POWER MODULE TYPE PS85

STYLE NO. 1757A99

I. INTRODUCTION

The PS85 power module is a power switch designed for application in Accurcon type inverters, both adjustable frequency and fixed frequency types. Each PS85 module consists of one inverter pole (equivalent to a single-pole double-throw switch). The module is housed in a slide out drawer (see Figure 1).

Two PS85 modules are connected together to make up a single phase bridge connection (stage) as described in I.L. 16-800-323 (Basic Theory and Principles for Adjustable Frequency Inverters). Up to four PS85 power modules along with stage transformers and auxilliaries are mounted in in PS85 power cabinet. A simplified schematic showing the interconnection in the power cabinet is shown in Figure 2. Connections to the PS85 power module are made through four bolted power connections and through two plug connectors. One plug connector is used for the gate control signals. The other plug is used to supply power (normally 23Ø Vac 1Ø) to the on-board heat sink fans.

The PS85 power circuit is an auto-commutated type, i.e., the firing of one thyristor acts to turn off the opposing one. This type of circuit requires fewer controlled devices and less sophistocated control circuitry than auxilliary commutated types of power circuits.

Protection for the PS85 power circuit is provided by fuses in each stage. Fuses 3Fu and 4Fu provide protection to the individual stages for shoot-thru faults through the main thyristors. The fusing configuration which is used causes the faulted stage to be isolated from the dc bus. This allows the inverter to continue operation in the event of a stage failure with a proportionate degradation in power output and waveform quality. Fuses 1Fu and 2Fu provide dc bus protection for faults not isolated by the stage fuses.

II. DESCRIPTION OF OPERATION

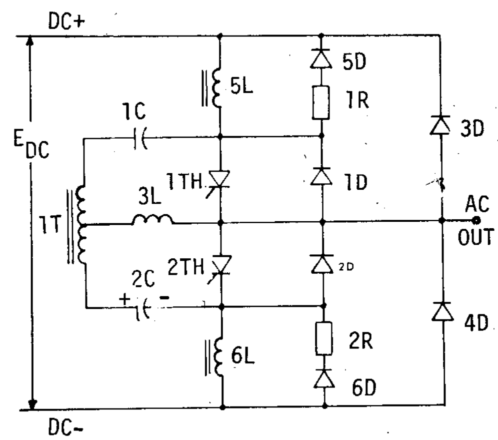
Power Circuit

Figure 3 is a simplified schematic showing the basic circuit elements.

Figure 4 is a complete power circuit schematic.

The circuit elements are listed below:

1TH, 2TH	Main Thyristor
1D, 2D	Commutating Diodes
3D, 4D	Free Wheel Diodes
5D, 6D	Damping Diodes
1R, 2R	Damping Resistors
5L, 6L	Buffer Reactors
3L	Commutating Reactor
1T	Commutating Transformer
1C, 2C	Commutating Capacitors



SIMPLIFIED POWER CIRCUIT SCHEMATIC

FIGURE 3

Elements 1TH, 2TH, 3D and 4D are the main load current carrying devices. Buffer reactors 5L and 6L are used to provide a high impedance across the dc source during the commutation interval. After the commutation interval these devices saturate causing only miminal impedance to the load. The combination of 5D, 1R and 6D, 2R provide a means for resetting the buffer reactors and for damping the stored energy in transformer 1T.

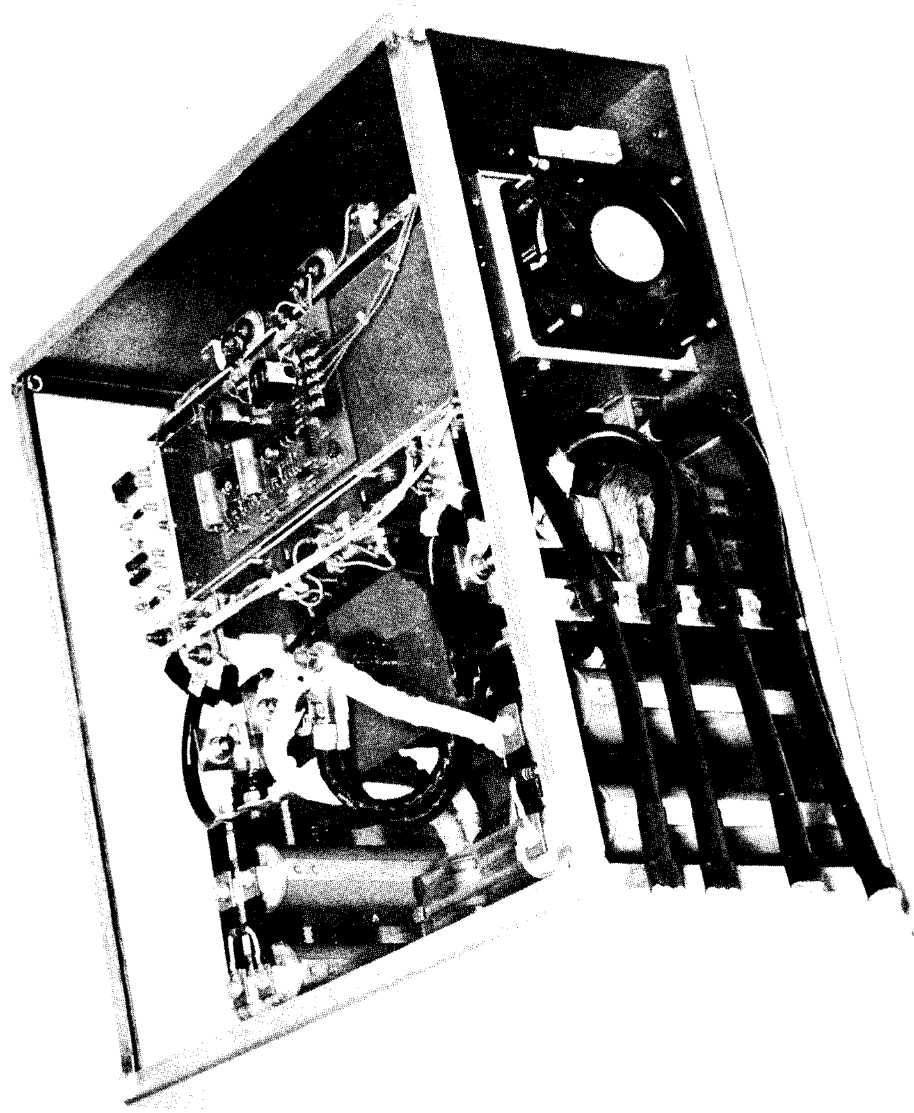
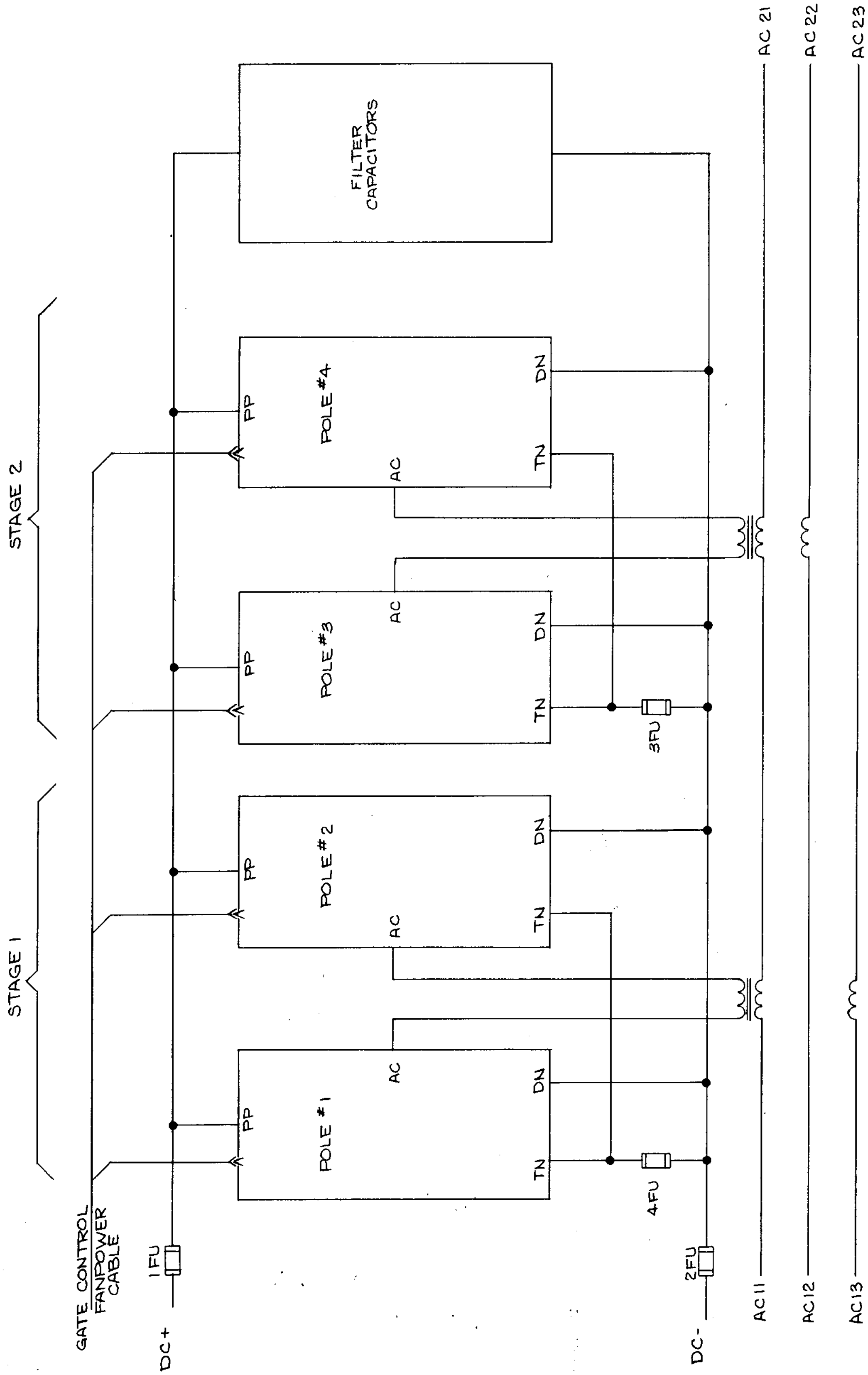
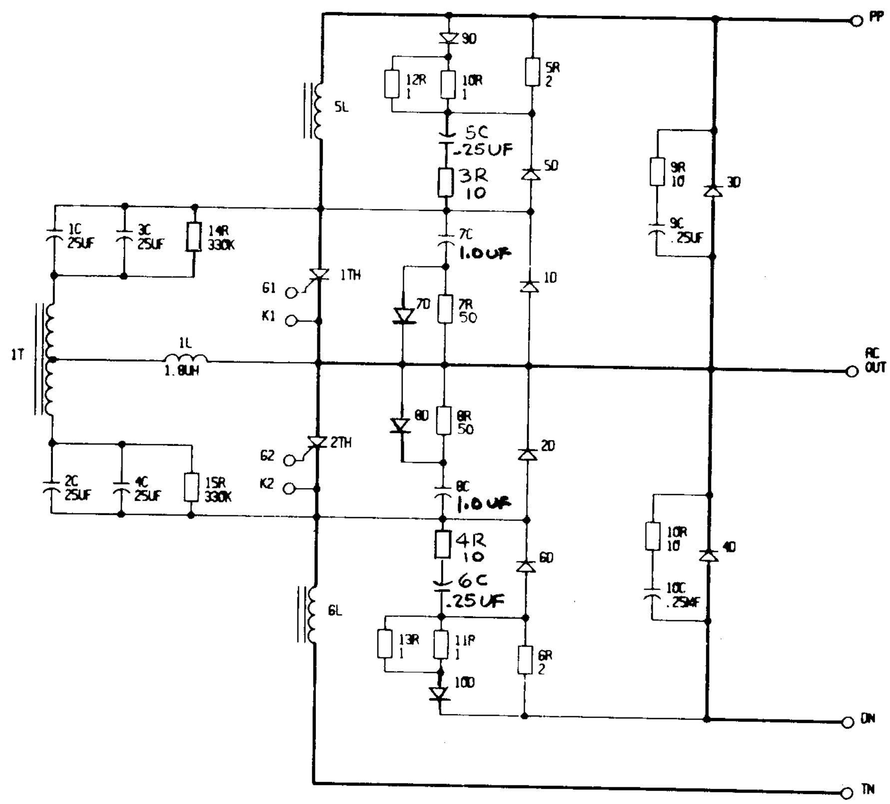


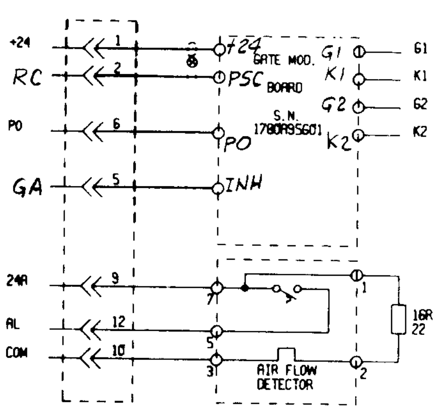
FIGURE 1

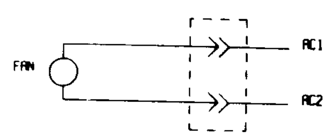


PS85 DRAWER CABINET INTERCONNECTION

FIGURE 2







PS85 SCHEMATIC

FIGURE 4

Circuit Operation

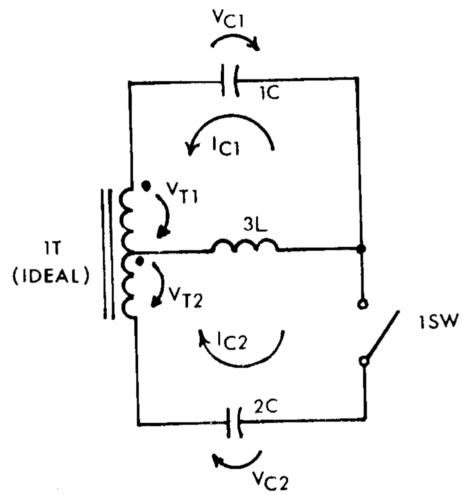
The operation of the circuit may be most easily understood by first examining the resonant discharge portion of the circuit. Figure 5 shows a representation of this portion when 1TH is being gated.

In Figure 5 capacitor 2C is charged to the dc bus potential in the direction shown. 1C is discharged. The commutation interval is begun by closing 1SW, i.e., gating 2TH. Circuit waveforms for this interval are shown in Figure 6.

When 1SW is closed, a resonant path is closed around the loop comprising 2C, 3L and the lower winding of 1T. A sinusoidal pulse of current builds up in this loop because of the LC arrangement and the initial charge on 2C. Because of transformer action, a nearly identical current builds up in the upper loop of 1C, 3L, and the upper winding of 1T. Note that the direction of this current is opposite to forward current in 1TH.

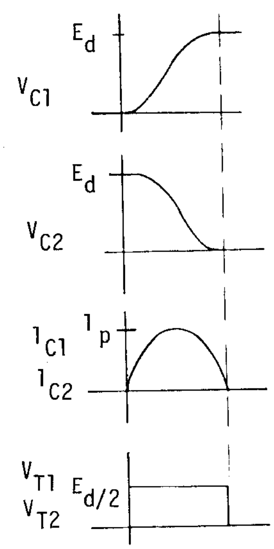
In the actual circuit when i_{C1} attempts to reverse direction, thyristor 1TH blocks. This ends the resonant discharge. At this time 1C has been charged to the dc bus voltage and 2C has been discharged. The circuit is therefore ready for the commutation of 2TH.

During the commutation interval a short circuit would occur across the dc bus because both thyristor-diode anti-parallel paths are conducting. A means must be provided for limiting the "short circuit" current during this interval. This is accomplished by means of the buffer reactors. During the commutation interval the buffer reactor which was not in the conducting leg must absorb the dc bus voltage. After the commutation interval the energy absorbed by the opposing buffer reactor and the energy absorbed by the commutating transformer is dissipated by the damping resistors.



RESONNANT CIRCUIT

FIGURE 5



RESONANT CIRCUIT WAVEFORMS

FIGURE 6

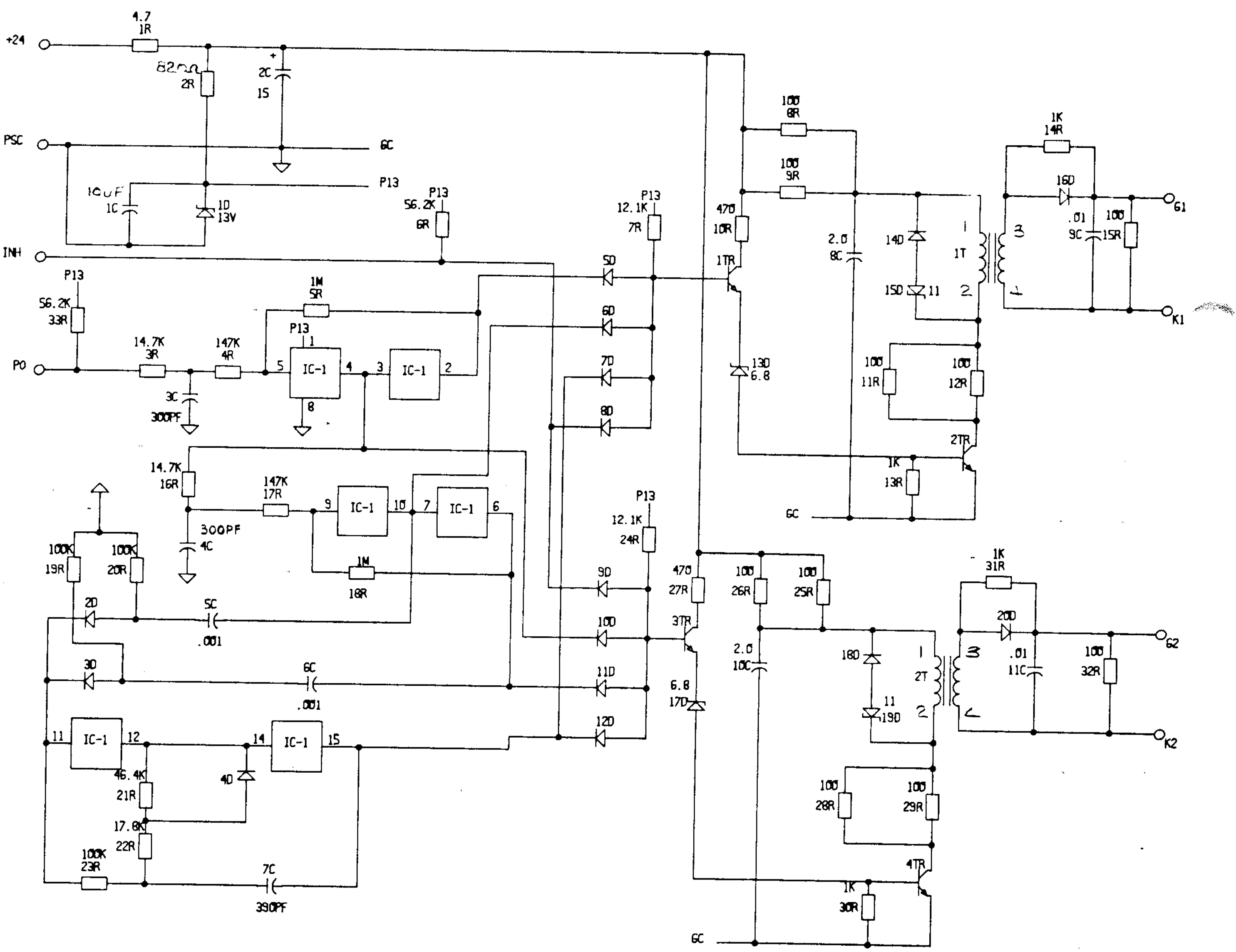
Gate Modulator Board

The PS85 Gate Modulator Board provides gate pulse distribution and amplification for the two thyristors in the PS85 inverter pole. A schematic of this board is shown on Figure 7. The board requires a 24V non-regulated supply (150mA max., 100mA typical). The +24V supply is regulated down to 13V through 1D for power to 1C1. 1C1 is a hex inverter CMOS chip. The gate control signal PO (for Pole Output) is a zero to +13V signal which comes from the inverter control logic. This signal is fed through a small filter network (3R, 4R, 3C) into 1C1. Resistor 5R provides some hysteresis for additional noise protection. Network 16R, 17R and 4C provides a short time delay (about 15 μsec) between the time that one gate pulse is terminated and the next one is fired. The main purpose of this time delay is to compensate for output transistor turn-off delays.

The other two gates on 1C1 are connected in an astable multivibrator configuration for generating a picket fence waveform for continuous pulsing at the output. To generate the initial "hard pulse" on each thyristor, signals are decoded through 5C and 6C and coupled into the picket fence generator.

The appropriate control signals are diode coupled and fed to the base 1TR and 3TR. These two transistors in turn drive output transistors 2TR and 4TR respectively. The R & C elements in the output driver circuits provide waveshaping and current limiting functions. The gate pulses are coupled through gate pulse transformers into a standard gate pulse secondary circuit.

The INH signal can be used to shut off all gating. As long as this signal is held to zero volts, even during power up or down conditions, no gate pulses will occur at the output.



GATE MODULATOR BOARD

FIGURE 7

III. TROUBLESHOOTING

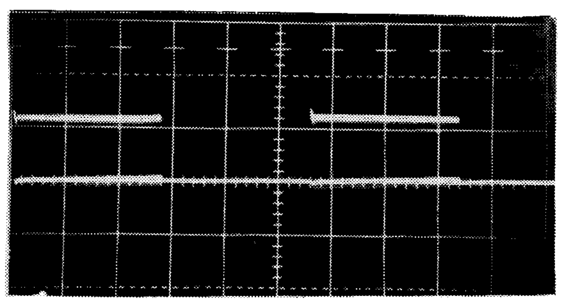
Normally a problem in a PS85 pole will show up as a blown stage fuse. When checking for the cause of a blown stage fuse it is necessary to check both PS85 power modules in the stage and the logic associated with that stage. A blown stage fuse can be caused by any of the following problems:

1. Defective Phase Shifter Board (1700A41) in the A1101 Logic drawer.
2. Defective Gate Modulator Board (1780A95) in a PS85 module.
3. Defective semiconductor device in a PS85 module.
4. Defective commutation component in a PS85 module.
5. Intermittent or loose connections in the PS85 modules or logic cables.

The best place to check for logic malfunctions is at the terminals for the gate leads in the PS85 module. The following procedure should be used to check these signals.

Gate Control Check

1. Remove all power from the inverter. Connect a scope to one set of gate leads in one of the PS85 poles. (Red gate lead to scope ground, white gate lead to scope probe).
2. Apply control power only to the inverter. Do not charge the dc link. Switch the test switch on the Voltage Regulator Board (1816A35) in the A1101 logic drawer to the "NORM" position.
3. Check that the gate waveforms are present per Figure 8. The gate pulses should be "ON" for 180° and "OFF" for 180°. The frequency of the pulsing envelope will be the same as the inverter frequency. The peak amplitude should be 2.5V ± 1.5V.
4. Check the three other gate waveforms in the PS85 modules associated with the faulty stage.
5. Switch the test switch on the Voltage Regulator Board back to the "OFF" position.



Vg @ 2V/div

t @ 1msec/div

(f 180 Hz)

TYPICAL GATE VOLTAGE

FIGURE 8

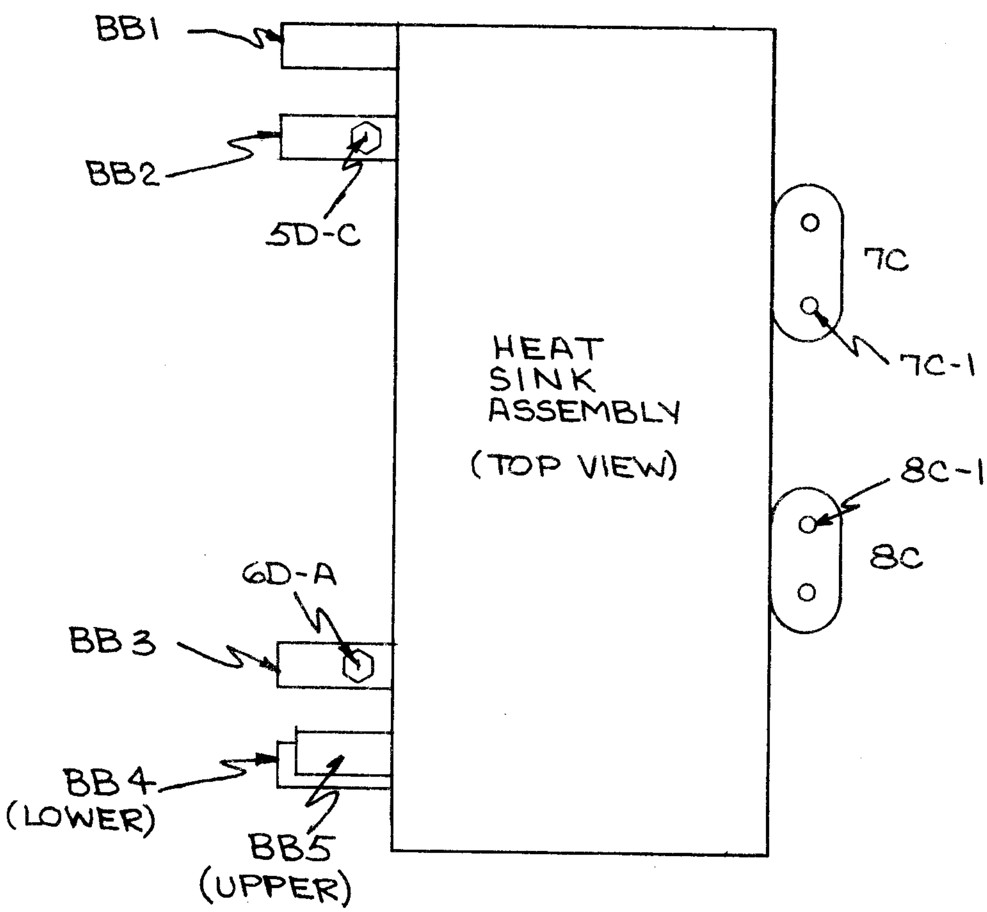
Semiconductor Device Check

1. Remove the PS85 module to be checked from the cabinet by disconnecting the power leads (4), the gate control plug, the fan plug and by removing the retainer bar.
2. Using a VOM on the 1 ohm scale check the semiconductor devices by using Table 1. Make sure none of the power cables are touching each other or the readings may be incorrect. The diagram of Figure 9 shows the location of the test points listed in Table 1.

TABLE 1

POSITIVE PROBE	NEGATIVE PROBE	READING *	DEVICE BEING CHECKED
BB1	BB4	> 100kΩ	3D
BB2	BB4	> 100kΩ	1TH, 1D
7C-1	BB4	Diode	7D
BB3	BB4	Diode	2TH, 2D
8C-1	BB4	50Ω	8D
BB5	BB4	Diode	4D
BB4	BB1	Diode	3D
BB4	BB2	Diode	1TH, 1D
BB4	7C-1	50Ω	7D
BB4	BB3	> 100kΩ	2TH, 2D
BB4	8C-1	Diode	8D
BB4	BB5	> 100kΩ	4D
BB2	5D-C	Diode	5D
5D-C	BB2	3Ω	5D
BB3	6D-A	> 100kΩ	6D
6D-A	BB3	Diode	6D

* A diode impedance will normally indicate between 5 and 50 ohms on the 1 ohm scale of a VOM.



TEST POINT DIAGRAM

FIGURE 9

Semiconductor Device Replacement

In the event that it becomes necessary to replace PS85 module semiconductor devices in the field, the following procedure should be used. In general it is best to return a faulty module to the factory so that repairs can be made and the module can be completely tested.

When replacing a device be sure to replace it with an exact replacement as listed in Table 2.

TABLE 2

SEMICONDUCTOR PART IDENTIFICATION

DEVICE	W STYLE NUMBER
1TH, 2TH	1757A79H01
1D	1538A79H60
2D	1538A79H10
3D	1538A85H60
4D	1538A85H10
5D	1538A84H60
6D	1538A84H10
7D	1538A82H10
8D	1538A82H60

In order to replace 1TH, 2TH, 1D, 2D, 3D, 4D, 7D or 8D it is necessary to remove the top baffle plate from the heat sink assembly. This is easily done by removing the six mounting screws and folding this plate over to the side. Any of the diodes can be replaced by simply disconnecting the "pigtail" lead and unscrewing the stud from the heat sink. Before replacing diodes recoat the heat sink mounting surface (not the stud hole) with heat transfer compound (ALCOA #2 or equivalent). Using a torque wrench seat the device to the torque listed in TABLE 3.

TABLE 3

DIODE MOUNTING TORQUE

DEVICE	MOUNTING TORQUE
7D, 8D	15 in-lbs
5D, 6D	25 in-lbs
1D, 2D, 3D, 4D	125 in-lbs

Reconnect the "pigtail" leads and replace the top baffle plate.

To replace a thyristor first disconnect the gate leads of the defective thyristor. Remove the top baffle plate from the heat sink assembly. Disconnect the power cables from the upper heat sink tab of the defective thyristor. Remove the two nuts on the heat sink clamp assembly. Remove the defective device from the clamp and snap the device out of the locator wafer. Snap the replacement device into the locator wafer and reinsert the device and locator over the clamp studs. Make sure the orientation of the device is the same as the one taken out i.e., 1TH should be mounted so that the flange with the red gate lead attached is nearest the bottom heat sink, 2TH should be mounted so that the flange with the red gate lead attached is nearest the top heat sink. Replace the top heat sink and clamp assembly. Tighten the two clamp nuts by hand until they are snug. Check that the upper heat sink is parallel to the lower one. Alternately tighten the nuts by 1/2 turn until the pressure indicator reads 400. Reconnect the power leads to the heat sink tab. Connect the gate leads back to the gate board. Replace the top baffle plate.

Fuse Replacement

In the event that a stage or dc link fuse needs replacement, it is important to replace the fuse with exactly the same type and rating per Table 4. These fuses are high speed current-limiting fuses which are selected to coordinate with each other and with the PS85 semiconductor devices. Failure to replace fuses with exact duplicates may result in damage to the equipment.

TABLE 4

FUSE PART IDENTIFICATION

FUSE	W STYLE NUMBER
1Fu, 2Fu	1816A26H02
3Fu, 4Fu	1816A26H01