ramp to 10 volts (±10%). Adjust ***LIN TIME*** until this time corresponds to the test data sheet linear time.

Set the ***LOC REF*** to the center position and switch to Diagnostic Run.

MAX SPEED (Maximum Speed)

Turn ***IMAX*** CW, and adjust the ***LOC REF*** until the motor is running at actual top speed. Adjust ***MAX SPEED*** until SFB is 10 volts (±10%).

SMET (Speed Instrument Calibration)

Turn the ***LOC REF*** potentiometer until SFB is 3 volts (±10%). The optional speed indicator should indicate 30% top speed. If it does not, push the RESET button to initiate a shut down. Remove power, adjust ***SMET*** and repeat.

Return the Diagnostic switch to Normal.

REF SCALE (Reference Scale)

Turn ***REF SCALE*** full CCW. Start the drive and apply top speed reference to SR. Adjust the ***REF SCALE*** potentiometer until SFB is 10 volts (±10%). This normalizes the timed reference, TR, and speed feedback, SFB for 10 volts (±10%) at top speed.

RSTOP (Regenerative Stop)

With the motor operating at some RPM, call for a drive stop by initiating the proper magnetics which will release 2TB-14 from —30 volts. The motor will decelerate to zero speed and the contactor will open. If the contactor opens before the drive comes down to a stop, ***RSTOP*** is set too far CW. If the contactor fails to open, ***RSTOP*** is set too far CCW. Push the RESET button to drop out the contactor prior to removing power. ***RSTOP*** should be adjusted with power removed.

GAIN, *RESPONSE*, and *COMP* (Stability Adjustments)

1. Place the Diagnostic switch in the static mode. Adjust ***CUR REF*** for 2.5 volts at test pin CFB. This is equivalent to rated armature current.

2. Set ***COMP*** potentiometer by reading at the CEMF test pin a value equal to 0.0312 (240V — motor CEMF) for 240V drives. For 500V drives use .0148 (500V — motor CEMF).

   Typical values of motor counter EMF:

TABLE XI MOTOR COUNTER EMF's

MOTOR HORSEPOWER	MOTOR COUNTER EMF	
	240V	500V
5 to 15	215	455
20 to 40	225	470
50 to 125	230	480
150 to 250	——	490

The reading at CEMF test pin is a voltage proportional to motor CEMF.

Example: 20 to 40 HP @ 240V

CEMF = 0.0312 (240 — 225)
= 0.468 volts

The ***COMP*** potentiometer is now set for proper operation. Regardless of overload range of IOC setting is correct and should not be changed.

4. Set the ***GAIN*** adjustment to minimum 7 o'clock position.

5. Set ***LIN TIME*** potentiometer at minimum 7 o'clock position.

6. Set ***RESPONSE*** potentiometer at minimum 7 o'clock position.

   When the drive is functioning properly in all other respects make small incremental step increases in speed. Observe armature current for bumping repeatedly before steady state speed is attained.

   Increase the ***RESPONSE*** setting (move CW) until bumpy current is observed. Then reduce the ***RESPONSE*** setting until no bumps (or only one) is observed. This is the maximum ***RESPONSE*** setting.

   In general, setting below 10 o'clock will show signs of increasing sluggishness. Settings greater than 2 o'clock may show signs of hard or even continuous bumping. Full ***RESPONSE*** setting (5 o'clock) will usually trip the IOC.

7. Reset ***LIN TIME*** to required setting.

TROUBLE SHOOTING

Although many of the problems which may arise can be effectively located with a multi-meter, an oscilloscope is a very powerful trouble shooting tool. The only requirements are that the selected scope have a DC input capability and a line synchronization mode. Caution should be exercised in measuring any point with a possible high potential with any instrument; however, particular care should be taken with an oscilloscope since the common clip is normally connected directly to the instrument case. If the grounded plug has not been defeated, it will cause a short circuit between the high potential point under test and ground.

RECOMMENDED INSTRUMENTATION

Simpson Multi-meter (or equivalent) 10,000 ohms/volt (or higher).

Hewlett-Packard, Tektronix or equivalent Dual Trace oscilloscope rated for operation from DC to 10 MHZ at 0.01V/CM with deflection factors to provide 0.01 V/CM to 1300 peak to peak deflection when used with appropriate attentuator probes.

PROCEDURES

In trouble shooting this drive system, the most appropriate place to start is to follow the SEQUENCE OF OPERATION (previously described) until a discrepancy or fault is noted. This step by step procedure will determine which part, sub-assembly or printed circuit card is causing the problem.

Included in this procedure is the use of the built-in Diagnostic Card (DGC) (or Test Circuit Fig. 11). This is another powerful tool for quickly locating drive system faults.

If the malfunction is a performance problem, then the quickest way to discover the problem is to follow the CALIBRATION PROCEDURE (previously described). There are two calibration procedures: (1) With Motor Field Control (MFC) and (2) With Motor Field Exciter (MFE).

Detailed adjustments for these two cards are found in GEK-24971 for the MFC card and GEK-24972 for the MFE card.

REMOVAL/REPAIR

PRINTED CIRCUIT CARDS

There should be no need to retune the drive after removal/repair of a conversion module, an SCR or any other removable sub-assembly unless, of course, an adjustment was inadvertently moved or disturbed. If a printed circuit card is replaced (other than the power supply card PSC):

1. Add stab-on jumpers to the replacement card just like the jumpers on the card that was replaced or as listed on the System Elementary Diagram "Programming" Table.

2. Add stab-on resistors and capacitors to the replacement card just like the components on the card that was replaced or as shown with values on the system elementary main control card (MCC) at stab-on terminals TL, RJ, SFB, DR, CL1, CLJ, PCJ, PC1 and PCR.

3. Set the potentiometers on the replacement printed circuit card to the position as was set on the card that was replaced or the position shown on the test data sheet. Recheck the recalibration procedures described.

4. Use caution when connecting or disconnecting stab-on connectors on the printed circuit cards to avoid breaking of the connector posts. Support the card if possible and use a pair of long nosed pliers to hold on to the connector crimp. Avoid pulling on wires when removing connectors.

HOW TO TEST AN SCR

WARNING

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

1. Disconnect the AC power and make sure the loop contactor (MD) is open.

2. Using a multi-meter selected to read ohms on the times 1K scale, check the forward and reverse resistance of SCR cell pairs. This is done by reading across power terminals K11 and GF, and K12 and GF. Be sure that the AC line fuses FU1 and FU2 are not open in the above check. If a zero reading is obtained, disconnect the anode leads and check each SCR individually.

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

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

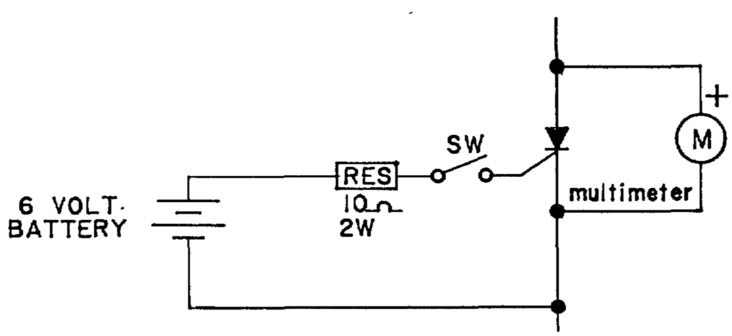


FIG. 13 SCR TEST CIRCUIT

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

4. If any SCR's are suspected of being faulty from the above resistance checks, the SCR should be removed. After the SCR cathode and gate leads have been disconnected, recheck the forward and reverse resistances before replacing the SCR. This should be done before any SCR is definitely classified as damaged or faulty, since a fault in another SCR or another part of the circuitry can produce a faulty reading from a good SCR before it is disconnected from the circuit.

SCR REMOVAL

An SCR is best removed as follows:

Disconnect the cathode lead from the current transformer stud.

Disconnect the SCR gate leads from the terminal board MTB. If markings are not legible, remark prior to removal. Remove the nut on the SCR anode and remove the SCR.

SCR REPLACEMENT

The joint between the SCR and the heat sink performs two functions (1) it carries the current and (2) it conducts the heat out of the SCR. To perform these functions properly, special care must be taken when reassembling an SCR to the heat sink.

Clean all surfaces of old lubricant and stray dust. Apply a thin film of General Electric G322L VERSILUBE™ and tighten with a torque wrench to 30 inch-pounds.

FANS (If supplied)

Remove the fan wires from the terminal board assembly and remove the two screws holding the terminal board assembly to the fan shelf. Loosen the two nuts on the bottom of the fan bracket and slide the fan bracket out.

GLOSSARY OF TERMS

	Page
ALIGN — Tachometer Loss Align Adjustment	20, 32, 33, 34
ALIM — A Current Limit Adjust Pot For A Current Limit	13, 24
ALM — A Current Limit Switch Input	13, 24
ALT — Auxiliary Linear Time Switch Input	24
AUX TIME — Auxiliary Linear Time Adjustment	13, 24
BLIM — B Current Limit Adjust Pot For B Current Limit	13, 24
BLM — B Current Limit Switch Input	13, 24
*CEMF — Counter EMF	11, 12, 13, 16, 22, 24, 30, 31, 33, 34, 35, 36
*CFB — Current Feedback	13, 20, 24, 29, 30, 31, 33, 34, 35, 36
*COM — Regulator Common	11, 12, 13, 17, 22, 26, 28
COMP — IR Compensation Adjustment	12, 13, 30, 31, 32, 33, 34, 35, 36
CPT — Control Power Transformer	11, 25, 29
CRM — Diagnostic Run Input	32
CROSS — Crossover Adjustment	20, 32, 33
CUR REF — Diagnostic Current Reference Potentiometer	20, 28, 31, 33, 34, 35
CUR LIMIT — Current Limit Adjustment	13, 24, 30, 31, 32, 33, 35
Diagnostic — Normal	20, 24, 29, 31, 32, 34, 35
Diagnostic — Run	20, 24, 29, 31, 32, 33, 35
Diagnostic — Static	20, 24, 28, 29, 31, 32, 33, 34, 35, 36
DFP — Delayed Firing Power	16
DGC — Diagnostic Card	11, 20, 22, 37
*DMAC — Diagnostic Card	11
*DM1—DM8 — Dummy Input/Output Points	17
*DP1—DP2 — Diagnostic Switching Signals	24
*DR — Driver Reference	13, 17, 24, 30, 31, 33, 34, 35, 37
*EAO — Error Amplifier Output	24, 30
EST — External Fault Stop	26
F1-F2 — Motor Field Connections	25
*FC — Field Current Signal	24, 33, 35
FDR — Field Diagnostic Reference (DFDR)	11, 20, 31, 32
*FGC — Forward Current Signal	16, 17, 24, 33, 35
FIZ — Forward Offset Adjustment	16, 32, 33, 35
FLOSS — Field Loss Adjustment	20, 32, 33, 35
FLT — Fault Relay	11, 17, 20, 26, 28, 30, 31
FMAX — Motor Field Maximum Adjustment	20, 32, 33
FMIN — Motor Field Minimum Adjustment	20, 32, 33
GAIN — Speed Loop Gain Adjustment	30, 32, 34, 36
GFR — Max Current Monitoring Point	16, 30
GPT — Generator Power Transformer	11, 12, 13, 15, 21, 22

TEST Points Located on Door Front (See MCC Illustration, Fig. 4)
(1) Also see Motor Field Control Instructions, GEK-24971

GLOSSARY OF TERMS
(continued)

Page

ICAL — Calibration Adjustment For CFB ... 17
IFC — Interface Card ... 11, 12, 17, 19, 22
IMAX — Gain Adjustment For Field Current Regulator ... 16, 31, 32, 34, 35
IMET — Current (Load) Instrument Output Adjustment ... 17, 27, 31, 32, 33, 35
IOC — Instantaneous Over Current ... 28, 34, 35, 36
IZERO — Bias Adjustment For CFB ... 17

LIN TIME — Linear Timing Adjustment ... 13, 24, 30, 31, 32, 33, 35, 36
LOC REF — Diagnostic Local Reference Potentiometer ... 20, 28, 29, 31, 32, 33, 34, 35
*LR — Local Reference from DGC ... 20, 24, 29, 31, 33

MA — Line Contactor ... 26
*MAC — MAX Control Signal ... 11, 16, 20, 24, 29, 30
MAX — Pilot Relay for M ... 11, 16, 17, 19, 20, 26, 30, 31
MAX SPEED — Adjustment ... 12, 29, 30, 32, 33, 34, 35
MCC — Main Control Card ... 11, 12, 13, 17, 18, 21, 22, 29, 37
MD — DC Line Contactor ... 11, 29, 30, 31, 37
MDR — Modification Rack ... 11, 12, 13, 17, 26
MFC — Motor Field Control Card ... 11, 13, 19, 20, 22, 24, 25, 28, 30, 31, 33, 37
MFE — Motor Field Exciter Card ... 20, 22, 32, 35, 37

OSC — Oscillator ... 28

*PCR — Phase Control Reference ... 16, 24, 30, 31, 37
PO — Pulse Outputs ... 30, 31
*PRE — Preconditioning ... 16, 24, 30, 31
PSC — Power Supply Card ... 11, 19, 24, 37

REF SCALE — Adjustment ... 13, 30, 31, 32, 34, 35
RESPONSE — Speed Loop Response Adjustment ... 30, 32, 34, 35, 36
RESET — Pushbutton ... 17, 26, 28, 29, 31, 32, 34, 35
*RGC — Reverse Current Signal ... 16, 17, 24, 33, 35
RIZ — Reverse Offset Adjustment ... 16, 32, 33, 35
RSET — Reset Input ... 2, 28
RSTOP — Regenerative Stop Adjustment ... 16, 17, 28, 31, 32, 34, 36
*RS1, RS2 — Synchronizing Signals ... 11, 21
*RTR — "Ready to Run" Indicator ... 24, 28, 29, 33, 35
*RUN — Run Switch Input ... 16, 24, 26, 30, 31

SA, SB, SC — Synchronizing Signals ... 30
*SFB — System Feedback ... 13, 17, 19, 24, 29, 30, 31, 33, 34, 35, 36, 37

*TEST Points Located on Door Front (See MCC Illustrations, Fig. 4)
(1) Also see Motor Field Control Instructions, GEK-24971

GLOSSARY OF TERMS
(continued)

Page

SLIM — Speed Limit Adjustment 32, 33
SMAX — Max Speed Adjustment 24
*SMET — Speed Instrument Output and Adjustment 17, 27, 32, 34, 35
*SR — Speed Reference 11, 13, 24, 25, 27, 29, 30, 31, 34, 35
SYNC — Synchronizing Input 16
*SYS — System Fault Trip 24, 28
TA — Tachometer Align Output 24, 33
*TFB — Tachometer Feedback Signal 11, 12, 13, 24, 30, 31
TKN — Negative Tachometer Input 27
TKP — Positive Tachometer Input 27
*TR — Timed Reference 12, 13, 17, 24, 30, 31, 33, 34, 35, 36

*VFB — Voltage Feedback 12, 24, 29, 32
*WFR — Weak Field Reference 20, 24

ZERO ADJ — Zero Adjustment 13

*TEST Points Located on Door Front (See MCC Illustrations, Fig. 4)
(1) Also see Motor Field Control Instructions, GEK-24971

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