LOUIS ALLIS

DRIVE EQUIPMENT

SABER 3400

SINGLE PHASE

ARMATURE REGENERATIVE

DC STATIC DRIVE

LouisAllis®
A Division of MagneTek Inc

NOTICE

This equipment is exempted from FCC regulations.

See 47CFR15.801.

CAUTION

NEVER CONNECT CAPACITORS ACROSS THE INVERTER OUTPUT AND MOTOR. UPON APPLICATION OF POWER, THE INVERTER INITIALLY SEES THE CAPACITORS AS A SHORT CIRCUIT, HIGH CURRENTS RESULT AND EQUIPMENT WILL BE DAMAGED.

IF REQUIRED, POWER FACTOR CORRECTION CAPACITOR NETWORKS MAY BE CONNECTED ACROSS THE INPUT POWER SOURCE ONLY AFTER CONSULTING LOUIS ALLIS.

IMPROPER USE OF POWER FACTOR CORRECTION CAPACITOR NETWORKS WILL DAMAGE EQUIPMENT.

WARNING

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

CAUTION

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 TELLS HOW TO TAKE OFF 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.

1. GENERAL

This instruction manual provides the necessary installation, maintenance, and adjustment procedures, plus principles of operation for the 1 thru 10 HP Saber 3400 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

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 Louis Allis Saber 3400 drive is a custom engineered static dc drive. The typical drive consists of a solid state power unit, a Louis Allis Flexitorq ® dc motor, 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.

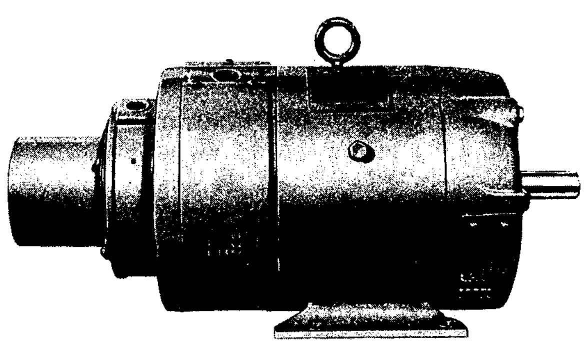


FIGURE 1. FLEXITORQ DC MOTOR

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

2.1.2 Modifications – Various mechanical modifications can be provided with Louis Allis Flexitorq dc motors. Consult the Louis Allis Company 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 pushbuttons, and any supplementary control or meters which may have been added as drive modifications.

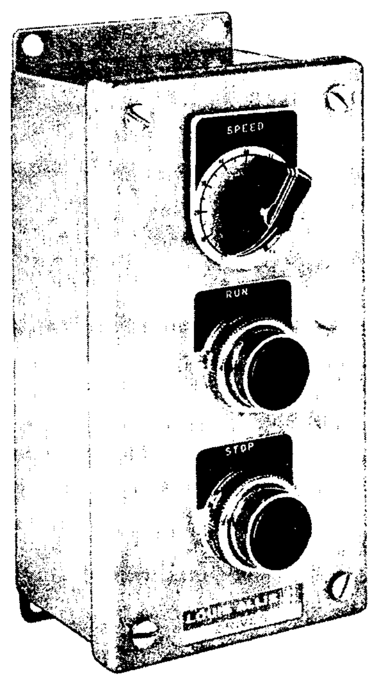


FIGURE 2. OPERATOR'S CONTROL STATION

2.3 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.

2.3.1 **Features** – Some of the outstanding features of the power unit include:

- Regeneration as standard on all Saber 3400 single phase drives permitting operation in all four quadrants of motoring and regeneration.
- DC tachometer-generator feedback as standard on speed regulated custom drives. This allows 1% regulation and wide speed range as standard. More precise regulation is readily available.
- Individual control components constructed as basic modules for rapid and easy servicing.
- Printed circuit boards mounted with plug-in or bayonet type terminals to allow easy replacement in the event of a failure.
- Integrated circuits, where feasible, for additional reliability.
- Separately adjustable current limit in both forward and reverse directions of current.
- Main input power fuses; the control circuits are separately fused.
- System components designed for a minimum of 600 volts clearance to ground.
- Thyristor protection by specially designed circuits such as:
  - 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.
  - Solid state components which are generously rated.
  - Improved thyristor gating techniques including burst or pulse train gating for normal firing.
- DC loop contactor and motor overload relays to provide standard motor control features including:
  - Protection against sustained overloads.
  - Inherent undervoltage protection.
  - Positive motor disconnect.

2.3.2 **Identification** – In any communication or correspondence with Louis Allis pertaining to the power unit, always reference the power unit serial number and other data stamped on the power unit nameplate.

2.3.3 **Modifications** – Because the Saber 3400 drive is a custom engineered drive, almost every power unit contains some modification or feature which is is custom engineered for the intended application. These special modifications are not discussed in this manual, but will be covered by the actual drive circuit diagram or supplementary instructions.

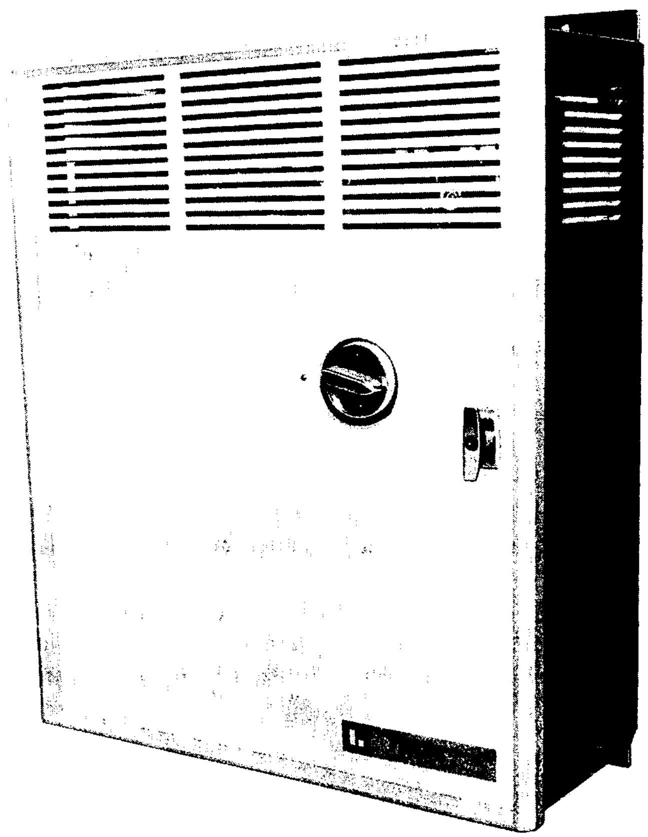


FIGURE 3. POWER UNIT

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 below. Total run-out should not exceed .002 inches.

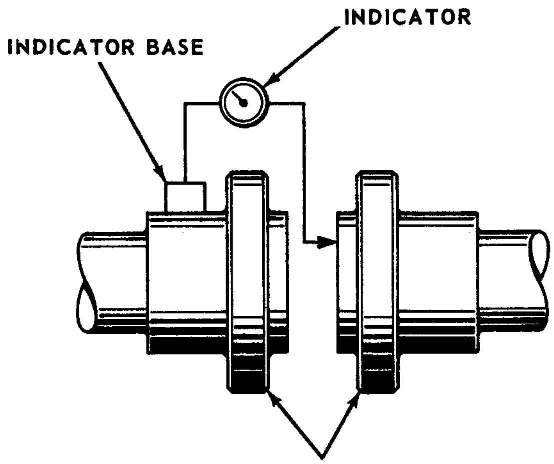


FIGURE 4. ANGULAR ALIGNMENT CHECK

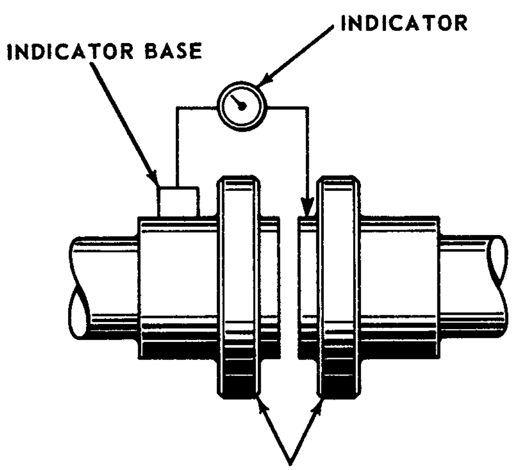


FIGURE 5. RUN-OUT CHECK

When the motor is belted to the load, the motor and load sheaves must be in line (figure 6). 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.

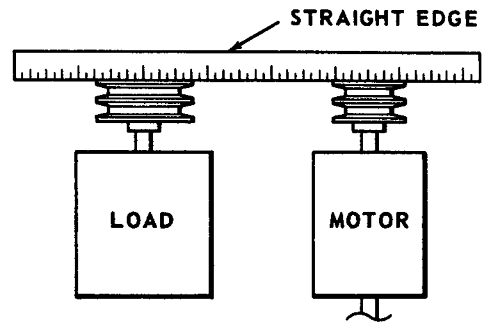


FIGURE 6. SHEAVE ALIGNMENT

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.

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 contactors drawings and all applicable codes. Refer to Interconnection Diagram to interconnect the Saber 3400 power unit and associated equipment. Figure 7 shows the interconnection points. Table I will aid in the selection of wire sizes.

NOTE

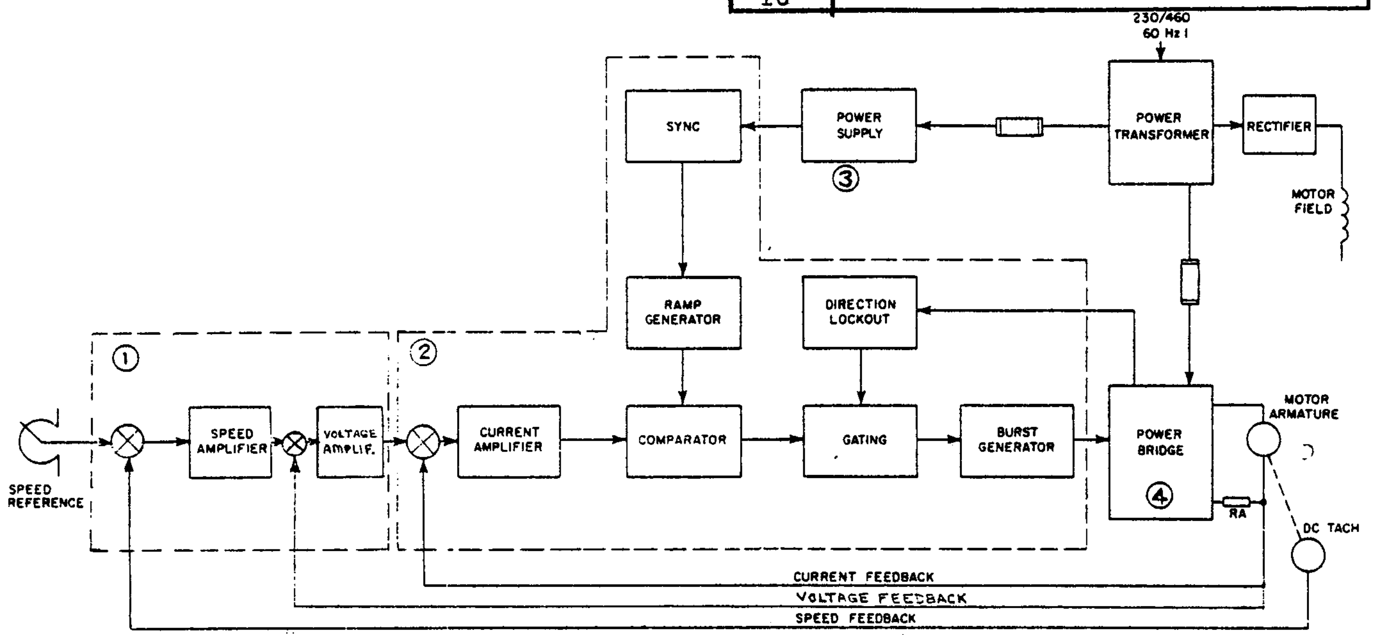
In long cable runs, care must be exercised to prevent excessive voltage drop.

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.

All shielded wire should be connected per the diagrams. Shielded wires, particularly those in long runs leading to the tachometer-generator, should be shielded, twisted pairs. This will reduce the effect of magnetic noise.

TABLE I
CURRENT RATINGS

Horse-power	AC Input Current at Full Load (Amps)		DC Armature Current at Full Load (Amps)
	230V Input	460 V Input	180 Volt Output
1	7.7	3.9	5.5
1.5	10.2	5.1	7.3
2	15.1	7.6	10.8
3	20.4	10.2	14.6
5	33.8	16.9	25
7.5 10	See Order Data		



SCHEMATIC REFERENCES

Drive Schematic Diagram......45S1620-0000

① Reference & Actuator PCB... 45S1629
② Main PCB..................45S1674-0010
③ Power Supply Module..... 45S1606
④ Power Bridge Module 45S1675-0010

FIGURE 8. SIGNAL FLOW DIAGRAM

4. DRIVE OPERATION

4.1 POWER UNIT

The following description of drive operation is for a typical speed regulated drive. Any modification not discussed in this manual will be covered by the actual drive schematic diagrams or supplementary instructions.

The operation of the power unit can be best understood by referring to the signal flow diagram, figure 8.

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.

The signal from the speed reference circuit is added to the tachometer-generator feedback signal to form the speed error signal. This signal is amplified and then applied to the current limit circuit which limits (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. Note that since a dc tachometer-generator is used, the polarity of the reference signal will determine the motor's direction of rotation.

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.

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 STARTUP

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 STARTUP 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.

5.2 Initial Start Up Adjustments

NOTE: 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 following phasing procedure:

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 on CHOP. Connect scope in the following manner:

   Ground Clip - Test point common on Main PCB.

   Channel #1 - 16 Conn -3 ($80V_{p-p}$)

   Channel #2 - 6 Conn -3 ($20V_{p-p}$)

4. Connect 500 ohm, 25 watt resistor (or equivalent) from main transformer secondary tap X4 to terminal GA 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 show the change on the drive schematic diagram.

8. Recheck phasing and if traces are in phase, turn off power, remove dummy resistor and proceed with the drive set up.

5.2.1 Adjustments –

SPEED (figure 9) – Allows operator to adjust the running speed of the drive. The drive speed is adjustable from the low limit (set by the LOW SPEED TRACKING adjustment) to the high limit (set by the MAX SPEED adjustment).

LOW SPEED TRACKING (minimum 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%.

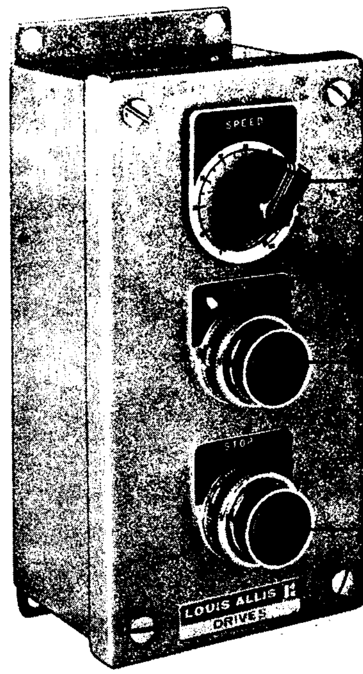


FIGURE 9. SPEED CONTROL LOCATION

FORWARD CURRENT LIMIT (figure 10) – Limits the maximum amount of armature current in the positive direction of current flow.

REVERSE CURRENT LIMIT (figure 10) – This adjustment limits the amount of armature current in the negative direction of current flow.

RESPONSE (figure 10) – 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.

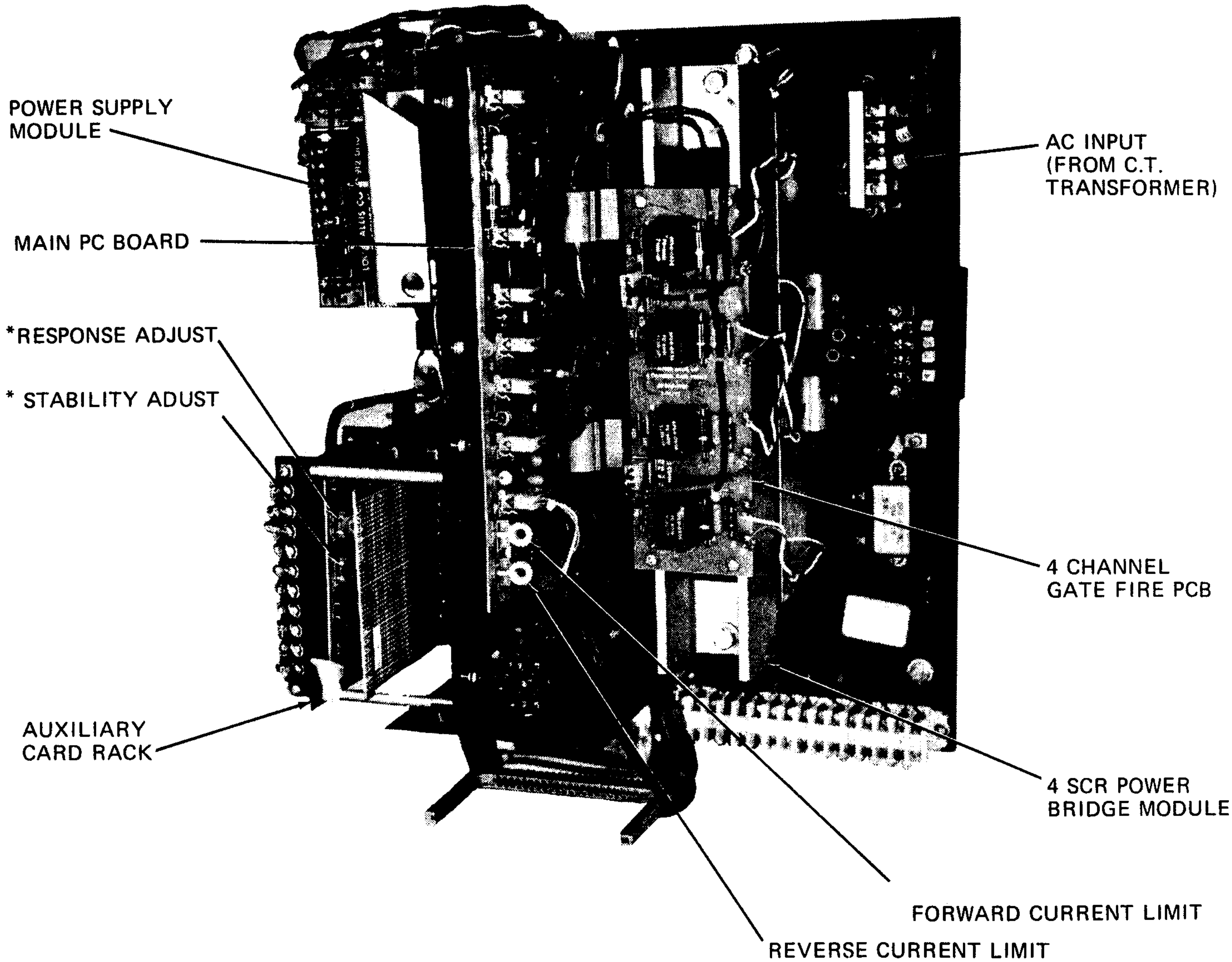
STABILITY (figure 10) - This adjustment controls the speed loop stability.

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).

OVERLAP (Main PCB) This adjustment controls the degree of separation 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 PBC) 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).

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).



* ON SPEED REGULATED DRIVES USING THIS REFERENCE AND ACTUATOR PCB

FACTORY ADJUSTMENTS ON MAIN PCB (REMOVE TO ADJUST) INCLUDE CROSSOVER FREQUENCY, BALANCE, OVERLAP, AND TAILFIRE.

FIGURE 10. LOCATION OF COMPONENTS AND ADJUSTMENTS

5.2.2 Initial Setup and Adjustment –

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

   LOW SPEED TRACKING – 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 – 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
   STABILITY - 90% setting

2. Close main circuit breaker.

3. Press START pushbutton.

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 LOW SPEED TRACKING 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 LOW SPEED TRACKING 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 and deceleration. Trim the FORWARD CURRENT LIMIT and REVERSE CURRENT LIMIT adjustments if armature current exceeds 150% of rated current.

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

    NOTE

    Incorrect settings may cause hunting or instability.

11. Press STOP pushbutton. 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 pushbutton. 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 increased or decrease accordingly.

   NOTE

   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 pushbutton. The drive motor will be deenergized and coast to a full stop.

   NOTE

   Even though the motor armature has been electrically disconnected, the motor field, as well as the control circuitry, is still at high potential.

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

Remove ac input power before attempting to perform any maintenance function on the power unit because personnel will be exposed to High Voltage when the enclosure door is opened. Electrical shock can cause serious or fatal injury.

Very little maintenance is required for the power unit. Periodic inspection should be maae 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 paragraph 9).

7.2.1 Component Location – Location of all major assemblies and components is shown in figure 10.

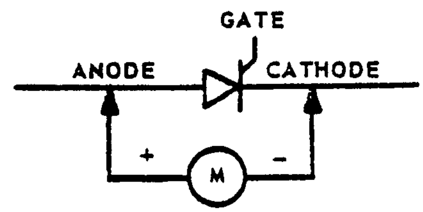
7.2.2 Control Assembly Components, Replacement and Repair – The power supply, card rack, and PCB's can be easily removed and replaced.

PCB repair requires special techniques. Do not attempt to repair a PCB before contacting Louis Allis

NOTE

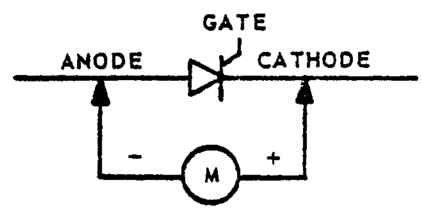
Your warranty may be voided if PCB repair is unauthorized.

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.



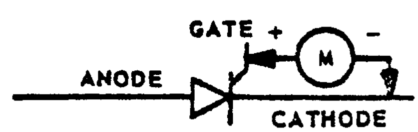
R X 10K Scale

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



RX1 Scale

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

THYRISTOR TEST

8. TROUBLESHOOTING

The troubleshooting chart (figure 7) 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.

Maintenance personnel should not stand on grounded surfaces or contact ground potential when touching oscilloscope. The oscilloscope chassis should not be grounded through a grounding plug or by contact with a ground surface.

If the drive fails to start when the "Run" button is pushed, first check the start circuitry at terminal board 1TB and connector 7 conn 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 tach feedback signal.

8.1 POWER SUPPLY CHECK

1. Remove ac input power.
2. Disconnect plugs from connectors 1 Conn and 2 Conn 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 5 Conn 1 (com).

+ 5 ± 0.5 vdc	5 Conn 4
+ 15 ± 1 vdc	5 Conn 5
- 15 ± 1 vdc	5 Conn 6
28 ± 5 vac	16 Conn 2
28 ± 5 vac	16 Conn 3
- 40 ± 6 vdc	16 Conn 4

5) If all voltages listed in step 4 are present, proceed to step 8.2.

6) If one or more of the above voltages are missing, check for the following voltages at the Power Supply module. Disconnect plugs from 5 conn, 15 conn, 16 conn and 17 conn on the Power Supply module prior to taking voltage measurements.

115 ± 10 Vac	....	1TB1 to 1TB3
+ 5 ± 0.5 Vdc	....	5 conn 4 to 5 conn 1
+15 ± 1 Vdc	....	5 conn 5 to 5 conn 1
-15 ± 1 Vdc	....	5 conn 6 to 5 conn 1
-40 ± 6 Vdc	....	16 conn 4 to 5 conn 1
28 ± 5 Vac	....	16 conn 3 to 5 conn 1
28 ± 5 Vac	....	16 conn 2 to 5 conn 1

7) If all voltages are present in step 6 but not in step 4 check the wiring between the Power Supply module and the main PCB. If the wiring is all right, replace the main PCB.

8) If 115 ± 10VAC is not present in step 6 check the input wiring to the Power Supply module and correct the wiring if necessary.

9) If 115 ± 10VAC is present in step 6 but one or more of the other voltages are missing, repair or replace the Power Supply module.

10) Replace all connector plugs.

8.2 GATING TIMER CHECK

1) Turn off ac input power.

2) Connect ac voltmeter (115VAC) to 7 conn 2 and 7 conn 3 on the main PCB.

3) Apply ac input power. The ac voltage must be present for approximately one second then fall back to zero volts.

4) If operation is not correct, replace the main PCB.

8.3 GATING OUTPUT CHECK

1) Remove ac input power. Remove connector 3 conn plug from main PCB. Remove ac line fuses. Connect a jumper wire from test point ZCD to test point com on main PCB. Set oscilloscope vertical input to 10 volts/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 1

Step	Jumper on Main PCB	Signal (See Fig. 1) @ 4 Channel Firing PCB	Approx. -10VDC Signal @ 4 Chan. Firing PCB
A	5 conn 6 to 3 conn 3	1 conn 3 to 1 conn 4	2 conn 3 - com
B	5 conn 6 to 3 conn 3	1 conn 1 to 1 conn 2	2 conn 1 - com
C	5 conn 5 to 3 conn 3	2 conn 3 to 2 conn 4	1 conn 3 - com
D	5 conn 5 to 3 conn 3	2 conn 1 to 2 conn 2	1 conn 1 - com

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

NOTE: The 4 Channel Firing PCB is mounted inside the Power Bridge Assembly.

3) If the proper signals are present, proceed to Section 8.4. If the proper signals are not present, check for identical signals at 1 conn and 2 conn on the main PCB. If the signals at 1 conn and 2 conn on the main PCB are not the same as on the 4 Channel Firing PCB, check the wiring between the PCB's. If the signals are identical and not proper, replace the main PCB.

8.4 THYRISTOR GATE SIGNAL CHECK

1) Check Main PCB gating outputs (paragraph 8.3).

2) Repeat steps A through D in table 1. 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 figure 2.

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 is all right, replace the 4 Channel Firing PCB.

4) Be sure power is OFF, then remove jumper and re-install ac line fuses.

8.5 ZERO CURRENT DETECTOR CHECK

1) Remove connector plugs 1 conn and 2 conn 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 6 conn 3 and 6 conn 4. Each should be a clipped sine wave with an amplitude of approximately + 11 volts and - 6 volts, 60Hz.

3) The signal at 6 conn 3 must have the same phase relationship as the signal at 16 conn 3 (approx. 40 volt peak). The signal at 6 conn 4 must be 180° out of phase with the signal at 16 conn 3. See fig. 3. 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 16 conn between the power supply and the main PCB, and
   (d) the connections of 6 conn 3 & 4.

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

8.6 ARMATURE VOLTAGE AND CURRENT CHECK

Figures 4A through 4G illustrate 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 I_{FBK} 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 4A illustrates normal power unit output under motoring conditions at 75% speed and 75% torque.

3) Figure 4B shows normal output waveforms under regenerative conditions at 75% speed and 75% torque.

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

5) Figure 4D shows normal output waveforms under current limited conditions and 30% speed; such as would occur during current limited acceleration.

6) Figure 4E shows abnormal "full-on" waveforms that could occur should a Reference & Actuator PCB or main PCB fail, or should wiring be incorrectly phased.

7) Figures 4F and 4G show abnormal unbalanced output waveforms that could occur should a main PCB fail or need adjustment.

8.7 CURRENT LOOP CHECK

Inspect current feedback circuit wiring from the dropping resistor in armature circuit to Reference & Actuator PCB for possible intermittent connections and proper phasing.

8.8 SPEED LOOP CHECK

Inspect speed feedback wiring from tachometer-generator to Reference & Actuator PCB for possible intermittent connections and proper phasing. Try substituting Reference & Actuator PCB.

8.9 THYRISTOR CHECK

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

(a) refer to paragraph 7.2.4 to determine which thyristor is defective

(b) check thyristor suppression 1C, 2C, 1R and 2R.

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 1 conn, 2 conn, and 6 conn on the main PCB.

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

5) Set osc illoscope 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 5A 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 5B is observed. This trace should be measured with respect to the channel #1 trace shown in figure 5A. Figure 5A represents the upper trace and figure 5B 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 5C. This trace should be measured with respect to the channel #1 trace shown in figure 5A.

10) Remove channel #2 probe. Readjust oscilloscope trigger until upper trace is like the waveform shown in figure 5D. 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 5E. This trace should be measured with respect to the channel #1 trace shown in figure 5D.

12) Remove ac input power. Remove channel #1 and #2 probes.

13) Reconnect plugs in 1 conn, 2 conn, and 6 conn.

14) Set 4RH, 5RH and 6RH to the same settings as the original main PCB.

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 6. Random "blinking" of voltage pulses is normal.

19) Adjust the OVERLAP potentiometer (1RH) until pulses in both directions appear (see figure 6).

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

21) If necessary readjust OVERLAP.

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 4F and 4G) turn CROSSOVER FREQUENCY adjustment (6RH) slightly. Stability and proper operation will probably be obtained with the potentiometer set from 0% to 25% from the counter-clockwise position.

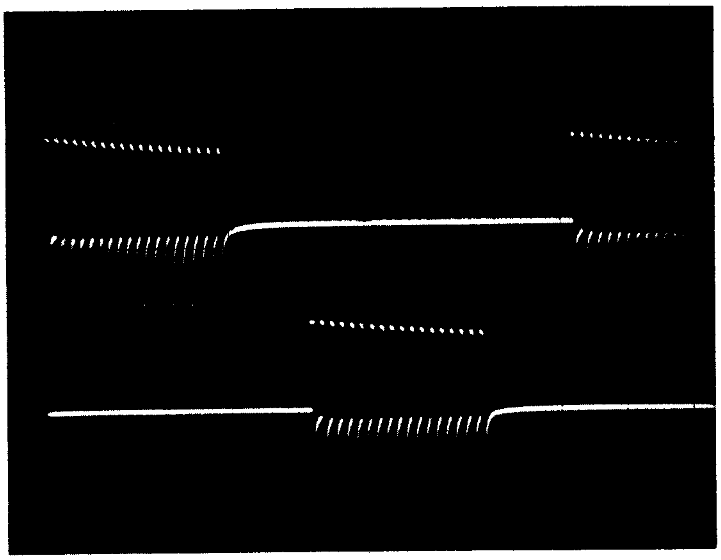


FIGURE 1. GATING OUTPUTS

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.

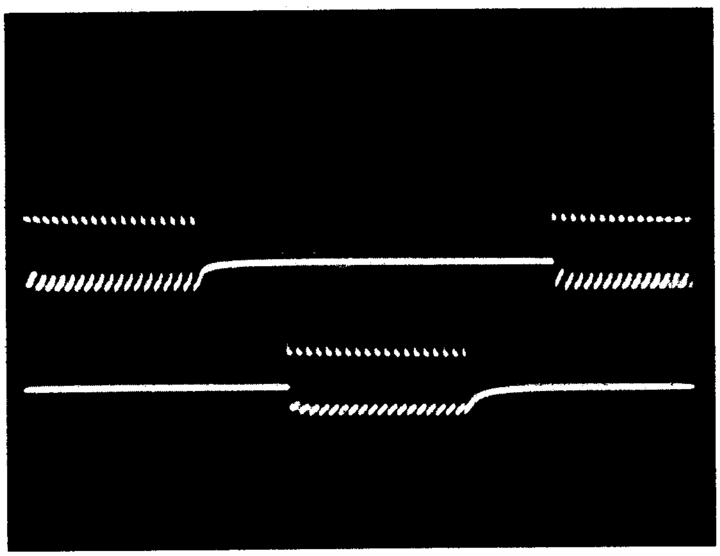


Figure 2. THYRISTOR GATE SIGNAL CHECK

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

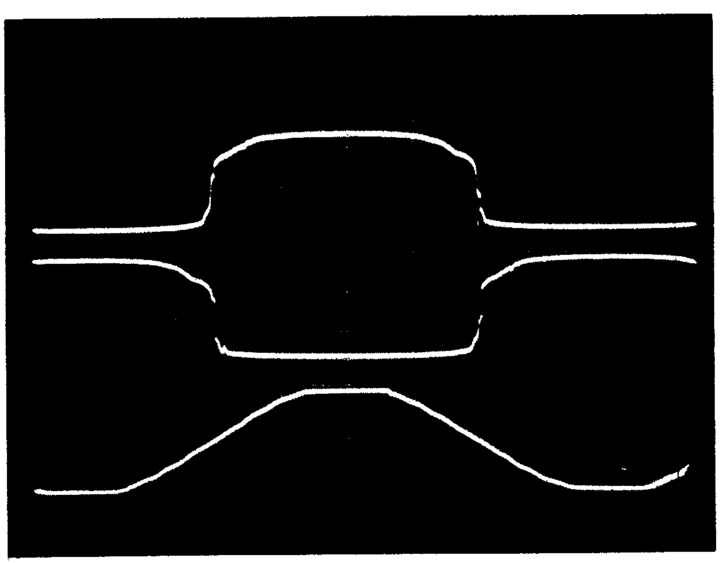
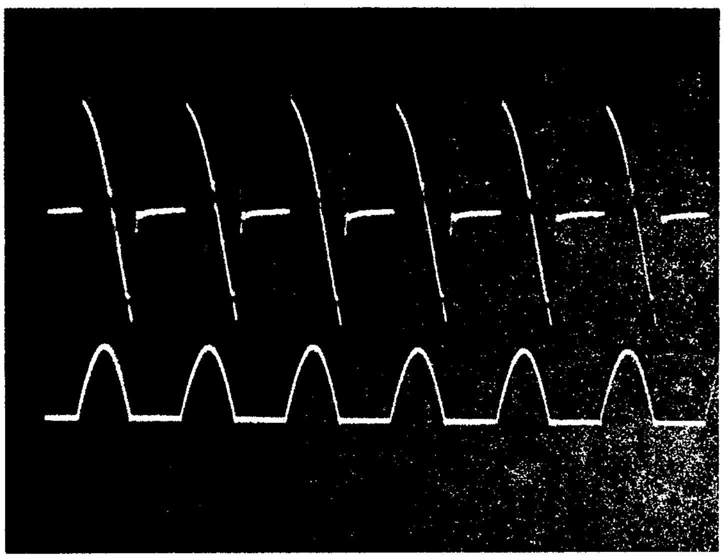


FIGURE 3. ZERO CURRENT DETECTION CHECK

6 Conn 3 (10V/cm)

6 Conn 4 (10V/cm)

16 Conn 3 (50V/cm)

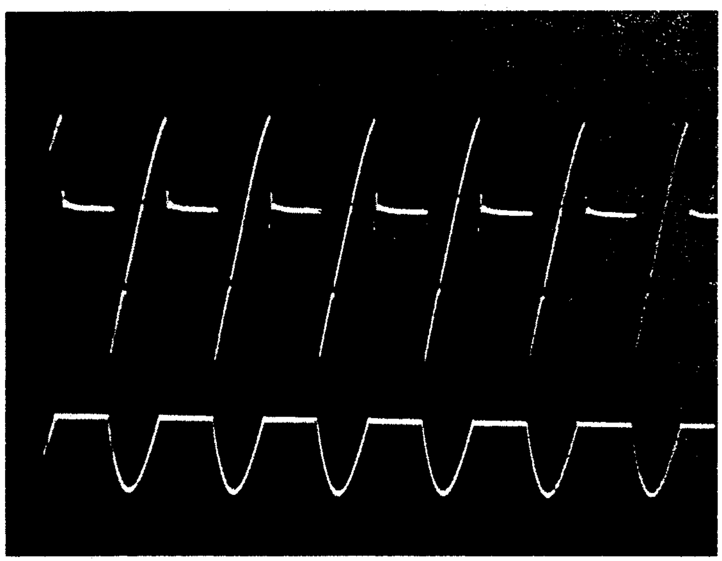


CALIB.

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

HORIZ: 5MS/DIV

A. MOTORING – 75% SPEED AND 75% TORQUE



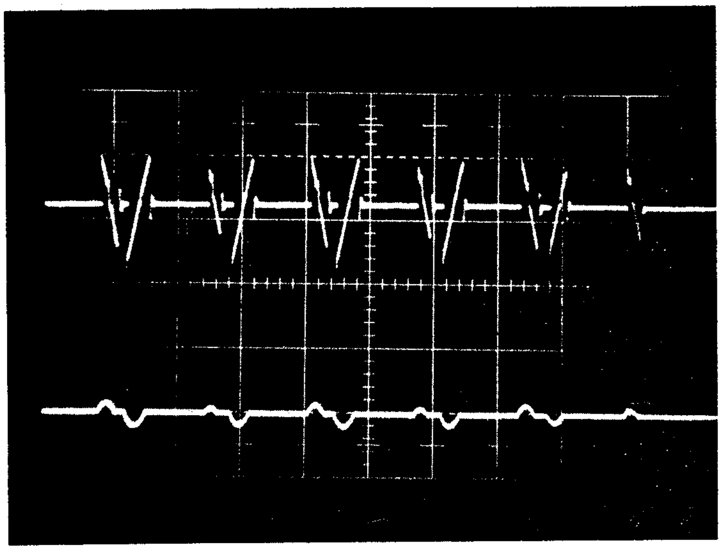
CALIB.

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

HORIZ: 5MS/DIV

B. REGENERATION – 75% SPEED AND 75% TORQUE

FIGURE 4. POWER UNIT OUTPUT WAVEFORMS

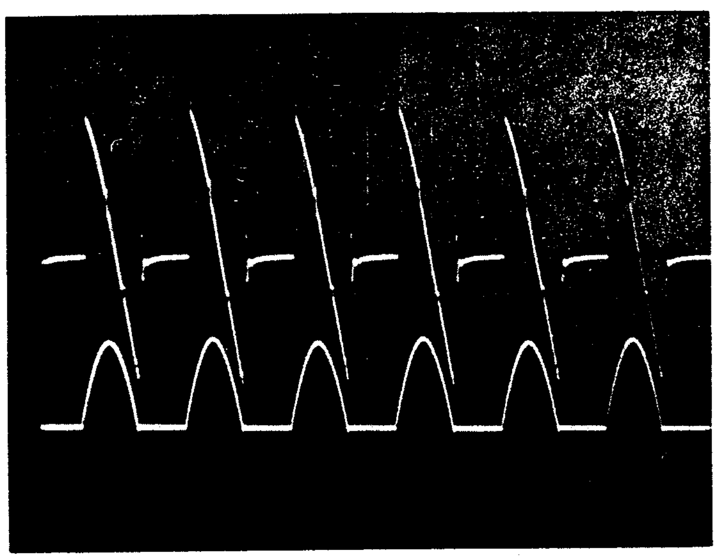


CALIB.

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

HORIZ: 5MS/DIV

C. NO LOAD @ 75% SPEED



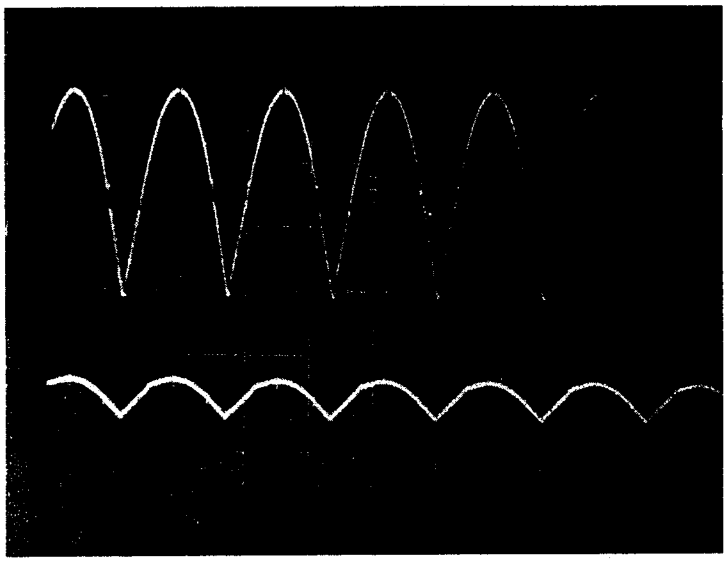
CALIB.

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

HORIZ: 5MS/DIV

D. CURRENT LIMIT ACCELERATION @ 30% SPEED

FIGURE 4. POWER UNIT OUTPUT WAVEFORMS (Continued)

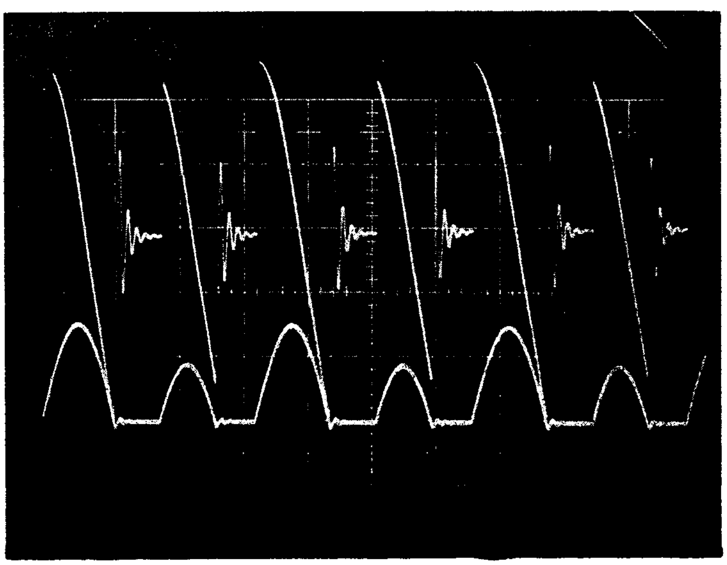


CALIB.

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

HORIZ: 5MS/DIV

E. FULL-ON CONDITION



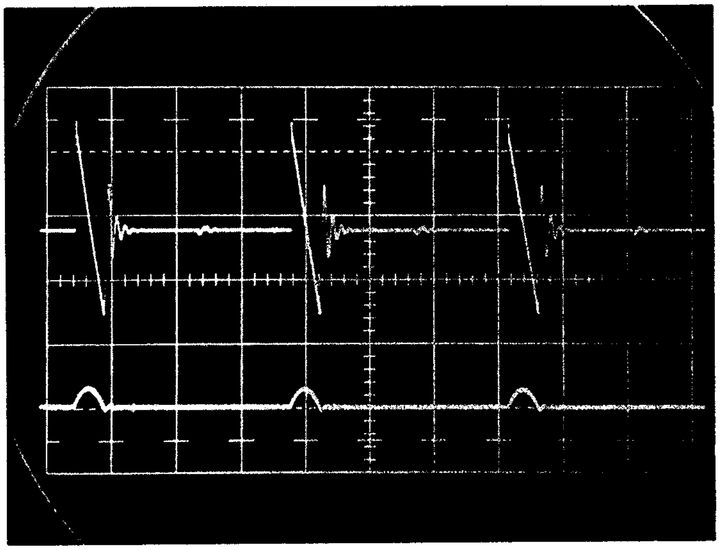
CALIB.

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

HORIZ: 5MS/DIV

F. UNBALANCED OUTPUT (WITH LOAD)

FIGURE 4. POWER UNIT OUTPUT WAVEFORMS (Continued)



CALIB.

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

HORIZ: 5MS/DIV

G. UNBALANCED OUTPUT (NO LOAD)

FIGURE 4. POWER UNIT OUTPUT WAVEFORMS (Continued)

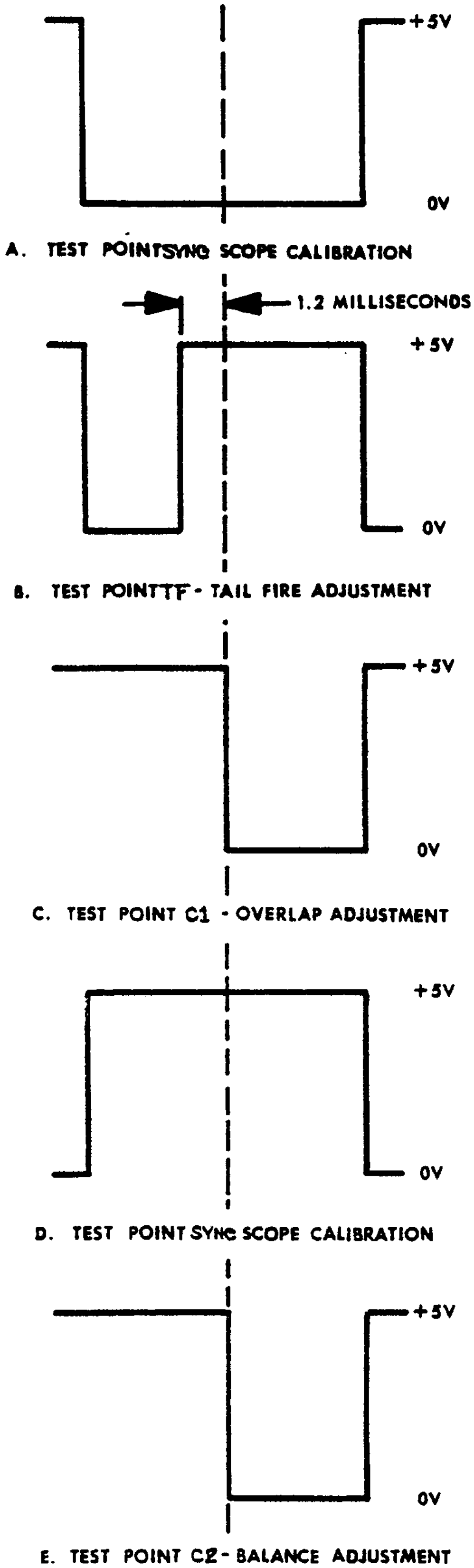


FIGURE 5. MAIN CONTROL PCB WAVEFORMS

FIGURE 6. ARMATURE VOLTAGE WAVEFORM

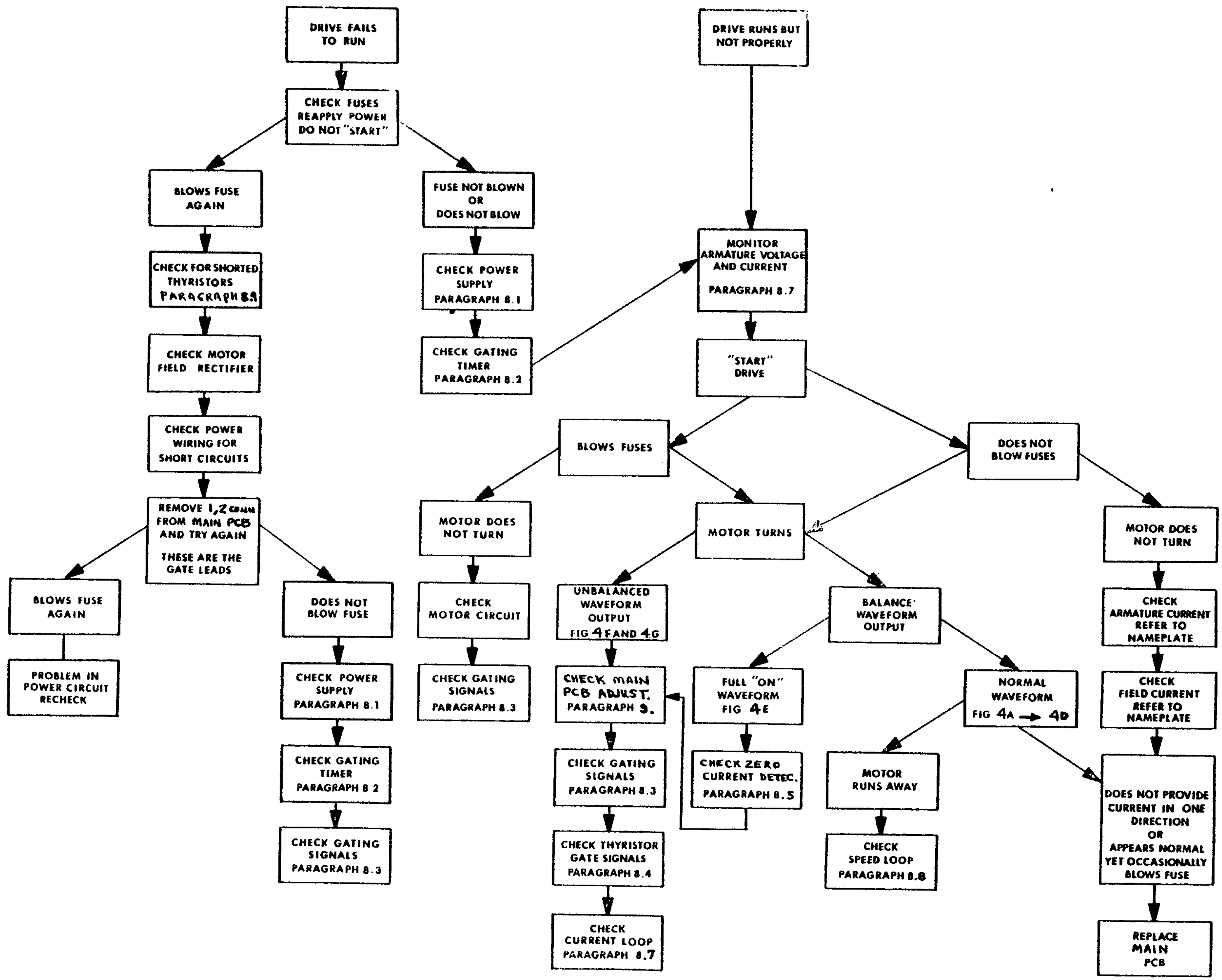


FIGURE 7. TROUBLESHOOTING CHART