TYPE 22-1000 THREE PHASE ADJUSTABLE SPEED DRIVE SYSTEMS

DESCRIPTION OF ELECTRICAL OPERATION

I. INTRODUCTION

Type 22-1000 three-phase systems provide a line of controlled-voltage drives for armature excitation of 240 volt dc machines from 5 HP to 40 HP. They require 230 volt, three phase 50/60 Hertz power and feature front accessibility, high package density, minimum number of adjustments, and NEMA I (drip proof) wall-mounted enclosures with optional panel-mounting. The system provides 150 volt dc field excitation throughout the full horsepower range.

Unlike the single-phase drives, the three-phase system is magnetically controlled only, since switches for controlling the armature are rather large over this horsepower range and under voltage protection is inherently available in a magnetically controlled drive.

II. SCOPE OF APPLICATION

The 22-1000 System is a full wave adjustable voltage armature control to be used with motors designed for use with full wave thyristor controls.

Since the System utilizes a semiconverter power circuit (i.e., one-half of the bridge is made up of diodes and one-half consists of silicon controlled rectifiers), single quadrant operation only (rectification) is possible. This means that the motor will coast to a stop when the reference is removed. Regeneration is generally required only when very fast, controlled deceleration is desired. When fast braking is required, dynamic braking is supplied as an option.

The drive includes as standard a Torque (current) Limit potentiometer, which can be used separately or in conjunction with a Torque Taper (current limit taper) adjust potentiometer for use on winder applications where a constant horsepower characteristic is desired. Maximum and minimum speed limits can also be set via potentiometers in the control cabinets.

When jogging, threading, and/or linear, independently adjustable acceleration and deceleration are desired, accessory kits are available for modification. Anti-plugging is included on all reversing drives to protect motor and control.

Specifications and Ratings of above features are covered in a later section of this I.L.

III. ELECTRICAL DESCRIPTION

The 22-1000, 3-Phase Adjustable Speed Drives consists of a 240 volt dc motor of the desired horsepower rating and a 3 phase, 22-1000 Control System of the corresponding horsepower rating. Each Control System consists of a 3 phase, 22-1000 Thyristor Control and either of two operator's stations depending on the level of sophistication desired.

The operator's station which is standard (1459A12G05) is used only when the three-Relay-Logic (3R-Logic), 1492A18G01 is used. The 3R-Logic uses a minimum of one relay and a maximum of 3 relays, which is required when a reversing drive is desired. A non-reversing application without dynamic braking requires only one relay. The 9R-Logic (1459A01G01) is required when much more sophistication is desired, such as AC Mechanical Brakes, Thread speed, and Linear Accel-deceleration is required. The 9R-Logic uses a minimum of 3 relays and a maximum of 9 relays. The following table shows what options and features may be obtained with each type of logic.

	Magnetic Options Available	Standard Logic	Optional Logic
1.	Reversing and Antiplugging	yes	yes
2.	Dynamic Braking	yes	yes
3.	Jog (separately adjustable)	no	yes
4.	Jog (adjusted via speed pot)	yes	no
5.	Linear Acceleration (coast or dynamic brake to stop)	yes	no
6.	Linear Accel-decel. (separately adjustable)	no	yes
7.	Thread Button (Speed separately adjust)	no	yes
8.	Limit Switch Control (disconnects armature and dynamic brake if required)	yes	yes
9.	AC Mechanical Brake Relay (brake after stopping or use for emergency stops using "on-off" switch)	no	yes
10.	Follower Operation (for following an external signal --not for Speed Pot)	yes	yes

The 22-1000 Thyristor Control, the heart of the system, contains the Controlled TPM Assembly and contactors, shunt, fuses (or breaker), dynamic braking resistors, 3R-Logic (or 9R-Logic), and other optional equipment such as the Test Kit and Linear Accel-Decel. Kit.

The Controlled TPM Assembly contains the semiconductor power devices (diodes and thyristors), the RC Suppression board, and the Controller board, which contains all control circuits, the gate pulse generator circuit, and the gate pulse suppression circuits. Discussion of the Controller board operation is reserved to a later section.

The semiconductor power devices are mounted in heat sinks, which become the supporting structure for the Controlled TPM Assembly above. The power semiconductors are wired as in Figure 1 below. The circuit illustrated is that of a 3 phase semiconverter, whose output is variable dependent on the controlled gating applied to the thyristor gates G1, G2, and G3.

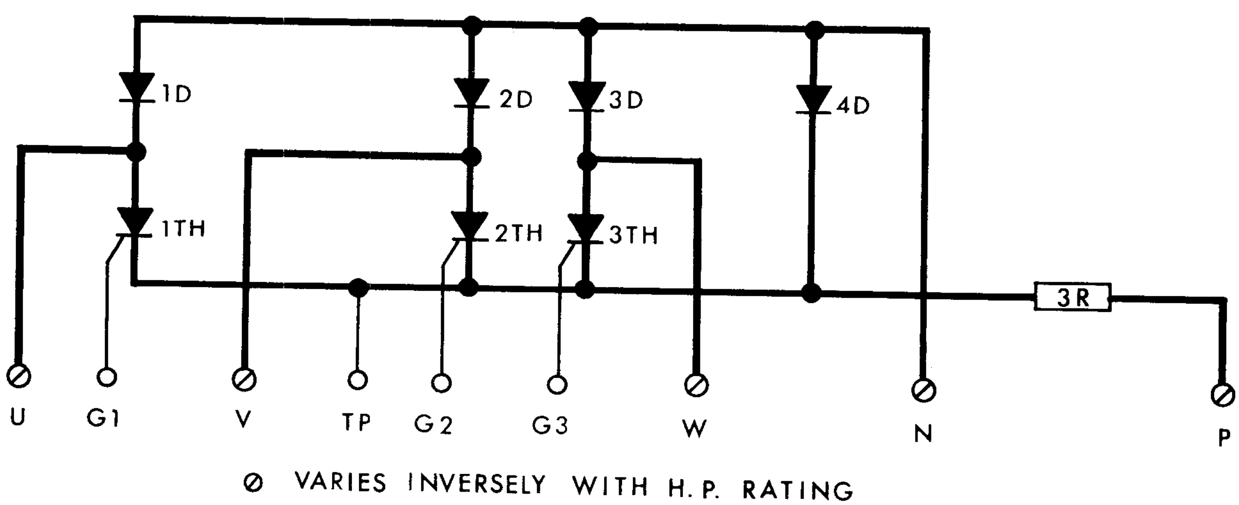


FIG. 1

The heavy lines signify power connections, whereas the light wires are low energy circuits. Consider for a moment that thyristors 1TH, 2TH and 3TH are replaced by power diodes. The familiar full wave rectified waveform of Figure 2 would result across the positive and negative bus terminals (P&N). This bus voltage from now on will be referred to as v_b. If i_1 is defined as that current which always flows through the diode replacing 1TH, i_2 as that current flowing through the diode replacing 2TH and i_3 as that flowing through 3TH then currents i_1, i_2, and i_3 will appear as shown in Figure 2, assuming a resistive load.

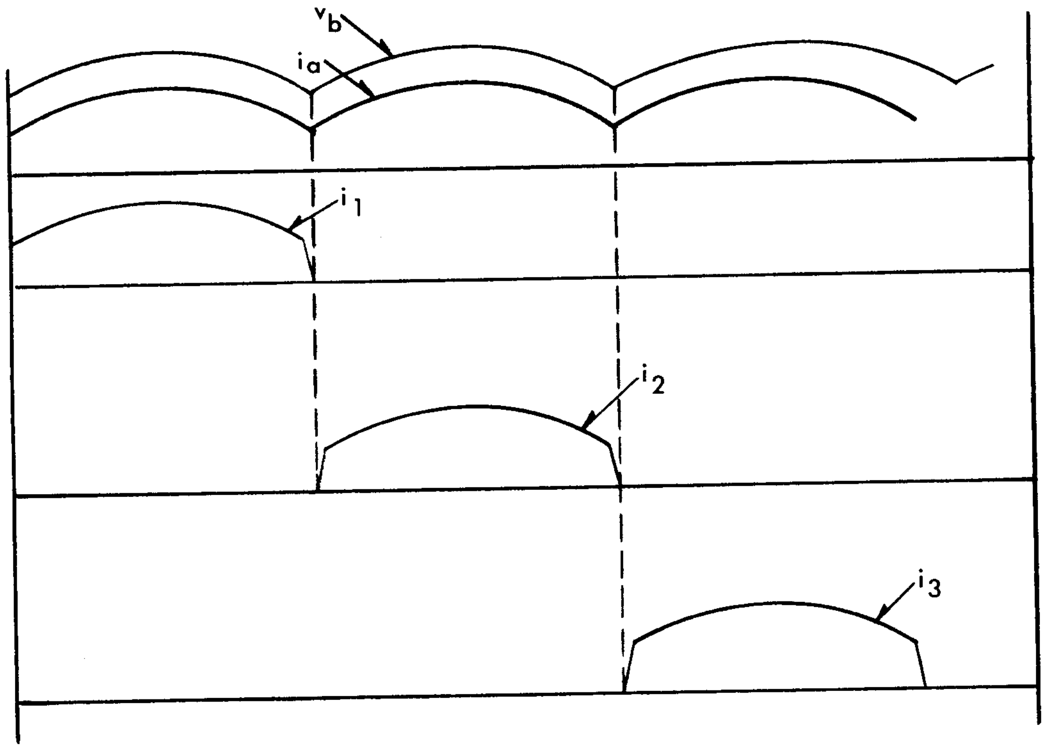


FIG. 2

The sum of currents i_1, i_2, and i_3 is equal to the total rectified current, i_a. A diode conducts in one direction only. In this respect a thyristor is 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 Figure 3 a Sin-wave generator, V_S, is shown connected to a thyristor and load, R_L.

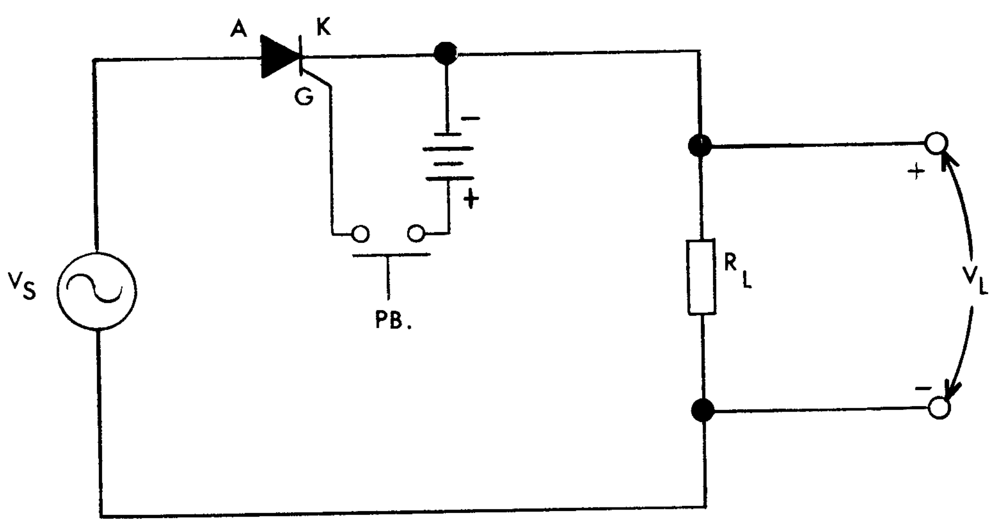


FIG. 3

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 any conduction to take place the pushbutton must be activated sometime during the first (positive) half cycle of V_S. Once gated conduction will continue until current tries to reverse, which will occur when the sign wave of V_S first goes negative, even if the pushbutton is released.

Gating angles, signified as α (alpha), may vary between 0 and 180 degrees of the excitation voltage as shown in Figure 4.

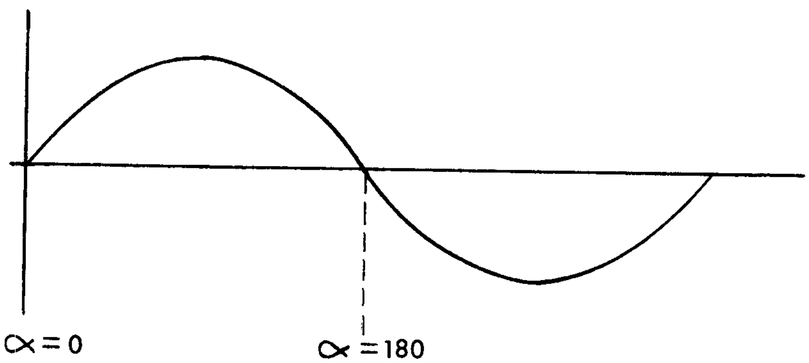


FIG. 4

The load voltage and current would appear as in Figure 5 if a gate pulse were released at $\alpha = 90^o$.

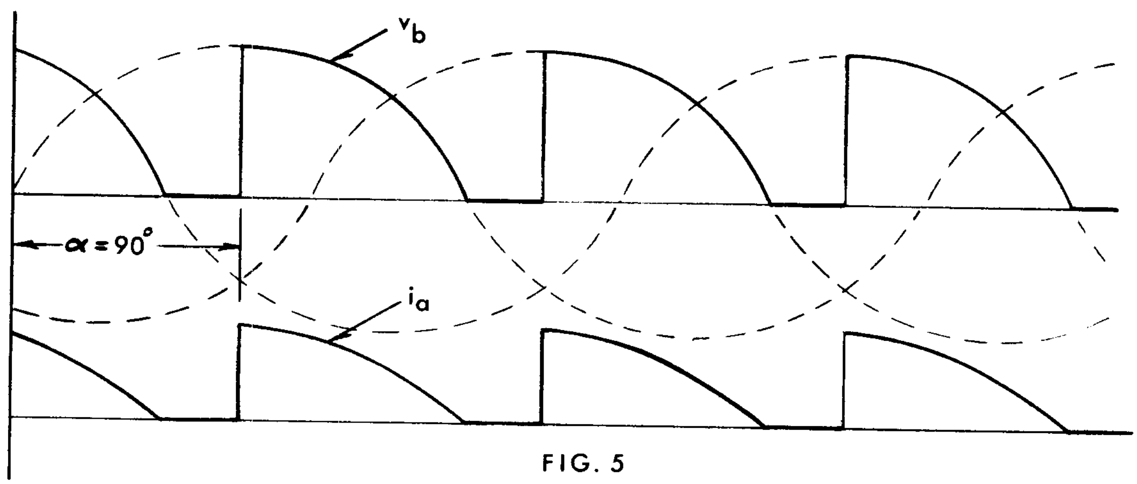


FIG. 5

If an inductive motor load were connected across terminals, P and N, in Figure 1, the armature voltage and current would appear as in Figure 6.

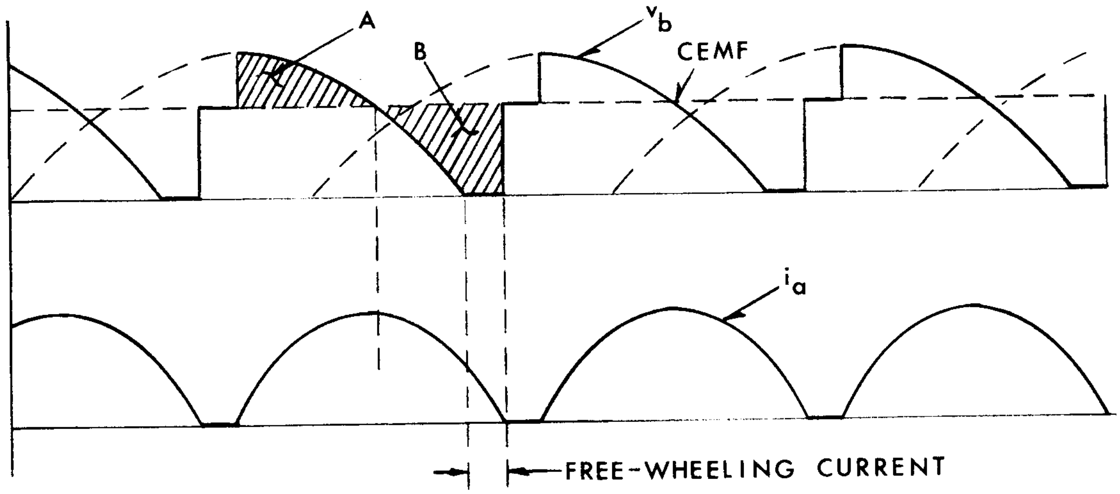


FIG. 6

Conservation of energy requires that areas A and B in Figure 6 be equal, if the resistive losses in the armature are neglected. Since these losses are usually 5% or less, this is a fair approximation. Whenever the current i_a goes to zero notice that the bus voltage v_b snaps up to the value of the motor CEMF. This is understandable, for when current ceases to flow in the TPM and motor armature, the motor is essentially disconnected from the TPM. It can only be reconnected after a gate pulse is sent to the thyristor. If continuous current were the case (i.e., the current never goes to zero) the bus voltage v_b would never be shown equal to the CEMF of the motor for any length of time, and current & voltage waveshapes would appear as in Figure 7.

In a three phase control, however, the chances of observing discontinuous current (Figure 6) are very low. Usually, with a moderate load on the motor continuous current is the case, as shown in Figure 7. The ripple current is lower in a three-phase drive, because there are three applications of line voltage per cycle across the load rather than two. For a given motor, the form factor for any given gating angle is much lower for a three phase bridge than it is for a single phase bridge. Therefore, for any given motor and gating angle the 3-phase bridge exhibits current which has a lower ripple content than the single-phase bridge.

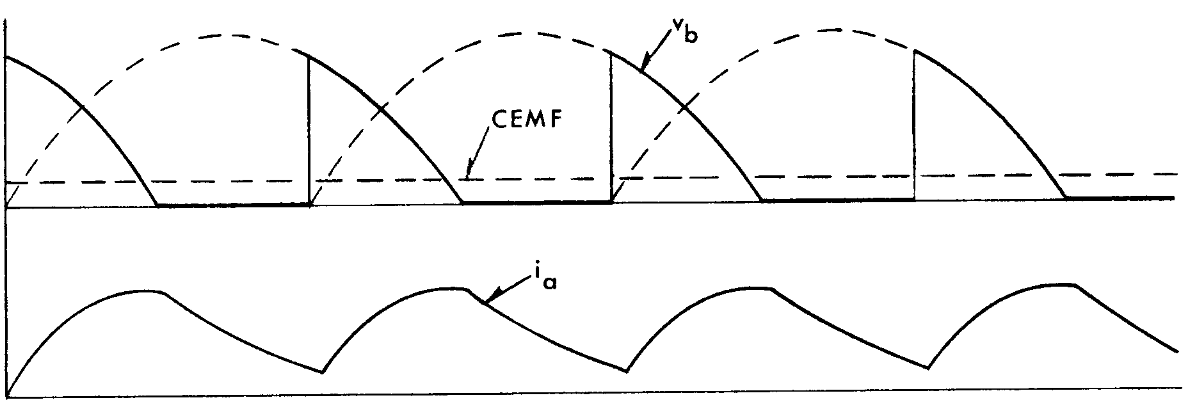


FIG. 7

The question might be posed --- "who cares whether the current is continuous or not?" The answer is Westinghouse cares. Ripple content is proportional to the form factor of the current waveshape. The form factor is defined as the ratio of RMS current to DC current. It is desirable to get 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. The higher the form-factor of the system, the more power is burned up 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. Also, the efficiency of the system is less. 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.

The type 22-1000 Controlled TPM Assembly supplies half-wave-rectified power to the motor field via bridge diodes 1D and 2D. Diodes 1D and 2D carry both armature and field current as shown in Figure 1. R-C circuits designed to balance voltage between 1TH, 2TH and 3TH equally when they are not conducting are connected from phase to phase. A filter is also used to absorb voltage spikes on the bridge seimconductors. The above filter components are mounted on a separate PC board and jumpered to the Controller board to which the power semiconductors are connected.

The question may arise as to the purpose of the diode, 4D, placed across the armature. Diode 4D is called a freewheeling diode, and its use is necessary in all semiconverter circuits wherever discontinuous current cannot be guaranteed over the full range of gating angle (α). For example, in Figures 6 and 7 where the bus voltage waveforms v_b reach zero volts (i.e., at $\alpha = 180^0$), the thyristor and diode last conducting, cease conducting and the stored energy in the motor armature inductance is shunted in the freewheeling diode. The current decays exponentially in the armature and the freewheel diode until it reaches zero, which can be observed in the bottom traces in Figures 6 and 7.

Resistor (3R) is a combination shunt which supplies current feedback ($-i_a$) to the controller board. Depending on horsepower, various portions of the shunt are utilized so as to always feedback approximately 0.5 volts for 100% rated armature current.

Type 22-1000 Controller and Gate - The Controller printed circuit board provides all of the dynamic control functions necessary for regulating the TPM. The Controller provides filtered ±24 VDC power and zener regulated DC power for all Controller and gating functions. If the Ramp Function Generator is added as an option, power for it is also provided by the Controller via push-on lance terminals and jumpers. In discussing the Controller it is best to start with the innermost functional block in the control loop, namely, the Gate Pulse Generator (G.P.G.). The G.P.G. is really a "sub-circuit" of the Controller board, but a very important one. In Figure 8, it is convenient to show the ±24 volt power supply as well as the G.P.G. Terminals (or points) marked "PSP" refer to + 24 volts, those marked "PSC" refer to "system ground" NOT EARTH GROUND, and "PSN" refers to -24 volts.

The power is received through points "U", "V", and "W" which is applied to the primary windings of transformers 1T, 2T, and 3T, which are connected in delta-star. The use of 3-single phase transformers rather than 1-three phase transformers was preferred because of large cost savings of the power. The secondaries of the transformers are fed to a 3-phase-bridge rectifier made up of diodes 34D through 39D. These very same secondaries supply reference timing waves to the input of the gate-pulse-generator circuit (upper half of Figure 8).

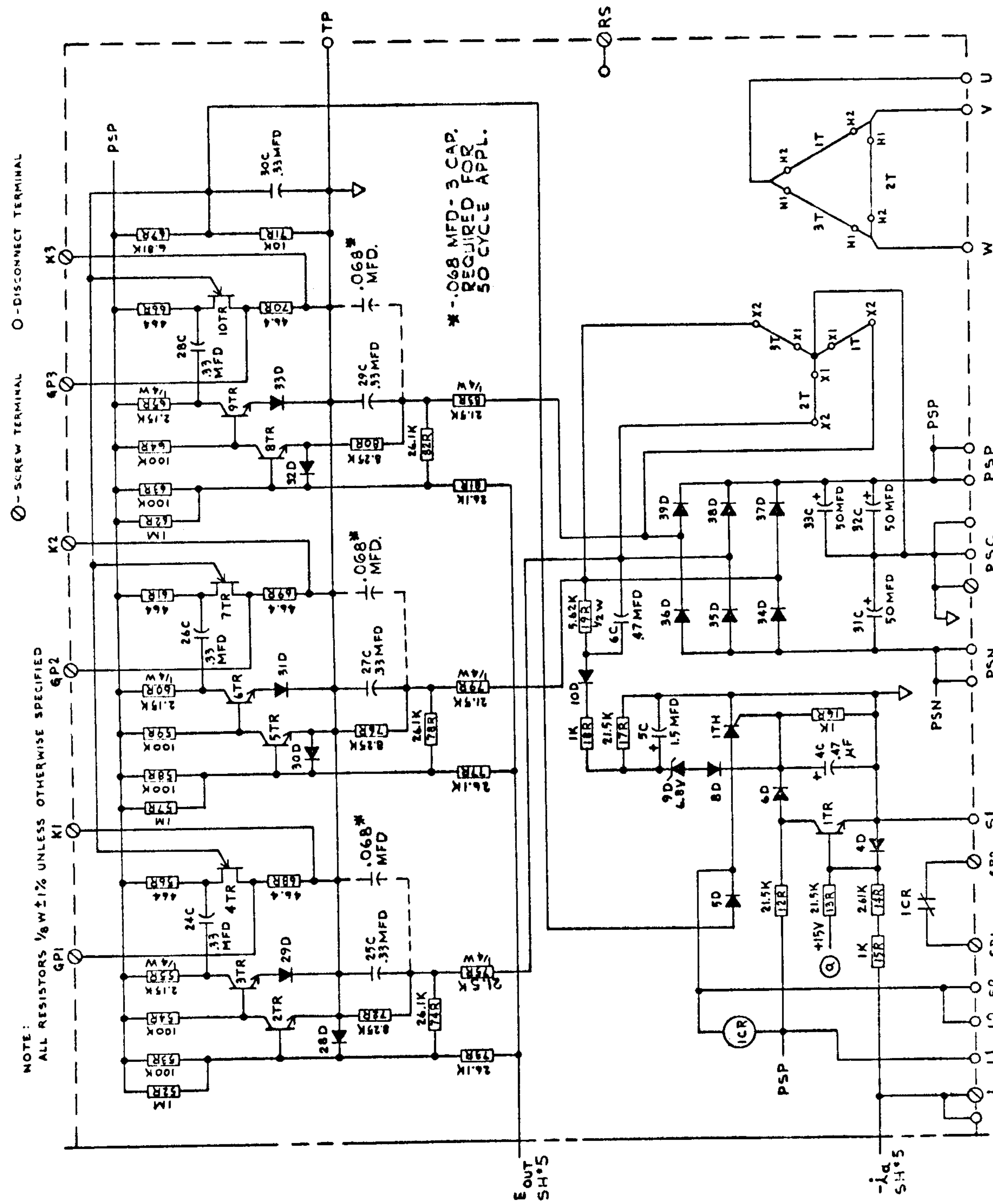

NOTE:
ALL RESISTORS 1/8 W ±1% UNLESS OTHERWISE SPECIFIED
⊘ - SCREW TERMINAL
O - DISCONNECT TERMINAL
* - .068 MFD. 3 CAP. REQUIRED FOR 50 CYCLE APPL.
TP
RS
PSP
PSC
PSN
K1
K2
K3
GP1
GP2
GP3
S1
S2
SR1
SR2
L1
L2
ICR
E OUT SH#5
U
V
W

FIG. 8

Gate Pulse Generator (Subcircuit)

A glance at Figure 8 will show 3 identical circuits comprising the G.P.G. Only one will be described since the other two function identically. The timing reference from X2 of transformer 2T is fed to a 30° delay filter comprising resistors 75R, 72R and capacitor, 25C. Since it is necessary to have close tracking of the 3 pulses, this capacitor has a tolerance of ±1% (the corresponding capacitors 27C and 29C also are ±1%). For convenience, a simplified diagram of Figure 1 is shown repeated in Figure 9.

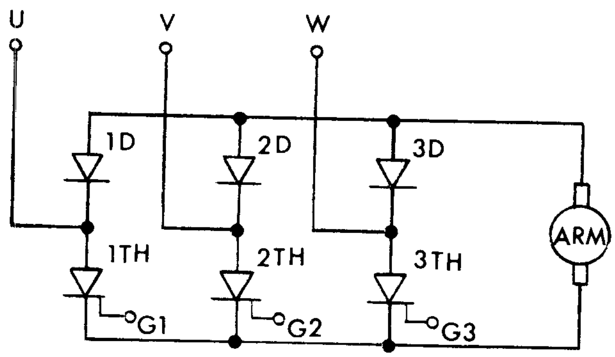


FIG. 9

Since, it is necessary to understand the power commutation process before one can understand gating requirements, a discussion of power commutation process follows. Figure 10 shows the sequence of the excitation voltage (U, V, W) and the corresponding sequence of pulses. Inside the rectangular boxes are the devices which are in conduction at each moment.

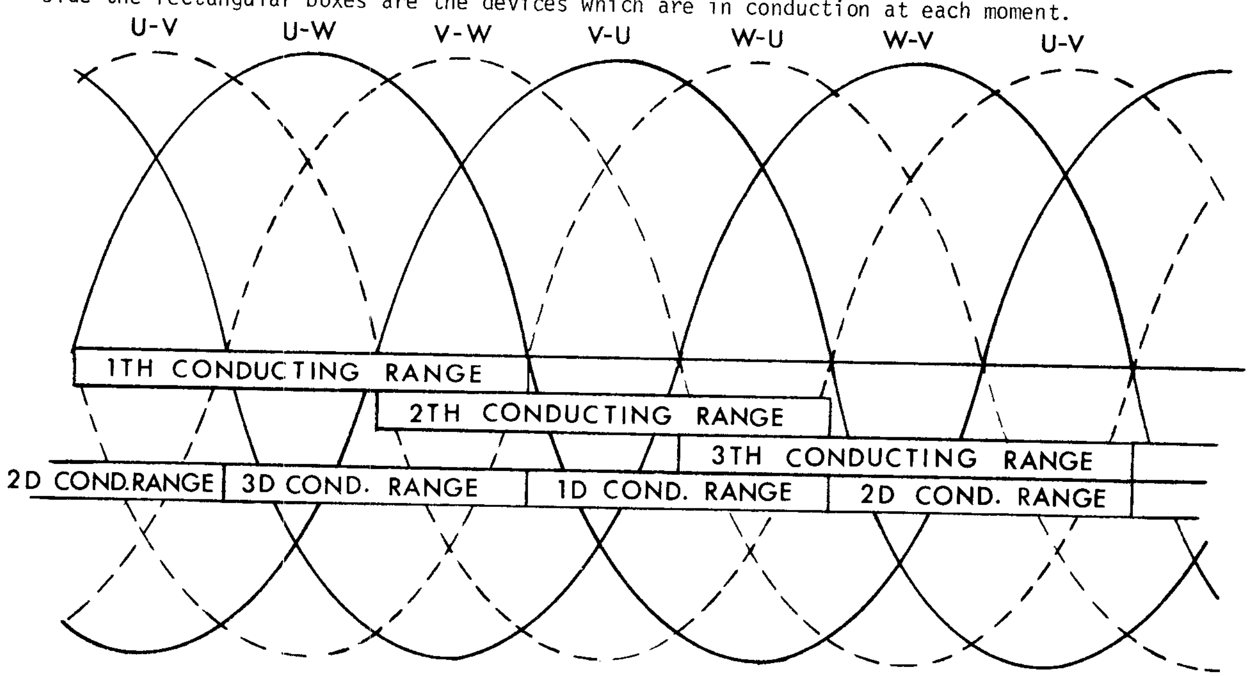


FIG. 10

Though the thyristor conduction periods are shown to overlap, in practice this is not the case. Only 120 degrees conduction is possible. The overlapping was necessary to show the range of possibilities of conduction. For example, 1TH can be gated anytime that the wave U-W is positive One third of a cycle later (120 deg.) 2TH is gated and any current remaining in 1TH is now commutated to 2TH. It is quite possible for the thyristors and diodes to conduct less than 120 degrees, becuase the freewheeling diode commutates the current from 3D rather than allowing 1D to do the job.

Since 1TH can be fired only during the time that the voltage (U-W) is positive, we want to use the voltage (U-W) as a reference wave to time pulse #1 (GP1) from the G.P.G. Likewise wave (V-U) becomes a reference wave for GP2, and wave (W-V) is the reference wave for GP3.

Ideally a linear relationship is desired between the input to the GPG (i.e., E_{out} from the operational amplifier circuit) and the Output of the thyristor rectifier. To generate this relationship a Cosine wave must be generated. The gate pulse is timed by shifting the level of the cosine wave with respect to PSC. When the cosine wave crosses zero volts (PSC) in the negative going direction, a pulse is released to the proper thyristor. Figure 11 shows the reference (excitation voltage) voltage (U-W) and the cosine wave biased to gate at α = 180 degrees.

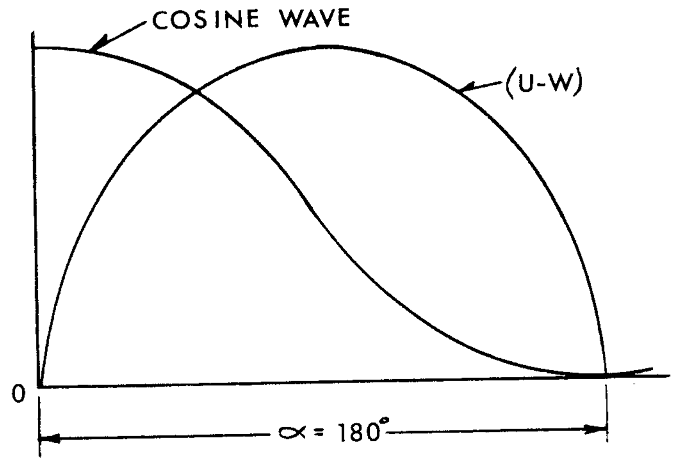


FIG. 11

The cosine wave, generated by the transformer, 2T, and the input filter on the G.P.G. must be shifted as shown in Figure 11 when no voltage is present at E_{out} (See Figure 8). The parallel combination of 52R and 53R performs this function. The voltage, E_{out}, has the limits: -10 volt $\leq E_{out} \leq$ 0 volts. When E_{out} is zero Figure 11 results. When E_{out} is -10 volts, it is desirable to approach a gating angle (α) of 0 degrees. This means that the peak-to-peak voltage of the cosine wave should be approximately 10 volts (i.e., equal to the maximum range of E_{out}. The same filter used to shift the 120 degree signal from 2T back 30 degrees also was used to attenuate the 50 volt peak-to-peak signal to 10 volts peak-to-peak.

The base of transistor, 2TR, sums this "timing wave" through 74R with the signal E_{out} through resistor 73R and the cosine shifting bias through resistors 52R and 53R as mentioned above. When the base of 2TR goes negative its collector jumps to +24 volts, which saturates transistor 3TR, changing its collector to about 0.7 volt. Capacitor, 24C, couples this signal to the base-2 of unijunction transistor 4TR. The time constant of 24C, 55R and 56R causes a negative-going spike to be seen on the unijunction's base -2 which causes it to fire. The energy to gate the thyristors comes from each of the three unijunctions 4TR, 7TR, 10TR via the charging capacitor, 30C.

Both the rate of charging and the final value of the voltage on 30C is governed by resistors 67R and 71R. The charging rate must not be so slow that the voltage doesn't reach its final value before the next pulse is to be released. The fixed potential of the capacitor must not be too large or the unijunction transistors will fire needlessly or at improper times. If the capacitor potential isn't high enough, the power used to gate the thyristors is substantially reduced. The voltage divider 67R and 71R also serves to compensate for line voltage changes. In that event the divider keeps the capacitor potential at a level which never exceeds the intrinsic standoff ratio of the unijunction.

Before it was mentioned that this cosine wave was necessary to produce a linear relationship between E_{out} and bus voltage (v_b). The derviation of this relationship follows.

Let E_{out} = peak voltage output of operational amplifier section (i.e., -10 volts).

e_{out} = actual output voltage of operational amplifier circuit.

α = gating angle. (0 to 180 degrees).

V_b = peak bus voltage available.

v_b = bus voltage for a particular gating angle (α).

Then $$\cos(\alpha) = \frac{2e_{out}}{E_{out}} - 1 \qquad \text{I}$$

Since the bus voltage (v_b) relates to α as follows.

$$v_b = V_b \frac{(1 + \cos\ )}{2} \qquad \text{II}$$

Solving for v_b as a function of e_{out}, equation I needs to be solved for α:

$$\alpha = \cos^{-1}\left[\frac{2e_{out}}{E_{out}} - 1\right] \qquad \text{III}$$

Substituting for α above in equation II

$$v_b = \frac{V_b\left[1 + \cos\left\{\cos^{-1}\left(\frac{2e_{out}}{E_{out}} - 1\right)\right\}\right]}{2} \qquad \text{IV}$$

Simplifying eg. IV above:

$$v_b = \left(\frac{V_b}{E_{out}}\right) e_{out}$$

Let $\frac{V_b}{E_{out}}$ = K = gain of the gate pulse generator

Then

$v_b = K \cdot e_{out}$ (i.e., the linear relationship)

GATE PULSE SUPPRESSION is also a subcircuit of the Controller board. Its operation is based on the tripping of a thyristor (1TH) which discharges the charging capacitor (30C) in the gate pulse generator subcircuit. The thyristor is tripped (or made conductive) only when the instantaneous armature current becomes greater than 400 per cent of rated motor current. Coupled to the gate-pulse-suppression subcircuit is a phase-sequence protection and detection circuit. The voltages on the secondary terminals (X2) of transformers 2T and 3T are fed to an RC network made up of capacitor 6C and resistor 19R which is sensitive to phase rotation. If phase rotation is correct, the voltage built up across capacitor 5C and zener diode 9D is less than the sener's breakdown voltage and no signal is seen at the gate of thyristor, 1TH. If phase rotation is incorrect, or if one of the phases is missing, the voltage will be high enough to break down the zener diode (9D) and gate the thyristor, 1TH. Whenever the thyristor is gated (i.e., when gate pulse suppression is activated), the voltage across the coil of relay 1CR and the gate pulse suppression lamp becomes equal to 24 volts, which lights the lamp and picks up the relay. Whenever the relay is picked up, the dc contactors are dropped out and the reference is removed. Complete restarting procedure is then necessary after the cause for gate pulse suppressing has been found, corrected, and the gate pulse reset pushbutton is depressed.

OPERATIONAL AMPLIFIER SUBCIRCUITS

In addition to the gate-pulse-generator, power supply, and gate pulse suppression subcircuits, there are three operational amplifier subcircuits of the Controller Board (See Figure 12). Amplifier (1-0A) is associated with the input reference circuit, which is made up of resistors 2R, 3R, 5R, 6R, 1R; potentiometers 1P and 2P; and capacitors 1C and 2C. The potentiometers 1P and 2P are for adjusting maximum and minimum speed set points. Resistor 4R is used for keeping the output of 1-0A at -0.5 volts through diode 15D in the feedback circuit. This clamping action is necessary when amplifier (1-0A) is convected for speed control (i.e., jumpr 2J connected to points 1, 2, 3 or 4). When connected for voltage control (CEMF Regulation), jumper 2J is connected to "CEMF" on the Controller Board. In this position resistor 20R is connected across the feedback of (1-0A) giving the amplifier a gain of Unity with respect to the reference input. When a CEMF regulator is desired, "IR Comp." potentiometer 3P is adjusted for best regulation at the desired speed. The current feedback signal comes from an expanded metal shunt, which feeds back approximately -0.5 volt for 100% rated armature current. This signal ($-i_a$) adds to the reference signal applied to the input of 1-0A, and is considered positibe feedback. For this reason 3P should never be adjusted so high it results in an increase of speed for an increase in load current, for instability may be the result.

The output of amplifier (1-0A) is proportional to bus voltage and becomes the reference ($+v_b^*$) for the voltage controller, amplifier (2-0A). The bus voltage reference ($+ v_b^*$) is summed with the bus voltage feedback ($-v_b$) in amplifier (2-0A) whose output (E_{out}) is fed to the Gate Pulse Generator subcircuit. It is this signal (Eout) which directly controls the gating of the thyristors and hence the bus voltage. Maximum limits are set on the outputs of each amplifier by the feedback diodes 15D, 16D, and 22D.

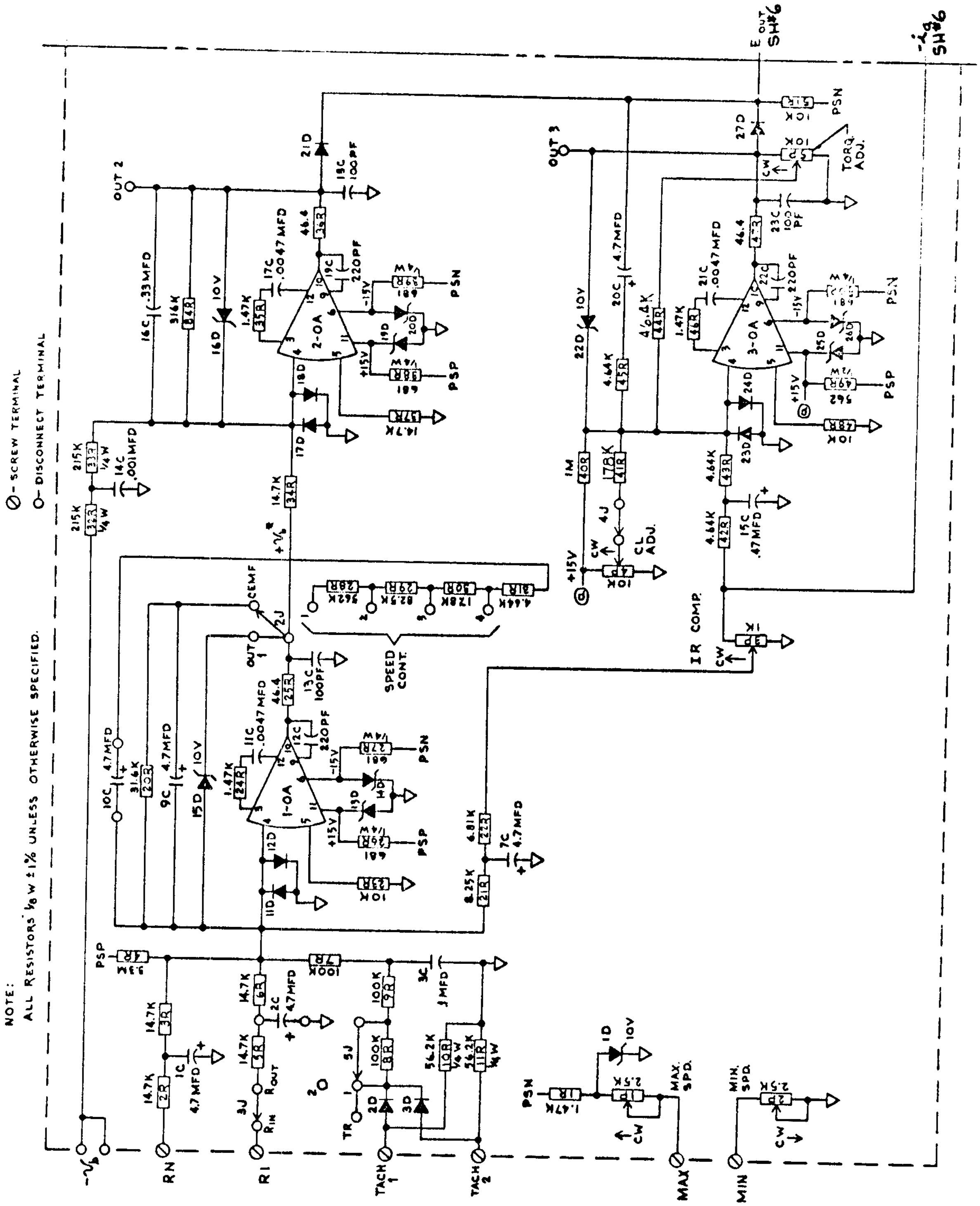

NOTE:
ALL RESISTORS 1/8 W ±1% UNLESS OTHERWISE SPECIFIED.
⊘- SCREW TERMINAL
○- DISCONNECT TERMINAL
OUT 2
OUT 3
SPEED CONT.
IR COMP.
CL ADJ.
TORQ. ADJ.
RN
RI
TACH 1
TACH 2
MAX
MIN

FIG. 12

The limits on the gate control voltage, E_{out}, are between zero and (-10 volts). The voltage can be generated by either the Current-Controller, 3-OA, or the voltage-Controller, 2-OA, depending on which output is least negative. Switching diodes, 21D and 27D, switch the least negative output to the gate pulse generator input (E_{out}). The more negative of the two switches into negative limit of (-10 volts). While a controller output is in negative limit it is said to be "out of control", and has no effect upon the bus voltage in any way. When two amplifiers are connected as above, they are said to be connected in parallel, and are referred to as parallel regulators. Such systems can be adjusted to give faster response than multi-loop systems. Because switching between two or more regulators is possible with a parallel regulator system, two different modes of operation are possible. In the 22-1000, 3-phase system the two modes of operation are voltage and current.

REGULATOR ADJUSTMENTS

The minimum and maximum speed adjust pots, briefly mentioned before, are used to set maximum and minimum speed points. The range of adjustment of the speed adjust potentiometer in the operator's station can be adjusted with these pots. Armature resistance drop compensation can be adjusted through use of "I R Comp." potentiometer 3P. An adjustment for limiting the armature current is available called the "Current Limit Adjust" potentiometer 4P in Figure 12. Adjustment of Armature Current is available over the range of 20% to 150% of rated armature current. In addition to adjustment of Current Limit available through 4P, one may remove jumper 4J and adjust current-limit through use of a follow signal entering at the stab terminal connected to resistor 41R. Applications requiring this might be on tension controls. The "Torque Adjust" potentiometer 5P adjusts the amount of negative feedback applied to the Current-Controller. The effect is to reduce the amount of current-limit reference current entering the summing junction of 3-OA, which is to say the current-limit is lowered as the output of 3-OA increases. The result is a sloped current-limit characteristic as shown in Figure 13.

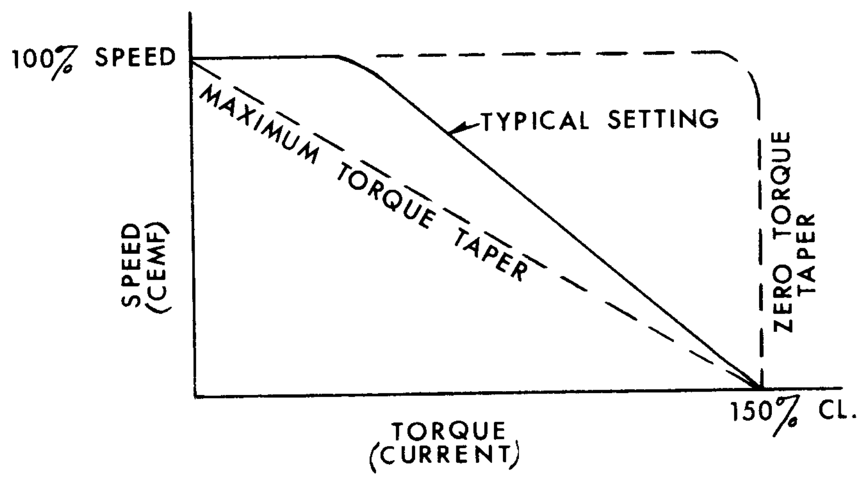


FIG. 13

Normally the CEMF mode of operation is used and a tachometer generator is not necessary. However, when extremely good regulation is desired over the full range of speed, a tachometer is necessary, and the amplifier 1-OA must be modified to a speed controller. Jumper 2J, connected to either position 1,2,3, or 4 accomplishes this. Position 1 should normally be used since it gives the slowest response, suitable for long motor time-constants. If the inertia of the system is known to be low, for example on 1750 rpm, 1150 rpm, and 350 rpm machines with loads of low inertia, the position of jumper 2J should be moved to positions 2, 3, or 4 in order to increase responsiveness of the system or stablize system when this is necessary.

MAGNETIC LOGIC AND POWER CIRCUITS

Each drive is equipped with either a three-relay-logic board or a 9-relay-logic board, which control the operation of the dc contactors used for disconnecting the power supply from the motor, dynamic braking, and for switching armature leads on reversing drives. The contactor in conjunction with the relays on the logic board protect the power supply against high current surges (i.e., plugging when reversing the drive), drop out when the line voltage **dips** too low for longer than a couple of hundredths of a second, and drop out when either the motor is overloaded, gate-pulse suppression is activated due to over-current greater than 400% rated current, single-phasing or incorrect phase-rotation. Figure 14 shows the magnetic logic, operator's station and the connections between them and other system blocks. Transformer 1T supplies 115 VAC 60/50 cycle power to the magnetic components. It is connected for 230 V. primary excitation and is connected to the control side of the primary fuses or circuit breaker. On reversing drives, the dc contactor electrical interlocks, connected to terminals 1, 2 and 3 of the logic board, prevents simultaneous energization (i.e., only one contactor can be energized at one time) These electrical interlocks are backed up by mechanical interlocks. If either the normally closed contacts of the thermal overload relay (O.L.) or the gate pulse suppression relay (1CR) opens up, the magnetic logic is de-energized to drop out the contactors. Anytime the stop button is depressed, the armature voltage at that time is applied (across terminals DB1 and DB2 which energizes the AP (anti-plugging relay). The AP relay prevents starting up again in either direction until the armature voltage has dropped to a safe level (i.e., about 10 volts). Terminals LSF-2 and LSR-2 on the logic board are for use when limit switches are desired. Wires coming from the electrical interlocks of the contactors are moved from LSF-1 to LSF-2 and from LSR-1 to LSR-2. Then the limit switch contacts are placed between LSF-1 and LSF-2, and LSR-1 and LSR-2, respectively, for the forward and reverse limit switches. The limit switches in this case remove power from the auxilliary relays FX and RX respectively, which in turn drop out the contactors.

The 3-Relay Logic discussed above is the simplest of the two logic types, and of course doesn't provide the degree of flexibility that the 9-Relay Logic provides. The 9-Relay Logic providing all options is shown on page 18, Figure 15. With 9-Relay Logic, automatic reversing is provided (i.e., by switching the switch, 2 SW, back and forth, the logic cycles the drive automatically). The switch could be replaced by limit switches to perform the same function. A separate potentiometer provides independent adjustment of jog speed. A thread pushbutton and relay, "THRD", and "TH", respectively allow the drive to run at the speed set by the "Min". speed pot on the Controlled Board. Pushing the run, "RN", push-button automatically sets the drive running at the speed set on the operator's station. Two antiplugging relays provide antiplugging (forward and reverse) and dynamic braking functions and the O. L. relay and G.P.S. relay act similarly as in the "3-Relay Logic" to sequence the drive to stop. By adding jumpers 1J and 2J the Ramp Function Generator may be used to provide constant-rate-acceleration and deceleration. See chart Figure 15, page 18.

An AC-Mechanical Brake "BR" relay can be provided which allows the drive to be held in place after coming to a stop due to dynamic braking, depending on the location of jumper, 3J. With the jumper in position (2), as shown, the brake will lock onto the motor shaft whenever the motor is at rest, or very near to rest, since PF or PR drop out with about 10 or 11 volts on the armature (of a 240 volt machine). In position (1), if switch, 1SW, is switched "off", the mechanical brake will lock in immediately, 1 SW acting as an "emergency stop".

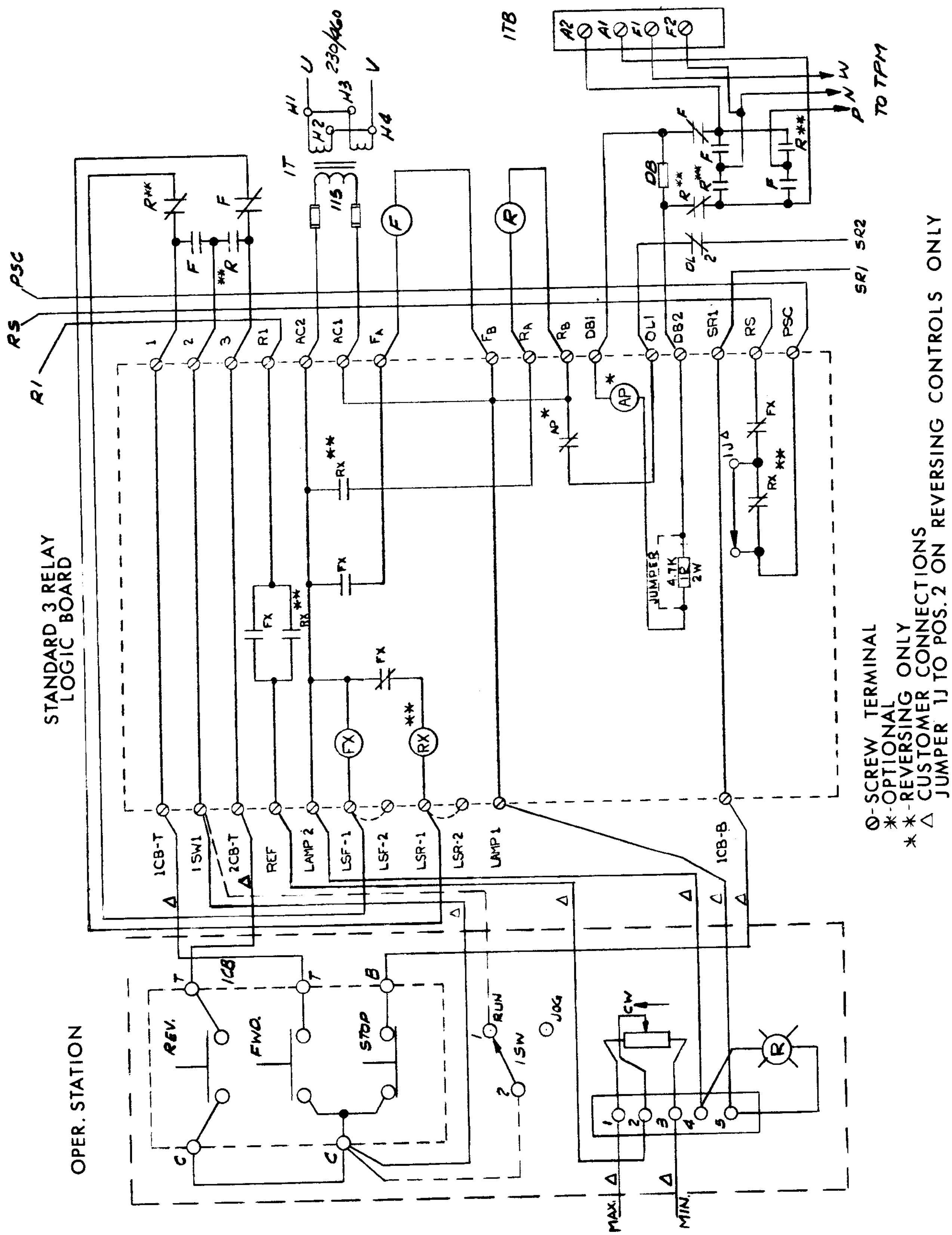

STANDARD 3 RELAY
LOGIC BOARD
OPER. STATION
1TB
1T
115
230/460
TO TPM
SR1 SR2
PSC
RS
R1
1CB-T
1SW1
2CB-T
REF
LAMP 2
LSF-1
LSF-2
LSR-1
LSR-2
LAMP 1
1CB-B
REV.
FWD.
STOP
RUN
JOG
1SW
MAX.
MIN.
JUMPER
4.7K
2W
Ø-SCREW TERMINAL
*-OPTIONAL
**-REVERSING ONLY
Δ CUSTOMER CONNECTIONS
JUMPER 1J TO POS.2 ON REVERSING CONTROLS ONLY

FIG.14

OPTIONAL ACCESSORIES

Jog Kit - Consisting of a plug-in relay and a pushbutton and contact block, modifies the system for jogging operation. A speed pot, which adjusts jog speed independently of other speed adjustments, is located on the "9R-Relay board". The jog function is also available with "3R- Relay logic", by simply adding a single pole single throw toggle switch to the operator's station. The switch selects the mode of operation (i.e., either jog or run) and the forward and reverse pushbuttons select direction of motor rotation. 3R- Logic jogs at that speed set on operator's station (i.e., it is not separately adjustable).

Linear Accel-Decel. Kit - Can be used on both 9R-Logic and 3R-Logic, but on the latter only timed Accel. is available. If 9R-Logic is used, 2 relays, 9 jumpers, and appropriate hardware and instructions are included. On 3R-Logic one relay (an antiplugging relay) is used, the reset relay (RS) being deleted. Different instructions are necessary depending on which logic kit is used.

Thread Kit - Used on 9R-Logic only allows running at the minimum speed setting by simply pushing the "Thread" pushbutton. Returning to run speed is accomplished by pushing the "Run" pushbutton. At anytime one may drop back to thread speed by just pushing the "thread" button again. The "Thread Kit" includes a plug-in relay (relay"THD"), pushbutton and contact block and appropriate instuructions.

A. C. Brake Kit -
Allows the application of a mechanical brake to hold the motor shaft after the shaft has come to rest through dynamic braking. By flipping the "on-off" switch to "off", the brake will engage either immediately, or upon stopping after dynamic braking, depending upon the position of jumper 3J on the relay logic board (9R-Logic only). The AC Brake Kit cannot be used with 3R-Logic. The kit includes a "BF" type relay, a plug-in octal pin dc relay(PF), fast-on terminals and other hardware and instructions for mounting. If a 22-1000 Accel.-decel. kit has been ordered, the dc octal pin plug-in relay is not necessary, since it is included in the Accel-decel. kit.

Dynamic Braking Kit - is added when quick stopping of the motor is required (i.e., not coasting). Be sure that the proper Dynamic Braking Kit is used, the kits are horsepower rated (i.e., by group number) and should match the motor horsepower rating. Instructions for mounting and wiring are included in each kit.

IV. SPECIFICATIONS AND RATINGS

A. Input Voltage: 230 Volts AC, +10%, -5%, 50 or 60 Hertz.

B. Output Voltage: 240 Volts DC.

C. Output Current (max. Current-Limit): 150% for 1 minute.

D. Minimum Current-Limit Adjustable to 20% rated dc motor current.

E. Load and Line Regulation: ±1% or less with tachometer feedback.
±2% or less standard.

F. Speed Range: 100/1 with tachometer
30/1 standard

G. Temperature Range: 0° to 40°C outside cabinet.
When not mounted in standard cabinet, the average of the temperatures just above the heat sink assembly and just below the heat sink assembly (with rated current) must not exceed 50°C.

H. Adjustments:

1. Maximum Speed Pot - 75% to 125%
2. Minimum Speed Pot - 0% to 30%
3. IR Compensation - adjustable from zero to 100%(drop at full load not exceeding 24 volts.)
4. Current Limit - adjustable from 20% to 150% of rated motor current.
5. Torque Taper Adjust - zero taper to 150% taper (i.e., 100% speed drop for 150% load cha

6. Speed Controller Compensation:

   position 2J to 1 : T_0 = 0.02 seconds
   position 2J to 2 : T_0 = 0.10 seconds
   position 2J to 3 : T_0 = 0.50 seconds
   position 2J to 4 : T_0 = 3.00 seconds

I. Follower Signals*: 0 to -8 volts corresponds to 0 to 100% speed.

*Follow signals must be isolated (i.e., not grounded) or else an isolation power transformer feeding the drive must be used.

J. Linear Accel.-Decel. time: (2-40 Sec. to full speed)

Accel.-decel times separately adjustable.

K. Gate Pulse Suppression (Instantaneous overcurrent protection)

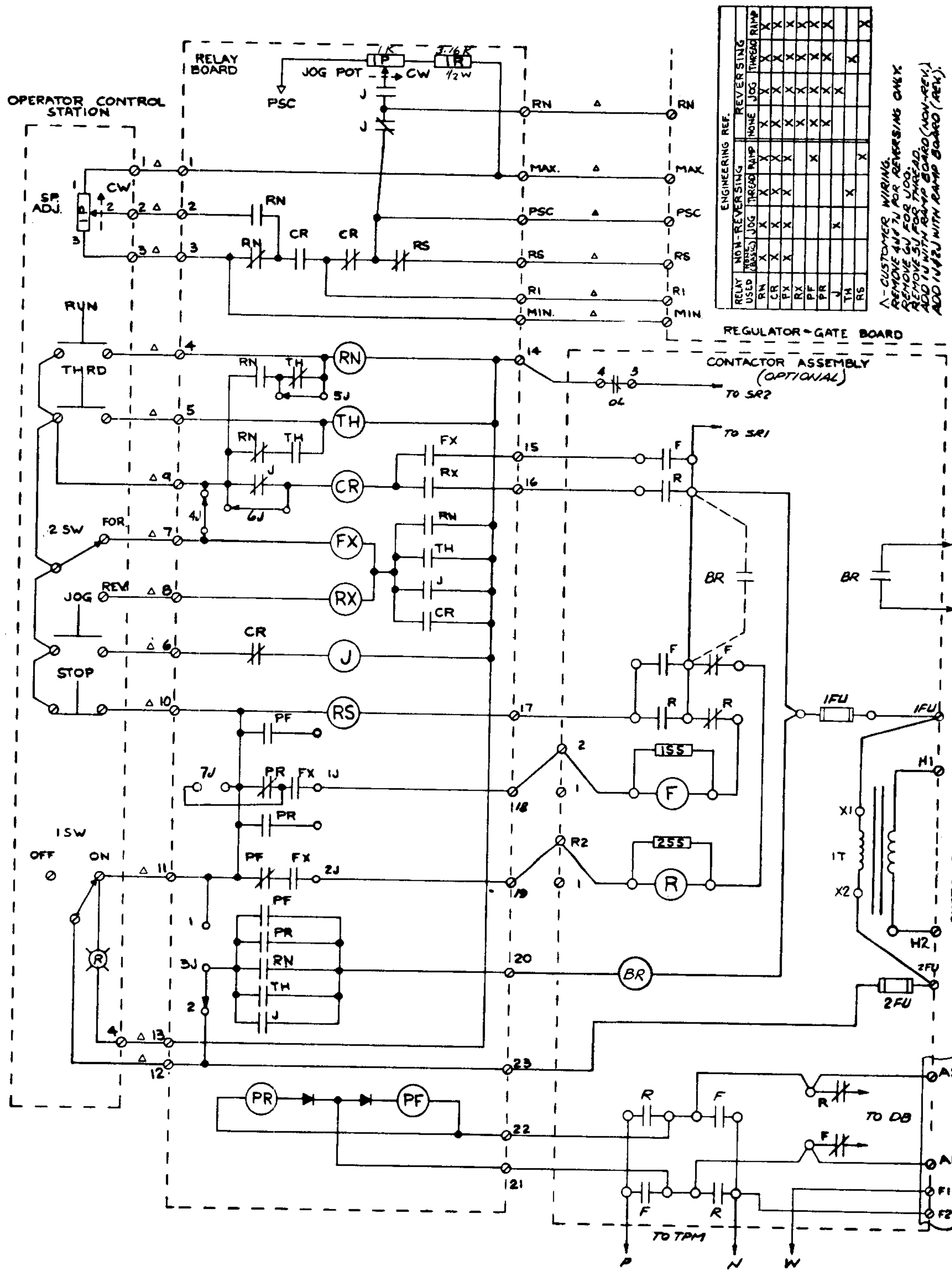
Permanently set to trip when the peak armature current exceeds 400% of rated dc armature current.

L. Motor Thermal Overload:

Set to protect the motor, based on 115% of motor full load current.

M. Jog Speed (Relay Board):

Adjustable up to 30% motor base speed using 9R - Relay Logic (adjustable via Speed Control pot on 3R-Relay Logic).



9 RELAY LOGIC BOARD

FIG. 15

V. APPENDIX

List of Instruction Leaflets for 22-1000 Drives

I.L. 22-1000 -	TITLE
1	Technical I. L. For Single Phase Drive
2	Technical I. L. For Three Phase Drive
3	Manual Non-Reversing Drive
4	Manual Reversing Drive
5	Magnetic Non-Reversing Drive
6	Magnetic Reversing Drive
7	Basic Controller
8	Dynamic Braking (Single Phase)
9	Tachometer Kit
10	Jog Kit
11	Signal Follow Magnetic Non-Reversing Drive
12	Signal Follow Magnetic Reversing Drive
13	Thread Kit
14	Accel - Decel Kit
15	A. C. Brake Kit
16	Signal Follow Manual Non-Reversing Drive
17	Signal Follow Manual Reversing Drive
18	
19	Test Kit
20	Three Phase Non-Reversing Drive
21	Three Phase Reversing Drive
22	
23	
24	
25	
26	
27	
28	Dynamic Braking (Three Phase)