VLA TECHNICAL REPORT 18

COMPRESSOR CONTROL UNIT

J. D. Liebenrood

September 1975

TABLE OF CONTENTS

1.0 RELATED DOCUMENTS

1.1 Drawings

Drawings	Number
Compressor Control Unit	C13130S1
Bill of Materials	A13130Z4

1.2 Manuals

Air Products and Chemicals Proposal for Helium Refrigeration Systems

Air Products and Chemicals wiring diagram 250129D

2.0 FUNCTION

The Air Products and Chemicals compressor package derives its controls for local and remote operation from the compressor control unit. In case of a fault, the compressor control unit provides both automatic shutdown and fault diagnosis. The control unit is mounted in a NEMA weatherproof box on the front panel of the compressor. Front panel instrumentation includes a red power pilot light, digital elapsed time indicator, and five fault indication LED's. A local start/stop switch is also mounted on the front panel, along with five fault check push button switches. The five push button switches are used to simulate a fault so that the fault control circuitry can be checked.

Any one of five faults will cause the compressor starter to open and shut down the compressor: high helium supply pressure, low helium return pressure, low oil differential pressure, first stage high discharge temperature, and second stage high discharge temperature. A fault will stop the compressor until the fault circuit is manually or remotely reset. The fault is "remembered" by a latching relay controling the LED fault display and compressor main power starter. If the fault corrects itself before the start/reset button is pushed, the compressor will not restart and the fault readout display will still indicate so that diagnosis of faults is still possible. In the event of a power failure the compressor will return to its previous state when the power is again supplied. When the start button is pushed, the fault circuit DC power will be delayed for ten seconds so that the low oil differential pressure during the initial startup can be ignored.

An analog voltage output is also provided from the fault circuitry for computer sensing of faults. This analog voltage is interfaced to the computer through an A/D convertor in the front end control module, F5. The following chart lists the resulting analog voltage versus faults.

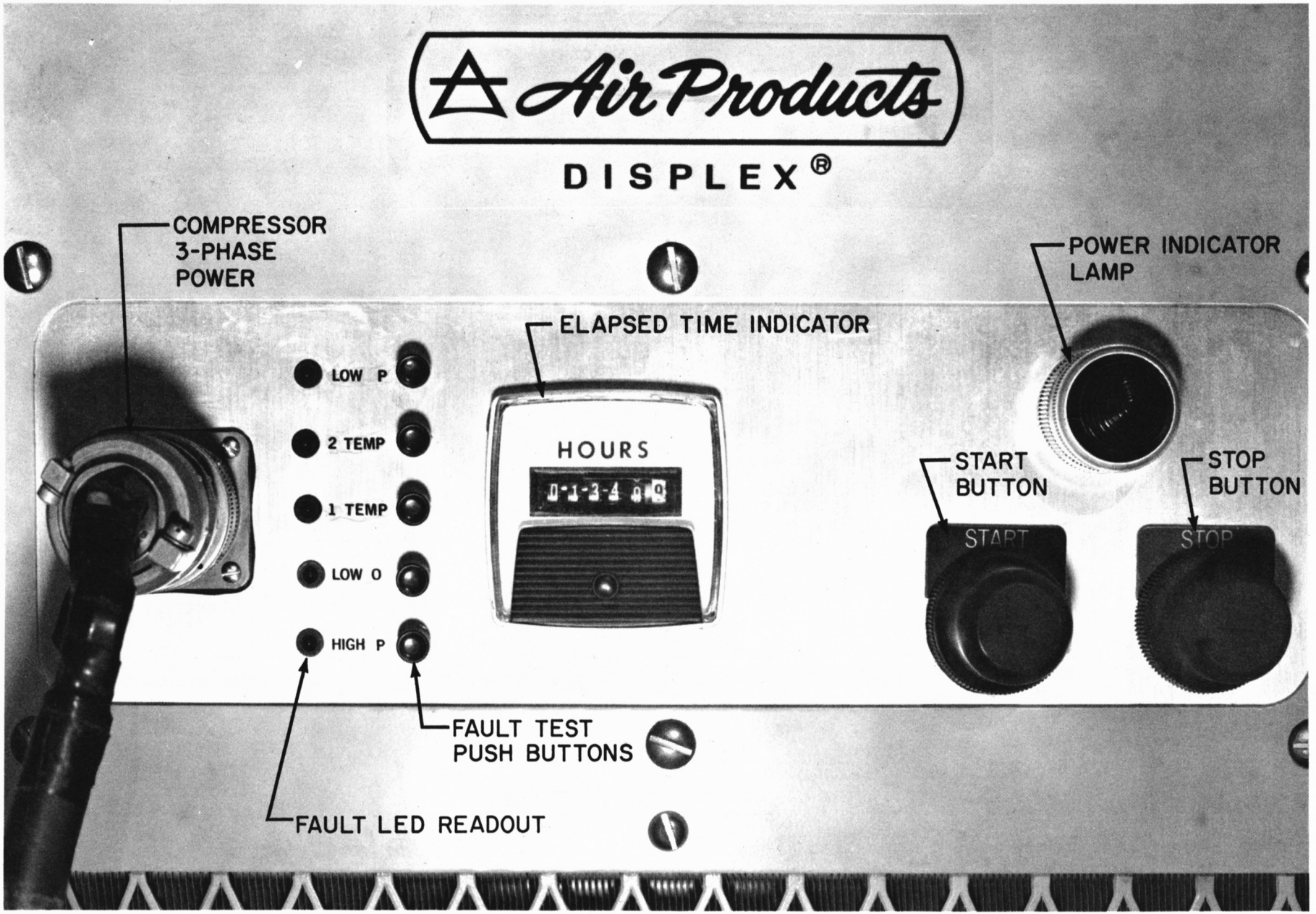


FIGURE 2.1 CONTROL UNIT (FRONT PANEL)

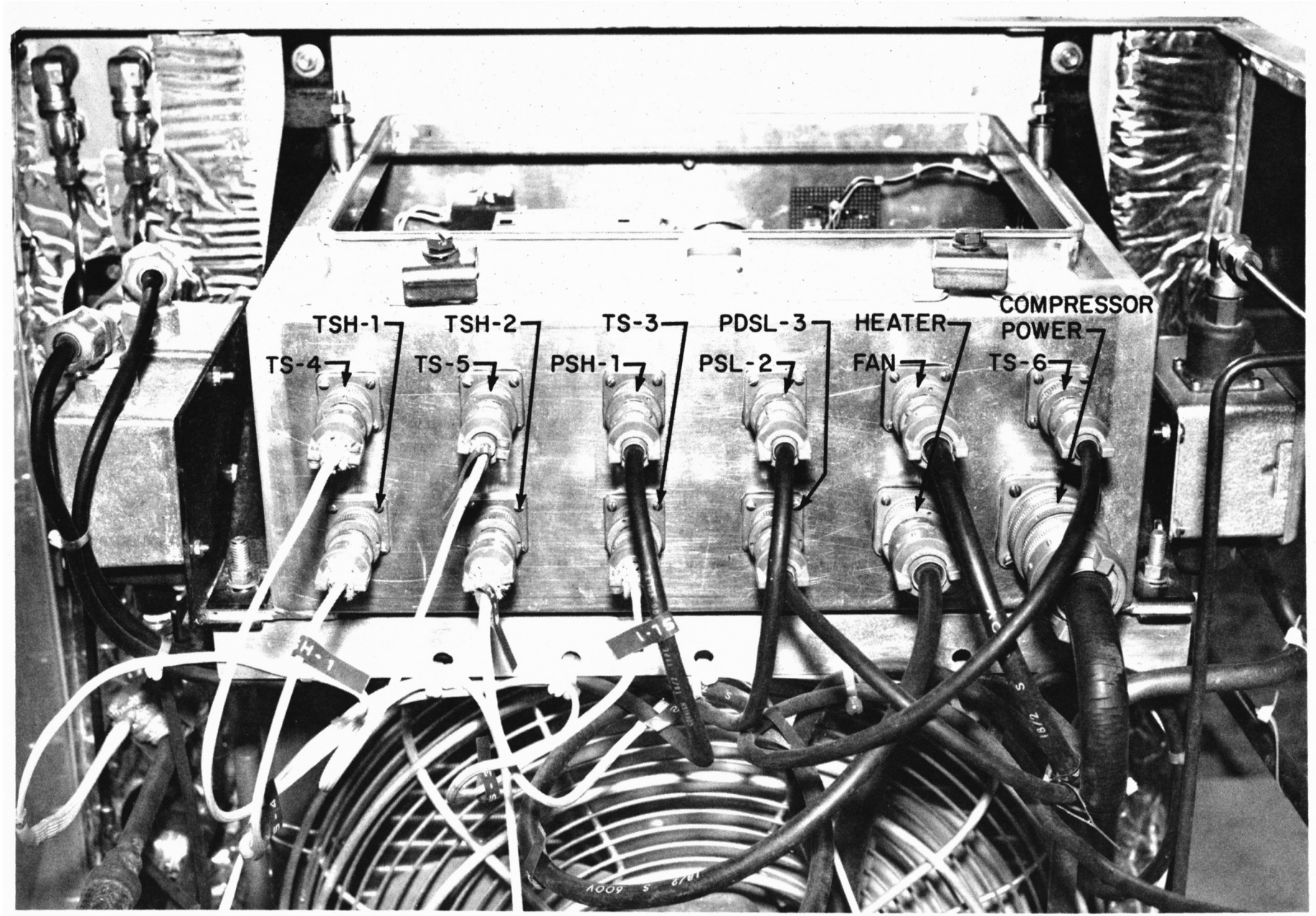


FIGURE 2.2 CONTROL UNIT (REAR PANEL)

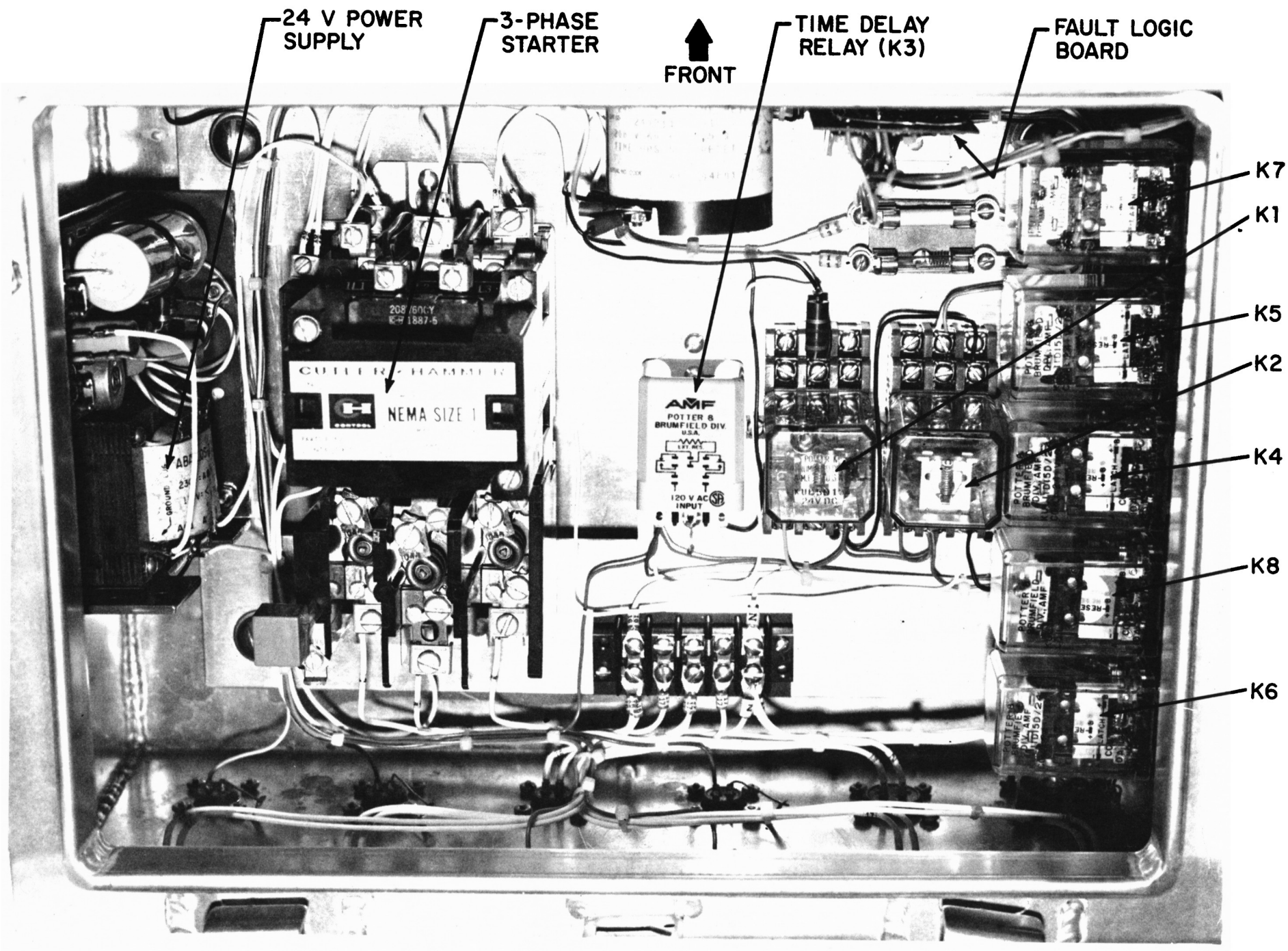


FIGURE 2.3 CONTROL UNIT (INTERIOR-TOP VIEW)

FAULT	ANALOG VOLTAGE ±5%
High Helium Supply Pressure	2.8
Low Helium Return Pressure	1.2
Low Oil Differential Temperature	0.59
First Stage High Discharge Temperature	7.0
Second Stage High Discharge Temperature	4.7

TABLE 2.1

Fault Monitor Voltages

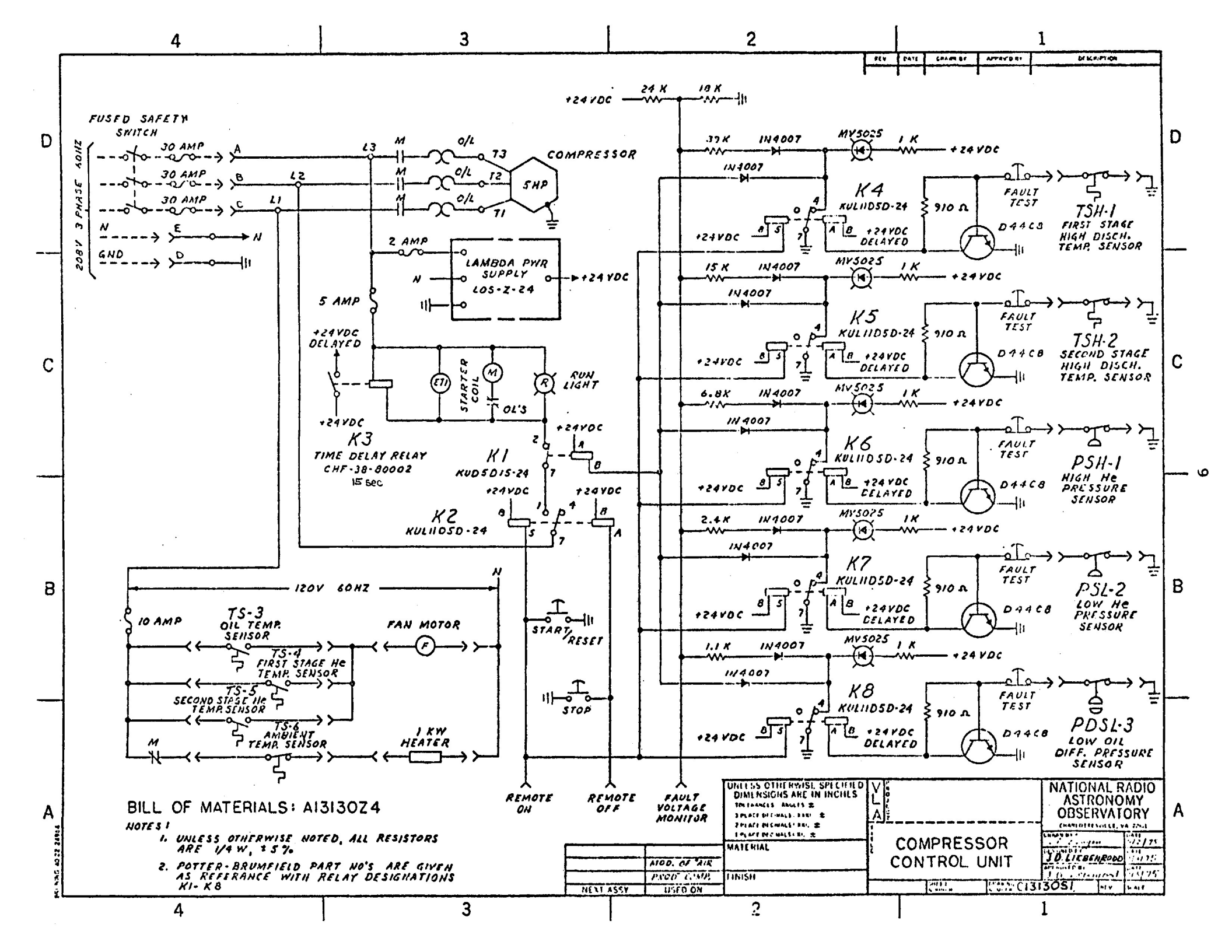
3.0 CIRCUIT DESCRIPTION

The compressor control unit controls the AC power to the compressor with a three-phase starter. (See Figure 3.1.) The 27-ampere three-phase magnetic starter is mounted in a NEMA weatherproof box and is driven by a 208V AC coil. The compressor starter coil is in series with two other relay contacts, K1 and K2. K1 is a set of normally closed contacts that open on any of five faults to interrupt the power to the starter coil. The second relay, K2, has SPST contacts that are part of a dual coil latching relay in the start/stop circuit. The latching relay, K2, allows a momentary push button to be used for starting the compressor and allows automatic startup in case of a power failure.

There are five fault sensors mounted in the compressor package. Each sensor is a normally closed switch that opens on a fault. Each sensor controls a separate double-coil latching relay. Any faulted or open circuited sensor will turn on its corresponding transistor and energize the latch coil of that fault relay. The relay will latch in a new position causing a fault LED to light and energize K1. Energizing K1 causes the starter to drop out and shut down the compressor. All five fault sensor circuits are identical in operation. The time delay relay, K3, delays the 24V fault circuitry power for ten seconds after startup so erroneous faults are ignored.

The analog fault indicating voltage that is sent to the computer is derived by switching different values of resistance into a voltage divider.

The compressor can be remotely started and stopped by momentarily grounding either the remote off or remote on terminals for more than 0.25 seconds. The remote switching circuitry should be capable of sinking 200 mA to ground.



BILL OF MATERIALS: A1313024

NOTES:

1. UNLESS OTHERWISE NOTED, ALL RESISTORS ARE 1/4 W, ±5%.
2. POTTER-BRUMFIELD PART NO'S ARE GIVEN AS REFERANCE WITH RELAY DESIGNATIONS K1- K8

REV	DATE	DRAWN BY	APPROVED BY	DESCRIPTION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMALS ±

MATERIAL
FINISH
NEXT ASSY | USED ON
MOD. OF AIR
PROD. CODE

VLA

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA 22901

DRAWN BY
CHECKED BY J.D. LIEBENBODO
APPROVED BY
DATE 7/1/75

COMPRESSOR CONTROL UNIT

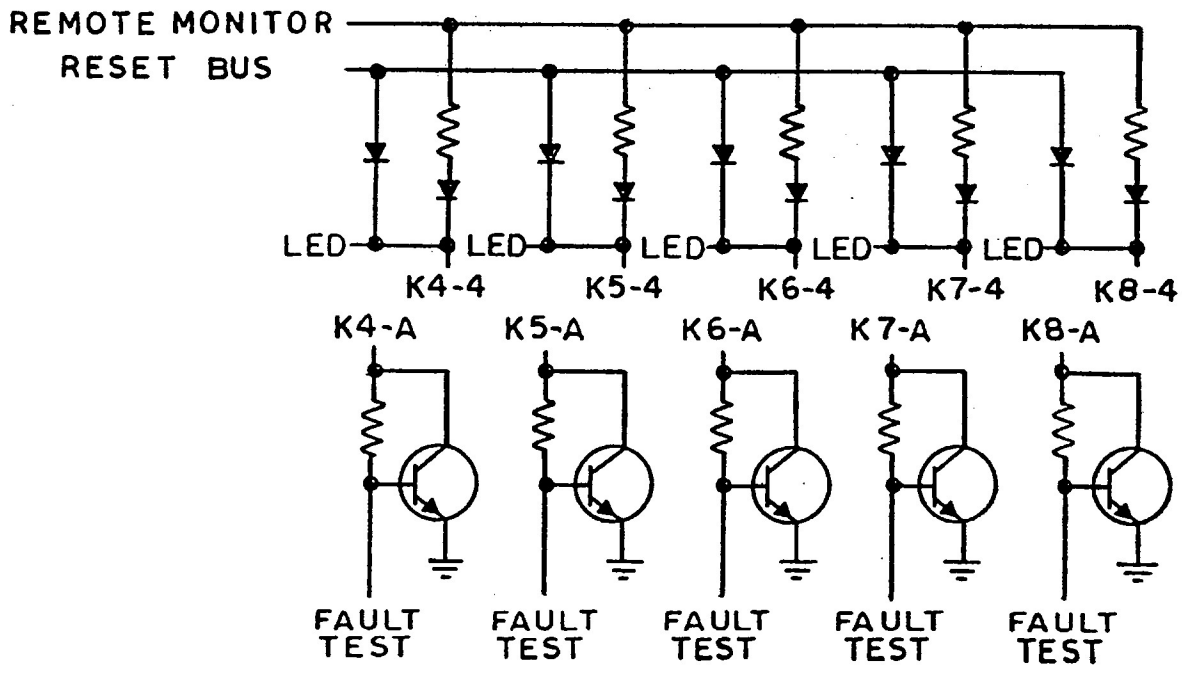
SIZE C | DRAWING NO. A1313051 | REV

SCALE

4.0 CONSTRUCTION

If the compressor control unit is built by modifying an existing Air Products control unit, a schematic of the existing control unit should be compared with the required modification schematic (Figure 3.1) so no necessary parts or wiring are removed. The three-phase starter wiring and temperature controlling circuitry involving the one kilowatt heater and fan will remain unchanged. Physical layout of the unit is not critical but proper wire size should be observed in high current sections. For ease of maintenance, plug-in relays with sockets should be used exclusively and spade lugs on wiring wherever possible. The fault relay drivers and analog fault indicator circuitry are both built on a single 2"x4" piece of vector board. The layout is shown below.

Figure 4.1 Fault Logic Layout



5.0 TEST AND ADJUSTMENT

Before any power is applied to the control unit, check all wiring. To test the control unit it should be mounted in the compressor package with all sensor and control cables connected. Disconnect the following three cables from the back of the control unit: compressor power, heater power, and fan motor power (Figure 2.2).

Apply three-phase power to the control unit. First check the 24-volt power supply output and adjust the voltage within 1 volt. Press the stop button to initialize the testing. To check that the time delay relay is operating properly, connect a DC voltmeter between the delayed 24V line and ground. Press the start/reset button. After ten seconds 24V should momentarily appear. Press the stop button. Press the start/reset button again and visually check that relay number K2 latches, the starter pulls in, and the red power lamp comes on. Press the stop button and confirm that the starter drops out and relay number K2 latches to a new position.

Since the compressor motor power is disconnected, a low oil pressure fault should occur. Press the start/reset button. After ten seconds the fault circuitry will be activated and a low oil pressure fault lamp should come on, and the starter should drop out to shut down the compressor. Press start and hold the remaining four fault test push buttons in until the starter again drops out. All five fault readout LED should be lit. As an added check, unplug each fault sensor individually and confirm that corresponding fault LED lights. This check should be repeated periodically to insure that the compressor will shut down on a fault.

The fan motor power cable and heater power cable should now be reconnected. Locate the ambient temperature switch by following the cable connected to the ambient temperature switch connector on the back of the control unit. The

ambient temperature switch will be mounted on a 10"x8"x6" box that houses a heater and fan. Cool the ambient temperature sensor with either freon freeze mist or ice water and confirm that the heater is operating by holding your hand under the heater and fan housing.

Before the power is applied to the compressor motor, check the phase voltages on the compressor power connector. If 208V AC is found between phases, push stop and connect the compressor power cable. Press start again and after ten seconds simulate a fault by pressing one of the fault test push buttons. The compressor should shut down. As a last test, confirm that the compressor will continue running after a simulated power failure. Periodic checks of the fault circuitry is highly recommended.

The analog voltage output should be checked against Chart No. 1 by simulating each fault individually. Under normal operation only the first occurring fault will be displayed, making multiple fault indications impossible.

As a final check, confirm that both remote start/reset and stop function properly.

6.0 CRYOGENIC SYSTEM STARTUP AND SHUTDOWN PROCEDURE

The following procedures may be implemented only if the system is in operable condition.

A. STARTUP

1. Make sure all aeroquip fittings are made up on both the compressor and the refrigerator.
2. The dewar vacuum should be less than twenty microns.
3. The valve and pump switches on the cryogenic control panel should be in Auto positions.
4. Turn on the refrigerator switch.
5. Go to the compressor and open the compressor bypass valve two turns.
6. With the power cord connected and the power on, push the compressor start button.
7. If no faults are indicated and the compressor stays running, close the bypass valve to complete the startup procedure. The following approximate pressures should be indicated on the compressor front panel.

   Supply 250-280 P.S.I. Intermediate 110-140 P.S.I.

   Return 30-60 P.S.I.
8. If a fault is indicated, contact the cryogenic lab and report the indicated fault.

B. SHUTDOWN

1. Push the compressor stop button and open the bypass valve two turns.

2. Go to the refrigerator and switch the refrigerator to Off position.
3. Switch the temperature monitor from 0-30 position to 0-300 position.
4. Leave the pump and valve switches on auto position unless there is an apparent leak in the dewar. If there is an apparent leak, place both switches in the Off position. This completes the shutdown procedure.

BILL OF MATERIAL

FOR MODIFICATION OF AIR PRODUCTS COMPRESSOR.

NATIONAL RADIO ASTRONOMY OBSERVATORY

[X] ELECTRICAL [ ] MECHANICAL BOM # _____ REV _____ DATE 9/2/75 PAGE 1 OF 2

NAME: Compressor Control SCHEMATIC DWG # C13130S1 LOCATION: Antenna QUA/SYSTEM: 1 PREPARED BY: JDL

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
1	K2-K8	Potter & Brumfield	KUL11D5D-24	Dual coil magnetic latching relay	6	
2	K1	Potter & Brumfield	KUD5D15-24	Single coil relay	1	
3	K3	Potter & Brumfield	CHF-38-80002	Time delay relay	1	
4		Potter & Brumfield	27E121 10A/300V	Screw terminal relay sockets	8	
5		Any	1N4007	Diode	10	
6		Monsanto	MV5025	LED	5	
7		General Electric	D44C8	High current transistor	5	
8		Grayhill	30-252	Sealed push button switches	5	
9		Lambda	LOS-Z-24	24V/0.9A power supply	1	
10		Any		5A fuse	1	
11		Any		2A fuse	1	
12		A-B	CB	910Ω, 1/4W, 5%	5	
13		A-B	CB	1KΩ, 1/4W, 5%	5	
14		A-B	CB	1.1KΩ, 1/4W, 5%	1	
15		A-B	CB	2.4KΩ, 1/4W, 5%	1	
16		A-B	CB	6.8K, 1/4W, 5%	1	
17		A-B	CB	15K, 1/4W, 5%	1	

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

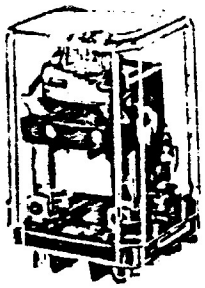
[X] ELECTRICAL [ ] MECHANICAL BOM # _____ REV _____ DATE 9/2/75 PAGE 2 OF 2

COMPRESSOR CONTROL

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
18		A-B	CB	39K, 1/4W, 5%	1	
19		A-B	CB	18K, 1/4W, 5%	1	
20		A-B	CB	24K, 1/4W, 5%	1	

POTTER & BRUMFIELD'S RELAY SERIES

KUL



KUL

SCALE: ONE INCH

magnetic latching relay single or dual coils

U/L File E22575
CSA File LR-15734

ENGINEERING DATA

The KUL is a small, commercial, magnetic latching relay that occupies approximately half the space of mechanically interlocking latching relays. The use of a permanent magnet in parallel with the normal magnetic circuit yields superior results compared with other latching techniques. KUL latching relays are recognized under the Component Program of Underwriters' Laboratories, Inc. and Canadian Standards Association.

Relays are available with single or dual-wound DC coils or a single-wound AC coil. Contact arrangements are available up to 3 Form C rated 5 or 10 amperes at 120 volts AC.

Reset is accomplished by reversing the voltage polarity in a single coil relay or by energizing the reset winding in a dual-wound coil relay. If overvoltage should occur during reset, the magnetic circuit is designed to prevent false operation of the contacts.

The KUL has good memory stability because it will maintain a permanent latch condition during loss of power. Continuous duty operation is practical because of the low power requirements of this relay. This feature provides for the coil to remain energized in the latch position without damage to the relay.

A variety of nylon sockets is available that includes a choice of solder, printed circuit, quick-connect, or screw terminals. All sockets are rated 10 amperes.

The various features designed into the KUL Series make it ideal for applications as diverse as alarm systems and machine tools, battery chargers and protective devices, process controls and business machines.

CONTACTS:

Arrangements:
DC single coil: 1 Form C, 2 Form C and 3 Form C.
DC dual coil: 1 Form C and 2 Form C.
AC single coil: 1 Form C, 2 Form C and 3 Form C.**

Material: Gold-flashed fine silver and silver-cadmium-oxide.

U/L Rating: 5 amps @ 120 V AC.
10 amps @ 120 V AC.

COILS:

Voltage: To 110 volts DC; 120 volts AC.

Resistance: Please see Coil Data chart.

Duty: Intermittent

COIL DATA FOR KUL SERIES

DC Single Coil		DC Dual Coil*			AC 50/60 Hz AC coil with diodes**		
Nominal Voltage	Coil Resistance ±10% @ 25°C	Nominal Voltage	Coil Resistance ±10% @ 25°C Latch	Reset	Nominal Voltage	DC coil resistance ±10% @ 25°C	Series Resistor
6	32.1	6	22	22	6	10.5	47Ω
12	120	12	90	90	12	37	150Ω
24	472	24	350	350	24	176	680Ω
48	1,800	48	1400	1400	48	585	2,200Ω
110	10,000				120	3700	15,000Ω

*Dual coil available only with 1 or 2 Form C contacts. On standard dual coil relays, the latch and unlatch voltage must be the same. For unlike voltages, please consult factory.

**Diodes and resistors included inside relay with 1 and 2 Form C contacts. For 3 Form C relays, the customer must furnish and wire diodes and resistors externally.

GENERAL:

Description: Small, commercial magnetic latching relay.

Insulating Material: Molded phenolic.

Initial Insulation Resistance: 100 megohms minimum.

Expected Life: Mechanical: 10 million operations.
Electrical: 100,000 operations minimum @ rated load.

Initial Breakdown Voltage:
1500 volts rms 60 Hz between all elements.
500 volts rms 60 Hz between open contacts.

Temperature Range: AC and DC: −45°C to +70°C.

Time Values:
Operate: 25 ms max. @ nominal voltage @ 25°C.
Reset: 10 ms max. @ nominal voltage @ 25°C.

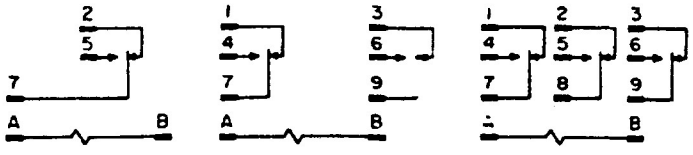
Weight: 3.4 ozs. approximately.

Operate: AC: 85% of nominal voltage @ 25°C.
DC: 75% of nominal voltage @ 25°C.

Enclosures: Clear plastic polycarbonate heat and shock resistant case.

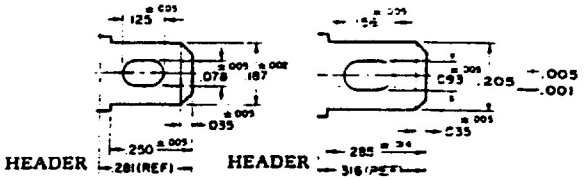
Terminals: .187" quick-connect standard for sockets, or .205" Q/C. Both punched for soldering. Printed circuit terminals available.

KU/KUP CIRCUIT DIAGRAMS



TERMINAL DIMENSIONS

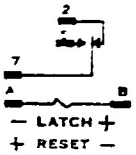
.187" STANDARD .205" QUICK CONNECT



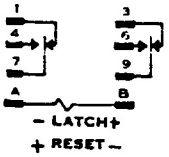
Thickness: .020 Thickness: .032

KUL CIRCUIT DIAGRAMS

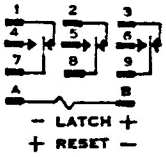
DC SINGLE COIL 1 FORM C



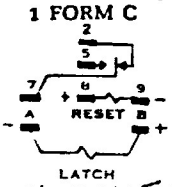
2 FORM C



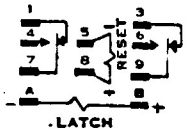
3 FORM C



DC DUAL COIL 1 FORM C



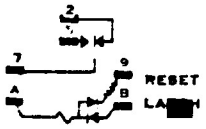
2 FORM C



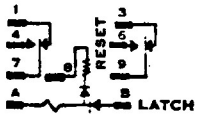
AC 3 FORM C ONLY

*Resistor and diodes connected by customer. See Coil Data Chart for resistor value. Recommend using diode similar to Edal B5E5 or SenTech SEC-4.

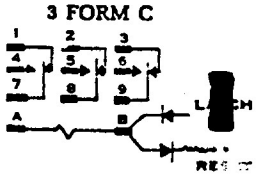
AC COIL 1 FORM C



2 FORM C



3 FORM C



ORDERING INFORMATION AND OPTIONAL FEATURES OF KU/KUP/KUB/KUL

① Type	② Contact Arrang.	③ Coil Power	④ Mountings (Drawings on pages 7 and 8)	⑤ Terminals & Contact Material	Example
KU Basic Open Relay	Please see Table on Page 4	A = AC D = DC	1 = # 6-32 stud, .218 locating tab. 2 = 2-hole bracket, # 6-32 tapped. 3 = # 6-32 tapped core, .125 locating tab. 4 = # 6-32 tapped core, .218 locating tab. 5 = # 6-32 tapped core, no locating tab.	1 = .187 quick-connect/solder, silver, 5 amps. 2 = .205 quick-connect/solder, silver, 5 amps. 3 = Printed circuit terminal/ solder, silver, 5 amps. 5 = .187 quick-connect/solder, silver-cad-oxide, 10 amps. 6 = .205 quick-connect/solder, silver-cad-oxide, 10 amps. 7 = Printed circuit terminal/ solder, silver-cad-oxide, 10 amps.	①②③④⑤ KU14D15 = Open relay, 3PDT, DC, = # 6-32 stud, .218 locating tab, .187 quick-connect/solder, silver-cad-oxide, 10 amps.
KUP Basic Enclosed Relay			1 = Plain case: 2 = with test button. 3 = with neon light. 4 = with test button & neon light. 5 = Bracket-mount case: 6 = with test button. 7 = with neon light. 8 = with test button & neon light. 9 = Stud on end of case A = Plain case # 6-32 stud: B = with test button. C = with neon light. D = with test button & neon light. E = Plain case tappped core: F = with test button. G = with neon light. H = with test button & neon light.		KUP11A21 = Enclosed relay, DPDT, AC, plain case with test button, .187 quick-connect/solder terminals and silver contacts, 5 amps. KUP11AA1 = 24V — Enclosed relay, DPDT, AC, plain case and # 6-32 stud mounting, .187 quick-connect/solder terminals and silver contacts, 5 amps.
KUB Basic Latching Relay			1 = Standard Mounting Plate 3.22 long, 1.812 wide with two sets of two .156 dia. holes on 1.375 centers.	1, 2, 5 and 6 only (see above)	KUB17A12 = Latching relay, 4PDT, AC, Stand. mtg. .205 quick-connect/solder, silver, 5 amps.
KUL Basic Enclosed Magnetic Latching Relay			1 = Plain case:	1, 3, 5 and 7 only (see above)	KUL11D11D6 = Enclosed magnetic latching relay, DPDT, DC, plain case, .187 quick-connect/solder, silver, 5 amps; with dual coils for 6 volts.

XXX XX X X X

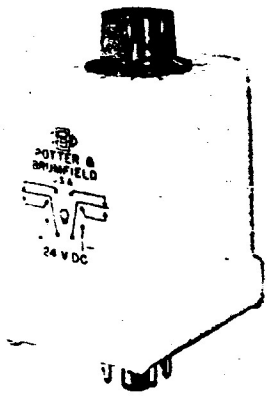
(Add XX Coil Voltage)
(For KUL add: S — Single coil D — Dual coil XX — Coil voltage.)

16

POTTER & BRUMFIELD SOLID STATE

CH series

TIME DELAY RELAYS



- KNOB-ADJUSTABLE
- PLUG-IN MOUNTING
- INTERVAL ON
- DELAY ON OPERATE OR RELEASE
- POLARITY REVERSAL PROTECTION
- COMPACT ASSEMBLY

CH Series time delay relays are engineered for a wide range of industrial applications where "timing cycle interrupt transfer" is acceptable.
They include an internally mounted P&B DPDT relay, forming a convenient and compact assembly. Enclosed in a molded white nylon dust cover, CH relays are available in fixed, resistor-adjustable and knob-adjustable styles. They are equipped with plug-in octal-type terminals and are available for AC or DC operation. The CH Series is designed for either delay on "operate" or on "release" as well as " adjustable interval." For CH time delays having special characteristics, please consult the factory.

engineering data

SPECIFICATIONS:

Tolerance:
Knob Adj.: −0 +20% of maximum specified @ high end.
Minimum specified, or less, @ low end.
Others: ±5%.
(For AC units add ±½ cycle 60 Hz.)

Delta Time: ±10%. (For AC units add ±1 cycle 60 Hz.)

Repeatability: ±2%. (For AC units add ±1 cycle 60 Hz.)

Temperature Range: Operating: −10°C to +55°C.
Storage: −55°C to +85°C.

Contact Rating: DPDT 10 amps @ 120V AC 60 Hz resistive.

Dial Scale: Reference only.

Release Time: 125 milliseconds typical: 200 milliseconds maximum.

Recycle Time: 125 milliseconds typical: 200 milliseconds maximum.

Transient Protection: 1000V, all 120V AC units.

Polarity Protection: Yes.

Timing Cycle Interrupt Transfer: Contacts may transfer momentarily if timing interval is interrupted.

INPUT VOLTAGES AND LIMITS

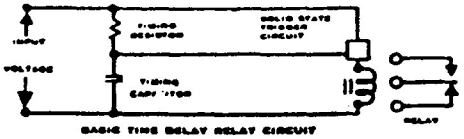
Nominal	Minimum	Maximum	Approximate Steady State Current Operate*	Release
24 VAC	20 VAC	28 VAC	20 mA	100 mA
120 VAC †	105 VAC	130 VAC	35 mA	55 mA
240 VAC	220 VAC	260 VAC	12 mA	—
24 VDC	20 VDC	32 VDC	20 mA	75 mA
48 VDC	41 VDC	55 VDC	20 mA	50 mA

***Same value before and after timing.**

†In 120V AC applications, where it is known that continuous operation exists (especially involving maximum temperature and voltage), it is recommended that CD or CK Series units be employed to minimize self-heating and assure maximum reliability.

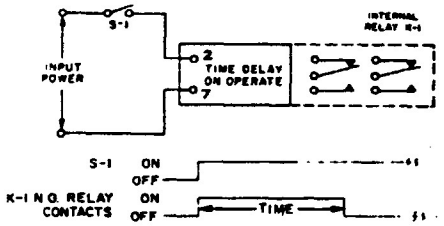
TIME DELAY ON OPERATE

When input voltage is applied to the basic timing circuit (consisting of a resistor in series with a capacitor), the voltage across the capacitor increases. A solid state trigger circuit is used to sense the capacitor voltage and acts to energize the coil of the switching relay. If the timing interval is interrupted, the switching contact may momentarily transfer (pick up and drop out). Release is accomplished by removal of the input voltage.

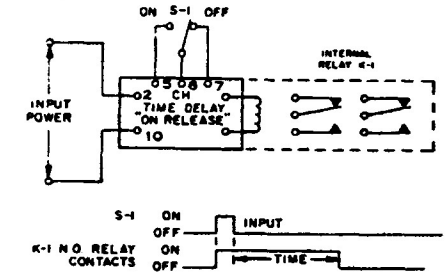


INTERVAL ON

The relay will operate immediately when the input voltage is applied. At the end of an adjustable interval the relay will release and remain in this state until re-application of the input voltage.

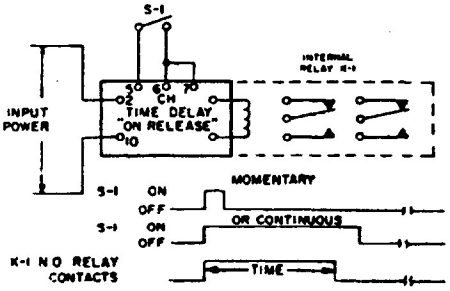


STANDARD CH DELAY "ON RELEASE"



An external switch or relay is required for time delay on release operation. The internal contacts will operate immediately when the external SPDT contacts are operated to the on position. When these contacts are returned to the off position the delay period is initiated and the relay contacts will not release until the end of the delay period.

CH DELAY ON RELEASE USED FOR "INTERVAL ON"



A jumper connects pins 6 and 7. Switch S-1, a SPST switch connects to pins 5 and 6. When switch S-1 is closed, either momentarily or for a period longer than the timing period, the time delay relay will be energized only for the time delay period.

CH RELAY SELECTION TABLE

KNOB-ADJUSTABLE TIME DELAY

In (Seconds)	Input Voltage	Delay on Operate	Delay on Release	Interval on
		Fig. 1	Fig. 3	Fig. 1
1.0 to 10	24 VAC	● CHB-38-30001	● CHB-38-30011	CHB-38-30021
1.0 to 60	24 VAC	CHB-38-30002	CHB-38-30012	CHB-38-30022
1.0 to 180	24 VAC	● CHB-38-30003	CHB-38-30013	CHB-38-30023
1.0 to 10	120 VAC	● CHB-38-70001	● CHB-38-70011	● CHB-38-70021
1.0 to 60	120 VAC	● CHB-38-70002	● CHB-38-70012	● CHB-38-70022
1.0 to 180	120 VAC	● CHB-38-70003	● CHB-38-70013	● CHB-38-70023
		Fig. 2	Fig. 4	Fig. 2
1.0 to 10	24 VDC	● CHD-38-30001	● CHD-38-30011	● CHD-38-30021
1.0 to 60	24 VDC	CHD-38-30002	CHD-38-30012	CHD-38-30022
1.0 to 180	24 VDC	● CHD-38-30003	● CHD-38-30013	CHD-38-30023
1.0 to 10	48 VDC	CHD-38-40001	CHD-38-40011	CHD-38-40021
1.0 to 60	48 VDC	CHD-38-40002	CHD-38-40012	CHD-38-40022
1.0 to 180	48 VDC	CHD-38-40003	CHD-38-40013	CHD-38-40023
		Fig. 1		
1.0 to 10	240 VAC	● CHB-38-80001		
1.0 to 60	240 VAC	CHB-38-80002		
1.0 to 180	240 VAC	CHB-38-80003		

FIXED TIME DELAY

In (Seconds)	Input Voltage	Delay on Operate	Delay on Release
		Fig. 1	Fig. 3
10	24 VAC	CHA-38-30001	CHA-38-30011
60	24 VAC	CHA-38-30002	CHA-38-30012
180	24 VAC	CHA-38-30003	CHA-38-30013
10	120 VAC	● CHA-38-70001	CHA-38-70011
60	120 VAC	CHA-38-70002	CHA-38-70012
180	120 VAC	CHA-38-70003	CHA-38-70013
10	240 VAC	CHA-38-80001	
60	240 VAC	CHA-38-80002	
180	240 VAC	CHA-38-80003	
		Fig. 2	Fig. 4
10	24 VDC	CHC-38-30001	CHC-38-30011
60	24 VDC	CHC-38-30002	CHC-38-30012
180	24 VDC	CHC-38-30003	CHC-38-30013

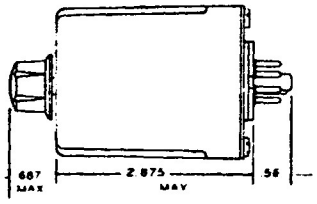
RESISTOR-ADJUSTABLE TIME DELAY

In Seconds	Input Voltage	Delay on Operate	Ext. Res. for Max. Time
		Fig. 5	
1-10	24 VAC	CHF-38-30001	200K
1-60	24 VAC	CHF-38-30002	1.2 Meg.
1-180	24 VAC	CHF-38-30003	3.5 Meg.
1-10	120 VAC	CHF-38-70001	200K
1-60	120 VAC	CHF-38-70002	1.2 Meg.
1-180	120 VAC	CHF-38-70003	3.5 Meg.
1-10	240 VAC	CHF-38-80001	200K
1-60	240 VAC	CHF-38-80002	1.2 Meg.
1-180	240 VAC	CHF-38-80003	3.5 Meg.
		Fig. 6	
1-10	24 VDC	CHH-38-30001	160K
1-60	24 VDC	CHH-38-30002	1 Meg.
1-180	24 VDC	CHH-38-30003	3 Meg.

● *Stocked by leading Electronic Parts Distributors.*

*1/4 *watt minimum resistor.*

38 STYLE OUTLINE DIMENSIONS & WIRING DIAGRAMS



(Bottom View - Pins Numbered Clockwise From Keyway)

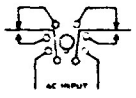


Fig. 1

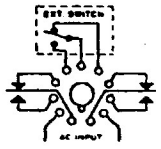


Fig. 3

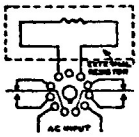
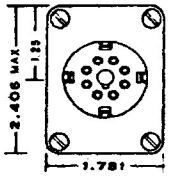
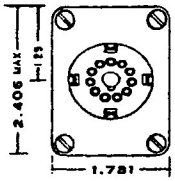


Fig. 5



8 PIN



11 PIN


Fig. 2

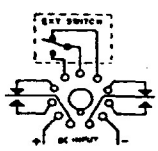


Fig. 4

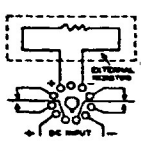


Fig. 6

ELECTRONIC INNOVATIONS IN ACTION

SEMICONDUCTORS

Silicon Power Pac Transistors

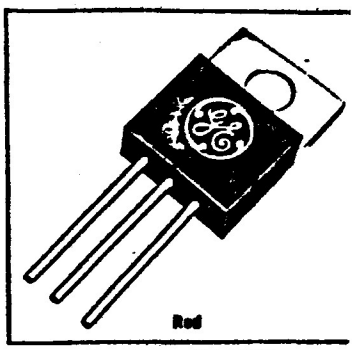
"Color Molded"

Preliminary

NPN

D44C 8

The General Electric D44C is a red silicone, plastic encapsulated, power transistor designed for output stages of stereo amplifiers, automobile stereo, automobile voltage regulators, and other general purpose industrial and consumer electronics applications. This is the NPN complement to the D45C.



Compatible with JEDEC TO-66 mounting registration

FEATURING:

- NPN complement to D45C PNP
- Red for NPN, green for PNP
- Very low collector saturation voltage (0.5V typ. @ 3.0A I_C)
- Excellent linearity
- Fast switching
- Round leads

absolute maximum ratings: (25°C) (unless otherwise specified)

		D44C1 D44C2 D44C3	D44C4 D44C5 D44C6	D44C7 D44C8	
Voltages					
Collector to Emitter	V_{CEO}	30	45	60	Volts
Emitter to Base	V_{EBO}	5	5	5	Volts
Collector to Emitter	V_{CES}	45	60	75	Volts
Current(1)					
Collector (Continuous)	I_C	←	3	→	Amps
Collector (Peak)		←	5	→	Amps
Power Dissipation(1)					
Case at 25°C	P_T	←	27	→	Watts
Case at 70°C		←	15	→	Watts
Free Air at 25°C		←	1.33	→	Watts
Free Air at 50°C		←	1.0	→	Watts
Thermal Impedance(2)					
Junction to Case	θ_{J-C}	←	3.75	→	°C/W
Junction to Ambient	θ_{J-A}	←	75	→	°C/W
Temperature(2)					
Operating	T_J	←	−55 to +125	→	°C
Storage	T_{STG}	←	−55 to +150	→	°C
Lead Soldering, 1/16" ± 1/32" from case for 10 seconds max.	T_L	←	+260	→	°C

Notes:
(1) Refer to the Safe Region of Operation curve for further information.
(2) Case temperature reference point is indicated on the Dimensional Outline Drawing.

electrical characteristics: (25°C) (unless otherwise specified)

		D44C3 D44C6		D44C2 D44C5 D44C8		D44C1 D44C4 D44C7
		Min.	Max.	Min.	Max.	Min.
Forward Current Transfer Ratio						
(V_{CE} = 1V, I_C = 0.2A)	h_{FE}	40	120	40	120	25
(V_{CE} = 1V, I_C = 2A)	h_{FE}	20	—	—	—	—
(V_{CE} = 1V, I_C = 1A)	h_{FE}	—	—	20	—	10

GENERAL ELECTRIC

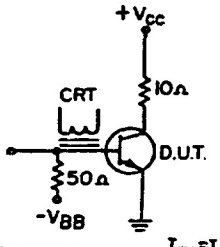
Electrical Characteristics (Continued)

		Min	Max	
Collector to Emitter Sustaining Voltage[3]				
(I_C = 100 mA) D44C1, 2, 3	$V_{CEO(sus)}$	30	—	Volts
D44C4, 5, 6		45	—	Volts
D44C7, 8		60	—	Volts
Collector Saturation Voltage[3]				
(I_C = 1A, I_B = 50 mA) D44C2, 3, 5, 6, 8	$V_{CE(sat)}$	—	0.5	Volt
(I_C = 1A, I_B = 100 mA) D44C1, 4, 7	$V_{CE(sat)}$	—	0.5	Volt
Base Saturation Voltage[3]				
(I_C = 1A, I_B = 100 mA)	$V_{BE(sat)}$	—	1.3	Volts
Collector Cutoff Current				
(V_{CB} = Rated V_{CBO}, T_J = 25°C)	I_{CBO}	—	10	μA
Emitter Cutoff Current				
(V_{EB} = 5V, T_J = 25°C)	I_{EBO}	—	100	μA
Collector Capacitance				
(V_{CB} = 10V, f = 1 mHz)	C_{ob}	—	100	pF

		Typ.	
Gain Bandwidth Product			
(V_{CE} = 4V, I_C = 20 mA)	f_t	50	mHz
Switching Times (See Figures 1 and 2)			
Rise Time and Delay Time			
(I_C = 1A, I_{B1} = 0.1A)	$t_d + t_r$	100	nsec
Storage Time			
(I_C = 1A, I_{B1} = I_{B2} = 0.1A)	t_s	500	nsec
Fall Time			
(I_C = 1A, I_{B1} = I_{B2} = 0.1A)	t_f	75	nsec

Note:
(3) Pulsed measurement, 300 μsec pulse, duty cycle ≤2%.

SWITCHING CIRCUIT TO MEASURE SWITCHING TIMES



RISE TIME = 1 NANOSECONDS MAX
FALL TIME = 1 NANOSECONDS MAX
I_{B1}=I_{B2}=0.1 AMPS
PULSE=10μ SEC
P.R.T. = 10m SEC
CRT=TEKTRONIX CURRENT TRANSFORMER

FIGURE 1

OSCILLOSCOPE DISPLAY OF INPUT AND OUTPUT PULSE WAVEFORM IS OF SWITCHING CIRCUIT SHOWN IN FIGURE 1

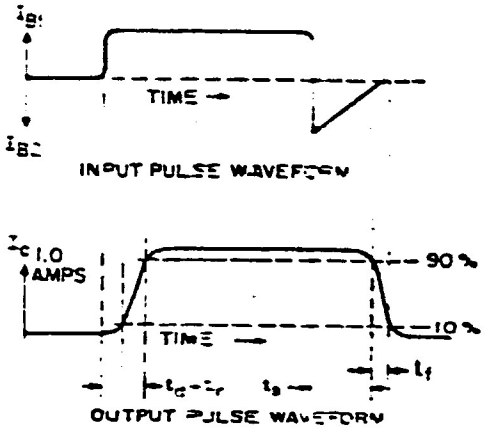
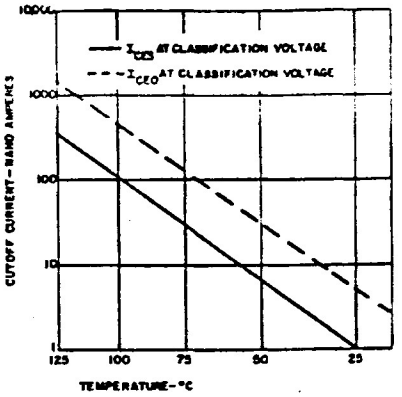
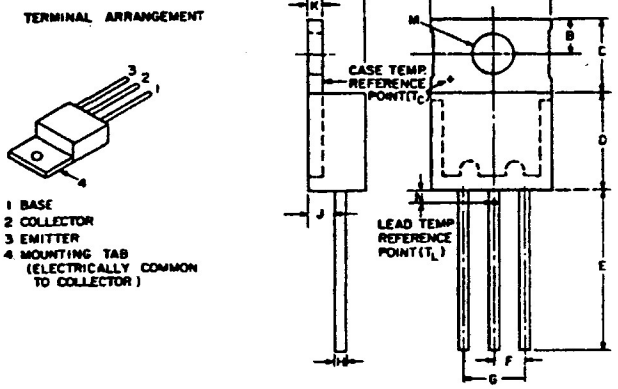


FIGURE 2

TYPICAL I_{CEO}, I_{CES} VS. TEMPERATURE

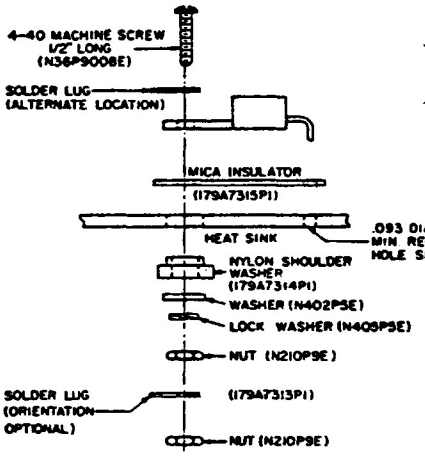


DIMENSIONAL OUTLINES



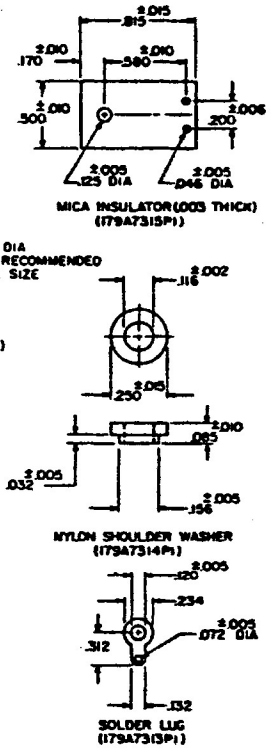
Sym.	Dec. In.		Metric MM	
	Min.	Max.	Min.	Max.
A	.395	.405	10.03	10.29
B	.110	.120	2.79	3.05
C	.250	.260	6.35	6.61
D	.340	.350	8.64	8.89
E	.500	——	12.7	——
F	.095	1.05	2.41	2.67
G	.190	.210	4.82	5.34
H	.029	.035	.73	.89
J	.085	.115	2.16	2.92
K	.050	.060	1.27	1.52
L	.170	.190	4.32	4.83
M	.141	.145	3.58	3.68
N	——	.065	——	1.65

TYPICAL INSULATING MOUNTING



NOTE: THE THERMAL RESISTANCE TAB TO HEAT SINK WITH THE MICA WASHER IS APPROXIMATELY 4.3°C/W WITHOUT ANY THERMAL CONDUCTING COMPOUND AND ABOUT 1.25°C/W WITH A THERMAL GREASE.

INSULATING KIT



Codes: 50, 52, 54, 55, 58; 41, 42, 45

INSTRUCTION MANUAL

REGULATED POWER SUPPLIES

LOS Z SERIES

SPECIFICATIONS AND FEATURES

DC OUTPUT — Voltage regulated for line and load. For voltage and current ratings see table I below.

TABLE I

MODEL	VOLTAGE RANGE	MAXIMUM CURRENT (AMPS) AT AMBIENT TEMPERATURE		
		40°C	50°C	60°C
LOS-Z-2	2 ±5%	3.0	2.4	1.8
LOS-Z-5	5 ±5%	3.0	2.4	1.8
LOS-Z-6	6 ±5%	2.5	2.1	1.6
LOS-Z-12	12 ±5%	1.6	1.3	1.0
LOS-Z-15	15 ±5%	1.4	1.2	1.0
LOS-Z-20	20 ±5%	1.0	0.8	0.6
LOS-Z-24	24 ±5%	0.9	0.75	0.55
LOS-Z-28	28 ±5%	0.8	0.65	0.45

Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range.

REGULATED VOLTAGE OUTPUT

Regulation (line) ..... 0.15% for input variations from 105-125, 125-105, 210-250, or 250-210 volts AC.

Regulation (load) ..... 0.15% for load variations from no load to full load or full load to no load.

Ripple and Noise ..... 1.5mV rms, 5mV peak to peak with either positive or negative terminal grounded.

Temperature Coefficient ..... 0.03%/°C

Remote Programming

External Resistor

LOS-Z-2 ..... Nominal 1000 ohms/volt output. The programming coefficient is negative. Increasing resistance decreases output voltage. Use a low temperature coefficient resistor to assure most stable operation.

LOS-Z-5 through LOS-Z-28 ..... Nominal 200 ohms/volt output. Increasing resistance increases output voltage. Use a low temperature coefficient resistor to assure most stable operation.

Programming Voltage ..... One-to-one voltage change. The programming supply must have a reverse current capability of 6 ma min. Programming supply need not have reverse current capability when programming LOS-Z-2.

Remote Sensing ..... Provision is made for remote sensing to eliminate the effect of power output lead resistance on DC regulation. Sensing leads should be a twisted pair to minimize AC pickup. A 2.5 mf elect. capacitor may be required between output terminals and sense terminals to reduce noise pickup.

OVERSHOOT — No overshoot under conditions of power turn-on, turn-off, or power failure.

AC INPUT — 105-125 or 210-250 volts AC at 47-440 Hz. Standard LOS-Z power supplies are factory wired for 105-125 volt input, but can be rewired for 210-250 volt input. See figure 1 and schematic diagram for rewiring of AC input. Input power 60 Watts*. Ratings apply for 57-63 Hz input. For 47-53 Hz input derate current 10% for each ambient temperature given in table I. For 63-440 Hz input consult factory.

*With output loaded to full current rating and input voltage 125 volts AC, 60 Hz.

OVERLOAD PROTECTION — Automatic electronic current limiting circuit, limits output current to a safe value, protecting load and power supply when external overloads and direct shorts occur.

INPUT AND OUTPUT CONNECTIONS — See outline drawing for location.

AC input	Terminals on transformer
Ground	Terminal on transformer
DC output	Turret terminal on printed circuit board
Sensing	Turret terminal on printed circuit board
Overvoltage Protector	Quick disconnect terminal on printed circuit board.

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE — Continuous duty from 0°C to +60°C ambient with corresponding load current ratings for all modes of operation.

STORAGE TEMPERATURE — -20°C to +85°C

DC OUTPUT CONTROL — Screwdriver voltage adjust control permits adjustment of DC output voltage. See outline drawing for location of control.

GUARANTEE — 60 day guarantee from date of shipment ..... materials and labor.

PHYSICAL DATA

Size	4-7/8" x 4" x 1-5/8"
Weight	2 lbs. net; 2-1/4 lbs. shipping
Finish	Gray, FED. STD. 595 No. 26081

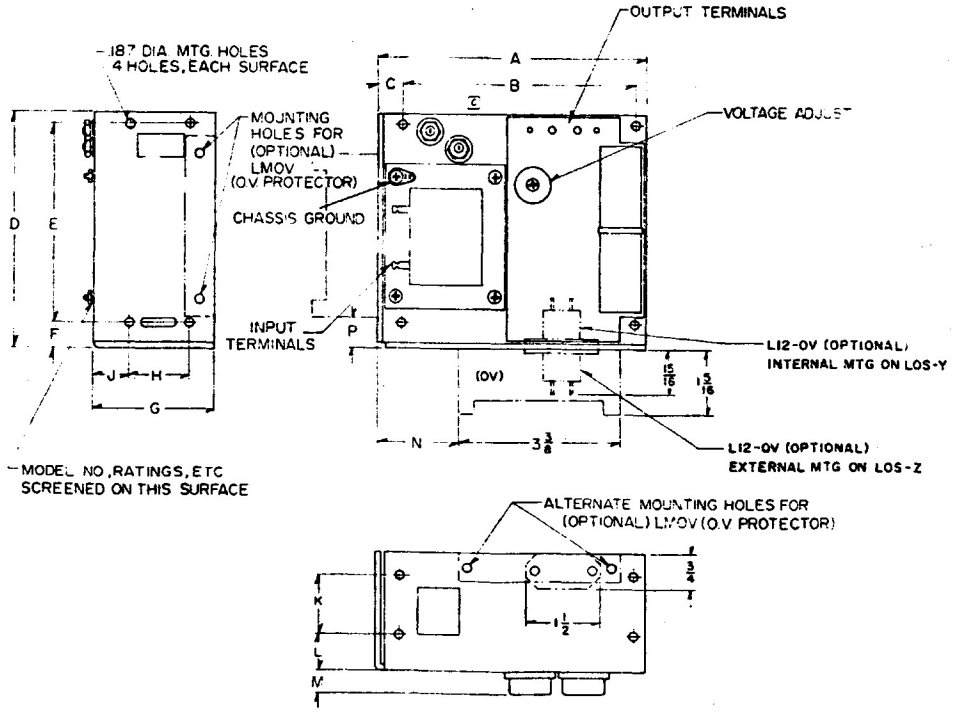
MOUNTING — Three surfaces, each with clearance mounting holes, can be utilized for mounting this unit. Transistors, diodes, and SCR's mounted on chassis must not contact any conductive material. Air circulation is required when unit is mounted in confined areas. Refer to Outline for mounting details.

"J" OPTION — Standard LOS power supplies can be obtained for 90-110 VAC, 47-440 Hz input. For 47-53 Hz input derate current 10% for each ambient temperature given in table I. For 63-440 Hz input consult factory.

ACCESSORIES

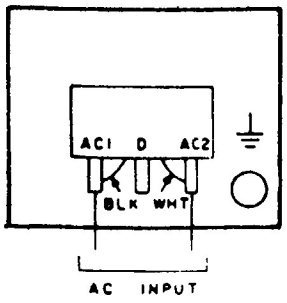
Overvoltage protector

Adjustable	Externally mounted Overvoltage Protectors LMOV-1, LMOV-2 and LMOV-3 are available for use with all models. Additional wire must be added to the Overvoltage Protector leads in order to reach the power supply output terminals. Quick disconnect terminals. HKA-01-023 are available to mate with OV terminals on power supply.
Fixed	Externally mounted L-12-OV series Overvoltage Protectors are available for use with all models. Overvoltage Protectors are supplied with Quick disconnect terminals to mate with OV terminals on power supply.



MODEL	DIMENSIONS													
	A	B	C	D	E	F	G	H	J	K	L	M	N	P
LOS-Z	4 7/8	4 1/8	1/2	4	3 3/8	3/8	1 5/8	0	1/4	0	1/4	15/32	1/4	3/8
LOS-Y	5 3/8	4 7/8	1/2	4 7/8	4 1/8	1/2	2 1/2	1 1/4	3/4	1 1/4	1/4	13/32	11/16	3/4

Outline Drawing



* AC INPUT CONNECTION SHOWN IS FOR 105-125VAC
FOR 210-250V INPUT, DISCONNECT BLK & WHT TRANFORMER
LEADS FROM TERMS AC1 & AC2 AND RECONNECT BOTH LEADS
TO TERM D

Figure 1. AC Input Connection.

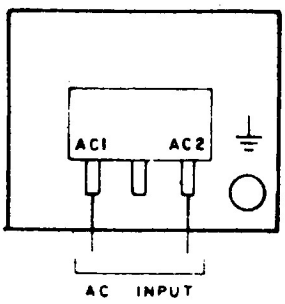
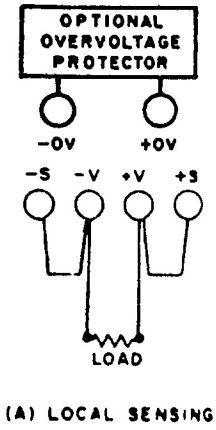


Figure 2. AC Input Connection, "J" Option.



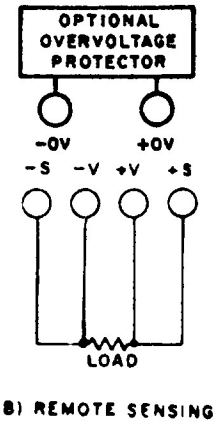
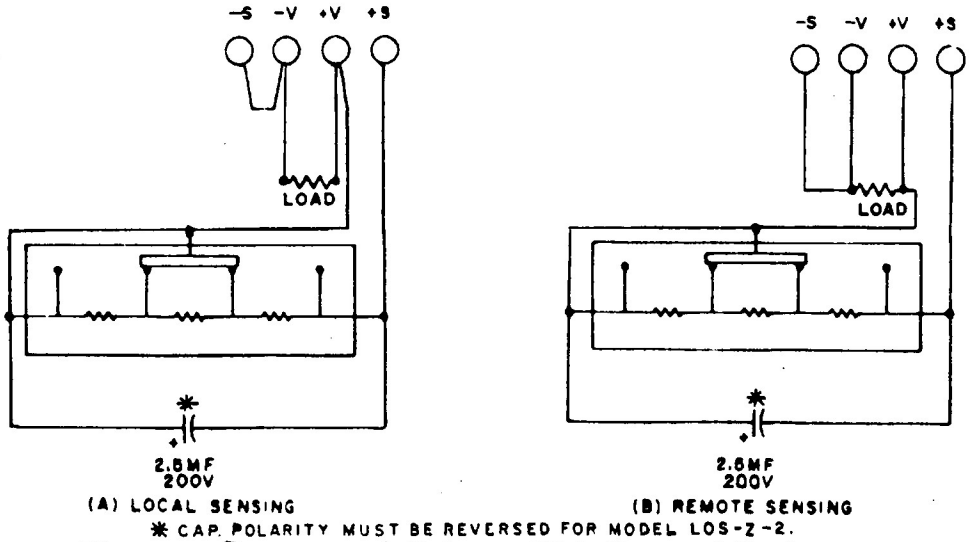


Figure 3. DC Output Connection.



* CAP. POLARITY MUST BE REVERSED FOR MODEL LOS-Z-2.

Figure 4. Programmed Voltage, With External Resistor

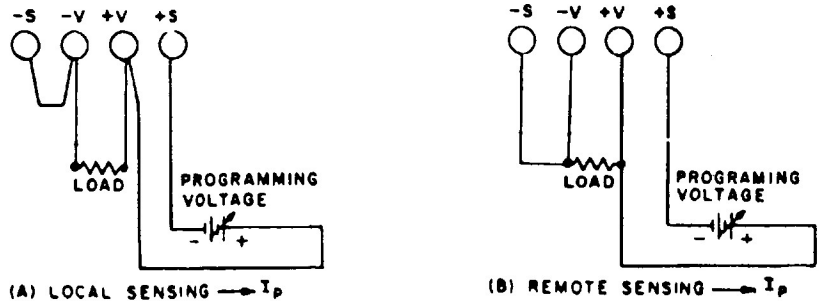
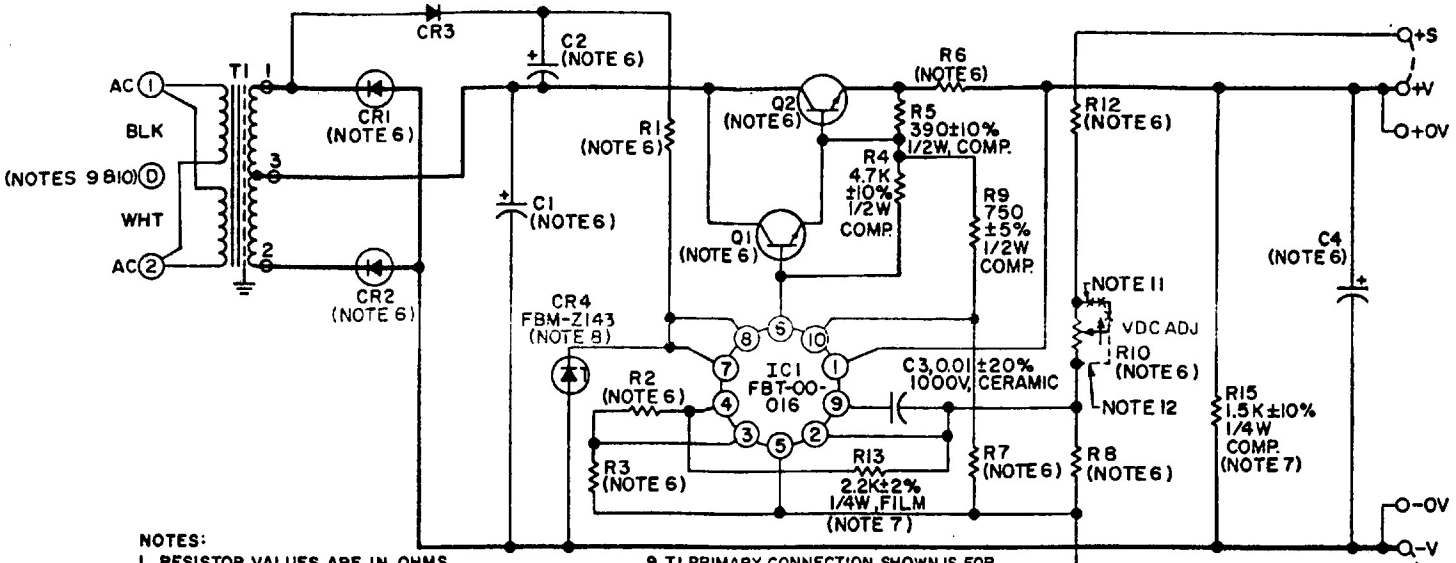


Figure 5. Programmed Voltage, With External Programming Voltage Source.



NOTES:

1. RESISTOR VALUES ARE IN OHMS.
2. CAPACITOR VALUES ARE IN MICROFARADS.
3. DESIGNATIONS ARE LAMBDA PART NUMBERS.
4. SYMBOLS:
   - INDICATES CLOCKWISE ROTATION OF SHAFT.
   - INDICATES CONNECTION TO CHASSIS.
   - LAMBDA PART NO. FBL-00-030; USE IN4002 DIODE FOR REPLACEMENT UNLESS OTHERWISE NOTED.
   - INDICATES TERMINAL ON PRINTED CIRCUIT BOARD.
   - INDICATES ACTUAL UNIT MARKING.
5. FOR OPERATION AT 47-53Hz, DERATE CURRENT BY 10%. FOR OPERATION AT 63-440Hz, CONSULT FACTORY.
6. SEE TABLE II FOR COMPONENT VALUES.
7. R13 AND R15 ONLY USED ON MODEL LOS-Z-2.
8. CR4 ONLY USED ON MODELS LOS-Z-12 THRU LOS-Z-28.
9. T1 PRIMARY CONNECTION SHOWN IS FOR 105-125 VAC INPUT. FOR 210-250 VAC INPUT: DISCONNECT BLK & WHT TRANSFORMER LEADS FROM TERMS AC1 & AC2 AND RECONNECT BOTH LEADS TO TERM D.
10. "J" OPTION UNITS HAVE SINGLE T1 PRIMARY. AC INPUT IS 90-110 VAC.
11. NOT USED ON MODEL LOS-Z-2.
12. ONLY USED ON MODEL LOS-Z-2.

FOR WIRING OF POWER SUPPLY TO LOAD REFER TO SUPPLY-TO-LOAD WIRING DIAGRAMS

DOTTED CONNECTIONS SHOWN INDICATE JUMPERS IN PLACE FOR LOCAL SENSING CONNECTION.

THIS SCHEMATIC APPLIES TO UNITS BEARING SERIAL NO. PREFIX A.

SCHEMATIC DIAGRAM
REGULATED POWER SUPPLY

MODELS
LOS-Z SERIES

LAMBDA
ELECTRONICS CORP.
MELVILLE, NEW YORK
A Veeco SUBSIDIARY

TABLE II
SCHEMATIC DATA REFERENCES
MODELS LOS-Z-2 THRU LOS-Z-28

Models	Schematic Components													
	C1	C2	C4	CR1, CR2	Q1	Q2	R1	R2	R3	R6	R7	R8	R10	R12
	-10+75% ELECT	-10+75% ELECT	-10+75% ELECT	*FBL-00-	*FBN-	*FBN-	COMP	FILM	1/4W FILM	±5% 2W WW	1/2W COMP	1/4W FILM	±10% 1-1/2W WW	1/4W FILM
LOS-Z-2	6900 mf 15 vdc	47 mf 35 vdc	330 mf 25 vdc	092	L113	L157	270 ±5% 1/2W	4.7K ±2% 1/4W	2.2K ±2%	0.15	1.8K ±10%	2.2K ±2%	600	Jumper
LOS-Z-5	6900 mf 15 vdc	47 mf 35 vdc	330 mf 25 vdc	092	L113	L157	1.8K ±10% 1/2W	2.19K ±1% 1/2W	3.83K ±1%	0.15	4.3K ±5%	825 ±1%	600	Jumper
LOS-Z-6	6900 mf 15 vdc	47 mf 35 vdc	330 mf 25 vdc	092	L113	L157	1.8K ±10% 1/2W	2.49K ±1% 1/2W	3.83K ±1%	0.15	5.1K ±5%	825 ±1%	600	Jumper
LOS-Z-12	3500 mf 30 vdc	47 mf 35 vdc	220 mf 50 vdc	094	L109	L156	4.7K ±10% 1/2W	619 ±1% 1/4W	Not Used	0.30	10K ±5%	1.47K ±1%	600	768 ±1%
LOS-Z-15	3500 mf 30 vdc	47 mf 60 vdc	220 mf 50 vdc	094	L109	L156	4.7K ±10% 1/2W	619 ±1% 1/4W	Not Used	0.30	13K ±5%	1.47K ±1%	1.2K	1.21K ±1%
LOS-Z-20	2200 mf 60 vdc	47 mf 60 vdc	100 mf 60 vdc	094	L109	L156	8.2K ±10% 1/2W	1K ±1% 1/2W	Not Used	0.39	18K ±10%	1.47K ±1%	1.2K	2.2K ±2%
LOS-Z-24	2200 mf 60 vdc	47 mf 60 vdc	100 mf 60 vdc	094	L109	L156	8.2K ±10% 1/2W	1K ±1% 1/2W	Not Used	0.39	22K ±10%	1.47K ±1%	1.2K	3.01K ±1%
LOS-Z-28	2200 mf 60 vdc	47 mf 60 vdc	100 mf 60 vdc	094	L109	L156	15K ±5% 1W	1K ±1% 1/2W	Not Used	0.51	27K ±10%	1.47K ±1%	1.8K	3.48K ±1%

*Lambda part no.