INSTALLATION/OPERATION INSTRUCTIONS FOR

Saber™ 3204

ARMATURE REGENERATIVE DC STATIC DRIVE

MagneTek Drives & Systems

WARNING

HIGH VOLTAGE EXISTS AT AND NEAR THE OVERLOAD RELAYS DISCUSSED BELOW! REMOVE ALL AC POWER TO THE CABINET BEFORE TOUCHING ANY RELAY.

BE SURE TO CHECK THE LEVEL OF OIL IN THE MAGNETIC OVERLOAD RELAYS, IF YOUR DRIVE IS EQUIPPED WITH ONE OR MORE OF THEM. THE RELAYS WILL TRIP OUT IMPROPERLY DURING AN OVERLOAD IF THE OIL LEVEL IS NOT RIGHT.

THIS TYPE OF OVERLOAD RELAY CAN BE IDENTIFIED BY LOOKING FOR A DEVICE WITH VERY HEAVY CABLES LEADING INTO AND OUT OF IT. A SMALL ALUMINUM CAN (2" LONG BY 1-3/4" IN DIAMETER) HANGS UNDERNEATH THE RELAY. THIS IS THE DASHPOT. IT CONTAINS A PISTON WHICH MOVES THROUGH THE OIL, THUS SLOWING DOWN THE ACTION AND PROVIDING A DELAY BETWEEN THE TIME THE OVERLOAD HITS AND THE TIME THE CONTACT OPENS.

THE DASHPOT CONTAINS NO OIL WHEN SHIPPED!

A SMALL BOTTLE OF SILICONE-BASE OIL (RED FOR SLOW ACTION, BLUE FOR FAST) IS TIED NEAR EACH MAGNETIC OVERLOAD RELAY. THE LABEL ON THE DASHPOT DESCRIBES HOW TO REMOVE THE CAN. BE SURE THE CAN AND PLUNGER ARE CLEAN, WITH NO LINT LEFT BEHIND FROM A WIPE RAG. FILL THE DASHPOT TO THE LEVEL MARK ON THE LABEL, USING ONLY THE OIL SUPPLIED WITH YOUR DRIVE. REPLACE THE CAN, AND DO NOT FORCE PARTS OR OVERTIGHTEN.

TABLE OF CONTENTS

1. GENERAL

This instruction manual provides the necessary installation, maintenance, and adjustment procedures, plus principles of operation for the 1-5 horsepower Saber 3204 single phase, armature regenerative, static DC drive. There are many different modifications available with the drive so it is not possible to cover the details of each; therefore, this instruction manual is written for a typical speed regulated regenerative drive. The schematic diagram is located at the rear of the instruction manual. Any modification not discussed will be covered by the actual drive circuit diagram, or by separate supplementary instructions.

A regenerative drive returns power from the motor back into the AC line when the voltage generated across the terminals of the motor is greater than the applied voltage to that motor. During this time, the motor is said to be in a regenerative or braking mode. For example, a regenerative mode may arise if a reduction in the Speed Reference signal causes a reduction in the applied voltage across the motor, and if the mechanical system driven by the motor has considerable inertia, then the motor will momentarily be driven by the load inertia at more than the command speed.

Since these instructions are general, problems may arise which are not in the scope of this manual. Should further information be desired, please contact your nearest Louis Allis representative.

2. DESCRIPTION

The typical Louis Allis Saber 3204 drive system consists of a solid state power unit, a Louis Allis Flexitorq ® DC motor, an isolation transformer, and an operator's control station.

2.1 DC MOTOR

Louis Allis Flexitorq DC motors are built in accordance with NEMA standards and are designed specifically for use with single phase, full wave rectified power supplies. These motors are available for all standard horsepower and base speed combinations, and feature low armature inertia, long life brushes and bearings, and many other prominent features.

2.1.1 Motor Type

Motors used with this drive must be straight shunt (without a series winding). Consult the factory concerning the use of any motor having a series winding.

2.1.2 Identification

In any communication or correspondence with Louis Allis pertaining to the DC motor, always reference the motor serial number and all other nameplate information.

2.1.3 Modifications

Various mechanical modifications can be provided with Louis Allis Flexitorq DC motors. Consult the nearest Louis Allis Drives & Systems sales office for specific information.

2.2 OPERATOR'S CONTROL STATION

Controls necessary for operation of the drive are located on the operator's control station (OCS). The OCS is a small, general purpose enclosure for industrial applications. It contains the SPEED potentiometer, START-STOP push buttons, and any supplementary control or meters which may have been added as drive modifications.

2.3 ISOLATION TRANSFORMER

A special isolation transformer having a dual secondary winding is required with each drive. The primary of the transformer is connectible for either 230 or 460 volts AC RMS. Secondary #1 supplies 115 volts AC RMS and secondary #2 provides 460 volts AC RMS center tapped. The transformer is either supplied loose or in the drive enclosure, depending on the specific application.

2.4 POWER UNIT

The function of the power unit is to convert the single phase AC input power to controlled DC power for the motor. Functionally, it consists of two basic sections: the power conversion unit and the regulator. These individual sections will be discussed later in the manual.

2.4.1 Features

Some of the outstanding features of the power unit include:

1. Regeneration as standard on all Saber 3204 single phase drives permitting operation in all four quadrants of motoring and regeneration.

2. Standard armature voltage feedback with load (IR) compensation providing 2% speed regulation. Available AC or DC tachometer feedback providing 1% regulation (0.1% regulation also available).

3. Individual control components constructed as basic modules for rapid and easy servicing.

4. Printed circuit boards mounted with plug-in connectors to allow easy replacement in the event of a failure.

5. Integrated circuits, where feasible, for additional reliability.

6. Separately adjustable current limit in both forward and reverse directions of current.

7. Main input power fuses; the control circuits are separately fused.

8. System components designed for a minimum of 600 volts clearance to ground.

9. Thyristor protection by specially designed circuits such as:

    a. RC transient suppression circuits on both the AC input line and thyristor assemblies to filter line spikes and noise pick up that might cause indiscriminate firing.

    b. Solid state components which are generously rated.

    c. Improved thyristor gating techniques including burst or pulse train gating for normal firing.

10. DC loop contactor and motor overload relays to provide standard motor control features including:

    a. Protection against sustained overloads.

    b. Inherent undervoltage protection.

    c. Positive motor disconnect.

2.4.2 Identification

In any communication or correspondence with Louis Allis Drives & Systems pertaining to the power unit, always reference the power unit serial number and other data stamped on the power unit nameplate.

2.4.3 Modifications

Because the Saber 3204 drive is a custom engineered drive, almost every power unit contains some modification or feature which is custom engineered for the intended application. However, six of the most commonly used modifications are available in convenient plug-in module form, they are:

JOG - Schematic #45S02049-0010
THREAD - Schematic #45S02049-0020
JOG & THREAD - Schematic #45S02049-0030
BIPOLAR LINEAR Accel/Decel - Schematic #45S02042-0030
CURRENT SIGNAL FOLLOWER - Schematic #45S02043-0020
VOLTAGE FOLLOWER - Schematic #45S02044-0020

Details of the modifications will be furnished with the individual drives utilizing them via the actual drive circuit diagram or supplementary instructions.

3. INSTALLATION

3.1 DC MOTOR

3.1.1 Mounting

The motor must be solidly mounted on a level bed plate, base, or platform which is rigid enough to prevent transfer of external vibration to the motor.

3.1.2 Connection to Load

Correct alignment of drive motor and load is essential for long, maintenance free motor life. Flexible couplings should always be used for direct coupling of motor to load. Check alignment with a dial indicator as shown in Figure 3.1. Total run-out should not exceed .002 inches.

When the motor is belted to the load, the motor and load sheaves must be in line (Figure 3.2). Belt tension must be sufficient for non-slip operation, but extreme tension will cause unnecessary strain on the motor bearings. In general, proper belt tension is achieved when the belt(s) can be depressed an amount equal to one-half its own thickness for each 24 inches of unsupported length. If special belts are used, refer to belt manufacturer's recommendations.

3.1.3 Temperature and Ventilation

Ambient temperature surrounding the motor must not exceed 40°C. Locate the motor in a clean, dry, well ventilated environment.

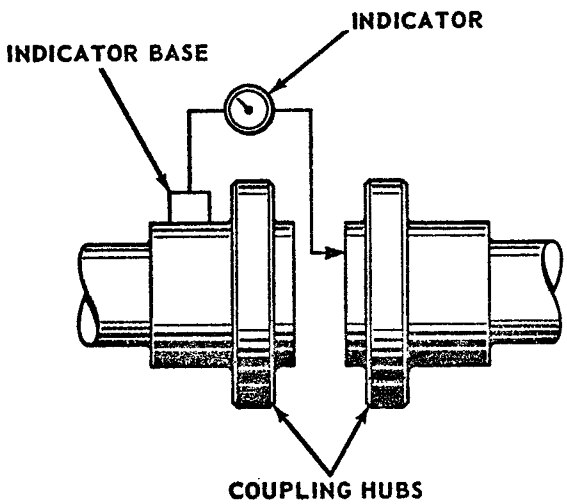
3.2 POWER UNIT

3.2.1 Handling

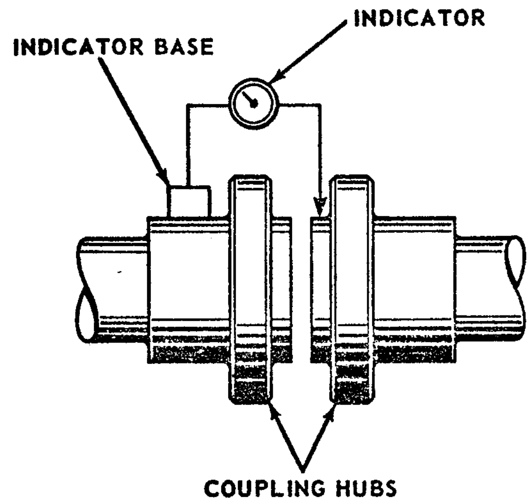
Care should be used when moving the power unit to prevent damage due to dropping or jolting. A fork lift truck or similar means of lifting and transporting can be used.

3.2.2 Mounting

Dependent upon customer or drive requirements, a power unit for floor or wall mounting can be provided. Be sure the power unit is level before it is permanently mounted and placed into position.



Angular Alignment Check



Run-Out Check

Figure 3.1

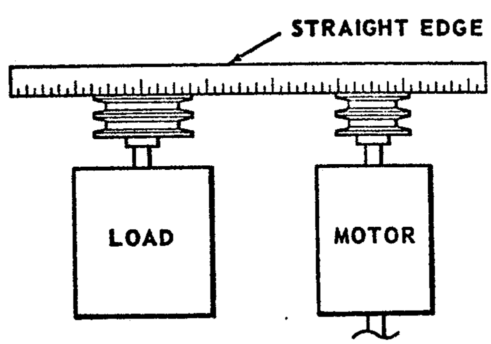


Figure 3.2 Sheave Alignment

3.2.3 Temperature and Ventilation

Ambient temperature surrounding the power unit must not exceed 40°C. Most power units are cooled by convection, but care must be taken to make sure cooling air is unrestricted. Power unit maintenance will be minimized if it is mounted in a clean atmosphere.

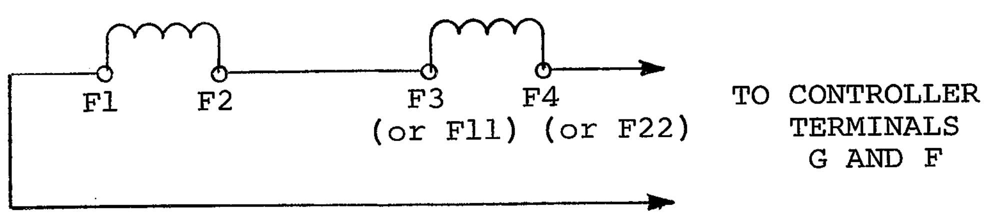
3.2.4 CABLING

Shielded cable, wire size, and disconnect devices should conform to installing contractors drawings and all applicable codes. Refer to Interconnection Diagram to interconnect the Saber 3204 power unit and associated equipment. Figure 3.3 shows the interconnection points. Table I will aid in the selection of wire sizes.

The DC motor may be furnished with either a single (200 volt) or a dual (100/200 volt) voltage shunt field winding. Refer to motor nameplate or other instructions to determine shunt field connections of motor furnished. When motor is furnished with dual (100/200 volt) shunt field windings:

1. Connect shunt field for 200 volt field supply as shown below.

2. Wire F1 and F4 (or F11 and F22) to terminals G and F of the Controller.



When motor is furnished with a single (200 volt) shunt field winding, it is necessary to connect only the motor shunt field (normally tagged either F1 and F2 or F1 and F4) to terminals G and F of the Controller.

NOTE

In long cable runs, care must be exercised to prevent excessive voltage drop.

AC and DC wires should be kept separate as much as possible. The motor armature DC leads should be separated from the leads used for speed reference and feedback signals.

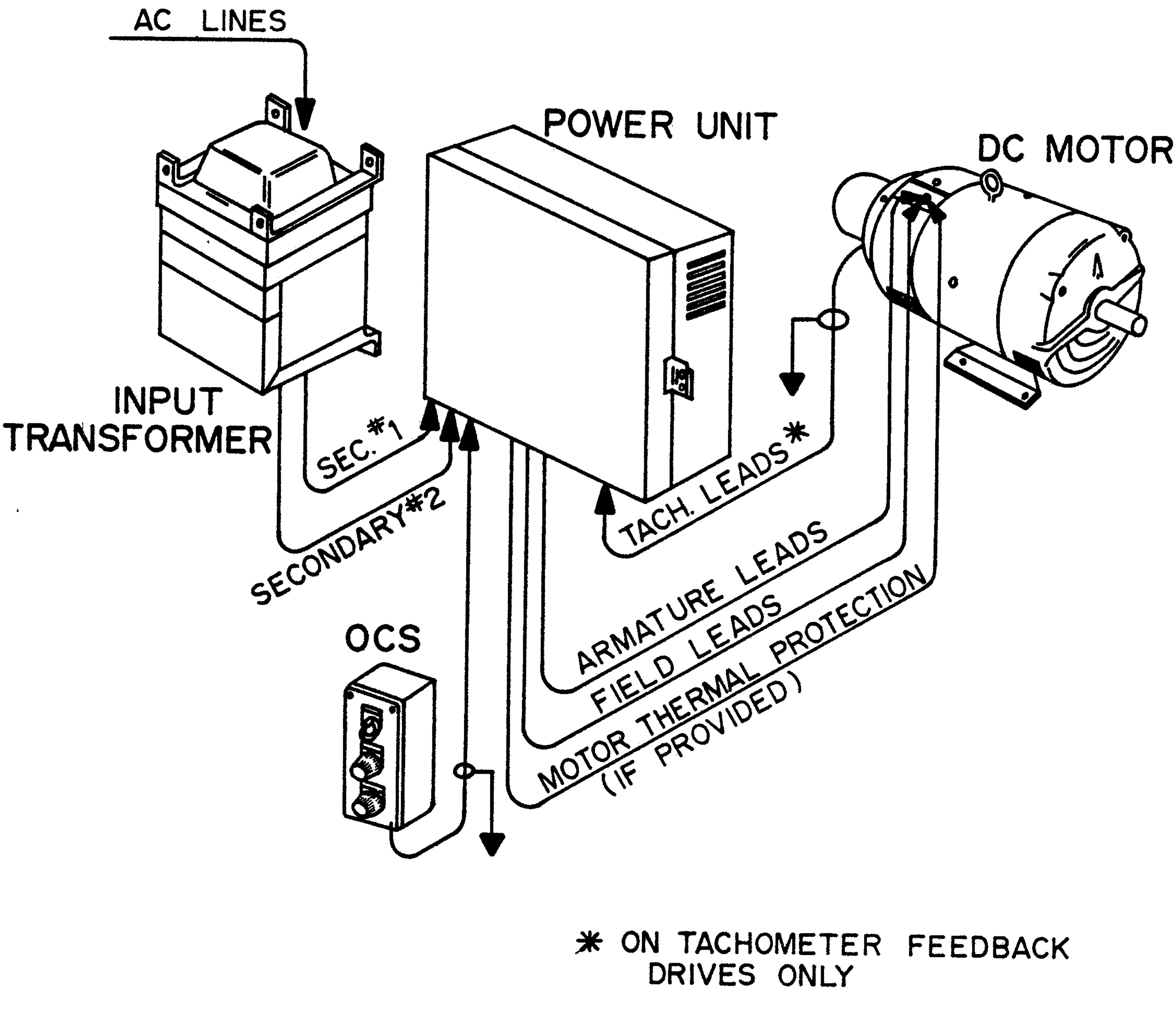


Figure 3.3 Interconnection Points

All shielded wire should be connected per the diagrams. Shielded wires, particularly those in long runs leading to tachometer-generators, should be shielded, twisted pairs. This will reduce the effect of noise. DO NOT CONNECT SHIELDS TO EARTH GROUND.

Table 1. Maximum Current Ratings

HP	Input Xfmr Primary Current at F.L. (RMS Amps)		Input Xfmr #2 Secondary* Current at F.L. (RMS Amps)	Motor Current for 180 Volt Armature	
	230V Input	460V Input		DC Amps	RMS Amps
1	11	5.5	6	6	9
1-1/2	14	7	9	9	12
2	18	9	12	12	16
3	24	12	16	16	23
5	36	18	25	25	36

* Note: #2 secondary winding is 460 VAC RMS with center tap.
#1 secondary is 115 VAC RMS - size for 5A RMS.

4. DRIVE OPERATION

4.1 POWER UNIT

The standard drive configureation utilizes armature voltage feedback (with associated IR compensation) to control drive speed, providing 2% speed regulation.

Optional drive configurations feature AC or DC tachometer feedback to provide 1% speed regulation (0.1% speed regulation available with special tachometer).

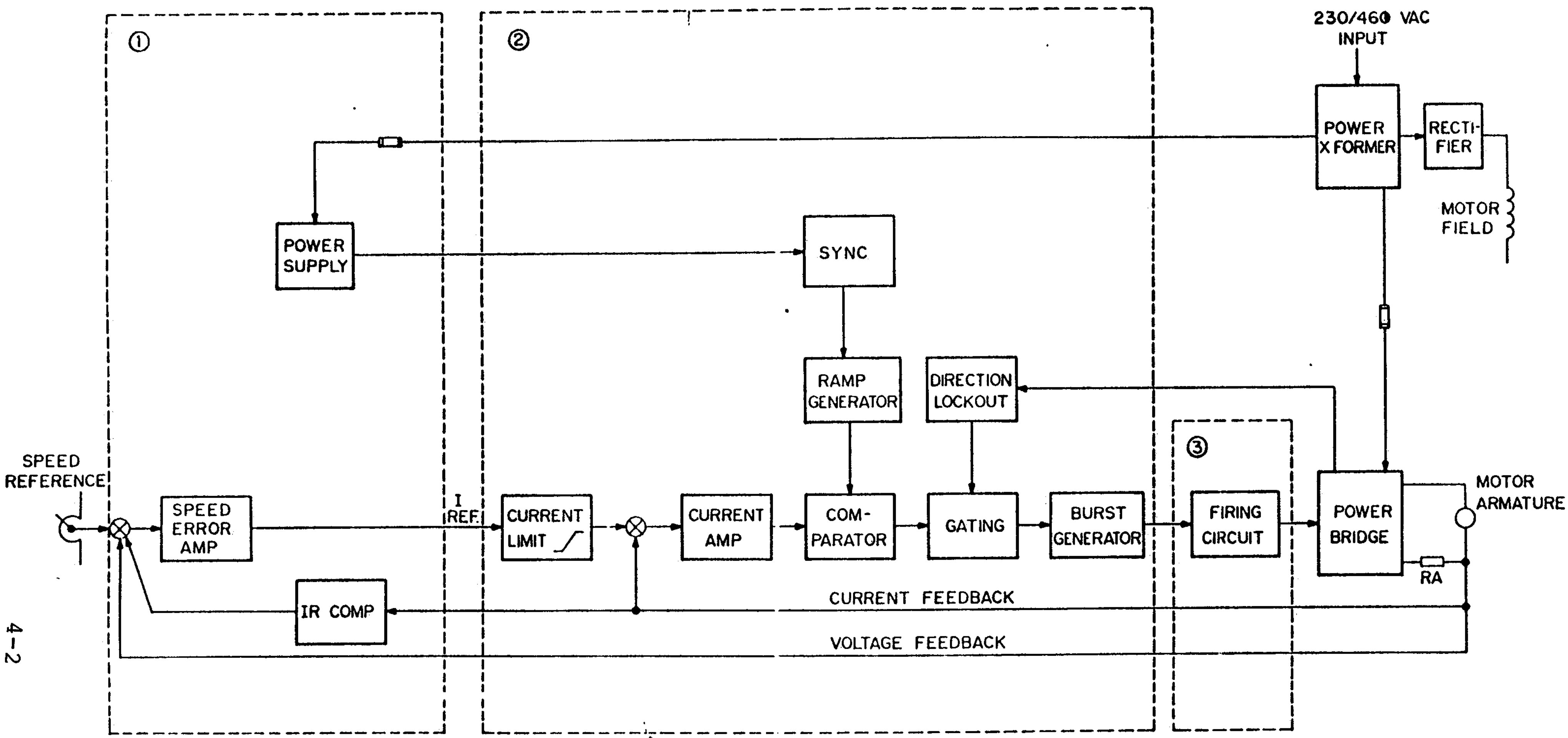
The simplified signal flow diagrams for either armature voltage feedback (Figure 4.1) or tachometer feedback (Figure 4.2) drives should be followed to understand drive operation. The following description of drive operation applies to typical speed controlled drives. Modifications not discussed in this manual will be covered by the actual drive schematic diagram or supplementary instructions.

The main function of the power unit is to supply controlled DC motor armature voltage. Controlled armature voltage is adjustable from 0-180 VDC. The power unit also supplies a constant 200 VDC to the motor field.

As can be seen from a comparison of Figure 4.1 and Figure 4.2, the two basic drive configurations differ mainly in the way in which the current reference signal is derived. In drives having armature voltage feedback control, the speed reference signal is summed with the armature voltage feedback and IR compensation signals. The resulting error signal is amplified by the speed error amplifier to provide the current reference signal. In tachometer feedback drives, the speed reference signal is summed with the tachometer feedback signal to generate the speed error signal. This signal is amplified and summed with the armature voltage feedback signal and the resulting error signal is amplified by the voltage amplifier to provide the current reference signal.

From the point of the generation of the current reference signal, the two drive configurations are basically the same. The current reference signal is applied to the current limit circuit, which clamps the signal at an adjustable level. This clamping action limits the amount of reference current signal which, in turn, limits the output current (armature current) to a preset level.

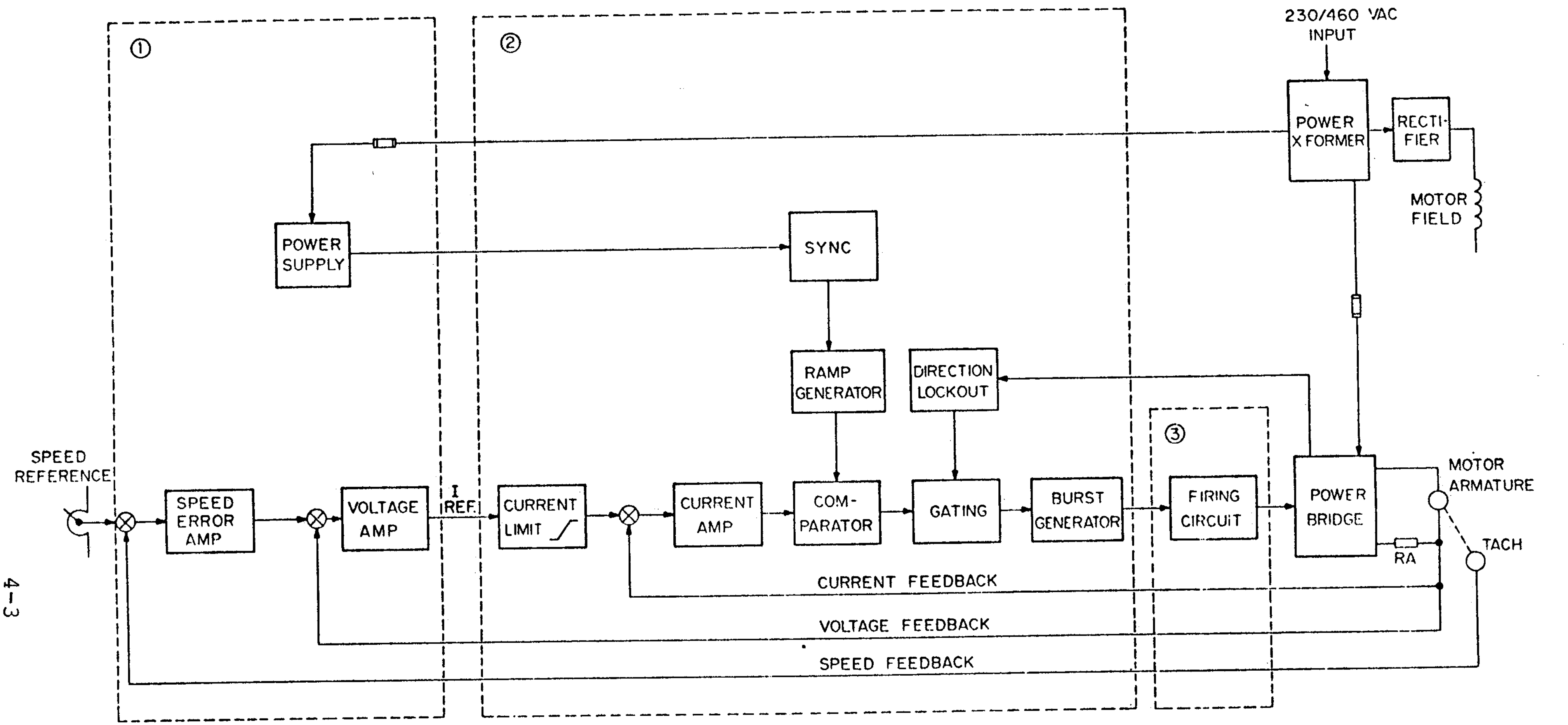
The output current from the current limit circuit is summed with a signal proportional to armature current. The resultant current error signal is amplified and applied directly to the phase control section of the unit as a signal representing the desired firing angle of the thyristors in the power bridge.



SCHEMATIC REFERENCES

① POWER SUPPLY AND REGULATOR PCB 45S02141-0010/0020
② MAIN PCB 45S01674-0031/0032
③ 4 CHANNEL GATE FIRING PCB 45S01675-0010

FIG. 4.1 SIGNAL FLOW DIAGRAM
ARMATURE VOLTAGE FEEDBACK DRIVE
(2% SPEED CONTROL)



SCHEMATIC REFERENCES

① POWER SUPPLY AND REGULATOR PCB ... 45S02141-0010/0020

② MAIN PCB 45S01674-0031/0032

③ 4 CHANNEL GATE FIRING PCB 45S01675-0010

FIG 42 SIGNAL FLOW DIAGRAM
TACHOMETER FEEDBACK DRIVE
(1% SPEED CONTROL)

Firing of the power bridge is synchronized to the AC input power supply by a circuit consisting of the main power transformer, DC control power supply, and a sync circuit which resets a ramp generator every cycle of the incoming power supply. The signal produced by the ramp generator is used as a timing base for firing the thyristors. The comparator circuit compares the ramp generator output signal with the current error signal. The comparator generates a "fire" command whenever the amplitude of the ramp signal exceeds the amplitude of the current error signal. Thus, the current error signal, which represents the desired firing angle, is changed into a timing signal in synchronism with the AC power supply.

The gating circuit provides the logic sorting function necessary to determine which particular thyristor will conduct when the comparator gives the "fire" command. Output from the gating logic turns the burst generator on and off. The burst generator provides a train or burst of pulses to the proper thyristor in the power bridge, forcing it into conduction. The output of the power bridge is connected to the motor armature and current sensing resistor R_A.

The direction lockout circuit determines which direction armature current should flow, and whether or not current flow in that direction can be accomplished safely. Its input signals are taken directly from the power bridge. Its output signals prevent firing of more than one thyristor; i.e., it forces the gating circuit to correctly select the thyristor which will conduct current flow in the proper direction to satisfy the speed or current regulator.

4.2 DC MOTOR

The drive motor used is a Louis Allis Flexitorq shunt wound DC motor. Speed control is achieved by holding shunt field voltage constant and varying armature voltage. Both voltages are supplied by the power unit. Motor speed is variable from base speed to effectively zero. The motor may require a blower if run below 60% of base speed for an extended period of time.

5. DRIVE START-UP

5.1 PREPOWER CHECK

The following checks should be made before applying AC input power to prevent damage to the control.

1. Visually inspect all equipment for any signs of damage during shipment, loose connections, or other defects.

2. Make sure the power supply voltage, frequency, and phase is correct for the particular drive being used. Check the drive schematic or nameplate to determine the proper power supply.

3. Remove all shipping devices and relay wedges. Manually operate all contactors and relays to make sure they move freely.

4. Check all electrical connections for tightness; tighten if necessary. The connections may have vibrated loose during shipment.

5. Make sure that all transformers are connected for the proper voltage according to the drive schematic.

5.2 INITIAL START-UP ADJUSTMENTS

Prior to shipment, each drive is tested at the factory and adjusted to give proper performance for the specified application. Minor adjustments may have to be made at the installation site.

Before making any adjustment, the contents of this manual should be studied carefully. Do not make any adjustments without proper measuring instruments, and until the function and limitation of the adjustment is clearly understood. Also make sure that all items in the prepower check, paragraph 5.1, have been checked before applying power to the control.

CAUTION

IF THE INPUT ISOLATION TRANSFORMER IS SUPPLIED FOR REMOTE MOUNTING FROM THE CONTROLLER OR IF THE INTERCONNECTION BETWEEN TRANSFORMER AND CONTROLLER HAS TO BE DISTURBED FOR REPLACEMENT OF COMPONENTS, ETC., IT IS ADVISABLE TO FOLLOW THE PHASING PROCEDURE DESCRIBED IN SECTION 8.1

5.2.1 Adjustments

SPEED (Figure 5.1) - Allows operator to adjust the running speed of the drive. The drive speed is adjustable from the low limit (set by the MIN SPEED adjustment) to the high limit (set by the MAX SPEED adjustment).

FORWARD CURRENT LIMIT (Figure 5.2) - Limits the maximum amount of armature current in the positive direction of current flow.

REVERSE CURRENT LIMIT (Figure 5.2) - This adjustment limits the amount of armature current in the negative direction of current flow.

RESPONSE (Figure 5.2) - See Note. This adjustment controls the speed response of the drive due to changes in either the reference signal or the feedback signal. Improper adjustment may cause drive instability.

STABILITY (Figure 5.2) - See Note. This adjustment controls the speed loop stability.

NOTE

Only used on tach feedback drives.

TAIL FIRE (Main PCB) - This is a factory set adjustment that should not be changed. It compensates for component tolerance in the tail fire circuit which prevents "shoot through". Proper adjustment requires an oscilloscope (see paragraph 9.1).

MIN SPEED - Determines drive speed when the SPEED control is set at zero.

MAX SPEED - Determines drive speed when the SPEED control is set at 100%.

OVERLAP (Main PCB) - This adjustment controls the degree of separatoin or overlap between the motoring and regenerative modes. This is normally set at the factory for proper operation, but may be adjusted or trimmed in the field in order to optimize drive performance (see paragraph 9.1).

BALANCE (Main PCB) - This is a factory adjustment that should not be changed. It equalizes the slope of the signal from the ramp generators to prevent firing unbalance between half cycles. Proper adjustment requires an oscilloscope (see paragraph 9.1).

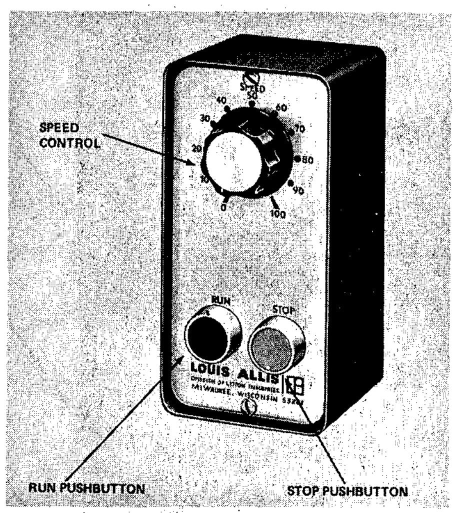
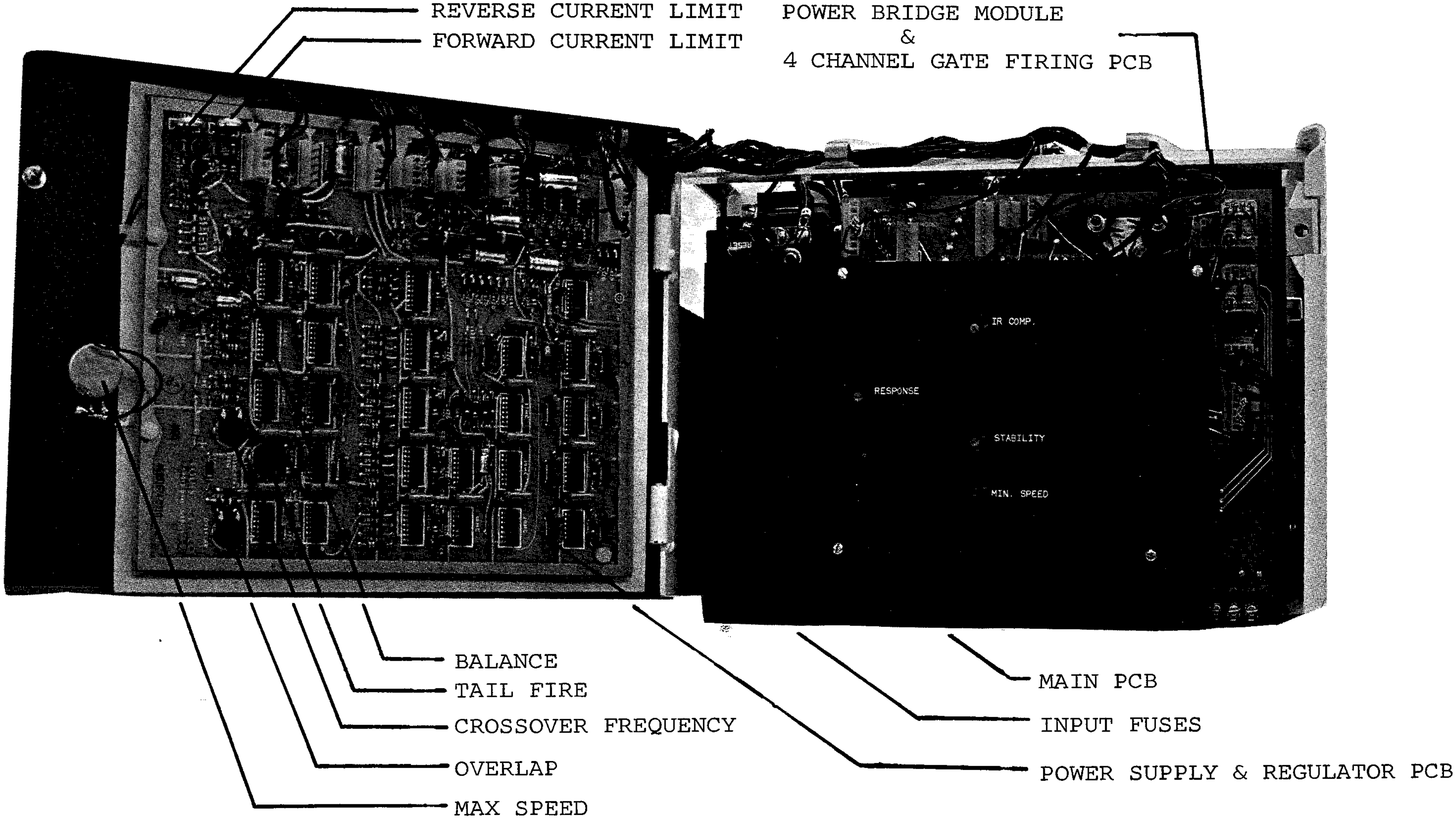


Figure 5.1. SPEED CONTROL LOCATION



NOTE
RESPONSE AND STABILITY ADJUSTMENTS ARE ON TACHOMETER FEEDBACK DRIVES ONLY.

FIGURE 5.2. LOCATION OF COMPONENTS AND ADJUSTMENTS

I FEEDBACK CAL. B. (Main PCB) - This adjustment calibrates the feedback signal originated by the dropping resistor in the motor armature circuit. Adjustment must be completed at time of installation or when the main PCB is replaced (see paragraph 9.1).

CROSSOVER FREQUENCY (Main PCB) - This adjustment is factory set to optimize drive response and stability. Its setting should not be changed. Proper adjustment requires an oscilloscope (see paragraph 9.1).

5.2.2 Initial Setup and Adjustment

1. Set controls, adjustments, and switches to initial positions as given below:

   MIN SPEED - Zero setting

   SPEED - Zero setting

   MAX SPEED - 25% setting

   FORWARD CURRENT LIMIT - Factory set and does not normally need to be adjusted. It is normally set to limit drive output current to 150% of rated current.

   REVERSE CURRENT LIMIT - Factory set and does not normally need to be adjusted. It is normally set to limit drive output current to 150% of rated current.

   RESPONSE - 10% setting (only applies to tachometer feedback drives).

   STABILITY - 90% setting (only applies to tachometer feedback drives).

   I FDBK CAL. - 30% setting

2. Close main circuit breaker.

3. Press START push button.

4. Slowly rotate SPEED control to 100% setting.

5. Adjust MAX SPEED adjustment setting until armature voltage is 180 VDC, or desired maximum speed is reached. DO NOT EXCEED 180 VDC.

6. Rotate SPEED control to zero.

7. Increase MIN SPEED adjustment setting until drive begins to rotate and then decrease setting until drive stops. If it is desirable to have the drive rotate at some minimum speed with the SPEED control set at zero, then increase setting of MIN SPEED adjustment until drive is rotating at desired speed.

8. Increase SPEED control setting until drive is rotating at desired run speed.

9. Monitor armature current during acceleration and deceleration. Trim the FORWARD CURRENT LIMIT and REVERSE CURRENT LIMIT adjustments if armature current exceeds 150% of rated current.

10. Connect DC voltmeter between testpoint IFDBK and common (TP COM) on main PCB. Voltage at testpoint should equal:

$$\text{IFDBK} = \frac{\text{Motor Amps During Test}}{\text{Rated Motor Amps}} \times 1 \text{ volt}$$

If not, adjust IFDBK potentiometer (7RH) on Main PCB until value is observed.

11. Check drive operation, regulation, and response. If necessary, turn RESPONSE towards 100 until desired operation is obtained. Turn STABILITY towards zero.

IMPORTANT

Too high of a Response setting may cause hunting, too low of a Stability setting may cause instability.

12. Press STOP push button. Setup is complete.

6. STANDARD OPERATING INSTRUCTIONS

NOTE

These instructions apply to a basic speed regulated drive only. Modifications will be covered by supplementary instructions or by the drive schematic.

1. Close the main circuit breaker or fused disconnect switch. This applies power to the control circuitry and the motor field.

2. Press the RUN push button. This closes the main loop contactor, 1M. The drive will accelerate under current limit control to the speed set by the SPEED control.

3. To change speeds, turn the SPEED control in the appropriate direction. The drive speed will increase or decrease accordingly.

IMPORTANT

The rate of speed increase or decrease will be limited by the setting of the REVERSE and FORWARD CURRENT LIMIT adjustments. Care must be exercised when changing the setting of these potentiometers. Refer to paragraph 5.2.1 for instructions.

4. To stop the drive, press the STOP push button. The drive motor will be deenergized and coast to a full stop.

<u>CAUTION</u>

EVEN THOUGH THE MOTOR ARMATURE HAS BEEN ELECTRICALLY DISCONNECTED, THE MOTOR FIELD, AS WELL AS THE CONTROL CIRCUITRY, IS STILL AT HIGH POTENTIAL.

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5. Open main disconnect switch or circuit breaker. This will deenergize the motor field and control circuit.

7. MAINTENANCE

7.1 DC MOTOR

Refer to the DC Motor Instruction Manual for maintenance and repair instructions.

7.2 POWER UNIT

WARNING
HIGH VOLTAGE

PERSONNEL WILL BE EXPOSED TO HIGH VOLTAGE WHEN THE ENCLOSURE DOOR IS OPENED. ELECTRICAL SHOCK CAN CAUSE SERIOUS OR FATAL INJURY. REMOVE AC INPUT POWER BEFORE ATTEMPTING TO PERFORM ANY MAINTENANCE FUNCTION ON THE POWER UNIT.

Minimal maintenance is required for the power unit. Periodic inspection should be made to see that the unit is kept clean and free from dirt and moisture; connections should be checked and tightened where necessary. Fuse contacts should also be inspected. Only qualified maintenance personnel trained to work with high voltage power circuitry and low voltage semiconductor circuitry should be allowed access to the power unit. All adjustments necessary to the operator are external to the enclosure. When a printed circuit board (PCB) must be repaired or replaced, it may be necessary to reset some of the adjustments (see section 9).

7.2.1 Component Location

Location of all major assemblies and components is shown in Figure 5.2.

7.2.2 Control Assembly Components, Replacement and Repair

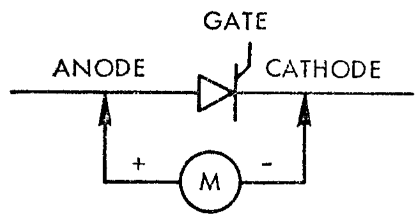
The power bridge assembly and PCB's can be easily removed and replaced.

PCB repair requires special techniques. Contact Louis Allis before attempting to repair a PCB.

IMPORTANT

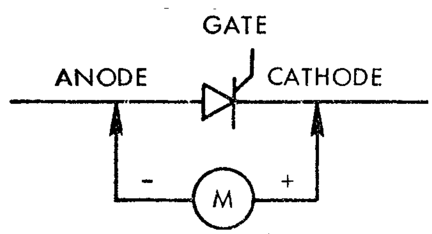
Your warranty may be voided if PCB repair is unauthorized.

The following test will not determine the true condition of a thyristor. When readings fall into the questionable or fault areas, do not replace the device until a comparison test is made with a known good device(s) in the same circuit. Always use the same meter when performing comparison tests.



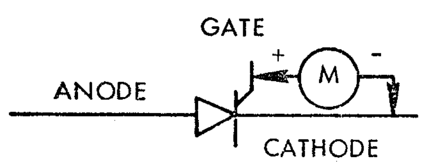
R X 10K Scale

R greater than 20K .... thyristor O.K.
R greater than 2K,
 less than 20K .... questionable thyristor
R less than 2K .... faulty thyristor



R X 10K Scale

R greater than 20K .... thyristor O.K.
R greater than 2K,
 less than 20K .... questionable thyristor
R less than 2K .... faulty thyristor



R X 1 Scale

R greater than 5 ohms,
 less than 100 ohms .... thyristor O.K.
R greater than 100 ohms,
 less than 1K .... questionable thyristor
R less than 5 ohms .... faulty thyristor
R greater than 1K .... faulty thyristor

THYRISTOR TEST

8. TROUBLESHOOTING

The troubleshooting chart (Figure 8.1) is designed to aid the serviceman in finding failures within the single phase drive with a minimum of steps. In general, the chart should be followed step by step until the failure is located. Since one failure can easily trigger another, it is suggested that all tests in any vertical column be performed before the drive is restarted. Each test is designed to isolate or partially isolate failures to the module or printed circuit board level. If the results of a particular test are not as indicated, additional steps necessary to isolate the problem or to correct the problem are given.

The following equipment is necessary to perform the troubleshooting tests: a general purpose VOM, a dual channel oscilloscope, and several short jumper wires. To avoid damage to the control components, the voltmeter should have a minimum sensitivity of 1000 ohms per volt, and the ohmmeter should have a maximum output of 6 volts.

WARNING
HIGH VOLTAGE

PERSONNEL WILL BE EXPOSED TO HIGH VOLTAGE WHEN THE ENCLOSURE DOOR IS OPENED. BE EXTREMELY CAREFUL WHEN PERFORMING TROUBLESHOOTING FUNCTIONS AS ELECTRICAL SHOCK CAN CAUSE SERIOUS OR FATAL INJURY. HIGH VOLTAGE TO GROUND WILL BE PRESENT AT MANY POINTS WITHIN THE POWER UNIT.

If the drive fails to start when the RUN button is pressed, first check the start circuitry at the terminal board on the Power Supply and Regulator PCB and connector 7CONN on the Main PCB. If the drive goes into a "full on" condition even though the speed setter is not fully advanced, check the power transformer connections and the phasing of the feedback signal.

8.1 PHASING

1. Remove non-metallic cover over controller.

2. Remove connector plugs 1CONN, 2CONN and 3CONN from Main PCB. Leave all other connectors in controller in place.

3. Set up dual trace oscilloscope with trigger source on LINE and channel selector to CHOP. Connect scope in the following manner:

   Ground Clip - Test point COM. on Main PCB
   Channel #1 - 16CONN -3 (80V p-p)
   Channel #2 - 6CONN -3 (20V p-p)

4. Connect 500 ohm, 25 watt resistor (or equivalent) from main transformer secondary tap X4 to terminal 2 on power bridge.

5. Turn on power to main transformer. Oscilloscope traces must be in phase.

6. If traces are in phase, turn off power, remove dummy resistor and proceed with the drive set up.

7. If traces are not in phase, turn off power and check all interconnection wiring. If wiring checks, reverse power leads from X3 and X5 of input transformer at incoming terminal strip and record the change on the drive schematic diagram.

8. Recheck phasing and if traces are in phase, turn off power and remove dummy resistor.

8.2 POWER SUPPLY CHECK

1. Remove AC input power.

2. Disconnect plugs from connectors 1CONN and 2CONN on Main PCB.

3. Apply AC input power.

4. Check that the following voltages are present at the indicated points on the Main PCB with respect to 5CONN-1 (COM).

+ 5 ±0.5 VDC	5CONN 4
+15 ±1 VDC	5CONN 5
-15 ±1 VDC	5CONN 6
28 ±5 VAC	16CONN 2
28 ±5 VAC	16CONN 3
-40 16 VDC	16CONN 4

5. If all voltages listed in step 4 are present, proceed to paragraph 8.3.

6. If one or more of the voltages listed in step 5 are missing, disconnect plugs 5CONN, 15CONN, 16CONN, and 17CONN from the Power Supply and Regulator PCB. Verify that the following voltages are present:

115 ±10 VAC	Term 19 to Term 21
115 ±10 VAC	Term 19 to Term 20
+5 ±0.5 VDC	5CONN 4 to 5CONN 1
+15 ±1 VDC	5CONN 5 to 5CONN 1
-15 ±1 VDC	5CONN 6 to 5CONN 1
-40 ±6 VDC	16CONN 4 to 5CONN 1
28 ±5 VAC	16CONN 3 to 5CONN 1
28 ±5 VAC	16CONN 2 to 5CONN 1

7. If all voltages are present in step 6 but not in step 4, check the wiring between the Power Supply and Regulator PCB and the Main PCB. If the wiring is correct, replace the Main PCB.

8. If 115 ±10 VAC is not present between terminals 19 and 11 in step 6, check the input wiring to the Power Supply and Regulator PCB and correct the wiring if necessary.

9. If 115 ±10 VAC is present between terminals 19 and 21 but not between 19 and 20, check the 3 amp fuse on the board.

10. If 28 ±5 VAC is present in step 6 from 16CONN 3 to 5CONN 1 and 16CONN 2 to 5CONN 1, but one or more of the other voltages are missing, first check the wiring from 18CONN on the Power Supply and Regulator PCB to dropping resistors 6R, 7R and 8R and verify the condition of the resistors with an ohmmeter. If the resistor assembly is acceptable, repair or replace the Power Supply and Regulator PCB.

11. If 115 ±10 VAC is present in step 6 but all of the other voltages are missing, disconnect 10CONN from the Power Supply and Regulator PCB and check for the following voltages at the connector attached to the harness:

28 ±5 VAC	10CONN 2 to 10CONN 1
28 ±5 VAC	10CONN 3 to 10CONN 1

12. If either of the voltages are not present in step 11, check the wiring going to the power supply transformer and the transformer itself.

13. Prior to proceeding with the troubleshooting of additional drive sections, replace all connector plugs.

8.3 GATING TIMER CHECK

1. Turn off AC input power.
2. Install temporary jumper between Terminal 14 and 15.
3. Connect AC voltmeter (115 VAC) to 7CONN 2 and 7CONN 3 on the Main PCB.
4. Apply AC input power. The AC voltage must be present for approximately one second then fall back to zero volts.
5. If operation is not correct, remove AC power and only then replace the Main PCB.
6. If operation still is not correct, check motor thermo-guard(s) and overload(s), and STOP push button.
7. Remove AC input power and only then remove jumper installed in step 2.

8.4 GATING OUTPUT CHECK

1. Remove AC input power. Remove connector 3CONN plug from Main PCB. Remove AC line fuses. Connect a jumper wire from test point ZCD to test point COMM on Main PCB. Set oscilloscope vertical input to 10 volt/div. and the horizontal sweep to 2 msec/div.
2. Connect an additional jumper wire between the points indicated and monitor the signals as listed in the table below.

Table II

STEP	JUMPER ON MAIN PCB	SIGNAL (SEE FIG. 8.2) @ 4 CHANNEL FIRING PCB	APPROX -10 VDC SIGNAL @ 4 CHANNEL FIRING PCB
A	5CONN 6 to 3CONN 3	1CONN 3 to 1CONN 4	2CONN 3 - com
B	5CONN 6 to 3CONN 3	1CONN 1 to 1CONN 2	2CONN 1 - com
C	5CONN 5 to 3CONN 3	2CONN 3 to 2CONN 4	1CONN 3 - com
D	5CONN 5 to 3CONN 3	2CONN 1 to 2CONN 2	1CONN 1 - com

Example: At step A, jumper 5CONN 6 (-15 volts) to 3CONN 3 (I_{ref} input). The signal shown in Figure 1 should be present from 1CONN 3 to 1CONN 4 at the 4 Channel Firing PCB. The signal from 2CONN 3 to com should be approximately -10 VDC.

NOTE: The 4 Channel Firing PCB is mounted on the side of the Power Bridge Aseembly.

3. If the proper signals are present, proceed to paragraph 8.5. If the proper signals are not present, check for identical signals at 1CONN and 2CONN on the Main PCB. If the signals at 1CONN and 2CONN on the Main PCB are not the same as on the 4 Channel Firing PCB, check the wiring between the PCBs. If the signals are identical and not proper, replace the Main PCB.

8.5 THYRISTOR GATE SIGNAL CHECK

1. Check Main PCB gating outputs (paragraph 8.4).

2. Repeat steps A through D in Table II. However, for this test, connect oscilloscope ground lead to terminal K and probe to terminal G of the 4 Channel Firing PCB with the scope vertical calibration at 2 volts/div. and horizontal sweep at 2 msec/div.

Step	Signal on 4 Channel Firing PCB
A	G1 to K1
B	G2 to K2
C	G3 to K3
D	G4 to K4

The above signals should appear as shown in Fig. 8.3.

3. If the amplitude of the signal is approximately 10 volts, instead of as shown, check the gate and cathode connections to the thyristor and check the gate-cathode junction of the thyristor. If the output signal is missing, check for a shorted gate-cathode junction of the thyristor. If the thyristor and the wiring are all right, replace the 4 Channel Firing PCB.

4. Be sure power is OFF, then remove jumper and reinstall AC line fuses.

8.6 ZERO CURRENT DETECTOR CHECK

1. Remove connector plugs 1CONN and 2CONN on the Main PCB.

2. Connect oscilloscope ground probe to test point COM on Main PCB. Apply AC input power and check the signals at 6CONN 3 and 6CONN 4. Each should be a clipped sine wave with an amplitude of approximately +11 volts and -6 volts, 60HZ.

3. The signal at 6CONN 3 must have the same phase relationship as the signal at 16CONN 3 (approximately 40 volt peak). The signal at 6CONN 4 must be 180° out of phase with the signal at 16CONN 3. See Figure 8.4. If the phase relationship of these signals is not correct, check:

   a. The power transformer connections.
   b. The control power supply connections.
   c. The interconnections of 16CONN between the Power Supply and Regulator PCB and the Main PCB.
   d. The connections of 6CONN 3 and 4.
   e. The connection of the power supply transformer.

4. If the signal amplitude is not correct and all wiring is OK, replace the Main PCB.

8.7 ARMATURE VOLTAGE AND CURRENT CHECK

Figure 8.5 A through G illustrates typical motor armature waveforms. The top trace is the voltage signal and the bottom trace is the current signal. Steps 2 through 7 below describe the illustrated waveforms.

Connect the oscilloscope leads and probes as follows:

Ground lead to test point COM on Main PCB.
One probe to test point IFDBK on Main PCB (Current Signal).
Second probe to center tap of input power transformer X4 (Voltage Signal).

1. Apply AC input power and press RUN button.

2. Figure A illustrates normal power unit output under motoring conditions at 75% speed and 75% torque.

3. Figure B shows normal output waveforms under regenerative conditions at 75% speed and 75% torque.

4. Figure C shows normal output waveforms with no load on motor at 75% speed.

5. Figure D shows normal output waveforms under current limited conditions and 30% speed; such as would occur during current limited acceleration.

6. Figure E shows abnormal "full-on" waveforms that could occur should a Power Supply and Regulator PCB or Main PCB fail, or should wiring be incorrectly phased.

7. Figures F and G show abnormal unbalanced output waveforms that could occur should a Main PCB fail or need adjustment.

8.8 CURRENT LOOP CHECK

Inspect current feedback circuit wiring from the dropping resistor in armature circuit to Power Supply and Regulator PCB for possible intermittent connections and proper phasing.

8.9 SPEED LOOP CHECK

Inspect speed feedback wiring from tachometer-generator to Power Supply and REgulator PCB for possible intermittent connections and proper phasing. Try substituting Power Supply and Regulator PCB.

8.10 THYRISTOR CHECK

Remove AC input power, then remove both AC line fuses. With an ohmmeter, check for a short circuit between terminals 1 and 2 (1 and 3 SCR), and between 3 and 2 (2 and 4 SCR) of Power Bridge Assembly. If either test indicates a short circuit:

a. Refer to paragraph 7.2.2 to determine which thyristor is defective.

b. Check thyristor suppression 1C, 2C, 1R and 2R.

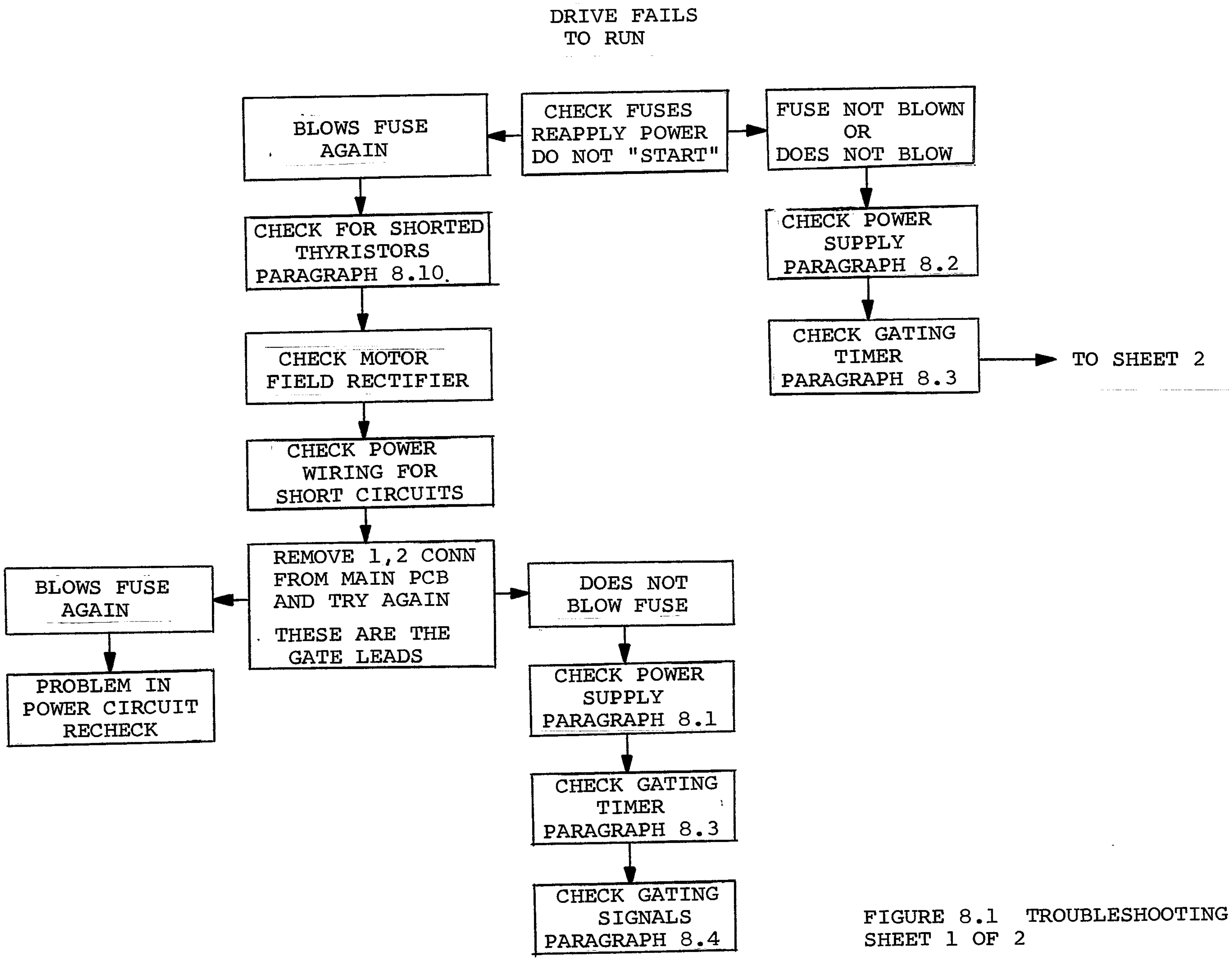


FIGURE 8.1 TROUBLESHOOTING CHART
SHEET 1 OF 2

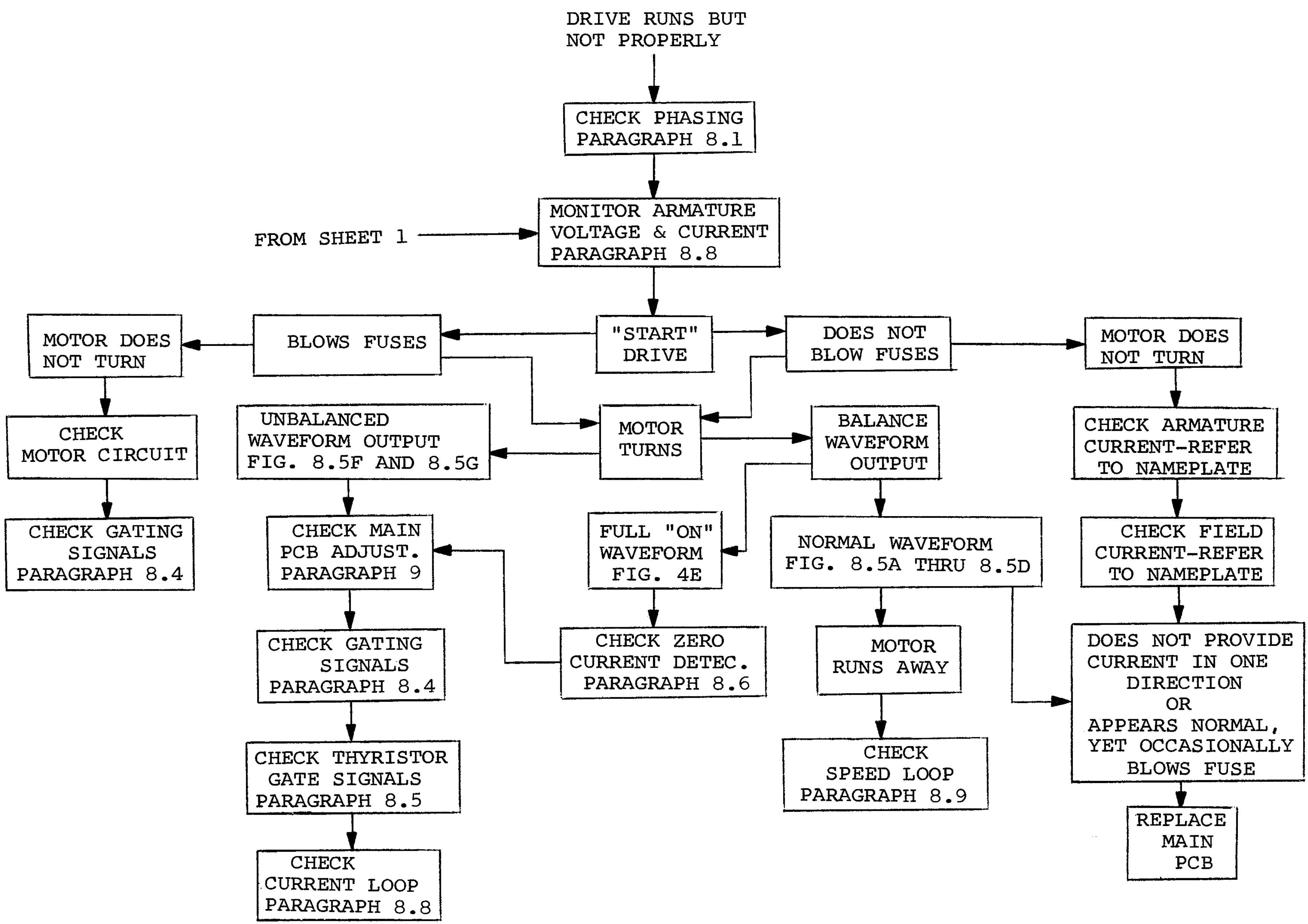


FIGURE 8.1 TROUBLESHOOTING CHART
SHEET 2 OF 2

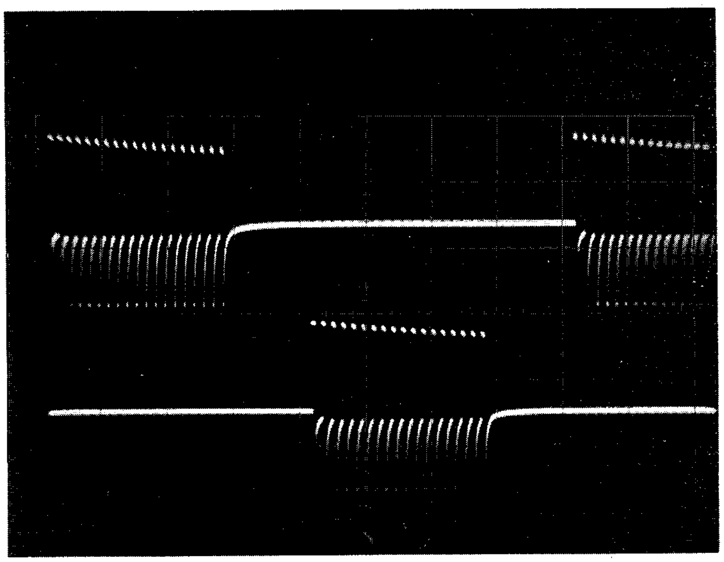


FIGURE 8.2 GATING OUTPUTS

Calib. Vert. 20V/cm
Horiz. 2Msec/cm

Upper:

1 Conn 3 to 1 Conn 4
at -10V input

2 Conn 1 to 2 Conn 2
at +10V input

Lower:

1 Conn 1 to 1 Conn 2
at -10V input

2 Conn 3 to 2 Conn 4
at +10V input.

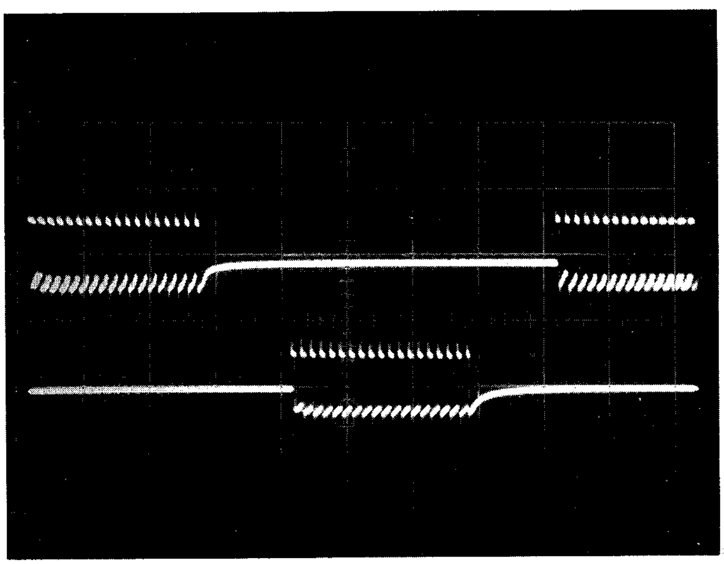


FIGURE 8.3 THYRISTOR GATE SIGNAL CHECK

Calib. Vert. 2V/cm
Horiz. 2Msec/cm

Upper:

G1 to K1 at -10V input
G4 to K4 at +10V input

Lower:

G2 to G3 at -10V input
G4 to K4 at +10V input

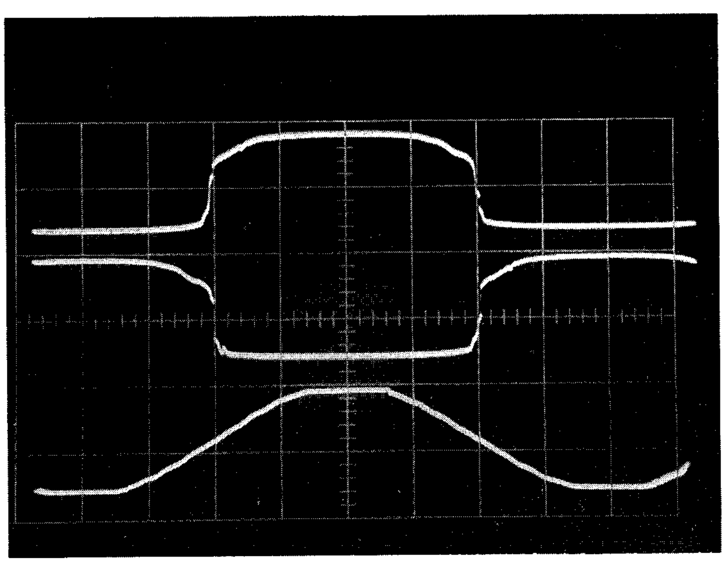
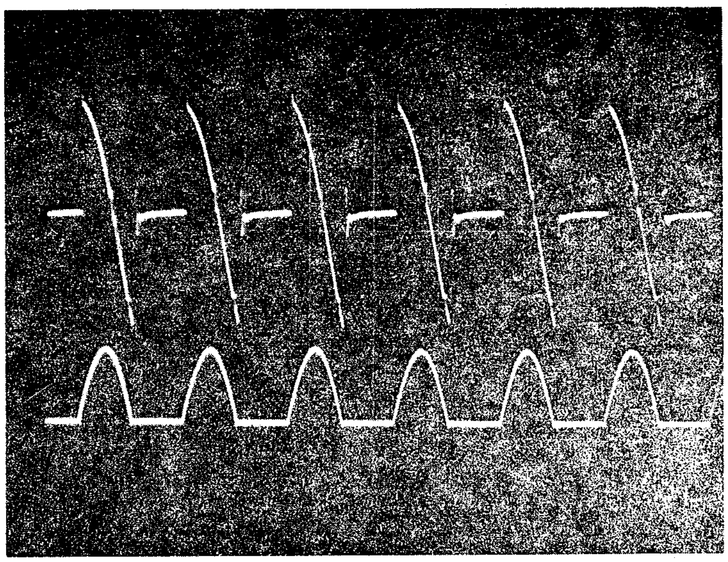


FIGURE 8.4 ZERO CURRENT DETECTION CHECK

6 Conn 3 (10V/cm)

6 Conn 4 (10V/cm)

16 Conn 3 (50V/cm)

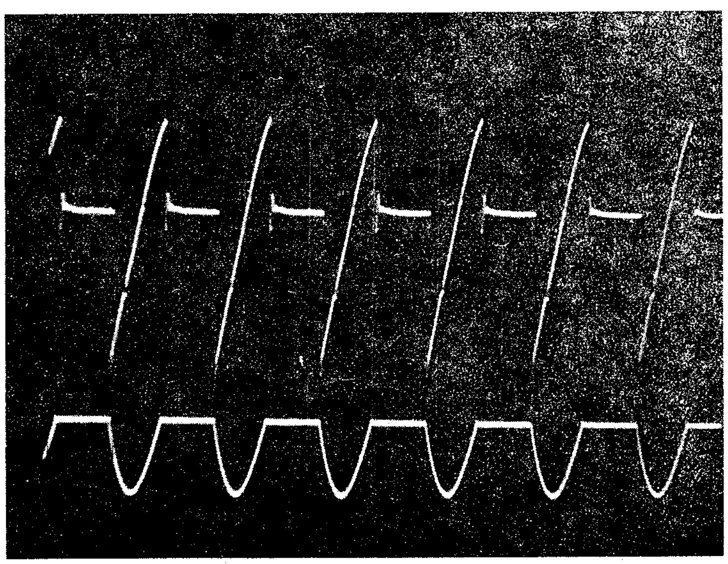


CALIB.

VERT:
TOP TRACE:
100V/DIV
BOTTOM TRACE:
2V/DIV

HORIZ: 5MS/DIV

A. MOTORING – 75% SPEED AND 75% TORQUE



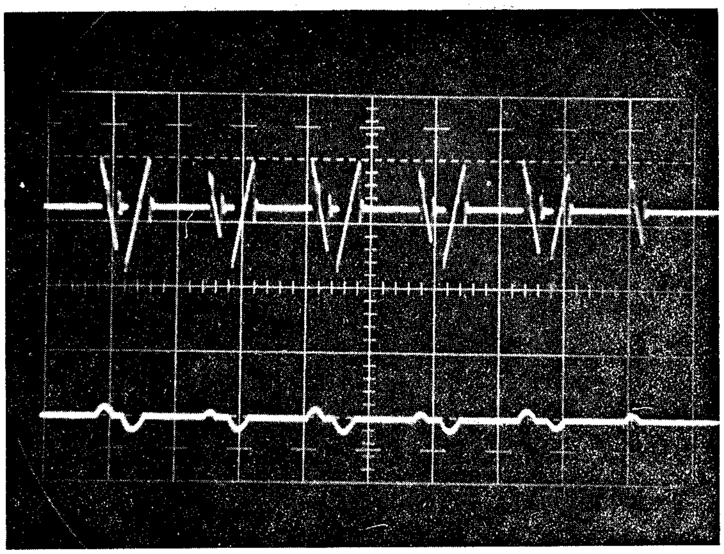
CALIB.

VERT:
TOP TRACE:
100V/DIV
BOTTOM TRACE:
2V/DIV

HORIZ: 5MS/DIV

B. REGENERATION – 75% SPEED AND 75% TORQUE

Figure 8.5 POWER UNIT OUTPUT WAVEFORMS

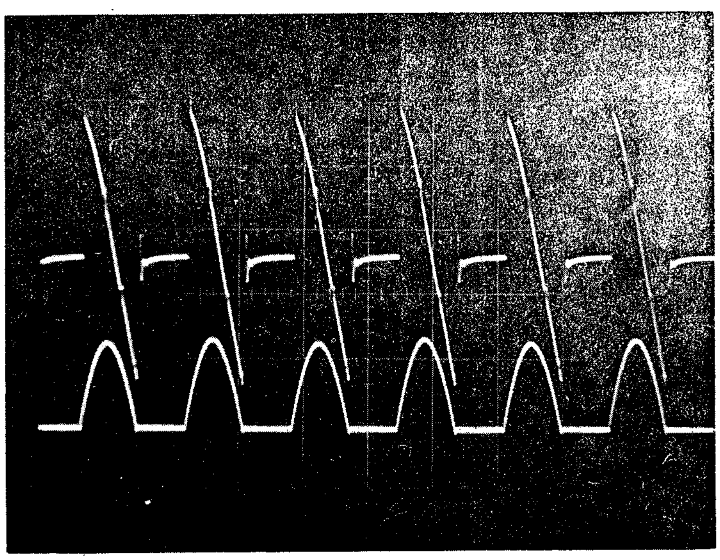


CALIB.

VERT:
TOP TRACE:
100V/DIV
BOTTOM TRACE:
2V/DIV

HORIZ: 5MS/DIV

C. NO LOAD @ 75% SPEED



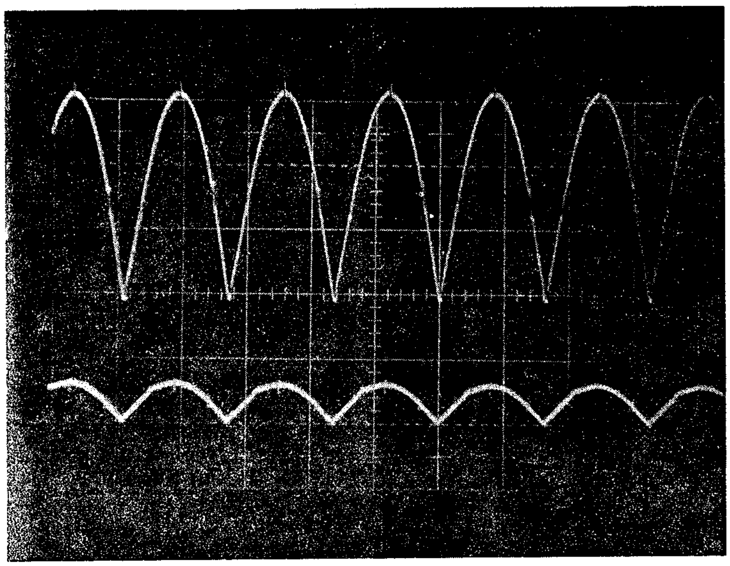
CALIB.

VERT:
TOP TRACE:
100V/DIV
BOTTOM TRACE:
2V/DIV

HORIZ: 5MS/DIV

D. CURRENT LIMIT ACCELERATION @ 30% SPEED

Figure 8.5 POWER UNIT OUTPUT WAVEFORMS (Continued)

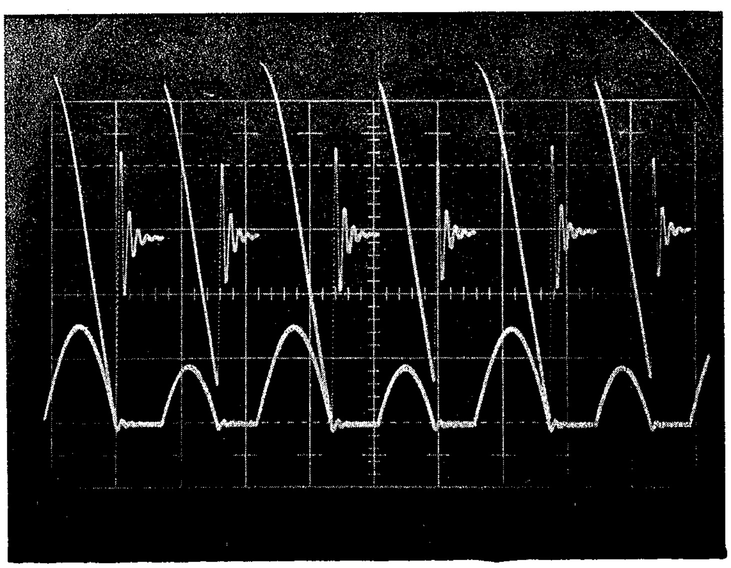


CALIB.

VERT:
TOP TRACE:
100V/DIV
BOTTOM TRACE:
2V/DIV

HORIZ: 5MS/DIV

E. FULL-ON CONDITION



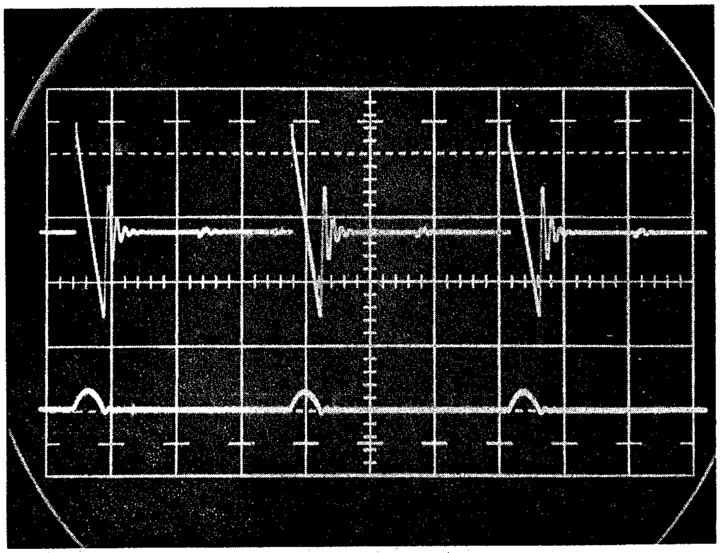
CALIB.

VERT:
TOP TRACE:
100V/DIV
BOTTOM TRACE:
2V/DIV

HORIZ: 5MS/DIV

F. UNBALANCED OUTPUT (WITH LOAD)

Figure 8.5 **POWER UNIT OUTPUT WAVEFORMS (Continued)**



CALIB.

VERT:
TOP TRACE:
100V/DIV
BOTTOM TRACE:
2V/DIV

HORIZ: 5MS/DIV

G. UNBALANCED OUTPUT (NO LOAD)

Figure 8.5 POWER UNIT OUTPUT WAVEFORMS (Continued)

9. PCB REPLACEMENT ADJUSTMENTS

Should it be necessary to replace the Main PCB, some factory set adjustments may have to be reset. A dual trace oscilloscope is required to make these adjustments.

9.1 MAIN PCB

1. Press drive STOP button and remove AC input power.

2. Install new Main PCB.

3. Remove connector plugs from 1CONN, 2CONN and 6CONN on the Main PCB.

4. Connect dual trace oscilloscope ground lead to test point COM on Main PCB.

5. Set oscilloscope trigger source to LINE, and channel selector to CHOP. Set horizontal sweep rate for 1 millisecond/cm.

6. Apply AC input power.

7. Connect channel #1 probe to test point SYNC of Main PCB. Adjust the oscilloscope until a trace similar to the one shown in Figure 9.1A is displayed.

8. Connect oscilloscope channel #2 probe to test point TF. Adjust TAIL FIRE potentiometer (3RH) until a trace similar to the one shown in Figure 9.1B is observed. This trace should be measured with respect to the channel #1 trace shown in Figure 9.1A. Figure 9.1A represents the upper trace and Figure 9.1B the lower trace.

9. Move channel #2 probe to test point C1. Adjust OVERLAP potentiometer (1RH) until the lower trace is similar to the one shown in Figure 9.1C. This trace should be measured with respect to the channel #1 trace shown in Figure 9.1A.

10. Remove channel #2 probe. Readjust oscilloscope trigger until upper trace is like the waveform shown in Figure 9.1D. The channel #1 probe should still be connected to test point SYNC and the horizontal sweep rate should remain set at 1 millisecond/cm.

11. Connect channel #2 probe to test point C2. Adjust BALANCE potentiometer (2RH) until the lower trace is similar to the waveform shown in Figure 9.1E. This trace should be measured with respect to the channel #1 trace shown in Figure 9.1D.

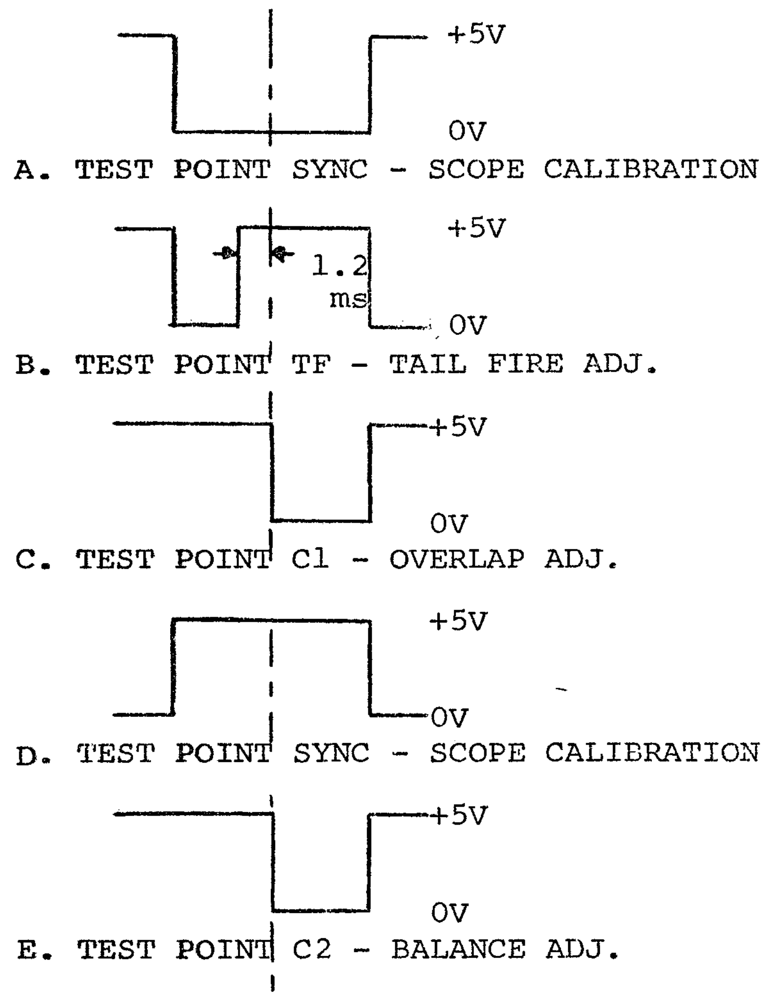


Figure 9.1. Main Control PCB Waveforms

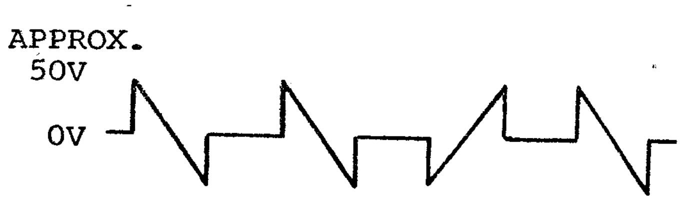


Figure 9.2. Armature Voltage Waveform

12. Remove AC input power. Remove channel #1 and #2 probes.

13. Reconnect plugs in 1CONN, 2CONN and 6CONN.

14. Set 4RH thru 7RH to the same settings as the original Main PCB.

NOTE

If Main PCB being replaced does not contain 7RH (IFDBK calib.), initially set 7RH to 30%.

15. Connect oscilloscope probe to center tap of input power transformer, X4.

16. Turn SPEED control to zero setting.

17, Apply AC input power. Press drive RUN button.

18. The observed waveform should be similar to the one shown in Figure 9.2. Random "blinking" of voltage pulses is normal.

19. Adjust the OVERLAP potentiometer (1RH) until phase in both directions appear (see Figure 9.2).

20. Adjust BALANCE potentiometer (2RH) until amplitude of voltage pulses are equal.

21. If necessary, readjust OVERLAP potentiometer (1RH).

22. Check setting of the POSITIVE CURRENT LIMIT and NEGATIVE CURRENT LIMIT adjustments as given in paragraph 5.2.2. Make necessary corrections to the adjustments. DO NOT reset CROSSOVER FREQUENCY adjustment (6RH).

23. If drive output current is unbalanced or unstable (Figures 8.5F and 8.5G), change CROSSOVER FREQUENCY adjustment (6RH) slightly. Stability and proper operation will probably be obtained with the potentiometer set from 0% to 25% from the counterclockwise position.

24. Connect DC voltmeter between testpoints IFDBK and COMM. With drive running at some constant load, adjust 7RH until voltmeter indication is equal to the calculation:

$$\text{IFDBK} = \frac{\text{Motor Amps During Test}}{\text{Rated Motor Amps}} \times 1 \text{ volt}$$