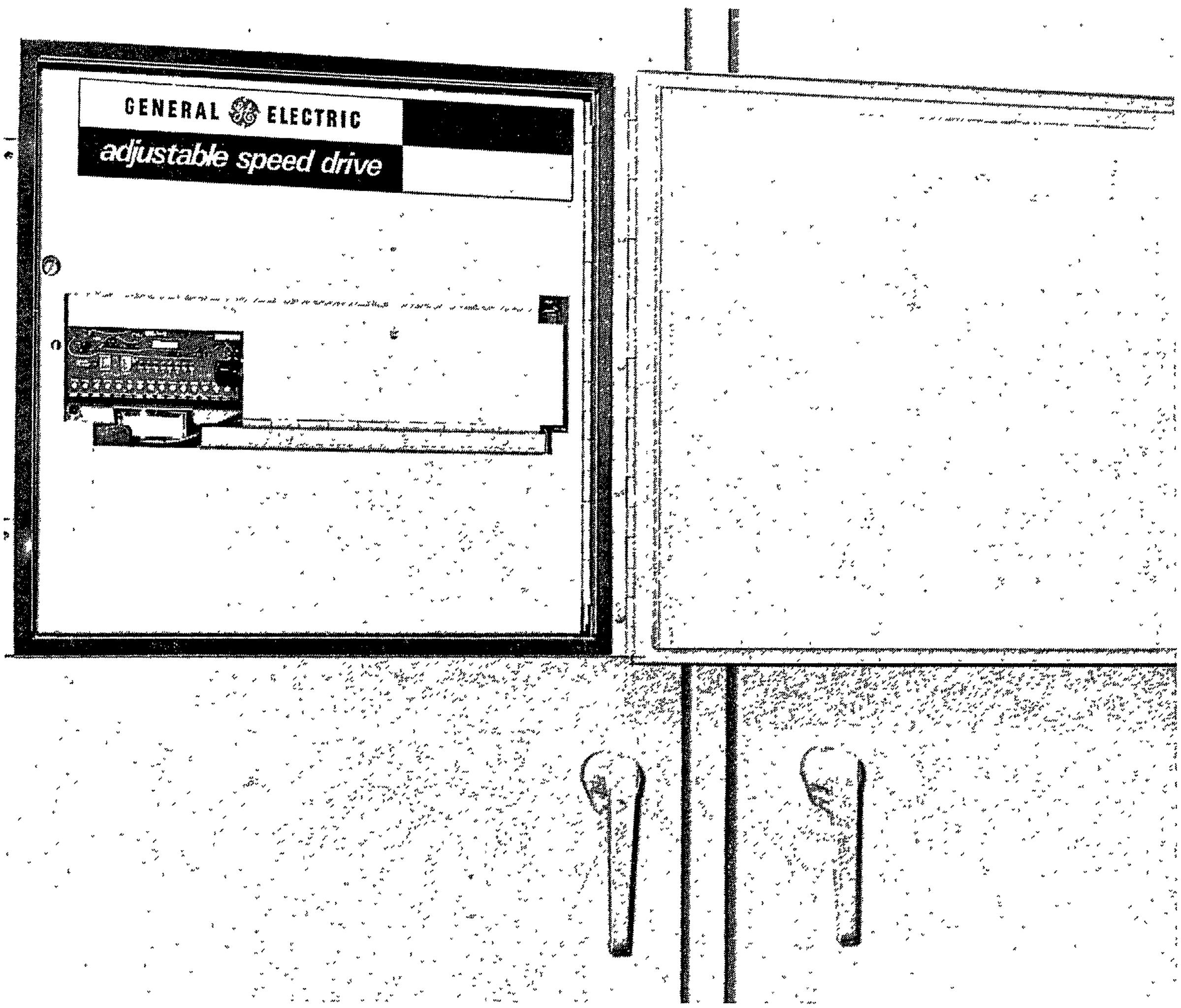
INSTRUCTIONS

VALUTROL* MAIN CONTROL MODULE

FULL WAVE, NON REGENERATIVE

INSTALLATION - OPERATION - MAINTENANCE



GENERAL ELECTRIC

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GENERAL DESCRIPTION

The basic elements of a typical VALUTROL industrial drive system are shown in the simplified typical block diagram, Figure 1. This diagram indicates the basic elements contained in the VALUTROL* main control module which functions to control output from a three–phase full–wave conversion assembly.

Three–phase AC power enters the system through fuses and is fed into the power conversion module (SCR) where it is converted to adjustable voltage DC power for the DC motor armature. Normally, the system may have an AC contactor (MA) that removes power from the drive when it is stopped. An alternate arrange–ment uses a DC contactor (MD) to disconnect the DC motor when the drive is stopped leaving the drive system otherwise completely energized.

Drive systems having a single conversion module (SCR) obtain the system current feedback signal from a DC line shunt as shown in Figure 1. Systems having paralleled conversion modules (SCR) obtain the current feedback signal from current transformers in the AC lines entering the converters.

The speed of the motor is proportional to the DC voltage applied to its armature. Speed is measured by motor CEMF (Armature voltage feedback with IR compensation). As an optional feature, speed can be measured by a tachometer generator directly connected to the DC motor.

The basic control is manufactured on four (4) removable printed circuit boards. These are the power supply card (PSC) the main control card (MCC) the interface card (IFC) and the motor field exciter card (MFE) or the motor field control card (MFC) (optional). Other cards, including a diagnostic card are also available as optional modifications.

The three phase inputs also supplies power to the Motor Field (MFE or MFC) and to the control power trans–former. This transformer is fitted with a 460/230V reconnectable primary winding and two isolated sec–ondary windings: (1) 115V to operate the coil of the MA or MD contactor, and other main control module relays, (2) the second winding is a 50 volt center tapped secondary which provides AC input to the power supply card.

POWER SUPPLY CARD (PSC)

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 out–puts are protected against over voltage conditions caused by a power supply card failure.

MAIN CONTROL CARD (MCC)

The primary purpose of the main control card is to drive the conversion module (SCR) as commanded by reference and feedback signals.

TYPICAL VALUTROL* DRIVE SYSTEM WITH MAIN CONTROL MODULE

BLOCK DIAGRAM

*WHEN AN AC CONTACTOR IS USED THE DC CONTACTOR IS OMITTED.
WHEN A DC CONTACTOR IS USED THE AC CONTACTOR IS OMITTED.

SR- SPEED REFERENCE
JOGR- JOG REFERENCE
TR- TIMED REFERENCE
DR- DRIVER REFERENCE
DE- DRIVER ERROR
CB- CIRCUIT BREAKER
VFB- VOLTAGE FEEDBACK
CFB- CURRENT FEEDBACK
CEMF- COUNTER EMF(V-IR)
SFB- SPEED FEEDBACK
CLF- CURRENT LIMIT FEEDBACK
SA, SB, SC- AC SYNCHRONIZING
MA- A.C. CONTACTOR
MD- D.C. CONTACTOR
PR- PRECONDITIONING

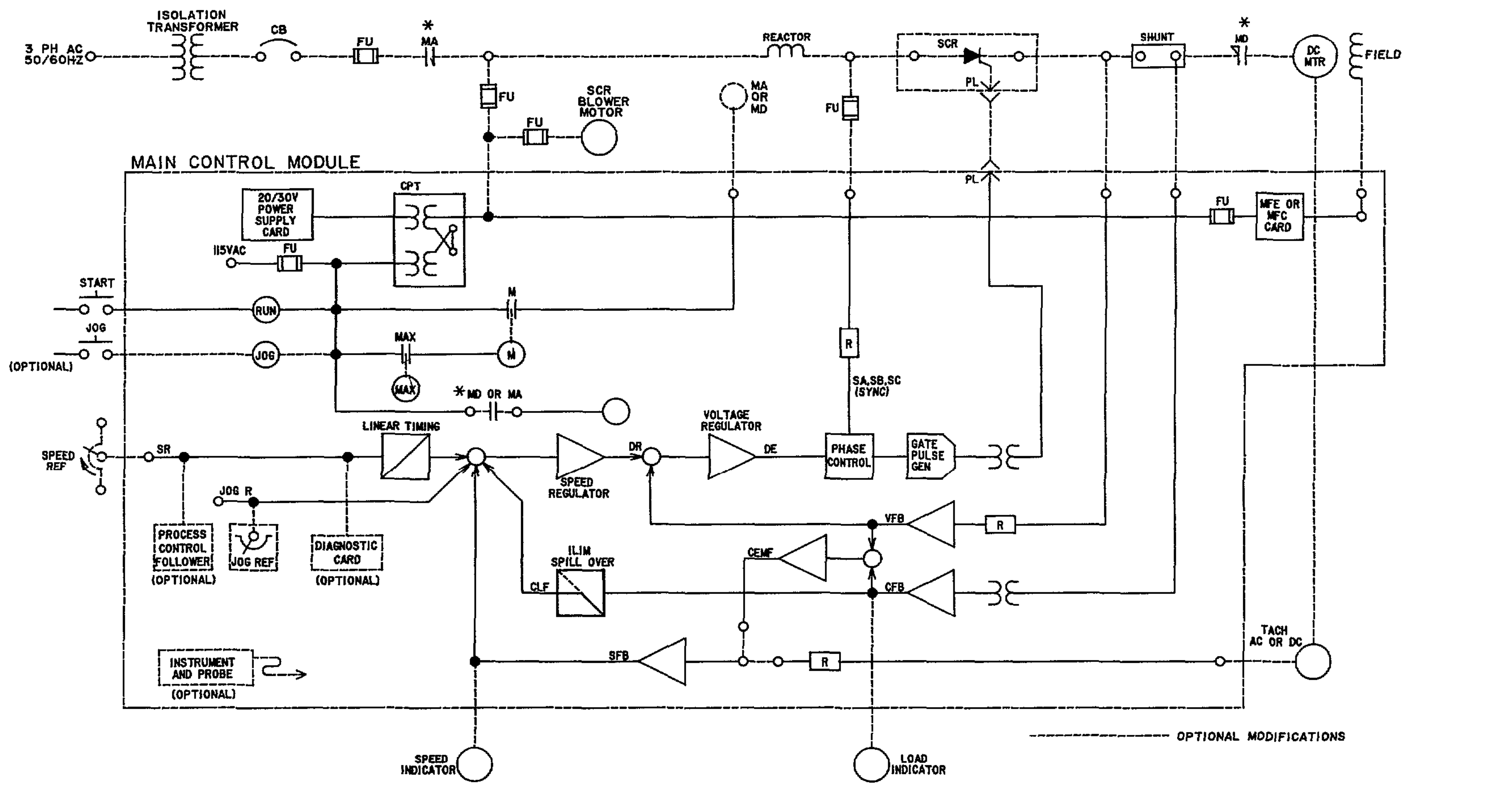
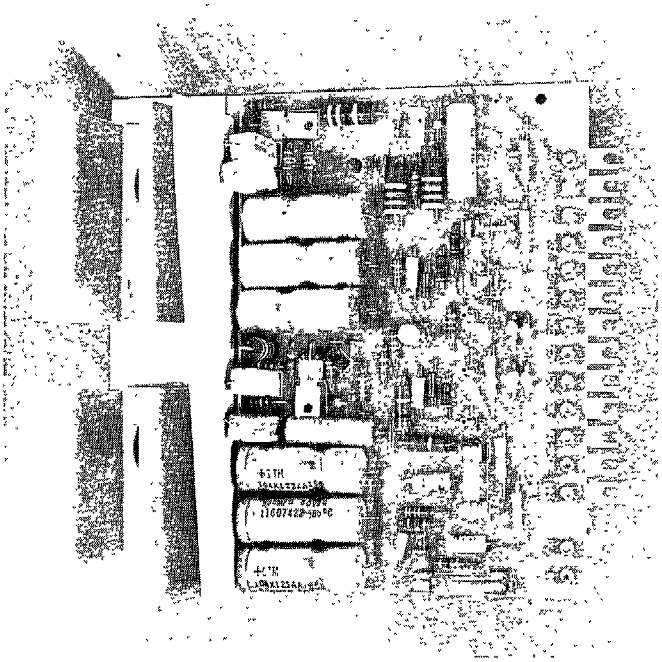


FIGURE 1



(Photo MG–5236–20)

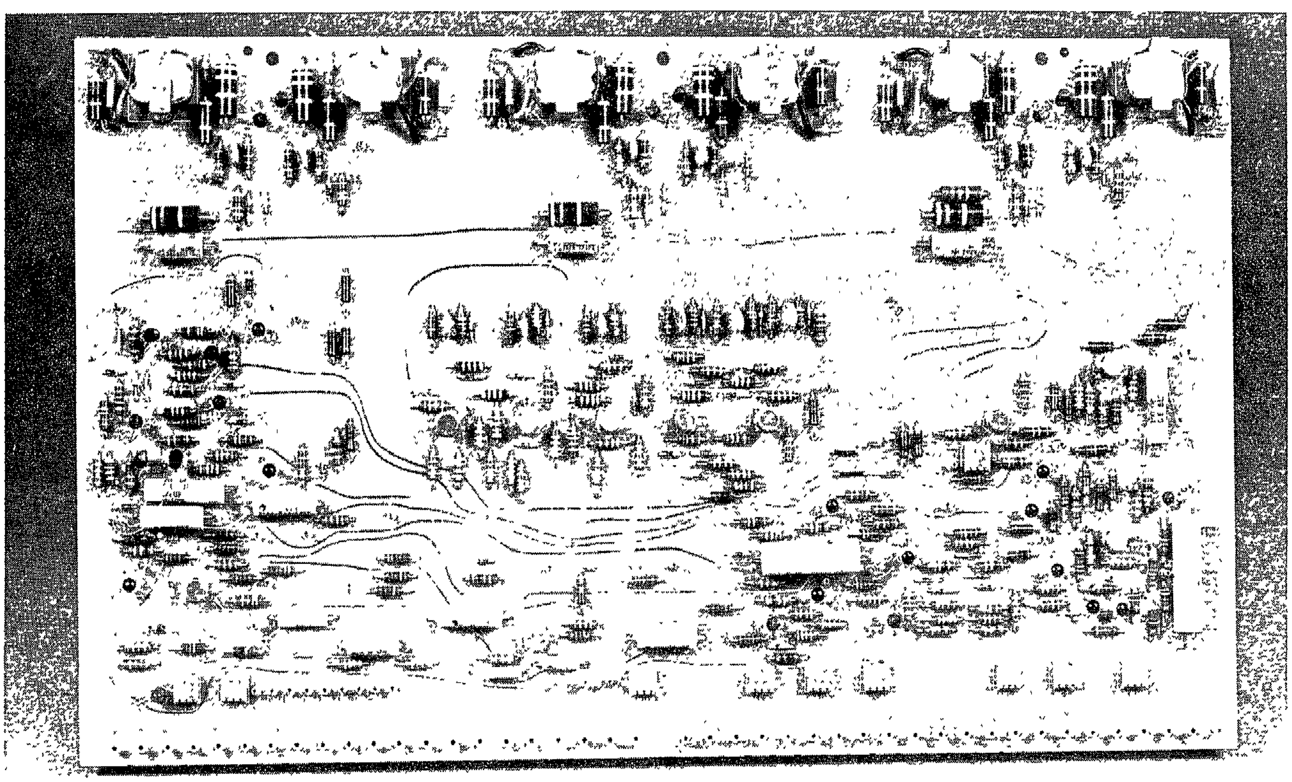
FIG. 2 POWER SUPPLY CARD

This card also performs several additional functions such as linear timing of the reference; current limit; "READY TO RUN" indicator; and various scaling and trimming adjustments.

A total of ten (10) potentiometers are provided on this card, nine (9) of which are accessible from the front of the controller. The tenth potentiometer is the card zero adjustment ZERO ADJ, which is preset at the factory and should not be disturbed. All adjustments have been pre aligned prior to shipment. These nine potentiometers are:

DAMP	MAX SPEED	MIN SPEED
CUR LIMIT	GAIN	REF SCALE
COMP	RESPONSE	LIN TIME

When the drive is first placed into operation the actual top speed may be different from what is required. By adjusting the MAX SPEED potentiometer, the proper top speed can be set without disturbing any other speed sensitive adjustments in the drive, except the ALIGN adjustment if the MFC card is used.



(Photo MG–5244–8)

FIG. 3 MAIN CONTROL CARD

TEST INSTRUMENT AND PROBE (OPTIONAL)

Located below the main control card (to the left) is a test instrument and probe that can be used to "read out" signals from any of the drive test points. The probe is fitted with two connections, one for the 4 volt instrument scale and the other for the 20 volt scale. Always apply the 20 volt connection first. If the reading is below 4 volts, switch to the 4 volt connection for improved accuracy of the read out.

INTERFACE CARD (IFC)

The primary purposes of the interface card are:

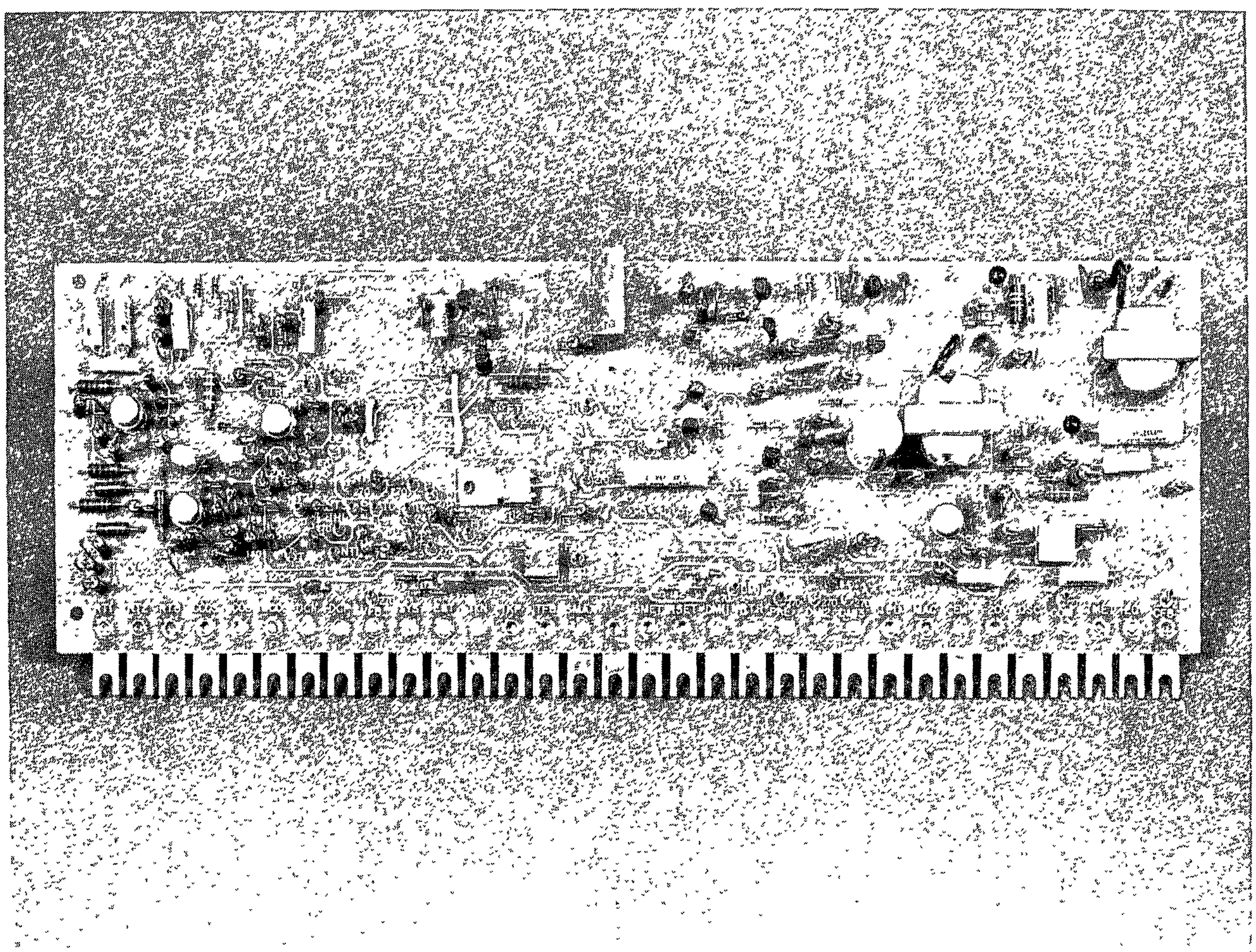
1. To provide low level isolated signals corresponding to the three phase AC line voltage, DC armature voltage, armature current and tachometer feedback (if used).
2. To control the start, stop and synchronizing signals of the drive while monitoring the system for ab– normal operating conditions.

OTHER OUTPUTS PROVIDE:

1. A one milliampere signal for the external speed or current indicators (optional).
2. A driver for an external relay with a N/O contact indicating MA or MD closure (MAX).

There are two (2) potentiometers on this card:

1. IMET is the calibration adjustment for the current indicator. (Optional)
2. SMET is the calibration adjustment for the speed indicator. (Optional)

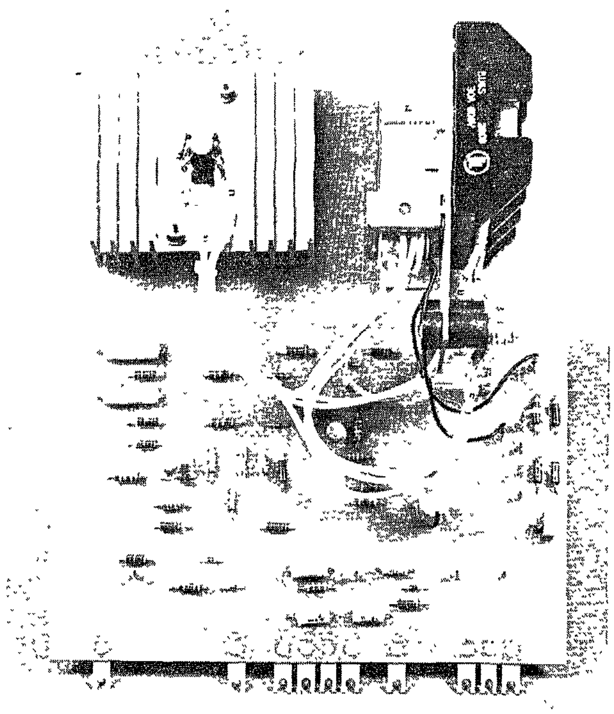


(Photo MG–5244–11)

FIG. 4 INTERFACE CARD

MOTOR FIELD EXCITER CARD (MFE)

This card provides a motor field voltage proportional to the AC line voltage for use with constant torque drives. A field loss circuit is also provided. See GEK-24972 for detailed instructions.



(Photo MG-5274-3)

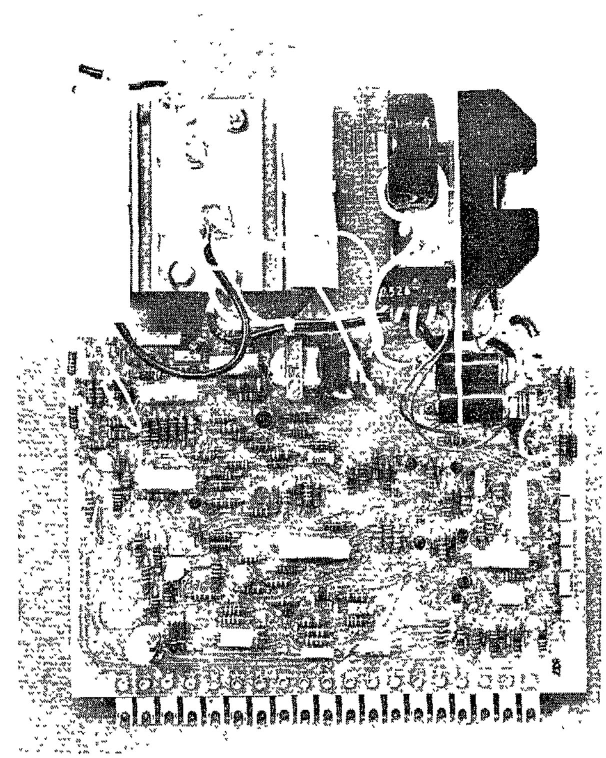
FIG. 5 MOTOR FIELD EXCITER CARD

MOTOR FIELD CONTROL CARD (MFC) (OPTIONAL)

This card provides a current regulated motor field supply for the DC motor. Constant field excitation is supplied in the constant torque range as armature voltage is measured from zero to rated voltage. A crossover CROSS adjustment is provided at which time the motor field current is automatically decreased thereby increasing the speed of the motor above base speed. In this range the drive characteristic changes from constant torque to constant horsepower.

Other functions performed by this card include a tachometer monitor circuit to detect the loss of tachometer feedback voltage (over speed) or to detect reverse polarity when a DC tachometer is employed. 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. See GEK-24971 for detailed instructions.

In the event it is desirable to provide motor field regulation, tachometer monitor, motor field reversing or special motor field voltages when constant horsepower performance is not a requirement, the motor field control card (MFC) can be used by moving the cross over (CROSS) adjustment to a setting of 5 o'clock.

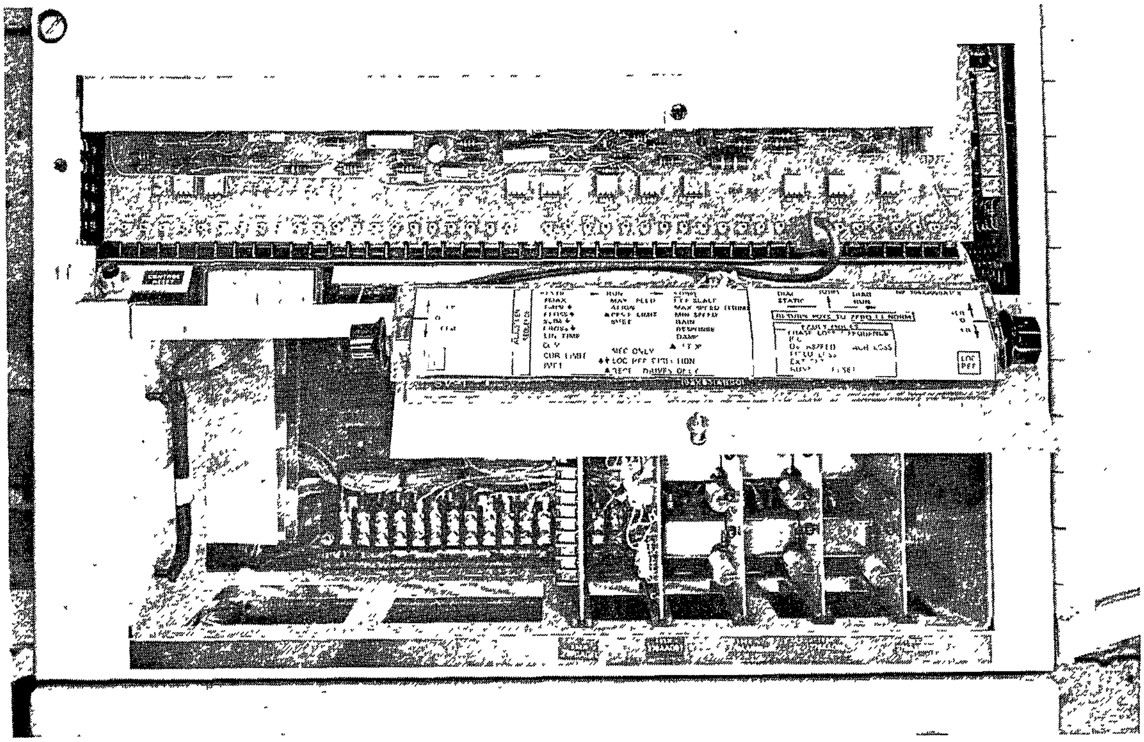


(Photo MG-5236-15)

FIG. 6 MOTOR FIELD CONTROL CARD

DIAGNOSTIC CARD (DGC) (OPTIONAL)

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. THIS CARD IS HIGHLY RECOMMENDED.



(Photo MG–5393– 1)

FIG. 7 DIAGNOSTIC CARD

EXCITER AND CONTROL POWER

Three phase power from an externally protected source is supplied to terminal board (TBN). The motor field card and the control transformer are connected to this power source.

SYNCHRONIZING SIGNAL POWER

Three resistance wires which provide line synchronization are connected through terminal board (TBN) to the AC line supplying the conversion module (SCR). Normally, these lines are fused in the conversion module. These fuses also protect metal oxide varistors (MOV's) in the conversion module which protect that unit from excessive transient over voltage conditions. The drive will not operate if any one of these fuses are open.

POWER CONNECTIONS

The DC motor shunt field connections are at points F1 and F2 on terminal board (TBN) located at the top of the main control module.

CONTROL CONNECTIONS

Control connections are made to terminal boards 2TB, TBC and TBN; and through plug (PL). Signals appearing on these terminal boards and their functions are described in Table 1. Optional connections are made at 3TB and 4TB. Refer to system elementary diagram for details. The SCR firing signals and the conversion module over temperature thermal switch signal are carried through the plug.

START–UP

The VALUTROL* main control module is factory tested with the complete drive system. 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.

START–UP (continued)

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 –20 volts with the external speed adjust potentiometer turned fully clockwise. Re–turn the potentiometer to zero (fully CCW).

5. If the diagnostic card option is provided, set the local speed reference (LOC REF) potentiometer to its center position and switch into the diagnostic run (DIAG RUN) position. The MA or MD con–tactor should pick up. Slowly turn the LOC REF potentiometer away from the control until the motor starts to rotate. If the tachometer feedback option was selected verify that a positive speed feed–back signal appears on the SFB test point, located on the bottom of the main control card (MCC) on the left hand side. Check motor rotation. Check tachometer polarity. With a DC tachometer TKP (2TB–29) is positive for forward rotation. Turn the LOC REF potentiometer back to the center position and switch to NORMAL. If the motor rotation was incorrect, remove power and inter–change the motor field connections F1 and F2 on TBN terminal board.

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

7. Run the drive from the external speed reference up to top speed. Adjust MAX SPEED as may be re–quired.

8. Close and secure the front door 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 IN–JURY OR LOSS OF LIFE WHETHER THE AC VOL–TAGE 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 CON–NECTED 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 ISO–LATED FROM GROUND AND ITS METAL PARTS TREATED AS LIVE EQUIPMENT. USE OF AN IN–STRUMENT HAVING BOTH LEADS ISOLATED FROM THE CASE PERMIT 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.

TABLE I SIGNAL CONNECTIONS

2TB NO.	NOMENCLATURE	DESCRIPTION
1	–30V	Unregulated negative DC voltage used as the return line for the CONTROL ON function and the static switches RUN and JOG, and possible modifications.
2	CONTROL ON	2TB(2) is normally jumpered to 2TB(1). IF CONTROL ON is not connected to –30V the drive will not start. If CON–TROL ON is opened with the drive operating, the MA or MD contactor will open and the drive will coast.
4	CONVERSION MODULE THSW	Conversion Module N C thermal switch (when used) is wired between 2TB(4) and 2TB(10) –115V AC fused source. Normally drive STOP/START Control is wired from 2TB(4) to 2TB(15).
5, 6	MAX	A NO relay contact which actuates when the "M" relay actuates to energize the MA or MD contactor wired between TBC(1) and TBC(2).
8, 27	COM	Signal common. All signals are measured with respect to common, unless otherwise noted.
9	EST	External Stop input. If EST is momentarily disconnected from common, the "M" Relay will open and the motor will coast. The drive may not be restarted until the reset line is momentarily connected to COMMON (2TB–12). If not used 2TB(9) is jumpered to 2TB(8).
10	FX1	The internal 115V AC, fused (1.0A).
11, 12	X2	The internal 115V AC, grounded to case.
13	JOG COIL	If the independent JOG option is furnished the JOG relay coil is wired between 2TB(13) and 2TB(12) (grounded side of 115V AC).
14	RUN	When –30V is applied to 2TB(14) the MAX relay and the "M" relay will pick up. The drive will run from the speed reference SR; applied from 2TB(28).
20, 21	± 20V	Regulated power supply outputs.
22	IMET	Output to an optional 1 ma load instrument. The instrument is calibrated with the IMET potentiometer on the Interface Card.
23	SMET	Output to an optional 1 ma speed instrument. The instru–ment is calibrated with the SMET potentiometer on the Interface Card.
26	SMIN	Output from the MIN SPEED potentiometer on the main control card.

TABLE I SIGNAL CONNECTIONS
(continued)

2TB	NOMENCLATURE	DESCRIPTION
25	JOGR	Reference input point for jog mode.
28	SR	Speed Reference input.
29, 30	TKP TKN	Input connections for motor mounted tachometer or machine mounted tachometer. NOTE: WITH A DC TACHOMETER, TKP IS POSITIVE FOR FORWARD DIRECTION.
3 17	START JOG	–30 volts applied when RUN picks up. When –30 volts is applied to 2TB(17) the MAX relay and the "M" relay will pick up. The drive will run from the JOG reference applied to 2TB(25).
16	RUN LATCH	A NO MAX interlock is connected between 2TB(16) and 2TB(15) for holding in the RUN relay while running.
15 7, 18, 19	RUN COIL	With 115V AC applied to 2TB(15) the RUN relay coil is energized. A NO RUN interlock is connected between 2TB(7) and 2TB(18) for latching the RUN relay. A NC interlock from an anti–plugging relay (APR) is connected between 2TB(18) and 2TB(19) to provide a start permissive function when the dynamic braking or reversing options are furnished. Refer to the appropriate operator control diagram to see how the interface between external and internal control is accomplished.

TBC NO.	NOMENCLATURE	DESCRIPTION
1	PS–2X	Internal 115VAC (grounded to case).
2	PS–3	Internal 115VAC applies through a NO "M" relay contact.
3, 5	M–PRE	NC "M" Relay contacts between TBC(3) and TBC(5) signal relay closure.
4	PR	PR Relay coil. Connect TBC(4) to TBC(2), energizes PR Relay making firing circuit operative.

TBN NO.	NOMENCLATURE	DESCRIPTION
K1, K2, K3	EXC–P	3 phase power for motor field (MFE or MFC) and control transformer (CPT).
T11, T12, T13	SYNC SIG	Synchronizing signals from converter power source.
DC1, A2	V FDBK	Voltage Feedback from DC motor armature.
1P, 1N	CURR FDBK	Current Feedback signal from DC line, 100MV shunt.
F1, F2	MTR FLD	DC Motor Field connection from (MFE or MFC).

SEQUENCE OF OPERATION

POWER APPLIED

The control transformer is energized and the cooling fan (if supplied) will come on.

The power supply card (PSC) is energized and the DC outputs (± 20 volts) are applied through their fuses to the rest of the cards. All readings carry a tolerance of ± 10% when read on the built–in instrument card.

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

NOTE

IF THE MOTOR FIELD REVERSING OPTION IS PROVIDED, THE MOTOR FIELD WILL NOT BE ENERGIZED UNTIL THE DRIVE IS STARTED. IF NO FAULTS HAVE BEEN DETECTED BY THE FAULT MONITOR SECTION OF THE INTERFACE CARD (IFC) THE "READY TO RUN" INDICATOR ON THE MAIN CONTROL CARD WILL ILLUMI– NATE. TABLE II TABULATES THE FAULT CON– DITIONS WHICH ARE MONITORED.

The oscillator will start the synchronizing signals SA, SB, SC, will measure 8.5 volts RMS (± 10%). See Fig. 14 and 16.

START

Connect RUN (or JOG) to –30 volts.

SWITCH LOGIC

RUN or JOG will be switched from +30 volts to –30 volts. (under purchaser's control).

TABLE II FAULT CONDITIONS

A fault has occurred if the READY TO RUN light is off. The conditions that can initiate a fault are as follows:

1. No three phase power to power unit.
2. Circuit breaker is open, or AC power fuse blown.
3. Control fuse is open.
4. Power supply plus or minus DC fuse is open.
5. Loss of an incoming phase.
6. Incorrect phase rotation.
7. ** Instantaneous overcurrent (IOC) level exceeded.
8. Motor thermo–switch (OL)
9. * Timed over current (TOC) – electronic
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 held depressed or RSET input held connected to Common.
15. Diagnostic mode selected with the motor rotating.
16. Oscillator failed "on".
17. * Tachometer fault (loss of tachometer signal or DC output open).
18. ** Overspeed (or excessive SFB voltage in DIAG. RUN).

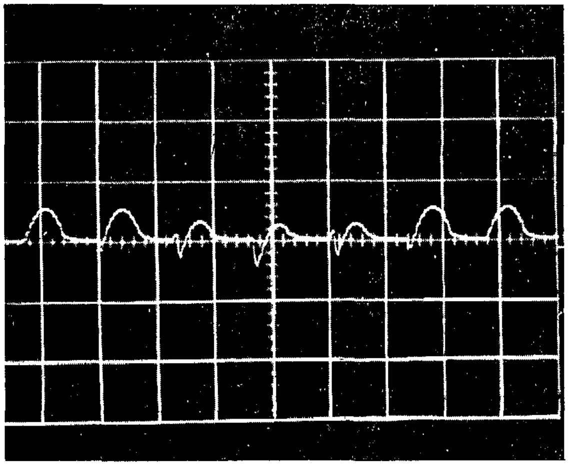
* May not be provided. Refer to instructions on Motor Field Supply and System elementary diagram.
** Can be caused by LOC REF and CUR LIM settings in Static Diagnostic mode.

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.

WAVEFORMS

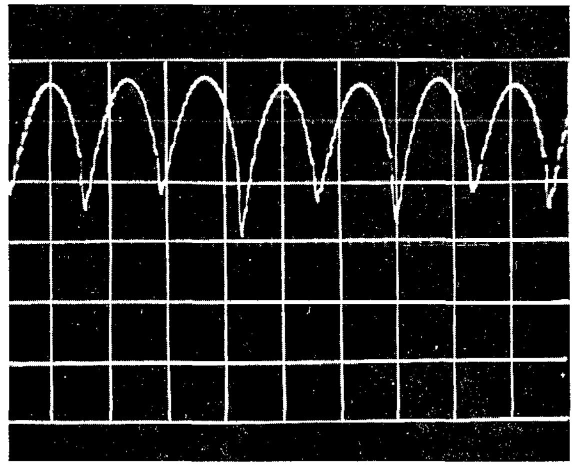
All illustrations were photographed with zero volts on center line at 2 msec per division.



2 msec/div

At low current level 1 volt/division

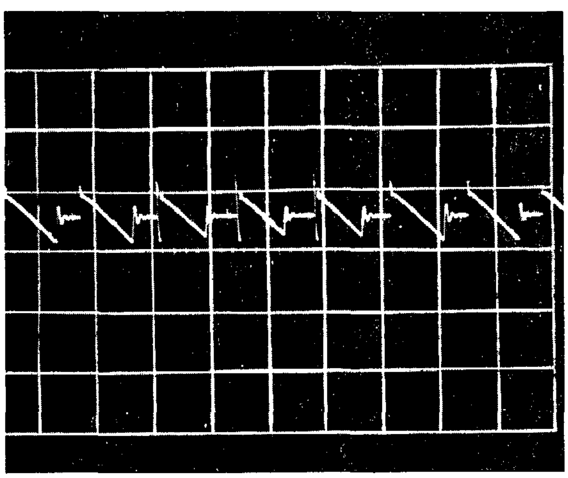
Fig. 8 Current Feedback (CFB) (Inverted)



2 msec/div

At Continuous current 1 volt/division

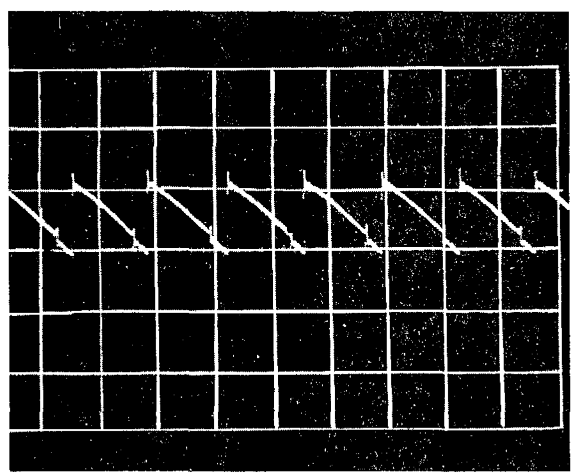
Fig. 9 Current Feedback (CFB) (Inverted)



2 msec/div

At low current and 50% output volts
5 volts/division

Fig. 10 Voltage Feedback (VFB) (Inverted)



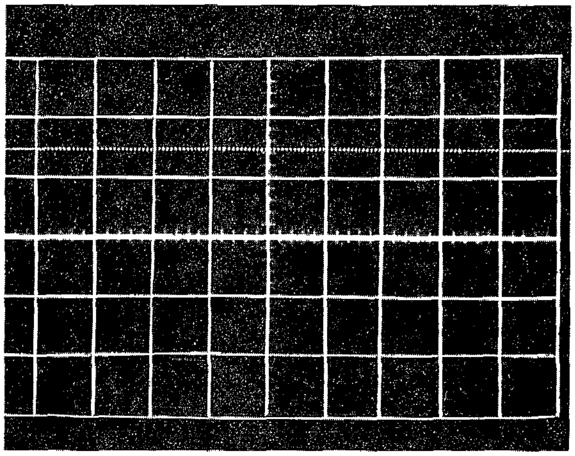
2 msec/div

At continuous current and 50% output volts
5 volts/division

Fig. 11 Voltage Feedback (VFB) (Inverted)

WAVEFORMS

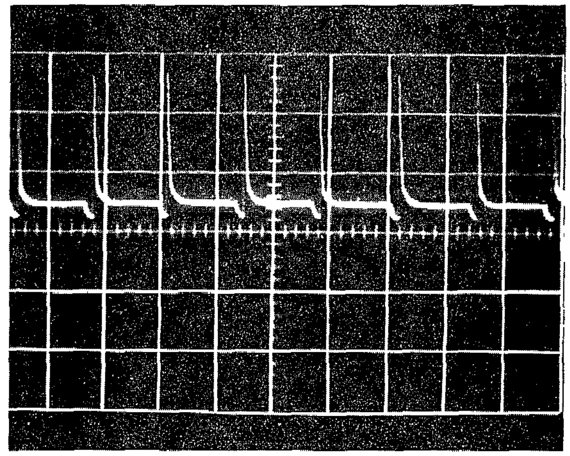
All illustrations were photographed with zero volts on center line at 2 msec per division



2 msec/div

10 volts/division

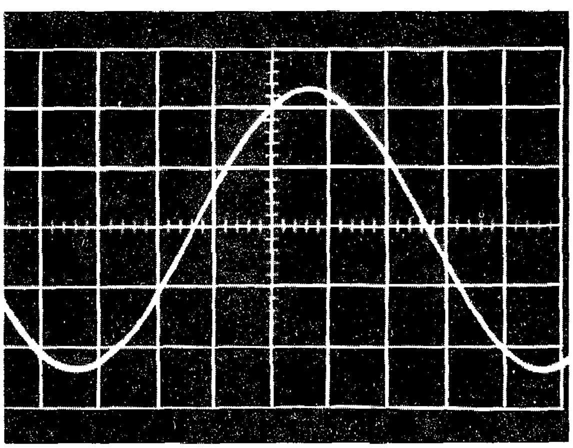
Fig. 12 Oscillator (OSC)



2 msec/div

At 50% output voltage
5 volts/division

Fig. 13 Initial Pulse (IPU)

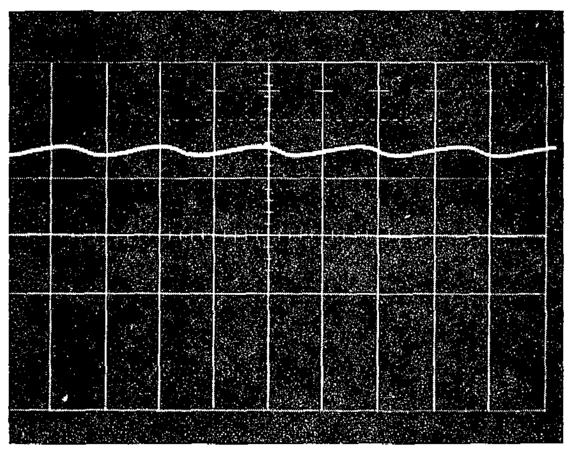


2 msec/div

Typical of SA, SB & SC

SB lags SA by 120°
SC lags SB by 120°
5 volts/division

Fig. 14 Synchronizing Signal (SA)



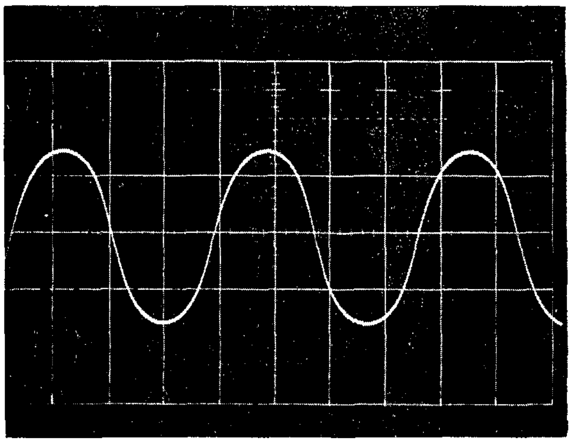
2 msec/div

With an AC tachometer at 450 RPM
1 volt/division

Fig. 15 Speed Feedback (SFB)

WAVEFORMS

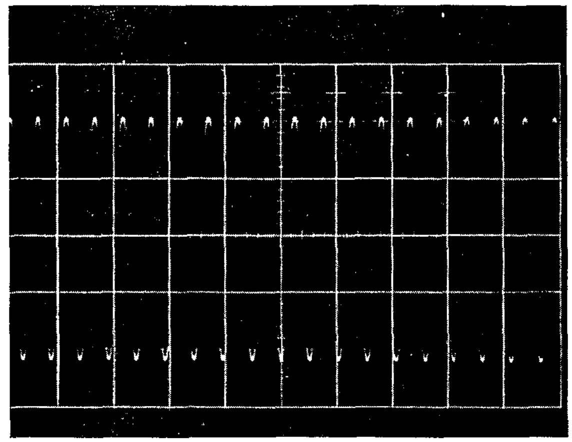
All illustrations were photographed with zero volts on center line at 2 msec per division.



2 msec/div

With an AC Tachometer at 450 RPM
1 volt/division

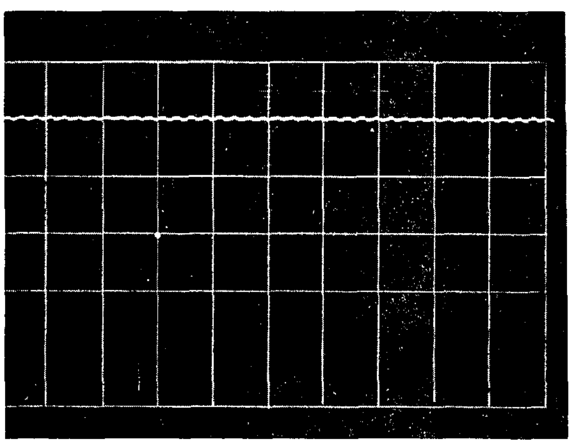
Fig. 16 Tachometer Feedback (TFB)



2 msec/div

With an AC Tachometer at 3160 RPM
5 volts/division

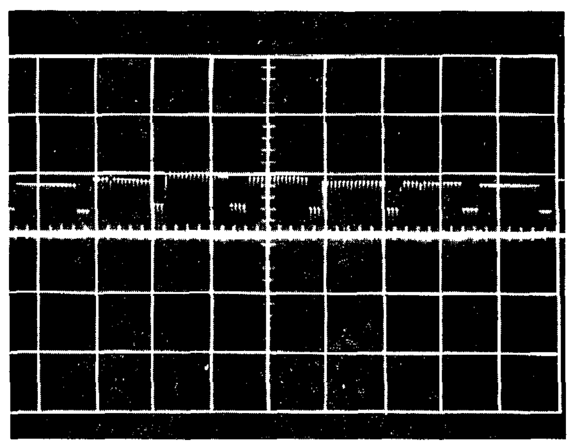
Fig. 17 Tachometer Feedback (TFB)



2 msec/div

With an AC Tachometer at 3160 RPM
5 volts/division

Fig. 18 Speed Feedback (SFB)



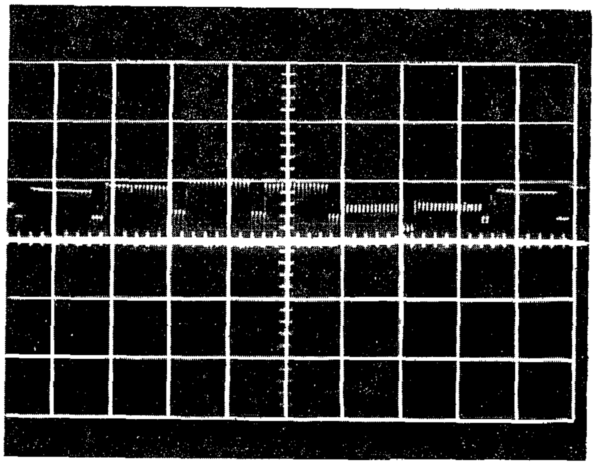
2 msec/div

Normal at 20% output volts.
0.5 volt/division

Fig. 19 Pulse Output (PO)

WAVEFORMS

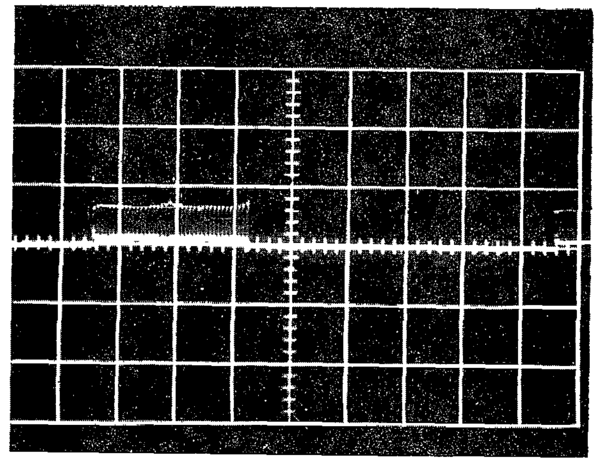
All illustrations were photographed with zero volts at center line at 2 msec per division.



2 msec/div

With one SCR gate lead open, 50% output volts.
0.5 volt/division

Fig. 20Pulse Output (PO)



2 msec/div

Gate to Cathode Firing Signal 1G-1C, with 50% output voltage continuous current. Typical of all six signals.
5 volts/division

Fig. 21

The MAX control line MAC from the main control card (MCC) to the interface card (IFC) will be pulled down to –20 volts.

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

MAX picks up applying power to the coil of the M relay. When M picks up it must cause the MA or MD coil to be energized. An interlock from the contactor across TBC(2) and TBC(4) applies power to the PR relay coil when the contactor closes. PR picks up and releases the preconditioning signal from common.

When PRE is released from common, it switches to –4 volts which will release the main control card pre–conditioning 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 switches, 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 0.3 to 60 seconds with the LIN TIME adjustment. See jumper table for the MCC card. (Ranges 0.3 to 7 sec. or 2 to 60 sec.)

The external tachometer signal (if used) or the internal CEMF signal must be selected by two (2) jumpers on the interface card (IFC) to provide a speed feedback signal, TFB to the speed feedback section on the main control card (MCC) where the signal is rectified (if required). 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 the desired top speed.

The timed reference TR, or the JOG reference, JOGR, and the speed feedback, SFB are summed by the regu–lator error amplifier. The error amplifier output EAO will be at low voltage (nearly zero) when the drive is

SIGNAL FLOW (continued)

regulating speed. EAO will not be low when the drive speed is changing. The gain of the error amplifier is set with the GAIN adjustment. The GAIN 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) card.

To maintain good speed regulation the error amplifier output (EAO) is fed into an 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. If the MFC card is used, the response is desensitized when the drive is operating in the weak field mode (constant horsepower). DO NOT ADJUST RESPONSE DURING THIS MODE OF OPERATION.

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

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

The driver reference DR, the voltage feedback, VFB and the damping adjustment, DAMP are summed at the output of the driver. The driver converts this error to pulse trains which drive the SCR (Thyristor) gates in such a manner as to maintain the motor voltage proportional to the driver reference. The damping adjustment DAMP controls the response of the driver. Generally speaking DAMP is used only to quiet small oscillations which occur in the current under light load conditions. Too much damping will slow down the system response and tend to cause over shoot.

The driver provides a signal IPU to the oscillator on the interface card (IFC) to generate an initial pulse at the exact point in time that an SCR is to be fired. See Fig. 13

Two driver monitor points are available, PCR and PO. PCR is the phase control reference which causes the output pulse trains to phase shift in time with respect to the AC line. As the driver error voltage, DE, changes from zero to –12 volts, the phase control reference, PCR, changes from –4 volts to +4 volts and the output pulses will shift from full off to full on. PO is used to monitor the pulse outputs to the SCR's. The PO signal will vary as the speed is increased but the shape and amplitude should repeat every 60° (2.8 msec). See Fig. 19, 20.

STOP

There are two sequences; normal stop and fault stop.

In either case preconditioning will be applied to phase back and lock out the SCR firing pulses such that the load current is reduced to zero prior to opening the MA or MD contactor.

The motor will coast to a stop or stop by dynamic braking if the DB option is provided.

If the motor stops by dynamic braking, the drive cannot be restarted until the motor speed has decreased to a low speed level at which time an antiplugging relay, (APR) drops out.

DIAGNOSTIC STATIC (SWITCH TO LEFT)

LOGIC

The RUN and JOG inputs are inhibited. This prevents the reference SR and JOGR from activating the drive and holds the M relay 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 speed feedback section. The local reference is also connected to the field diagnostic reference FDR. Refer to motor field control (MFC) instructions (GEK–24971) for details of operation.

To simplify signal tracing, the gain of the regulator and drive is reduced and the speed feedback signal to the regulator 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

SIGNAL FLOW (continued)

voltage equal to LR in magnitude and polarity in a time determined by the setting of LIN TIME.

The local reference (LR) is applied to the input of the last stage of the speed feedback section. The output SFB will be equal to LR in magnitude but opposite in polarity. The tachometer scaling circuit and output TFB are unaffected by the local reference and will remain at zero. As the signal from SFB into the regulator amplifier is inhibited, the primary purpose of exercising SFB is to check the SFB function of the MFC card (if used).

A dummy feedback signal to replace the normal SFB signal is connected from the output of the regulator integrator 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 below the current limit setting. As the current reference is raised the current feedback signal CFB will exceed the current limit level set by CUR LIMIT and force the DR output to zero. See Fig. 8 and 9.

Current feedback 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 drive is reduced so that the driver error (DE) is equal to the magnitude of the driver reference (DR) as long as the current reference is set to zero.

With an oscilloscope, the initial pulse output (IPU) and the pulse output (PO) may be monitored to verify proper operation. See Fig. 13, 19, and 20.

DIAGNOSTIC RUN (SWITCH TO THE RIGHT)

In diagnostic run, the local reference LR and the diagnostic switch are substituted for the SR reference 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.

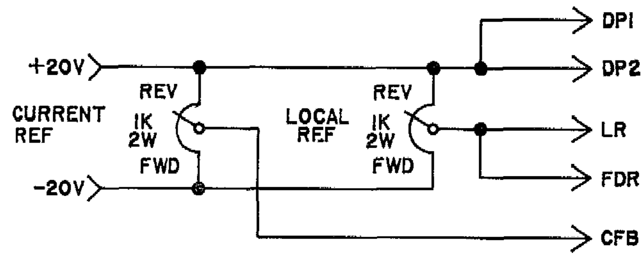
The net effect is the drive operates as a base speed voltage regulated drive from the LOC REF potentiometer.

CALIBRATION PROCEDURE

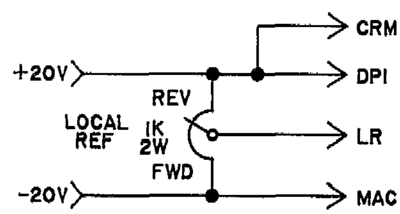
The diagnostic card is used to generate the appropriate test signals and operating modes to calibrate the drive. If a diagnostic card has not been furnished, one may be ordered.

To avoid confusion and possible interaction, the adjustments should be made in the following sequence. Two sequences are listed: (1) when a motor field exciter (MFE) is provided and (2) when a motor field control (MFC) is furnished. Refer to the system elementary diagram to determine which has been provided.

All of the high voltage inputs to the controller have been scaled down with the scale factors shown on the test data sheet (located on the inside door of the power unit).



DIAGNOSTIC STATIC



DIAGNOSTIC RUN

FIG.22 DIAGNOSTIC TEST CIRCUITS

For Example:

For 460VAC/550VDC drives
VFB=5.62V at 550VDC

For 230VAC/240VDC drives
VFB=5.6V at 240VDC

CALIBRATION WITH MOTOR FIELD CONTROL (MFC)

Refer to motor field control instructions GEK–24971 for details of operation.

All readings have a tolerance of ± 10% when read on the test instrument.

Select DIAGNOSTIC STATIC and set the CUR REF and LOC REF to the center positions.

FMAX (maximum field)

Set the LOC REF potentiometer for –1 volt at LR. Adjust FMAX until FC corresponds to the 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.

COMP (Compensation – IR)

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

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

On a speed regulated drive, COMP may be retrimmed for stabilizing the drive when operating above base speed.

On a voltage (CEMF) regulated drive, COMP should be set for zero speed regulation at a specific speed (typic–ally 50%) when the load changes from minimum to maximum. If the speed decreases with increasing load the COMP potentiometer should be turned further clockwise. Always re–check the MAX SPEED adjust–ment after making a COMP adjustment.

CUR LIMIT (current limit)

Set LOC REF for 10 volts at DR. 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 starts to decrease.

IMET (load instrument calibration)

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

FLOSS (field loss – fault)

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

Monitor FC and move the LOC REF potentiometer Rev (+LR) until FC corresponds to the field loss value on test data sheet. Slowly rotate FLOSS CW until the "Ready to Run" light turns off indicating a drive fault. Normally set at 75% of the FMIN setting.

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 (–LR) 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. Normally set with 11.5 volts (115%) at SFB. Set the LOC REF to center position and reset the drive.

CROSS (cross over – field)

Set CROSS full CCW. Turn the LOC REF potentio–meter Fwd (–LR) 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 –10 volts with the LOC REF potentiometer. Flip the diagnostic switch to NORMAL, then back to STATIC and measure the time for TR to ramp from 0 to –10 volts. Adjust LIN TIME as required.

Set the LOC REF to the center position, reset the drive and switch to DIAGNOSTIC RUN, to operate the drive as a voltage regulator.

TABLE III

Recalibrating Adjustment Sequences

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

*Some drives may be provided with a motor field control card (MFC) and not have any constant HP range. On such drives set CROSS full CW and FMIN per Test Data Sheet or at 80% of rated field current.

Drives with a motor field exciter (MFE) do not have CROSS, FMIN, SLIM, and ALIGN adjustments.

NOTE: A MOTOR FIELD CONTROL CARD (MFC) MAY BE FURNISHED ON BASE SPEED DRIVES (CONSTANT FIELD) TO PROVIDE FIELD ECONOMY, TACHOMETER MONITOR OR FIELD CURRENT REGULATION FUNCTIONS.

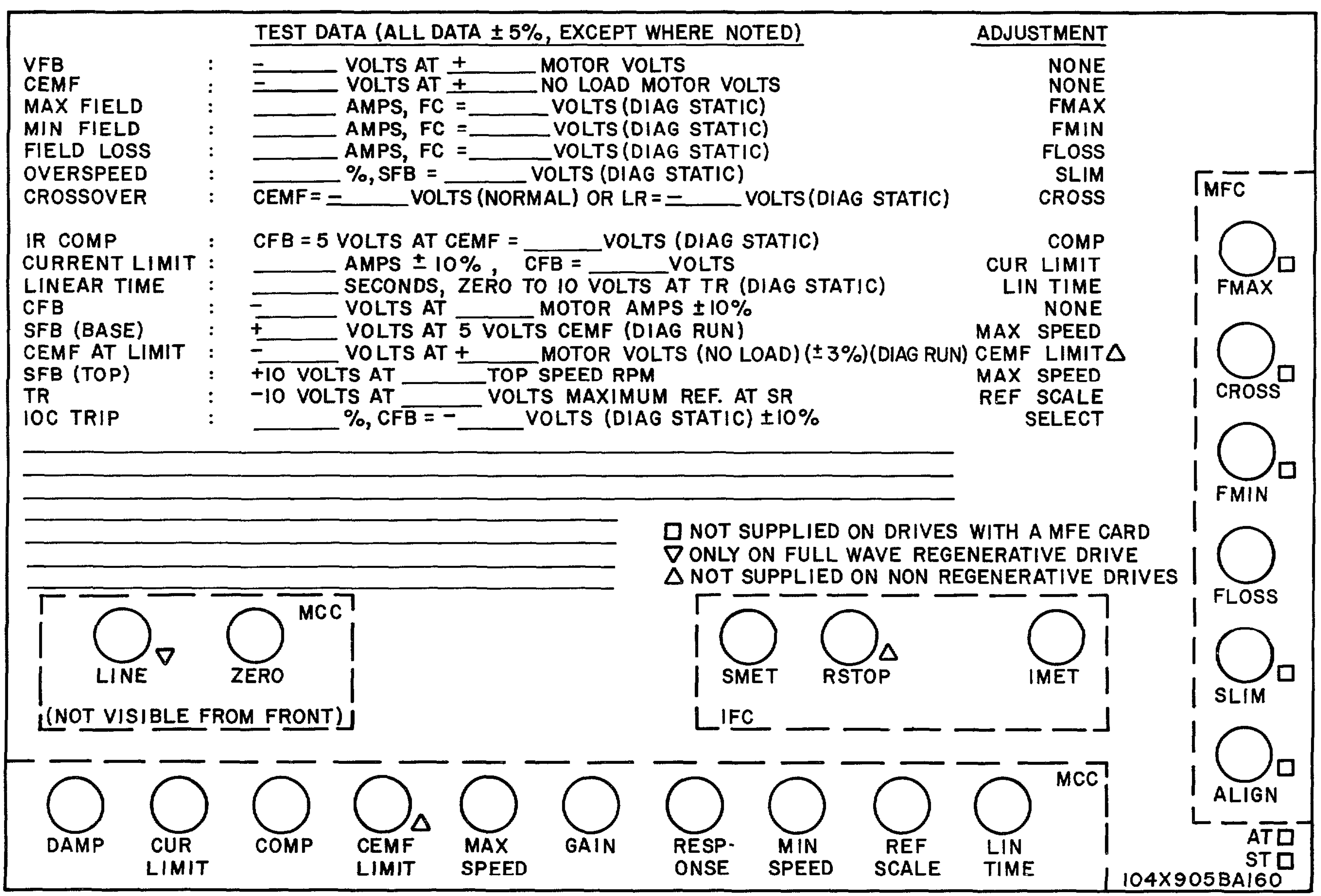


FIG.23 TYPICAL TEST DATA SHEET

MAX SPEED/ALIGN (Max speed/tachometer loss align)

Turn MAX SPEED full CW. 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, switch to NORMAL 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.

MIN SPEED (minimum speed)

Reduce the system reference to zero and start the drive. Adjust MIN SPEED, as required, to meet system minimum speed requirements.

GAIN, RESPONSE, DAMP (stability adjustments)

The GAIN adjustment affects the stability over the entire speed range. This potentiometer will normally be set between 9 and 12 o'clock.

The RESPONSE adjustment affects stability in the constant torque region (below base speed). Adjustment should not be made when operating above base speed. The potentiometer will normally be set between 10 and 1 o'clock.

The DAMP adjustment primarily affects the region around cross over between the constant torque and constant horsepower regions. Normally damping is not required and the potentiometer is set fully counter clockwise (7 o'clock).

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.

FLOSS (field loss – fault)

Adjust FLOSS full CCW and reset the drive.

Monitor FC and move the LOC REF Rev (+LR) 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. Normally set at 50% of rated motor field current.

COMP (compensation – IR)

Adjust the LOC REF potentiometer to the center position and reset the drive. Adjust the CUR REF potentiometer Fwd until CFB is at –5 volts (± 10%).

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

On a voltage (CEMF) regulated drive, COMP should be set for zero speed regulation at a specific speed (typically 50%) when the load changes from minimum to maximum. If the speed decreases with increasing load the COMP adjustment should be turned further clockwise. Always re–check the MAX SPEED potentiometer after making a COMP adjustment.

CUR LIMIT (Current limit)

Set the LOC REF for 10 volts at DR. 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 starts to decrease.

IMET (load instrument calibration)

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

LIN TIME (linear time)

Set the LOC REF and CUR REF to center. Monitor TR and set to –10 volts with the LOC REF potentiometer. Flip the diagnostic switch to NORMAL then back to STATIC and measure the time for TR to ramp from 0 to –10 volts. Adjust LIN TIME according to the test data sheet or as required.

Set the LOC REF to the center position and switch to DIAGNOSTIC RUN.

MAX SPEED (maximum speed)

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, switch to NORMAL, to initiate a shut down. Remove power, adjust SMET and repeat.

Return the DIAGNOSTIC SWITCH TO NORMAL.

REF SCALE (reference scale)

Turn the REF SCALE potentiometer 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.

MIN SPEED (minimum speed)

Reduce the system reference to zero and start the drive. Adjust MIN SPEED as required to meet system minimum speed requirements.

GAIN, RESPONSE, DAMP (stability adjustments)

The GAIN potentiometer is normally set fully counter clockwise (7 o'clock).

The RESPONSE potentiometer is adjusted for stable operation normally in the range of 10 to 1 o'clock.

Normally damping is not required and therefore DAMP should be set fully counter clockwise (7 o'clock).

TROUBLESHOOTING

Although many of the problems which may arise can be effectively located with a multi–meter, an oscilloscope is a very powerful troubleshooting tool. 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 or 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 1300V peak to peak deflection when used with appropriate attentuator probes. A line synchronizing mode is needed.

PROCEDURES

In troubleshooting 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) (Figure 7). 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 decribed). 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

PRINTED CIRCUIT CARDS (continued)

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 ON TERMINALS TR, RJ, SFB, NDE, CL1, CLJ AND LT2 OR ON THE DM1, DM2, ETC. TERMINALS ON ANY OTHER PRINTED CIRCUIT CARD.

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.

HOT LINE TELEPHONE NUMBER

The Contract Warranty for VALUTROL drives is stated in General Electric Apparatus Handbook Section 105, Page 71.

The purpose of the following is to provide specific instructions to the Valutrol–Drive user regarding warranty administration and how to obtain assistance on out of warranty failures.

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

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

General Electric Company
Erie, Pennsylvania
814–455–3219
(24 Hour Phone Service)

or

Contact the nearest

General Electric Installation and Service Engineering Office listed in your telephone directory. Before calling, list model numbers of the power unit and dc motor.

GLOSSARY OF TERMS

	Page
ALIGN – Tachometer Loss Align Adjustment	6, 22, 23, 24, 25
*CEMF – Counter EMF	4, 5, 18, 19, 20, 21, 23, 24, 25, 26
*COM – Regulator Common	11
COMP – IR Compensation Adjustment	5, 6, 19, 20, 21, 22, 23, 24, 25, 26
CPT – Control Power Transformer	5, 12
*CFB – Current Feedback	5, 15, 19, 20, 21, 22, 23, 24, 25
CUR REF – Diagnostic Current Reference Potentiometer	19, 21, 24, 25
CROSS – Crossover Adjustment	8, 21, 22, 23, 25
CUR LIMIT – Current Limit Adjustment	6, 14, 19, 20, 21, 22, 23, 24
DAMP – Dampening Adjustment	6, 19, 22, 23, 24, 25
Diagnostic – Normal	21, 22, 24, 25
Diagnostic – Run	10, 20, 21, 22, 23, 25
Diagnostic – Static	21, 22, 23, 24, 25
DGC – Diagnostic Card	8, 25
*DM1–DM2 Dummy Input/Output points	
*DP1–DP2 Diagnostic Switching Signals	
*DR – Driver Reference	5, 19, 20, 21, 22, 24, 26
*EAO – Error Amplifier Output	18, 19
EST – External Fault Stop	11
F1–F2 – Motor Field Connections	
*FC – Field Current	21, 23, 24
FDR – Field Diagnostic Reference	19, 21
FLOSS – Field Loss Adjustment	21, 22, 23, 24, 25, 26
FMAX – Motor Field Maximum Adjustment	21, 22, 23
FMIN – Motor Field Minimum Adjustment	21, 22, 23, 25
GAIN – Speed Loop Gain Adjustment	6, 19, 22, 23, 24, 25
IFC – Interface Card	4, 7, 13, 18, 19, 21, 23
IMET – Current (Load) Instrument Output & Adjustment	7, 11, 16, 20, 21, 22, 23, 24, 25, 26
*IPU – Initial Pulse	16, 18, 19, 20, 21
*JOG – Jog Switch Input	5, 11, 12, 13, 18, 19, 20
*JOGR – Jog Reference	5, 18, 20
LIN TIME – Linear Timing Adjustment	6, 18, 20, 21, 22, 23, 25
*LR – Local Reference From DGC	19, 20, 21, 23, 24, 25
LOC REF – Diagnostic Local Reference Potentiometer	10, 14, 19, 20, 21, 24, 25, 26
M – MA or MD Energizing Relay	5, 11, 12, 18, 20

* Test Points Located on MCM Door Front (See MCC Illustration, Fig. 3 & 7)

GLOSSARY OF TERMS
(Continued)

* Test Points Located on MCM Door Front (See MCC Illustration, Fig. 3 & 7)

GENERAL ELECTRIC COMPANY – DC MOTOR & GENERATOR DEPARTMENT
SPEED VARIATOR PRODUCTS OPERATION
ERIE, PENNSYLVANIA 16531

GENERAL ELECTRIC

GEK–24993 (11/78) 3M (F)