CLASS 22-1000Z SINGLE PHASE ADJUSTABLE SPEED DRIVE SYSTEM
DESCRIPTION OF ELECTRICAL OPERATION

I. INTRODUCTION

Type 22-1000Z systems provide a line of controlled-voltage drives for armature excitation of 90 volt or 180 volt dc machines from 1/4 hp to 5 hp. They require 115 or 230 volts, 50/60 Hertz, single phase AC power and feature front accessibility, high package density, minimum number of adjustments, wall-mounted or panel mounted enclosures. The system is designed to provide full-wave 100 volt or 200 volt dc field excitation depending on the horsepower rating.

The Z series offers the following standard features:

1. NEMA I, drip-proof wall mounted cabinet with front access.
2. Door mounted operator stations.
3. Static logic sequencing with static reversing on a plug-in pc card.
4. Minimum number of adjustments.
5. CEMF voltage control with IR compensation.
6. Speed control - forward and reverse.
7. Jog speed control - forward and reverse.
8. Maximum speed and minimum speed set adjustment.
9. Current limit adjustment with torque taper adjustment.
10. AC breaker protection.
11. Antiplugging protection.
12. Under voltage protection.
13. DC contactor for positive motor disconnect.
14. Integrated thyristor power module.
15. Fixed voltage DC field supply.

Optional features available include the following:

1. Timed acceleration and deceleration with independent adjustments.
2. Remote operator stations.
3. Dynamic braking.
4. Isolator.
5. Instrument follow.
6. Tachometer feedback speed control.

II. MECHANICAL DESCRIPTION

The standard 22-1000Z drive is available with a front accessible NEMA I type enclosure which is wall mounted. (Refer to Figure 1). The enclosure is accessible by a hinged door at the front. The door provides a mounting surface for the AC breaker and the operator station, (OS). The rear panel of the enclosure provides a mounting surface and heat sink for the electrical components.

Customer connections enter the enclosure through 1-3/8" "knockout" plugs in the top and bottom panels of the enclosure. Customer connections are made to terminal blocks provided on the controller board, (CB).

The enclosure is also available with NEMA 12 type construction.

III. DESCRIPTION OF ELECTRICAL SYSTEM

The electrical system of the S100Z consist of the following major components and circuits:

1. Thyristor power module, (TPM).
2. DC contactors, (F and R).
3. AC breaker.
4. Control power supply.
5. Field power supply.
6. Speed reference control.
7. Armature voltage sensor.
8. CEMF controller.
9. Voltage controller with spill over current limit, (CL).

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10. Gate pulse generator, (GPG).
11. Sequencer control or logic board, (LB).
12. Operator station, (OS).

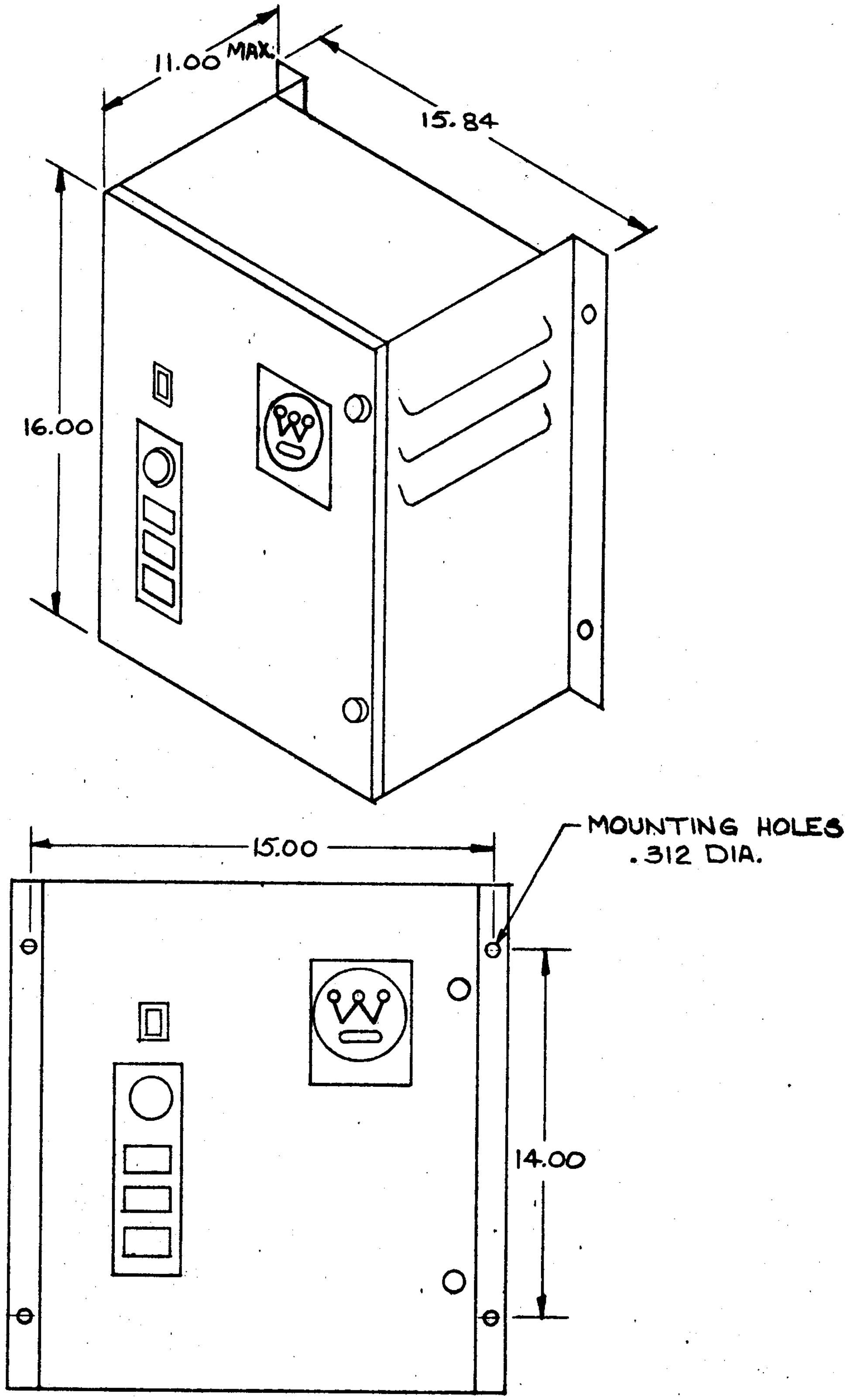

FIGURE 1 S100Z WALL MOUNTED ENCLOSURE

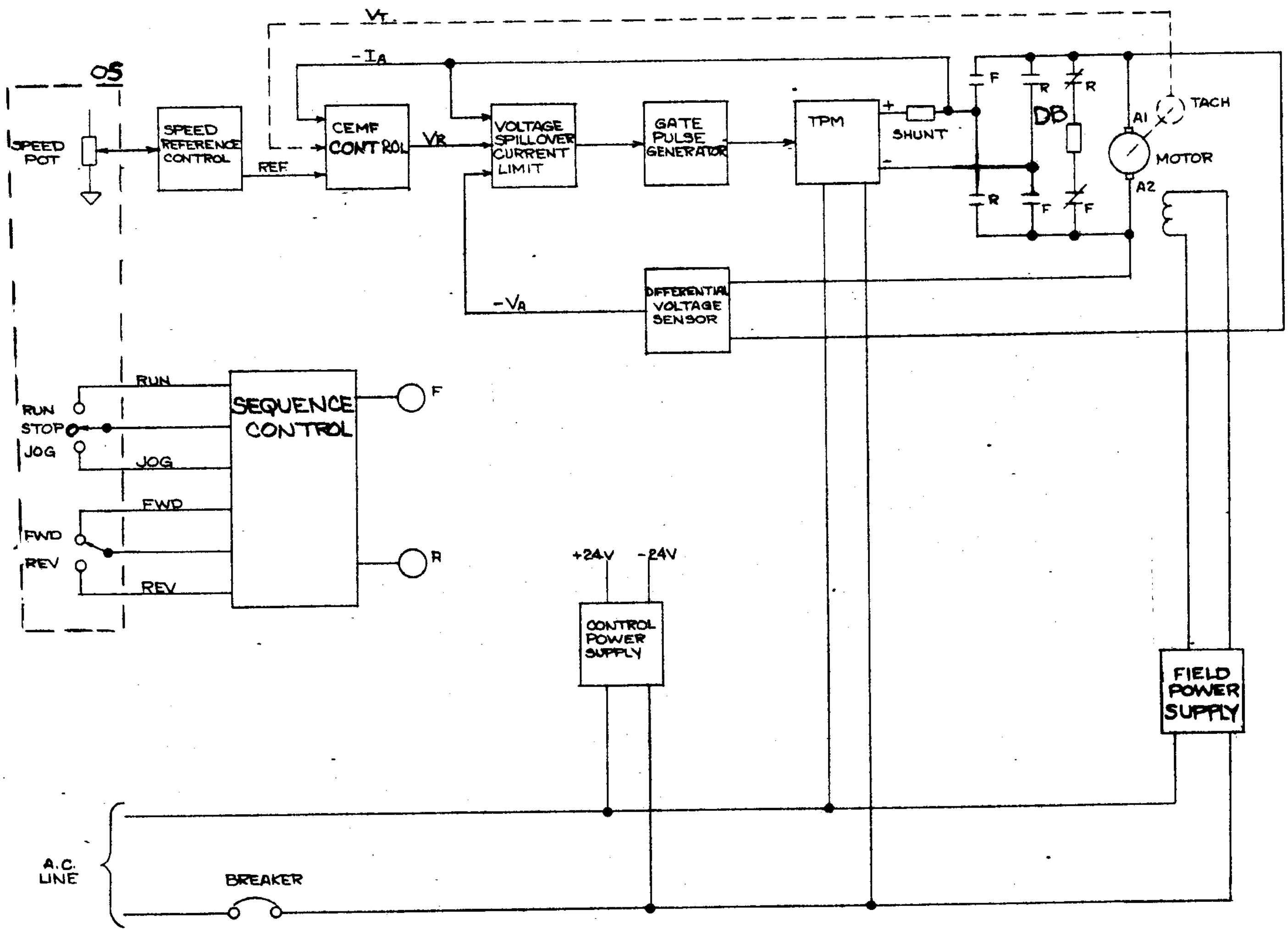

FIGURE 2

Figure 2 shows a block diagram indicating the interdependence of these major electrical components. In the following section we will briefly describe the function and operation of each.

1. TPM Module

The TPM consist of a typical semiconverter bridge with a free wheeling diode as shown in Fig. 3. The bridge consist of diodes 1D and 2D, and thyristor 1TH and 2TH, and free wheeling diode 3D. The TPM converts the AC power to DC and becomes the instrument by which the load voltage is controlled.

Consider for a moment that thyristors 1TH and 2TH are replaced by diodes, and a sine wave is applied across AC1 and AC2, with a resistive load applied across TN and P. The familiar full wave rectified waveform will appear across TN and P as shown in Fig. 4. The voltage across TN and P is designated by V_A, and i_1 is defined as the current which passes through the diode replacing 1TH, and i_2 is defined as the current which passes through the diode replacing 2TH.

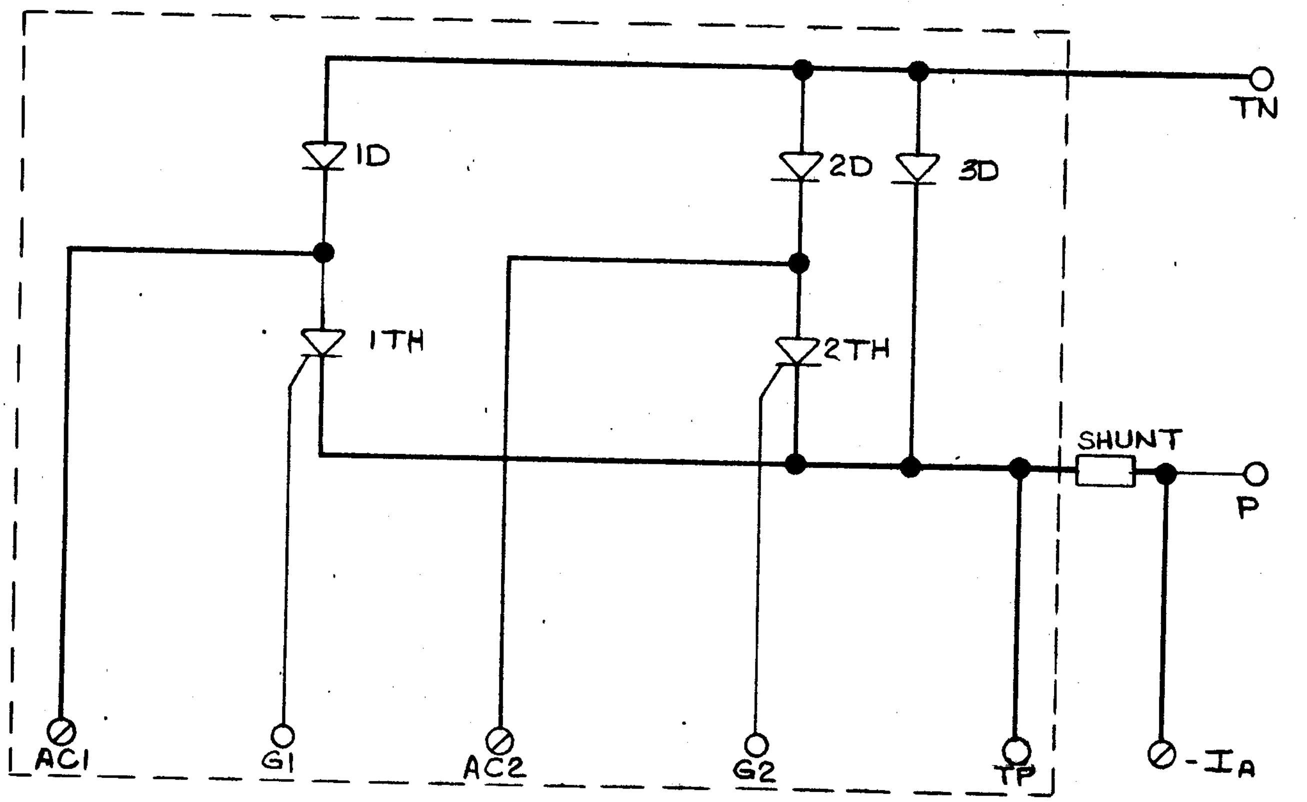

FIGURE 3

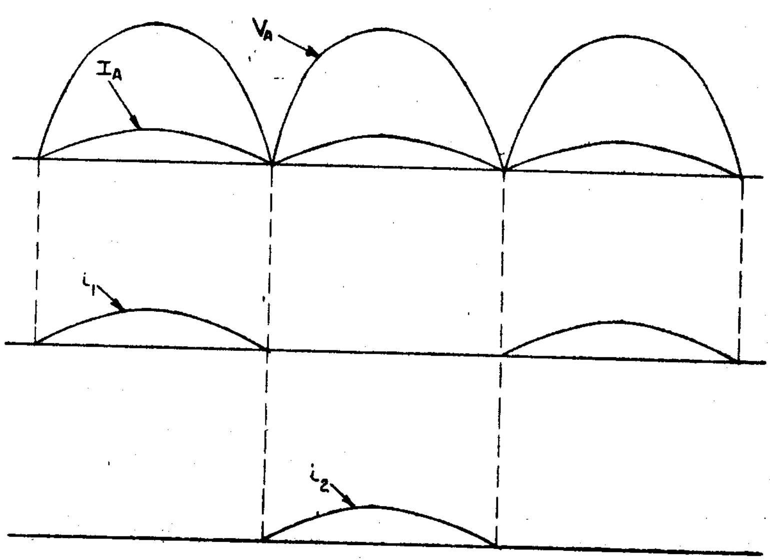

FIGURE 4

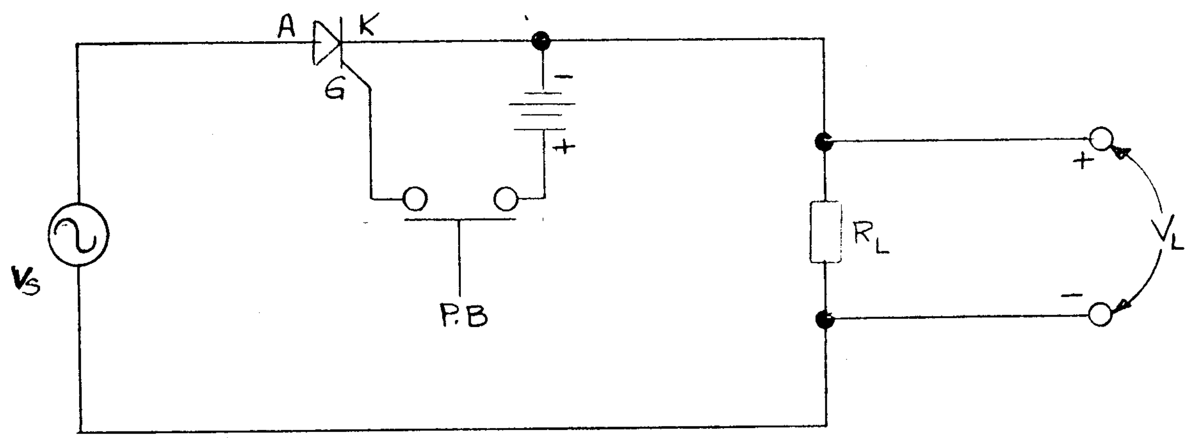

FIGURE 5

The sum of currents i_1 and i_2 is equal to the total rectified current, I_A. A diode conducts in one direction only; in this respect a thyristor and diode are equivalent. But a thyristor can be made to block current in both directions (both polarities), or it can be gated at various times during its positive half-cycle. In Fig. 5 a Sine-wave generator, V_S, is shown connected to a thyristor and load, R_L.

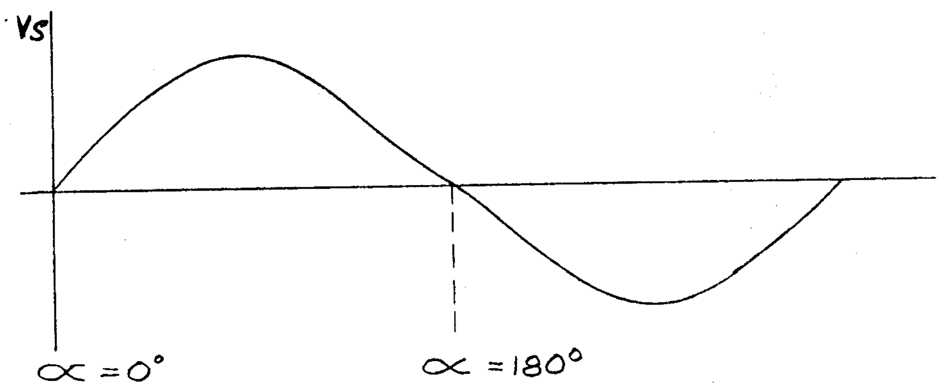

FIGURE 6

The anode of the thyristor, (A) must be positive with respect to the cathode, (k) for conduction to take place. In addition pushbutton, (PB), must be closed in order to gate the thyristor. In order for conduction to take place the pushbutton must be activated sometime during the positive half cycle of V_S. Once gated conduction will continue even if the pushbutton is released until the current reverse, which will occur when the sine wave of V_s first goes negative.

The gating angle, (defined as α) varies between 0 degrees and 180 degrees (i.e., when voltage on the thyristor is positibe from Anode to Cathode).

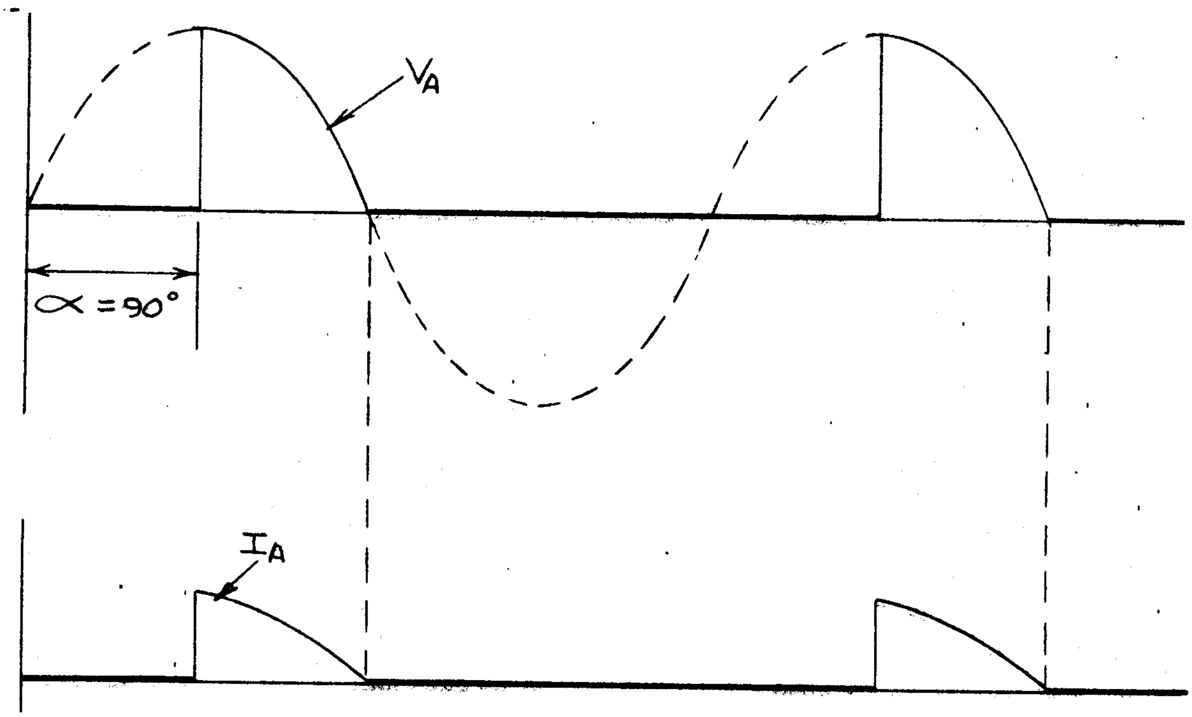

FIGURE 7

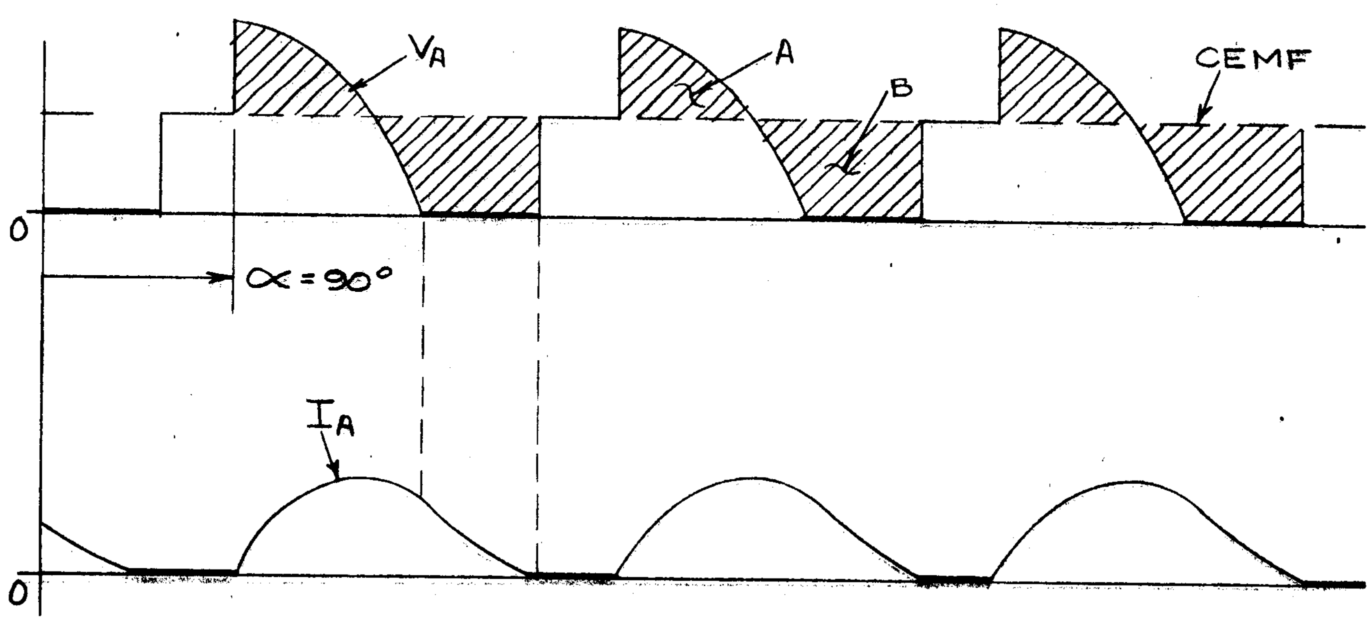

FIGURE 8

Let us now consider the semiconverter bridge shown in Fig. 3, with a resistive load connected across TN and P. Let us assume that the gate 1TH is gated at α = 90 degrees. The load voltage and current waveforms will appear as shown in Fig. 7. When I_A decreases to zero 1TH is commutated off and the load becomes disconnected from the source. When 2TH becomes forward biased and α = 90 degrees it will be commutated on.

If the resistive load across TN and P is replaced by a resistor an inductor and a CEMF and once again 1TH is gated at α = 90 degrees, then load voltage and current waveform will appear as shown in Fig. 8. When I_A decreases to zero 1TH is commutated off, & V_A snaps to the value of the CEMF. 2TH may not be gated on until the source voltage exceeds the CEMF, forward biasing 2TH, and a gate signal is applied to the gate of 2TH.

Note that the law of conservation of energy requires that area A and area B of Fig. 8 be equal if the resistive portion of the load is zero. This is because of the magnetic energy stored in the inductor is proportional to the voltage across the inductor and the energy going into the inductor must equal the energy returned out.

If the inductive portion of the load is sufficiently large, the current I_A will be continuous, (i.e., the current will not go to zero), as the waveforms in Fig. 9 indicate. In this case, the load current is commutated from 1TH to the free wheeling diode, 3D, to 2TH, etc.

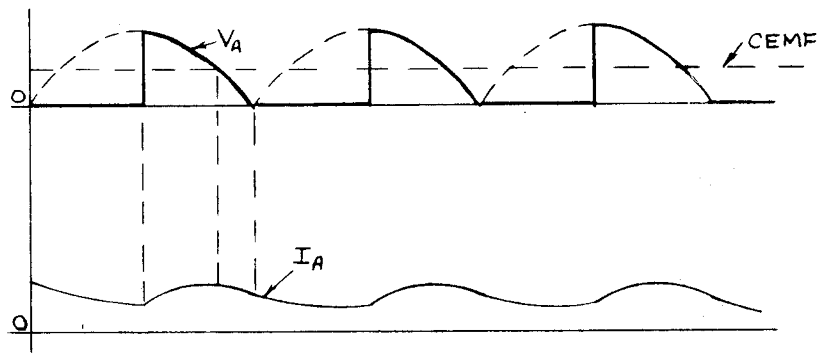

FIGURE 9

In the case of discontinuous current, there is a higher ripple content in the current than there is in the continuous current waveform of Fig. 9. Ripple content is proportional to the form factor of the current waveshape. The form factor is defined as the ratio of RMS current to average current. It is desirable to have the form factor as close to unity as possible, which is to say we would like to have the current as ripple-free as possible. A higher form-factor will dissipate more power in the motor armature circuit, TPM, and power connections. When more power in the TPM is consumed, the thyristors and diodes run hotter and the TPM may need to be derated. In an attempt to supply more power per dollar to our customer, Westinghouse Motors are recommended, since these motors have fairly high inductances, low-form factors and will result in greater economy of operation.

2. D. C. Contactors

DC contactors are provided between the TPM and the load. These contactors provide a positive disconnect between the TPM and the load. The contactors also provide a means of reversing the voltage supplied to the load. In Figure 2 it can be seen that by closing the forward contactor, (F) positive output voltage is applied to A1 of the motor with respect to A2. However, if the reverse contactor, (R) is closed negative output voltage is applied to A1 with respect to A2. On fractional horsepower drives, (i.e., 1/4 to 3/4 HP) the contactors are mounted on the controller board, (CB). On integral horsepower drives, (i.e., 1 to 5 HP) the contactors are mounted on the enclosure rear panel.

3. AC Breaker

An A. C. breaker is provided to protect the drive against excessive current overload. The breaker connects power directly to the control power supply, the field power supply, and the TPM. This breaker is a single pole breaker. It provides only overload protection. It does not provide current limit protection or positive disconnect from the line.

4. Control Power Supply

The control power supply consist of a control transformer, mounted on the enclosure rear panel, and a full wave diode bridge and filter capacitors mounted on the controller board, (CB). The control transformer is connected to the controller board by a plug type connector. The power supply generates filtered ±24 volts. The ±24 volts is then regulated to ±15 volts and -12 volts by zener diodes.

5. Field Power Supply

A full wave bridge is mounted on the controller board, (CB) to provide DC field voltage. The supply is rated at 100VDC at ½ amp on fractional horsepower drives and 200VDC at 1 amp on integral horsepower drives.

6. Speed Reference Control

The speed reference control consists of a zener power supply and 3 potentiometers mounted on the controller board, (CB), and one potentiometer, (speed pot) mounted on the operator station, (OS). (Refer to Fig. 10). A voltage divider, adjustable by the speed pot, generates a voltage reference signal proportional to the speed pot setting. Potentiometer 1P establishes the lower limit of the speed reference range. Potentiometer 2P establishes the upper limit of the speed reference range.

The jog reference is generated from a voltage divider network consisting of 3P. Either the speed reference signal or the jog reference signal may be applied to the reference input, (REF), by depressing the "RUN/STOP/JOG" switch.

The adjustment procedure is as follows:

Switch the drive to RUN. Set the speed pot to the extreme clockwise position. Set 2P for the desired maximum drive speed. Set the speed pot to the extreme counterclockwise position. Set 1P for the desired minimum speed. Switch the drive to JOG. Set 3P for the desired jog speed.

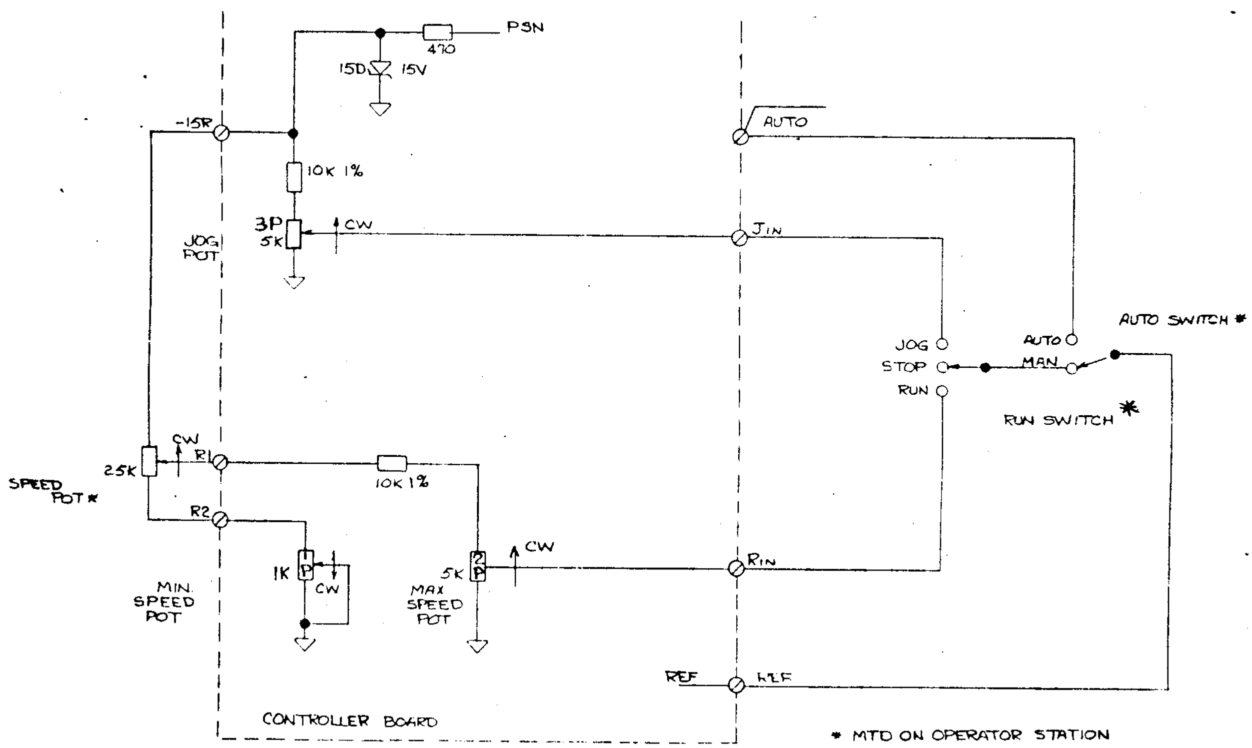

FIGURE 10

7. Armature Voltage Sensor

The armature voltage sensor is located on the controller board, (CB) and consist of a differential amplifier and an absolute value circuit. (Refer to Fig. 11). The differential amplifier attenuates the armature voltage and provides current isolation through the high input impedance of the amplifier. The absolute value circuit converts the output of the differential amplifier to a negative signal proportional to the armature voltage.

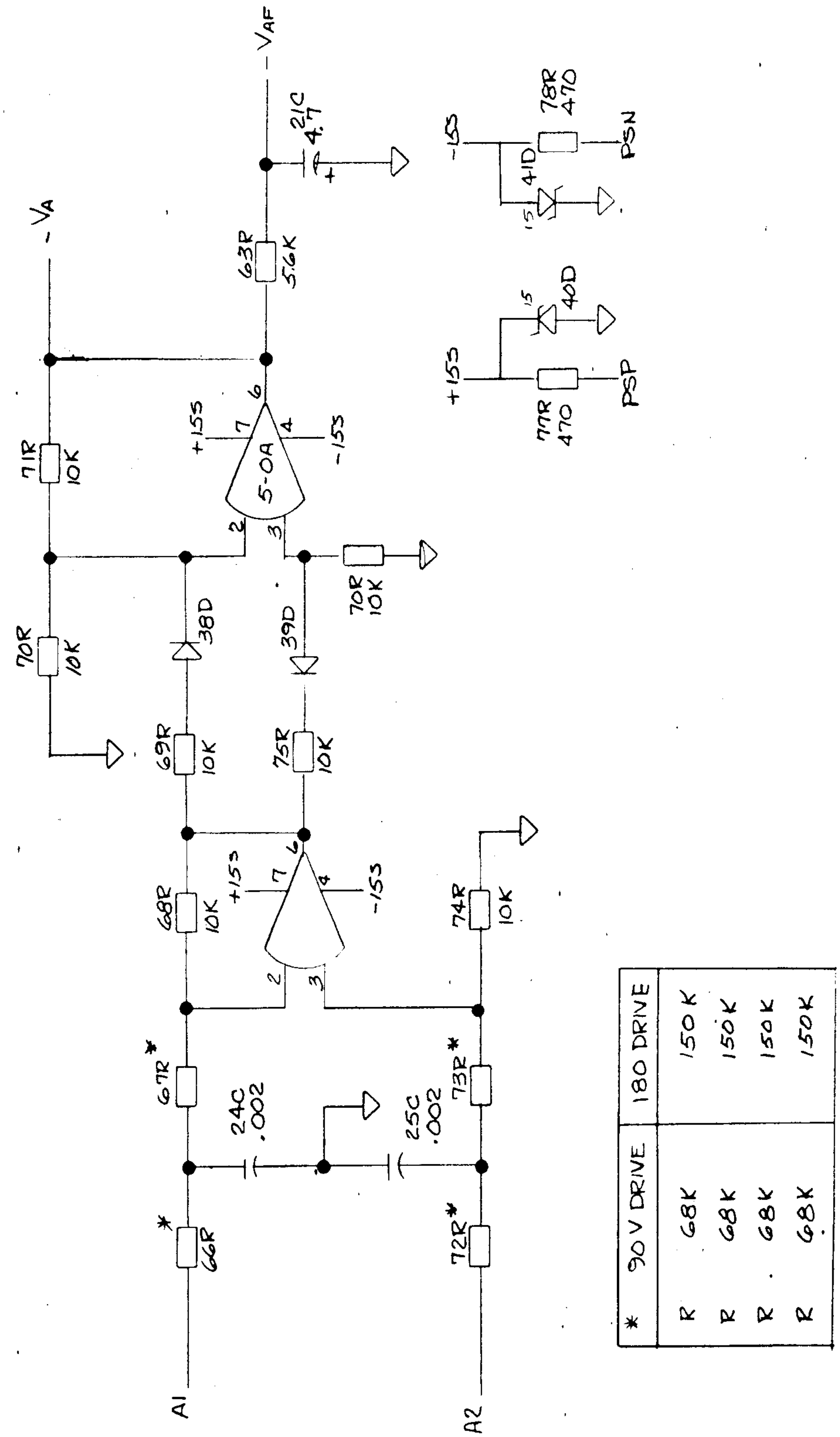

FIGURE 11

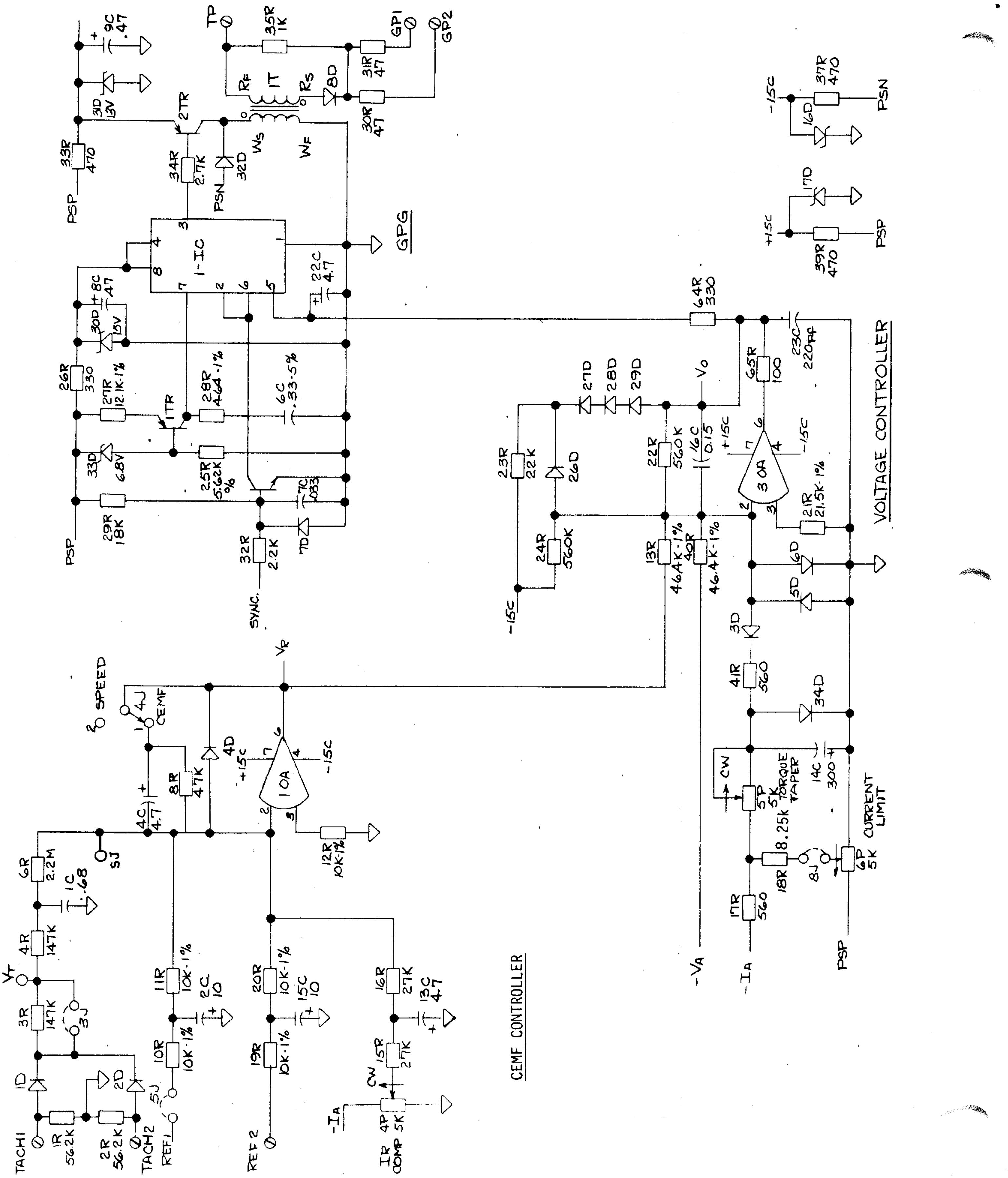
VOLTAGE CONTROLLER
CEMF CONTROLLER
SPEED
CEMF
TORQUE TAPER
CURRENT LIMIT
IR COMP 5K
TACH1
TACH2
REF1
REF 2
SYNC.
GPG
GP1
GP2
TP
PSP
PSN

FIGURE 12

8. CEMF Controller

The CEMF controller is mounted on the controller board (CB). (Refer to Fig. 12). Speed may be controlled quite accurately by means of the CEMF controller. The gain of the controller is approximately equal to -1.0 with a high frequency roll-off at about 4.6 radians/sec. The current feedback signal is fed through potentiometer 4P, (IR Compensation Adjust), and resistors 15R and 16R to the summing junction of the operational amplifier, (1-OA), where it is summed along with the speed reference signal from terminal R1. The current signal is considered positive feedback, since an increase in current tends to advance the gating angle of the TPM, which in turn tends to further increase the current, etc. Positive feedback in a system tends to make it unstable.

Setting of I.R. Compensation

Be sure that the IR Compensation Adjust is fully CCW <u>before</u> starting up the drive the first time.

I. R. Compensation is set by pot 4P on CB. CW adjustment increases the percent of compensation.

For CEMF regulated drives pot 4P is set to give constant RPM for full-load and minimum load. This setting is usually made at some operating speed of approximately 20 to 25% of motor base speed. Pot 4P is adjusted to obtain the same motor RPM at rated full-load current as at minimum load. If the minimum operating RPM is greater than 20 to 25% of motor base speed, I. R. Compensation can be set at the lowest operating speed.

If flat compensation is set at a high motor speed and operation is at a much lower motor speed, instability may result due to over compensation at the low motor speed.

9. Voltage Controller with Spillover Current Limit

The voltage controller circuitry is located on the controller board (CB). (Refer to Fig. 12).

The voltage controller, (3-OA) sums the armature voltage reference from 1-OA, current limit reference, and the armature voltage, feedback from 2-OA. A bias voltage applied through 24R forces 3-OA into positive saturation. When 3-OA is in positive saturation, no gate pulses are generated and the control is biased off. As positive voltage reference from 1-OA increases, the output of 3-OA goes negative from positive saturation, but is limited at a value determined by the sum of the diode drops 27D, 28D and 29D less the diode drop of 26D, which is biased on by resistor 23R. Since the drop of 27D will approximately cancel the drop of 26D, the 3-OA output can go no further negative than about +1.2 volts, the combined drop of 28D and 29D. The reason for limiting the output of 3-OA to +1.2 volts is that the timer, 1-1C, operates poorly below about +1.0 volts.

Spill-over current limit is provided by circuitry consisting of diode 3D, resistors 41R, 17R and 18R; pots 6P, and 5P; and capacitor 14C. Resistor 41R established the gain of the current limit circuit in conjunction with pot 5P, (torque taper). The time constant 17R X 14C is chosen to eliminate ripple voltage from 14C to produce as sharp a current-limit characteristic as possible. The 14C voltage must go negative sufficiently to bias diode 3D on for current-limiting to take place. The amount of armature current necessary for this (i.e., voltage necessary at "$-I_a$" terminal) is determined by the bias supplied by 6P, (current-limit adjust pot). The torque taper pot, 5P, adjusts the slope of current-limit characteristic. (i.e., speed vs. current limit characteristics. Refer to Fig. 13 and 14.

Current feedback ($-I_A$) is obtained from a shunt in the armature circuit. At FLA $-I_A$ is approximately equal to -1.0VDC for all Hp ratings. This characteristic is obtained by selecting the appropriate shunt value for each Hp rating.

Setting of Current Limit, (CL)

CL is set by pot 6P on CB. CW rotation of pot 6P increases the value of current at which armature current is limited. Figure 13 shows typical speed vs. current characteristics for several settings of CL.

a. Remove AC power for the drive and disconnect the DC motor shunt field at terminal block F1. Block the motor shaft to prevent rotation. Insert a DC ammeter in the motor armature circuit. The ammeter should have a range of at least 200% FLA. Set the speed pot for zero speed. Set pots 5P and 6P on CB in the ECCW position.

b. Apply AC power and start the drive. Slowly turn the speed pot CW to mid range. Carefully but quickly adjust pot 6P CW until the desired current limit value is obtained.

c. Stop the drive, remove AC power, and restore the normal operating connections.

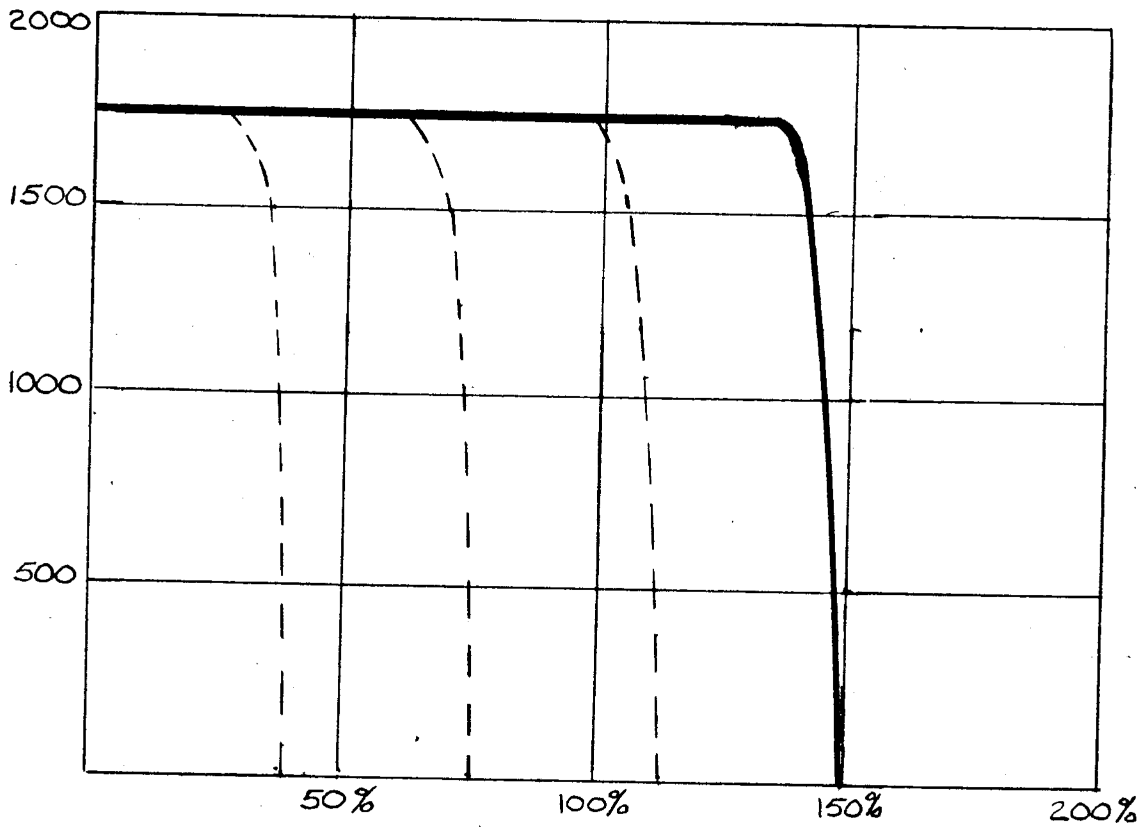

FIGURE 13

Setting of Torque Taper

Torque taper is set by 5P on CB. CW rotation of 5P decreases the slope of the speed vs. current characteristics shown in Figure 14.

a. Remove AC power from the drive. Insert a DC ammeter in the armature circuit. The ammeter should have a range of at least 200% FLA. Set 5P in the ECCW position and 6P in ECW position.

b. Start the drive and bring it to full speed. Load the drive to its maximum full speed load. Adjust 6P CCW until the motor speed begins to decrease.

c. Stop the drive and remove AC power. Disconnect the DC motor shunt field at terminal block F1. Block the motor shaft to prevent rotation. Set the speed pot for zero speed.

d. Apply AC power and start the drive. Slowly turn the speed pt CW to mid range. Carefully but quickly adjust pot 5P CW until the desired current limit is obtained.

e. Stop the drive, remove AC power and restore the normal operating conditions.

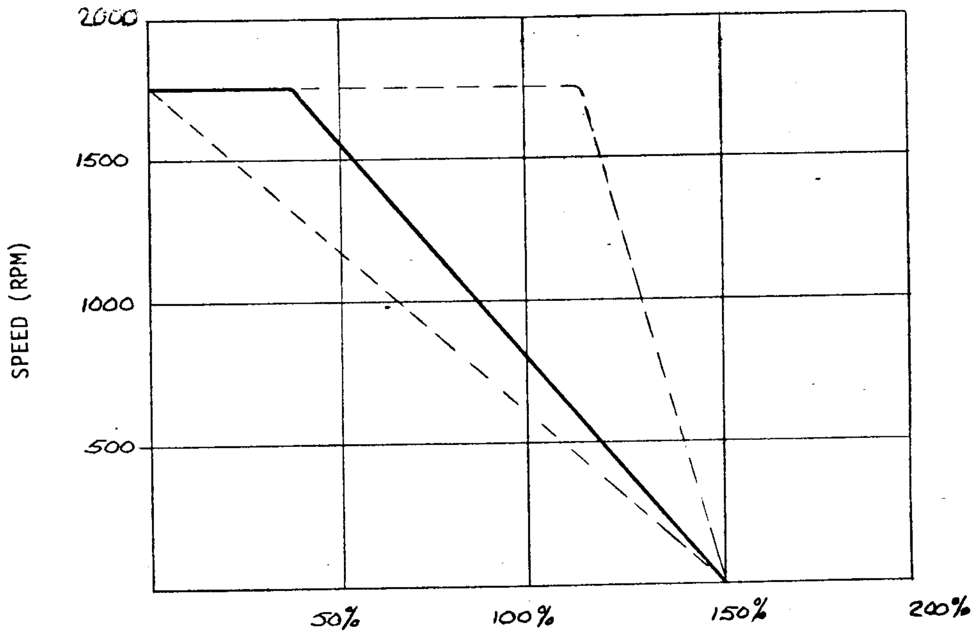

FIGURE 14

10. Gate Pulse Generator

The gate pulse generator consists of a ramp generator, (33D, 25R, 27D, 28R, 6C and 1TR), a timer (1-IC), a sync circuit, (32R and 3TR), and a driver circuit, (2TR, 32D, 1T, 30R and 31R). A constant current is generated by resistors 25R and 26R in conjunction with transistor 1TR and 33D. The magnitude of the current is given by:

$$\frac{V_Z - V_{BE}}{12.1k} = I$$

where V_Z = 6.8 volts

V_{BE} = 0.6 volts

I = charging current

The constant current charges 6C linearly. The circuit comprised of diodes 9D, 14D, 7D resistors 29D and 32R, capacitor 7C, and transistor 3TR establish a zero pulse at the end of every half cycle of the AC line signal, thereby providing the necessary synchronization between ramp and line voltage waveforms. Timer, 1-IC compares the ramp voltage at pins 2 and 6 with a dc level at pin 5. When pin 6 equals or exceeds pin 5 voltage a transistor inside the timer pulls pin 7 to PSC, discharging the capacitor 6C through resistor 28R which determines the discharge time constant and hence the gate pulse width. Once pin 2 voltage reaches a potential equal to 1/2 pin 5 voltage, a trigger is initiated inside the timer which resets the circuit to start the charging cycle over again. When pin 3 voltage goes toward PSC transistor 2TR turns on driving into the pulse transformer primary. Capacitor 9C and zener diode 31D supply power for this purpose. The power source is decoupled from the main supply by resistor 33R. Diode 32D forces the primary transformer voltage to -24 volts which forces the transformer to reset very rapidly. Diode 8D keeps the current contribution from the thyristor package from feeding the transformer primary. Resistor 35R provides (dv/dt) insensitivity by shunting the gate-cathode capacitance of the thyristors, necessary for reliable simultaneous gating.

(Refer to Figs. 12 and 15).

Gate pulses may occur as often as every 7 degrees, the frequency and occurrence depending on the pin 5 voltage. The period between gate pulses equals 1/2 the delay angle, α).

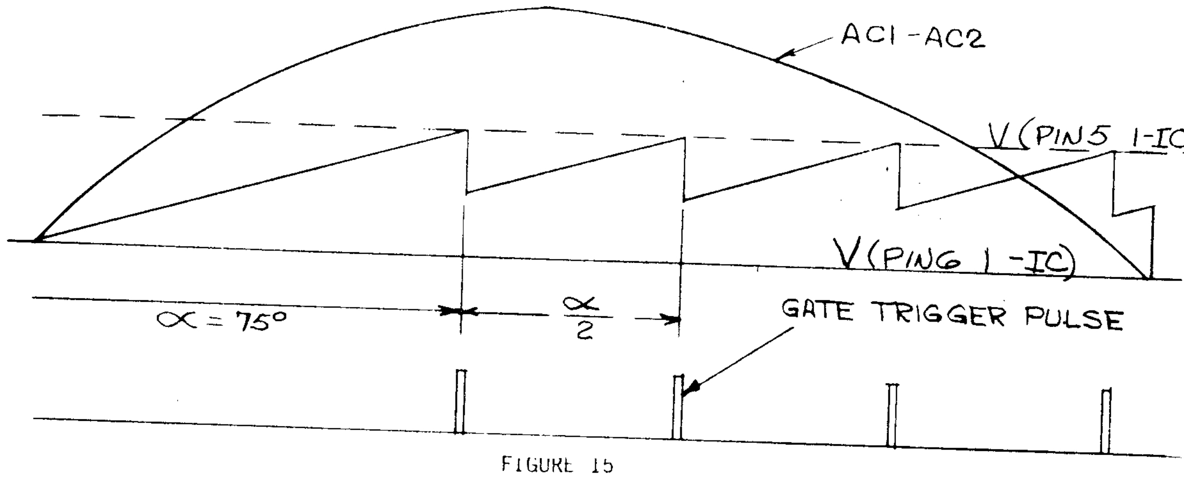

FIGURE 15

II. Sequencing Control

The sequencing control is located on the S100Z logic board, (LB), (S#1810A90). This board is a plug in type and plugs directly into the controller board. This board provides solid state logic for sequencing the forward and reverse contactors and the speed reference signal.

CAUTION: The logic board contains CMOS integrated circuits and is very susceptible to damage from static electricity. Repair work on the logic board should be done on a work bench with a metal surface which has been grounded. The soldering iron and repairman should also be grounded.

The board contains three voltage detectors, two contactor drivers, a speed reference signal clamp, and an optional speed reference ramp circuit. The first voltage detector, (line voltage detector) senses that line power is available and line voltage is not less than 30% below nominal. The second voltage detector, (voltage reference detector) senses zero reference at the input of the voltage controller. The third voltage detector, (armature voltage detector) senses 20% rated armature voltage. The output of the three voltage detectors, an external "forward" signal, an external "reverse" signal, and an external "reset" signal, (RS), operate into the logic circuit to sequence the forward contactor driver, and the reverse contactor driver, on and off and also controls the speed reference clamp.

The board functions as follows: (Refer to Fig. 16).

The line voltage signal is applied through the control power transformer to T3 and T5. The signal is rectified and filtered. A "power up" signal, (P), is generated by the line voltage detector after a 0.5 second delay if the line voltage is not less than 30% of nominal. After the "power up" signal becomes available the external "reset" signal must be set to a logic zero, (-12.0 volts), and then set to a logic one. (0.0 volts). After the "reset" signal is sequenced the "enable" signal is generated which will allow either the forward or the reverse contactor driver to be energized. If the line voltage drops below 30% of nominal or the interlock switch is opened, then the "enable" signal goes to a logic zero and an energized contactor driver will become de-energized. The "enable" signal will remain a logic zero until line voltage is restored and the "reset" signal is resequenced as described above.

NOTE 1: T4 and T7 must be jumpered together or interconnected through a normally closed interlock switch.

The forward or reverse contactor drivers may be energized if the following conditions hold:

1. The "enable" signal is a logic one.
2. The armature voltage is less than 20% of rated.
3. The voltage reference is zero.
4. The "forward" or "reverse" signal is selected.

The "forward" signal is selected by setting B11 to a logic one and B12 to a logic zero. The "reverse" signal is selected by setting B12 to a logic one and B11 to a logic zero. This is accomplished by the "FORWARD/REVERSE" selector switch.

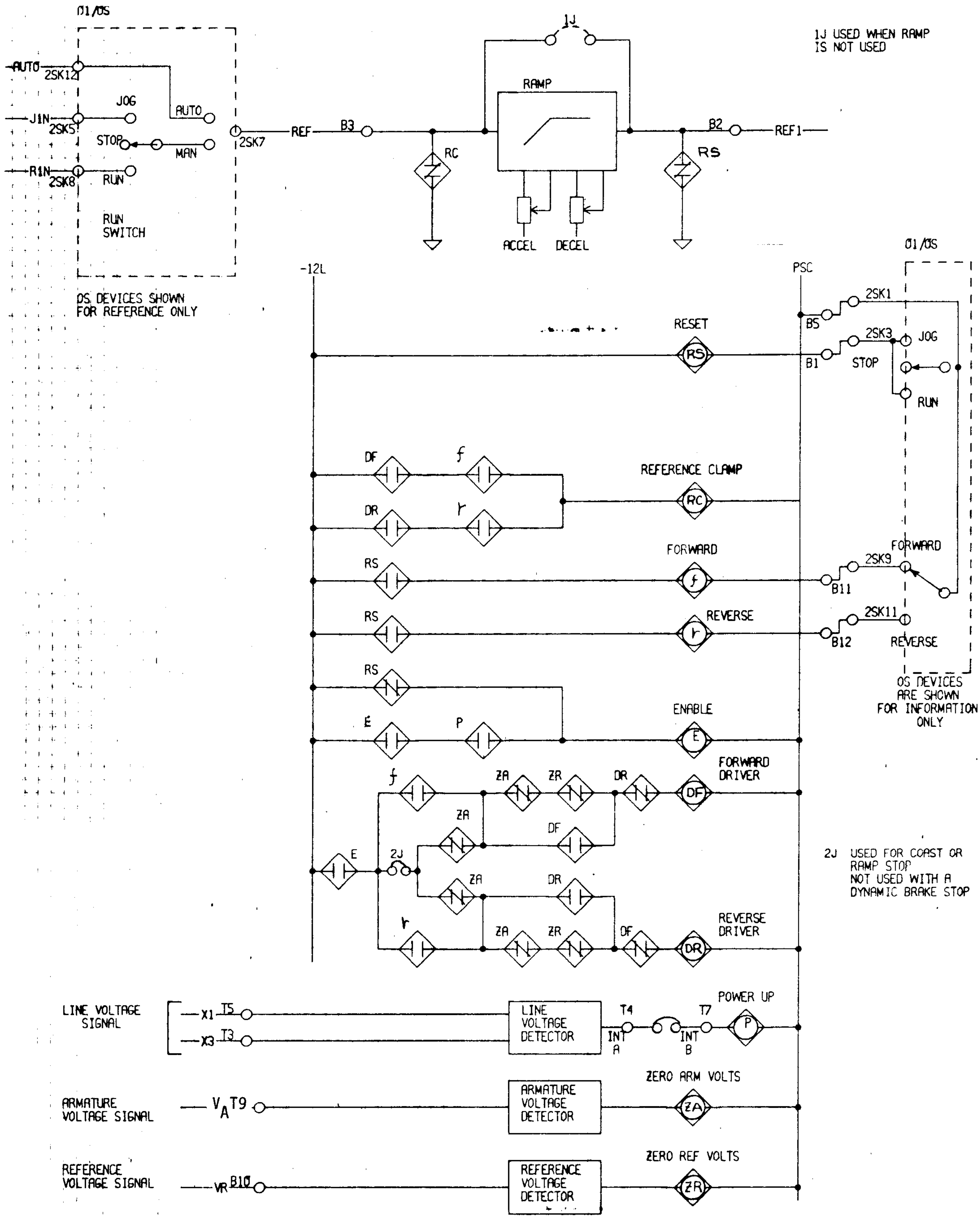
01/OS
AUTO
2SK12
JOG
AUTO
J1N
2SK5
STOP
MAN
2SK7
REF
B3
R1N
2SK8
RUN
RUN SWITCH
OS DEVICES SHOWN FOR REFERENCE ONLY
1J
1J USED WHEN RAMP IS NOT USED
RAMP
RC
ACCEL
DECEL
B2
REF1
RS
-12L
PSC
01/OS
2SK1
B5
RESET
2SK3
JOG
B1
STOP
RUN
DF
f
REFERENCE CLAMP
DR
r
FORWARD
FORWARD
2SK9
B11
RS
REVERSE
2SK11
B12
REVERSE
OS DEVICES ARE SHOWN FOR INFORMATION ONLY
ENABLE
E
P
FORWARD DRIVER
ZA
ZR
2J
2J USED FOR COAST OR RAMP STOP NOT USED WITH A DYNAMIC BRAKE STOP
REVERSE DRIVER
LINE VOLTAGE SIGNAL
X1
T5
X3
T3
LINE VOLTAGE DETECTOR
T4
T7
POWER UP
INT A
INT B
ARMATURE VOLTAGE SIGNAL
VA T9
ARMATURE VOLTAGE DETECTOR
ZERO ARM VOLTS
REFERENCE VOLTAGE SIGNAL
VR B10
REFERENCE VOLTAGE DETECTOR
ZERO REF VOLTS

FIGURE 16

If the above conditions hold then the selected contactor driver will be energized after a 100mS delay. An interlock signal prevents the forward and reverse contactor drivers from being energized simultaneously. An additional interlock signal is generated at the instant the contactor driver is energized. This second interlock signal holds the contactor driver on after the motor is set in motion and conditions 2 and 3 no longer hold. However, condition 1 must hold or the contactor driver will be de-energized through a 10mS delay.

The speed reference clamp holds the speed reference signal at zero volts unless one of the two following conditions are met.

1. The "forward" signal is selected and the forward contactor driver is energized.

2. The "reverse" signal is selected and the reverse contactor driver is energized.

These conditions prevent the speed reference from being applied when the contactors are open.

A drive may be reversed by selecting the opposite direction rotation signal. (i.e., "forward" or "reverse"). This causes the speed reference signal to be clamped to zero volts after a 10mS delay. The voltage controller input signal ramps toward zero volts causing the motor to slow down. After the motor slows sufficiently and the armature voltage decreases to 20% of rated voltage then the contactor driver will be de-energized. After the voltage reference has decreased to zero the opposite contactor driver will become energized after a 100mS delay. The speed reference clamp will be released after a 100mS delay and the speed reference will increase to the level applied to B3.

The drive is stopped in a similar manner by setting the "reset" signal to zero. The same sequence of events will take place as described above, with the exception that both contactor drivers will remain de-energized and the speed reference will remain clamped as long as the "reset" signal is a zero.

The drive may be restarted by setting the "reset" signal to a one. The selected contactor driver will be energized after a 100mS delay. The speed reference clamp will then be released after a 100mS delay and the speed reference will increase to the level applied to B3.

The logic may be modified to provide dynamic braking during reversing and stopping. This is accomplished by removing jumper 2J. This causes both contactor drivers to de-energize at the instant of reversal or at the instant the "reset" signal is set to a zero for stopping.

The speed reference signal may be applied to an adjustable ramp circuit as provided on G02. (Jumper J1 by-passes the ramp when it is not used). The acceleration and deceleration rates of the ramp circuit are independently adjustable with pots. The output of the ramp is instantaneously reset to zero volts when the "enable" signal is a zero.

12. Operator's Station

There are four standard operators stations available for use with 22-1000Z series drives. The features provided by the four types are listed below:

1. Non-Reversing - RUN-STOP-JOG.
2. Reversing - RUN-STOP-JOG.
3. Non-Reversing - Manual - Automatic* RUN-STOP-JOG.
4. Reversing - Manual - Automatic* RUN-STOP-JOG.

All the above operator stations are provided with a speed control pot.

*NOTE: The automatic switch enables the selection of an external speed reference for instrument follow.

The standard operators station is provided with a connector plug. When the operator station is locally mounted as on the door of the drive enclosure, the connector plug is inserted into the 1SK connector on the controller board.

Remote operator stations are also available with either NEMA 1 or NEMA 12 type enclosures. (Refer to 1801A54 and 1757A40). When remote operator stations are used, the preferred method of connection to the drive is to connect corresponding operator station terminals to the 12 point terminal block located on the controller board, and marked with the following designations.

a. -15R
b. R1
c. R2
d. RIN
e. REF2
f. JIN
g. Rs
h. REF
i. FWD
j. REV

In the event that a remote operator station is used, the enclosure of the station must be connected to earth ground with an appropriate gauge of conductor.

IV. INSTALLATION

The drive must be wall mounted in a location which will allow air to flow over the heat sink mounting flange on the rear of the drive. An air duct is provided by the shape of the mounting flange. The maximum ambient temperature around the drive must not exceed 40 degrees C (104 degrees F). It is recommended that two or more inches of clearance be provided all around the drive to assure adequate air flow.

Conduit entering the enclosure must be properly sealed for NEMA 12 applications. Wiring used for purposes other than the control of the specific drive should not enter into the drive enclosure.

The drive must be connected to earth ground by attaching an appropriate guage conductor in the mounting flange, and earth ground. The necessary wire gauge of the ground wire is determined by the rating of the branch circuit breaker feeding the drive.

The customer connections to the drive must be made at the terminal block located on the right hand edge of the controller board.

Customer Connections

a. The A. C. line is terminated at AC1 and AC2 with appropriate spade terminals. (The line voltage is indicated on the nameplate).

b. The motor armature conductors are terminated at A1 and A2 with appropriate spade terminals. (The polarity convention for the motor armature circuit is A1 is positive for forward operation).

c. The motor field conductors are terminated at F1 and F2 with appropriate spade terminals. (F1 is positive).

CAUTION: This drive is protected against faults on feeder lines which provide no more than 900 amps available current. If the feeder line provides available current exceeding this value, then a fuse must be placed in the feeder line.

For fractional horsepower drives a CARBONE-FERRAZ CLASS FA 250VAC 20 amp fuse is recommended. For integral horsepower drives a CARBONE-FERRAZ CLASS F/L 250 VAC 40 amp fuse is recommended. The CLASS FA FUSE will protect the drive on a feeder with up to 10,000 amp available current.

V. SPECIFICATIONS AND RATINGS

1. Basic Characteristics

   a. Single-phase, full wave semi-converter with free wheeling diode.

   b. 50 or 60 hertz, 1/4 through 3/4 hp - 115V, 1 through 5 hp - 230V.

   c. 100:1 speed range with tachometer - 30:1 standard.

   d. Line voltage regulation of 1% for ±10% line voltage change.

   e. Ambient temperature range: 0 degrees C to 40 degrees C.

2. Speed Commands

   a. Manual potentiometer control on operator's station. Interdependent adjustments for maximum and minimum speed are available on controller board, with maximum speed range of 0% to 125% and minimum speed range to 25%.

   b. Automatic speed control following signal from an external source where -4 volts corresponds to rated voltage or speed.

3. Speed Control

   a. Standard is voltage feedback with IR compensation adjustable from zero % to at least

100% for IR drops not exceeding 10% of rated CEMF at full load.

b. Speed feedback from motor mounted AC or DC tachometer, optional, with 100V/1000 rpm tachometer used for 1150 rpm and 1750 rpm motors and 50V/1000 rpm tachometer used for 2400 rpm and 3500 rpm motors. 200V/1000 rpm tachometer used for 850 rpm motors.

4. Standard Protection Features

a. Current limit is adjustable from 100% to 200% at stall speed; at rated speed the onset of C. L. is 75% to 150%. This variation is due to the finite gain of the gating circuit and the C. L. control. Torque adjust increases C. L. at stall speed but not the onset of C. L. at rated speed, for use on reel or center winder drives, for example.

b. Primary AC line breaker protection is coordinated with the TPM current handling capability.

c. Transient voltage protection and under voltage protection.

5. Overload Capability

The capability of the TPM matches the motor which is 150% load for one minute.

6. Load Regulation

a. Less than ±2% no load to full load.

b. Less than ±1% no load to full load with tachometer feedback.

7. Field Supply

a. 1/4 through 3/4 hp - 100VDC at 1.0 amp.

b. 1 through 5 hp - 200VDC at 1.0 amp.