Loyola FIRST IN SCR POWER CONTROLS
controls inc. 1099 N. BATAVIA ST. ORANGE, CA. 92667

BPAC FIELD TROUBLESHOOTING GUIDE

February 1975

CONTENTS

GENERAL DESCRIPTION

The BPAC is an SCR or thyristor power control utilizing the zero crossover firing method. The single phase BPAC (BPAC-1) uses only one set of back-to-back SCR's. The three phase BPAC (BPAC-3) utilizes the master-slave technique for three phase power control. It encorporates two sets of back-to-back SCR's to control the power in a delta three phase load. L1 to T1 is the master or controlled section; L3 to T3 is the slave set of SCR's; and L2 to T2 is a direct connection and has no control.

Troubleshooting of the BPAC in the field can be relatively simple if the troubleshooting is kept to changing of defective SCR's or circuit boards. Plug-in circuit boards can best be repaired at the factory.

INDICATIONS OF MALFUNCTION

A malfunction is present if:

1. Output is full on and not controllable.
2. No output is obtainable under any input condition. (Check to see that the interlock circuit is not open.)
3. Output voltage is not approximately proportional to the command signal.
4. Operation is erratic or inconsistent.
5. The BPAC-3 has unbalanced outputs. This is usually due to wrong phase rotation on L1, L2 and L3 connections. Correct by reversing any two leads to L1, L2 or L3.
6. There is indication of over-heated or broken silicon controlled rectifiers or wiring.
7. Testing indicates half wave output.

TEST EQUIPMENT REQUIRED

1. VOM (volt ohm milliampmeter)
2. Clamp-on ammeter
3. Half wave detector (can be easily made; see Figures 3, 4)

SYSTEM TROUBLESHOOTING

Use extreme caution when the power is on; the heat sinks are electrically "hot".

PROBLEM	PROBABLE CAUSE	ACTION
No output	No power input	Check for proper voltage L1 to L2, L2 to L3, and L1 to L3
No output	Improper command signal	Check command signal for proper control input (see below)
No output	Blown fuses	Check fuses
No output	Open load contactor	Check load contactor
No output	Open heaters	Check heaters
No output	Bad PC board	See below
Partial output or partial heat	Improper or low command signal	Check for proper or full command signal
Partial output or partial heat	Loss of 1 phase (BPAC-3 only)	Check all phases for output with volt meter and clamp-on ammeter
Partial output or partial heat	Half wave operation	Check output with half wave detector; T1 to T2, T1 to T3, and T2 to T3 (see Figures 3 and 4)
Uncontrolled Full output	Shorted SCR	See below
Uncontrolled Full output	Bad PC board	See below

CHECKING SCR's

NOTE: Power OFF only

1. Testing SCR's

A shorted SCR will give full uncontrollable line voltage at the T terminals. Turn off main power and remove L wires and T wires. With the unit disconnected, measure the resistance between terminals L1 and T1 on the BPAC-1, and also L3 and

1. Testing SCR's (continued)

and T3 on a BPAC-3. If resistance is less than 5 ohms, at least one SCR is shorted. A "0" ohm reading will be obtained between L2 and T2. This is normal.

Typically, only one SCR will be defective. Since the two SCR's in each line are in parallel, at least one must be isolated to determine which SCR is defective. (Unsoldering or disconnecting the heavy load at the cathode of the SCR may be the most convenient method.) Remove one lead. Again, check resistance between T1 and L1 (plus L3 and T3 in the BPAC-3 units). If resistance is greater than 10K, the disconnected SCR is defective; if resistance is less than 5 ohms, the connected SCR is defective.

Remove the SCR by carefully unsoldering gate and cathode leads. In larger units, the leads must be unbolted or removed from the terminal strips.

2. Installing SCR's

The installation of the new SCR must be done carefully. Refer to Figures 1 and 2 below. In all cases, the SCR must be installed with an adequate amount of silicon grease such as Dow Corning DC4. It is most important that the grease be on the under side of the SCR to fill all microscopic voids between the SCR and the heat sink. Do not apply silicon grease to the mounting stud of the SCR.

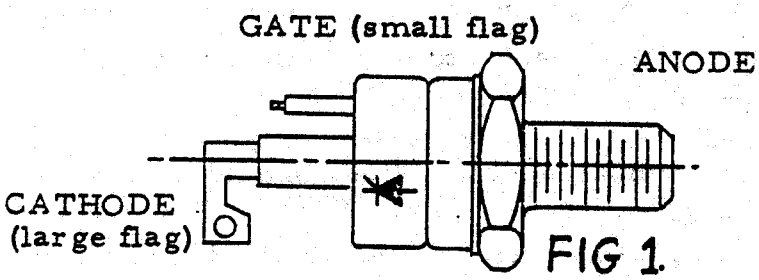


FIG 1.

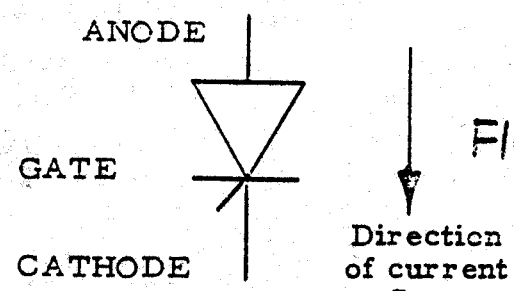


FIG 2

When mica or beryllium oxide washers are used, the silicon grease must be spread generously on both sides of the washer. The teflon sleeves are absolutely necessary. Be sure they are reinstalled so that the thread of the SCR does not contact the side of the hole in the heat sink.

The SCR junction may be damaged if too much torque is applied during the installation of the SCR. Note carefully the values listed in Table I. below for recommended mounting torques. Too little torque will allow the SCR to run too hot and it will burn out.

2. Installing SCR's (continued)

TORQUE VALUES FOR MOUNTING SCR's			
STUD SIZE	MAXIMUM TORQUE		
	Inch Lbs.	Foot Lbs.	Kg m
1/4 inch	25-30	2 1/2	0.288--0.346
1/2 inch	125-150	12	1.440--1.728
3/4 inch	280-300	25	3.226--3.456

TABLE I.---Recommended SCR Mounting Torque

CAUTION: Under no circumstances permit anyone to file or scrape the white beryllium-oxide washer. The beryllium washer is safe to handle in its present form. However, beryllium dust is very toxic. Do not scrape the washer.

CHECK-OUT OF PC BOARD AND ENTIRE UNIT

1. Unit can be operated with its normal load, or with a dummy load (see Figure 5).
2. Disconnect all control wires from TB1.
3. Connect a jumper from terminal 1 to 2 of TB1, if it is not already present. (This is an interlock; opening 1 and 2 will kill power output).
4. Apply power to unit. No output should appear at T terminals.
5. Temporarily connect terminal 3 to terminals 1 and 2 of TB1. Full output should appear at T terminals.
6. With a VOM set for DC, check the voltage from TB1 terminal 5 (-) to terminal 3 (+). Voltage should be between 2 and 2.5 VDC.
7. Connect a 150 ohm potentiometer to terminals 3, 4 and 5 on TB1. (Wiper to 4.)
8. With the wiper of the pot all the way toward terminal 5, power should be off.
9. As the wiper is slowly turned toward number 3, the BPAC should turn on for longer and longer periods, until it is full on when the wiper reaches the end connected to terminal number 3.

BPAC Field Troubleshooting Guide
Addendum One

BPAC-H PC BOARD ASSEMBLY 08-0960 THROUGH 08-0974

1. Description

The BPAC-H or slow cycle board is used primarily for large heating loads where the heating load is a large percentage of the total KVA available. It's primary purpose is to prevent light flicker due to rapidly turning the heaters on and off as with the standard board.

2. Differences

The BPAC-H circuit board is interchangeable with the standard (08-0305) PC board with the following exceptions:

a. Input modifications for milliamp or special voltages are done on the board and not on the terminal strip.

b. The time base is either 6 or 12 seconds instead of the standard one cycle variable time base.

c. Scope measurements 1 through 7 do not apply. 8 through 13 are the same as on the 08-0305 board.

3. For input values and timing information, see 02-0460 schematic.

HALF WAVE DETECTORS

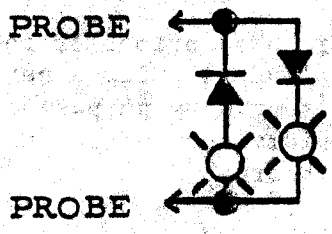


FIG 3

Half Wave Detector:
120V and 240V

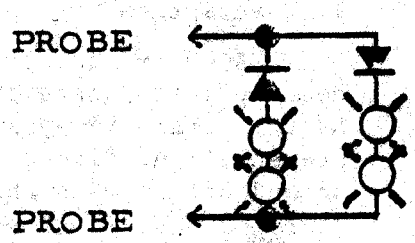


FIG 4

Half Wave Detector:
277V and 480V

All Bulbs: 7.5W, 120V night light

Diodes, 120V and 240V: 500 ma, 400 PIV

Diodes, 277V and 480V: 500 ma, 800 PIV

If power output is proper, all bulbs should light equally when probes are connected between T1 and T2 (BPAC-1 only), and between T1 and T3, and T2 and T3 (BPAC-3).

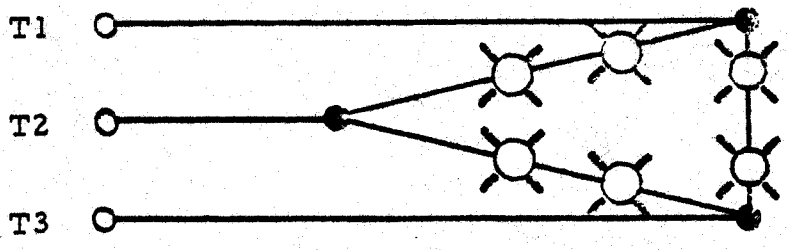


FIG 5 Dummy Load

All Bulbs: 100W, 240V

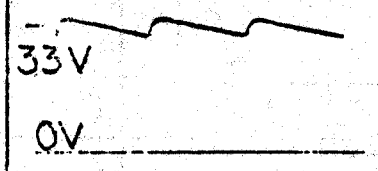
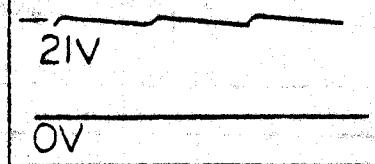
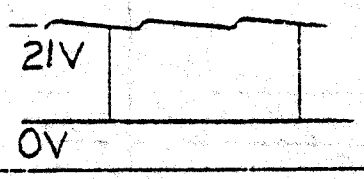
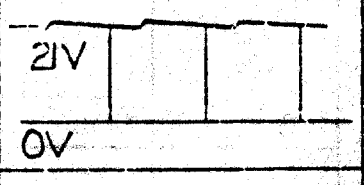
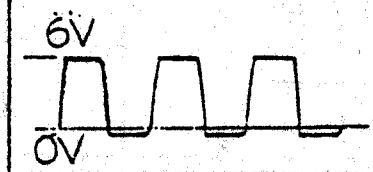
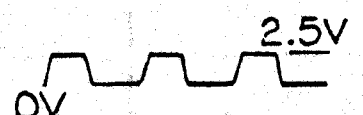
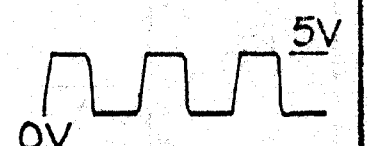
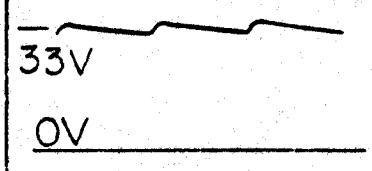
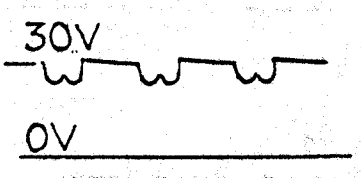
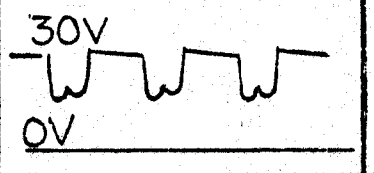
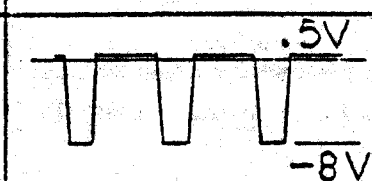
For 240V, only one bulb is needed per phase.

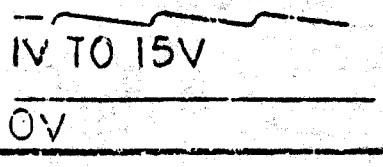
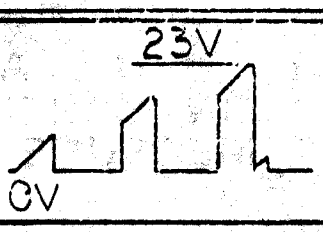
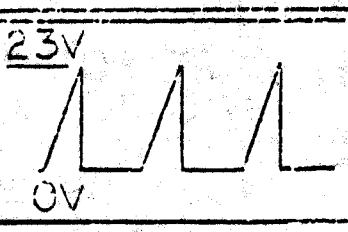
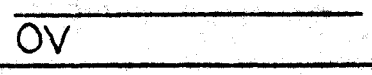
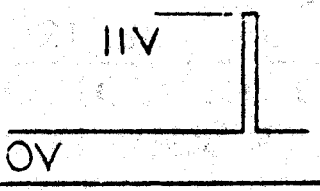
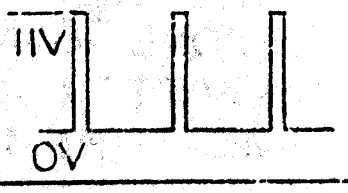
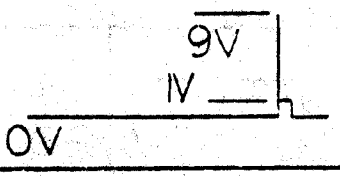
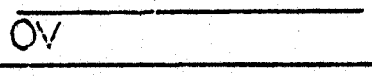
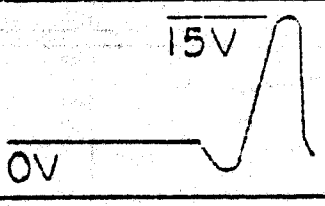
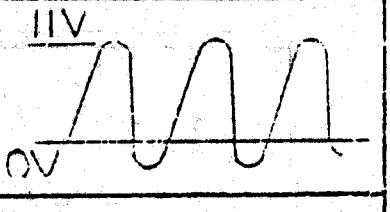
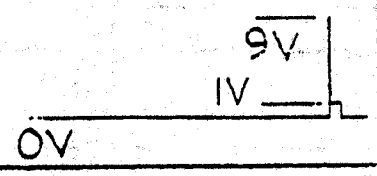
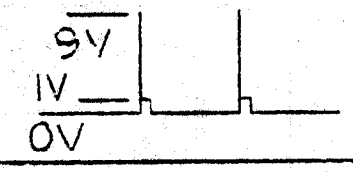
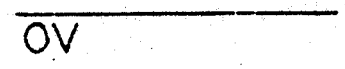
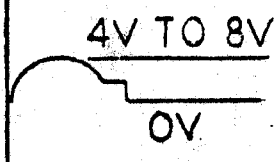
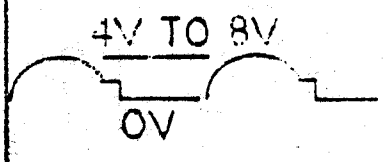
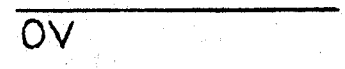
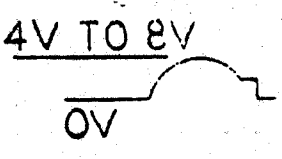
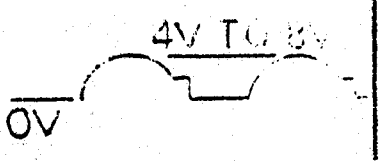
NOTE: Refer to Recommended Spare Parts Listing or consult the factory for correct replacement SCR for controllers.

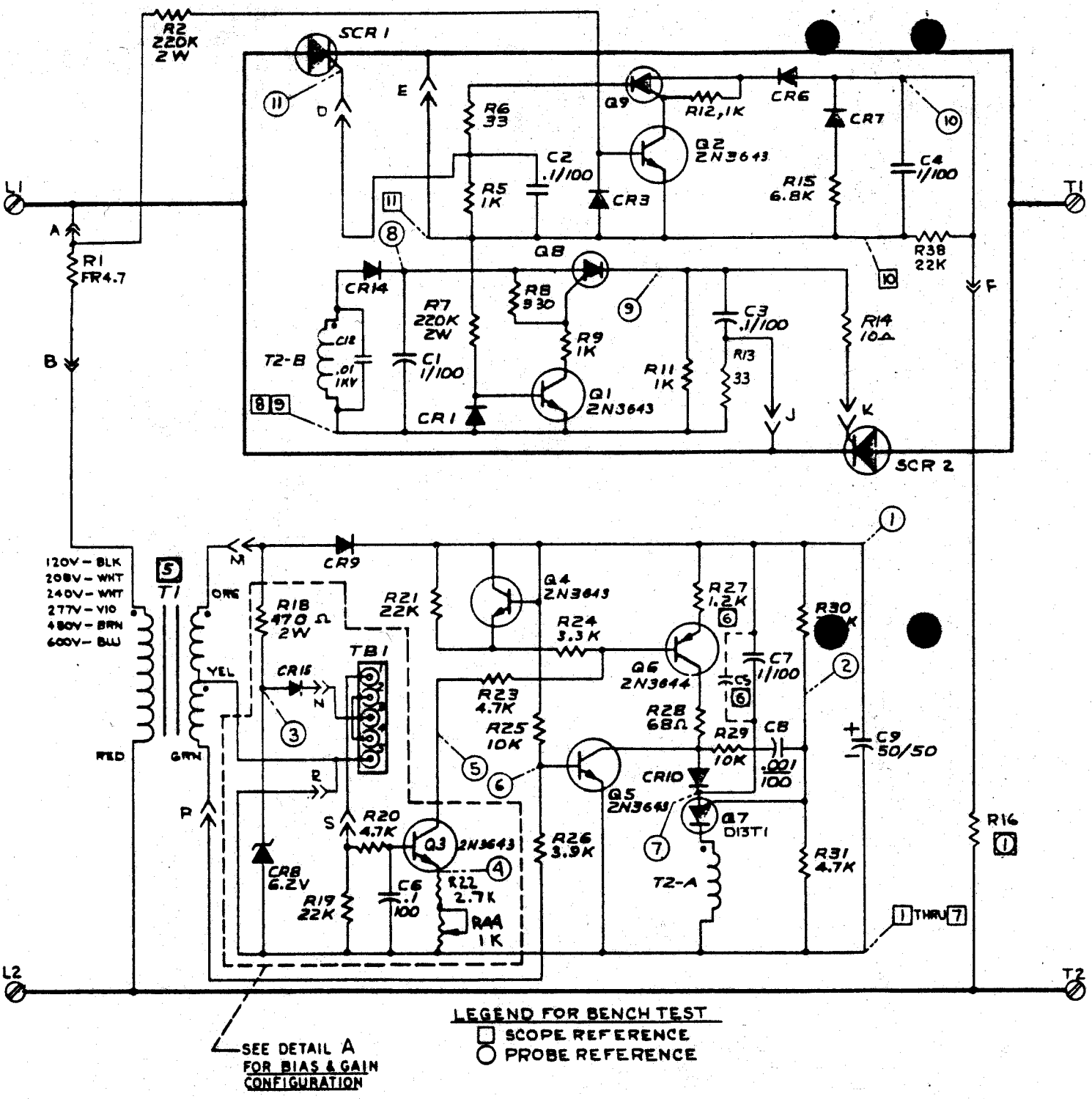
BPAC-1 AND BPAC-3
WAVE FORM AND VOLTAGE CHART

NOTE:

1. TEST POINTS 1 THRU 7 ARE MEASURED WITH SCOPE GROUND AT 1 ON SCHEMATIC.
2. CAUTION: FOR MEASUREMENTS 8 & 9 SCOPE GROUND MUST BE MOVED TO 2 & 3 RESPECTIVELY. THESE ARE ELECTRICALLY HOT AT POWER LINE POTENTIAL SCOPE CASE MUST BE ISOLATED WITH AC GRD ADAPTER AND/OR ISOLATION TRANSFORMER WHEN MEASUREMENTS ARE MADE. SCOPE CASE IS HOT.

TEST POINT NO.	0 OUTPUT POT FULL CCW	HALF OUTPUT POT 1/2 WAY	FULL OUTPUT POT FULL C.W.
1		SAME	SAME
2			
3		SAME	SAME
4			
5			
6		SAME	SAME

TEST POINT NO.	0 OUTPUT POT FULL CCW	HALF OUTPUT POT ½ WAY	FULL OUTPUT POT FULL CW
7			
8			
9			
10			
11			
12			
13			



[5] T1 TO BE 16-0082 FOR 120V; 16-0083 FOR 208/240V, 16-0084 FOR 277V; 16-0085 FOR 480V; 16-0086 FOR 600V.

4. ALL RESISTORS ARE ½W, EXCEPT R1, FUSIBLE & R44 (¼W)

3 ALL DIODES ARE 18-1035.

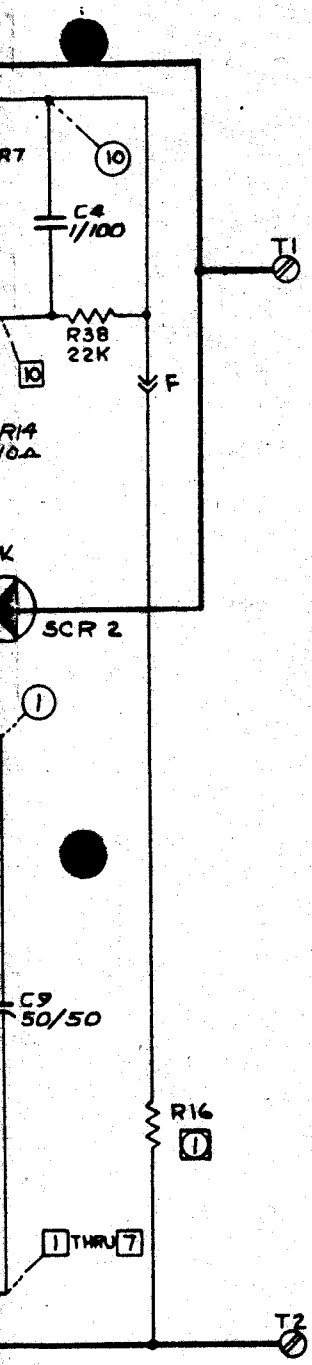
2. LAST USED REF DESIG: R44, C10, CR15, Q9 + SCR 2

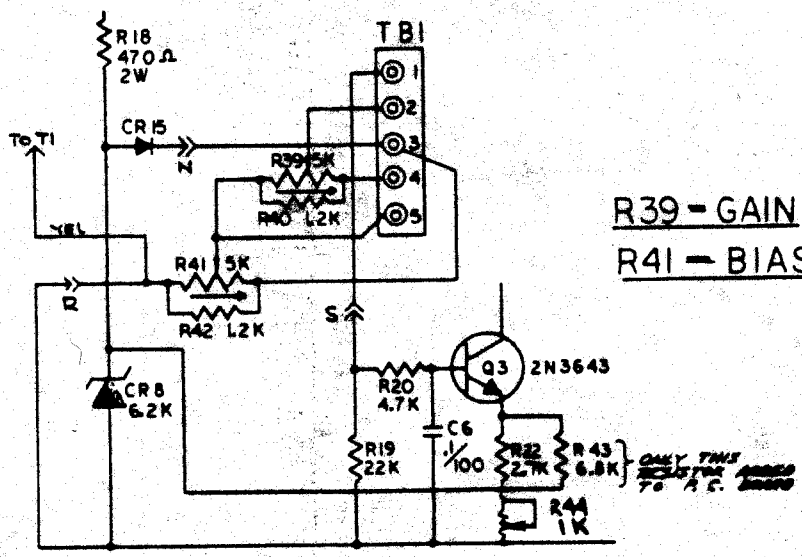
[1] R16; 120V, 25K/10W; 208/240V, 50K/25W; 277V, 50K/25W; 480V, 100K/25W; 600V, 100K/25W.

NOTES: UNLESS OTHERWISE SPECIFIED.

[6] UNITS WITH SCR'S REQUIRING A GATE DRIVE CURRENT ADD C5 (1 R27 TO 620 OHMS. (AMPLITUDE C1, NORMALLY 12V ± 1.2V, WILL C

REV	DESCRIPTION	BY	DATE
A	SEE ECN#1206		
B	SEE ECN# 1206		
C	SEE ECN #1316		
D	SEE ECN#1401		
E	1517		
F	1520		
G	SEE ECN#1535		
H	ECN 1554 R22 WAS 3.3K		
I	ECN 1573 R18 WAS 330Ω		
J	R22 WAS 3.3K ECN 1629		
K	TRANSIENT PROTECTION ADDED ECN 1672		
L	ADDED CONFIG. FOR BIAS & GAIN A.C. COUPLE		
M			
N			
P	R22 WAS 2.7K PER ECN 1990		
Q	ECN 2026 R22 WAS 3.3 ADD R44	DM	5-12-77





R39 = GAIN

R41 = BIAS

DETAIL A
FOR BIAS & GAIN
CONFIGURATION

ITS WITH SCR'S REQUIRING A 200MA OR GREATER
TE DRIVE CURRENT ADD C5 (1MF/100V) & CHANGE
27 TO 620 OHMS. (AMPLITUDE OF VOLTAGE ACROSS
, NORMALLY 12V±1.2V, WILL CHANGE TO 21V±2.1V)

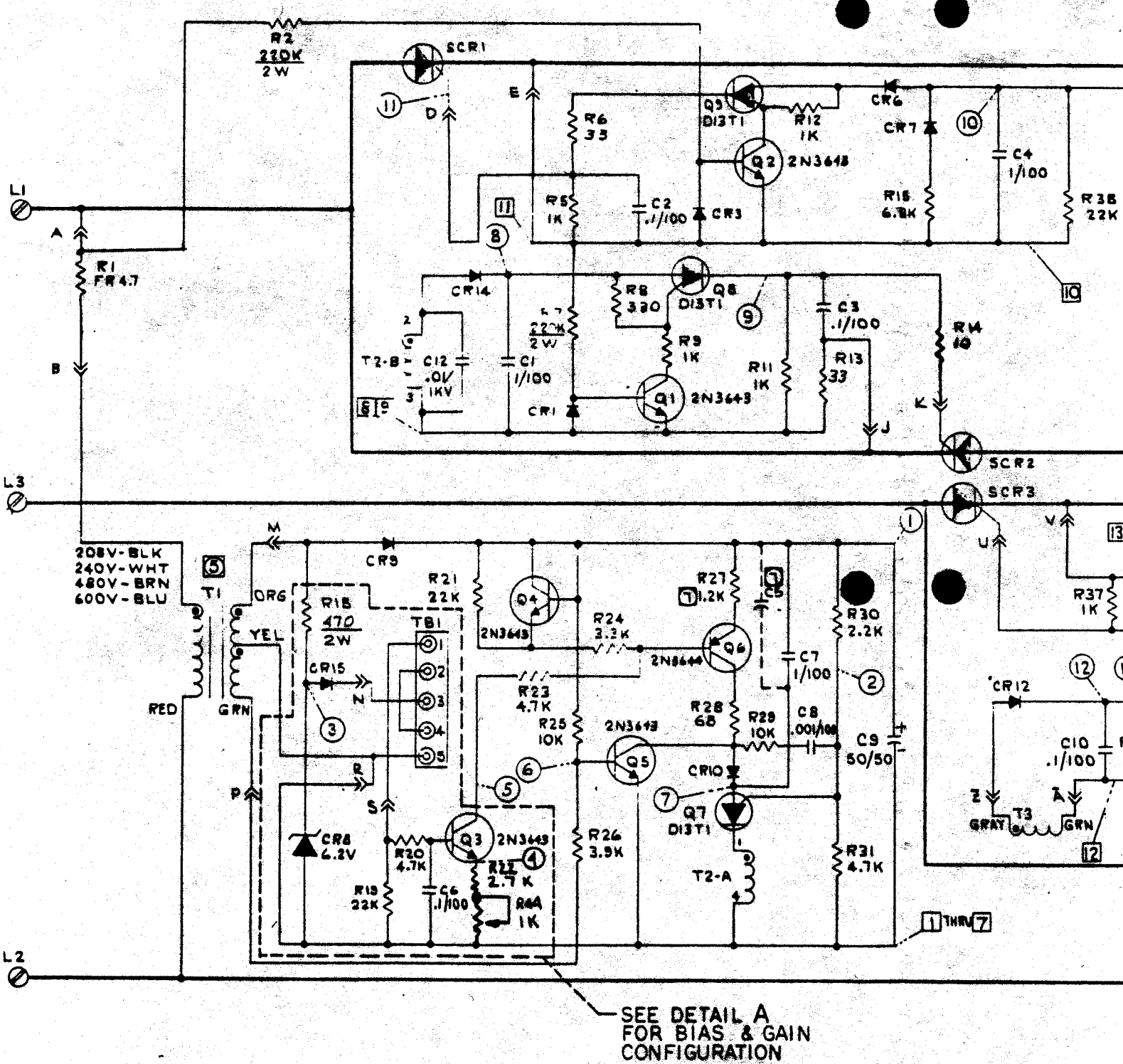
QTY	REF DESIG	DESCRIPTION

SCHEMATIC DIAGRAM
BPAC-1 FOR SN# 21000 & UP

FRACTIONS ± 1/32
DECIMALS ± .015
ANGLES ± 2°
HOLE DIA ± .005

NEXT ASSY

02-0183 Q



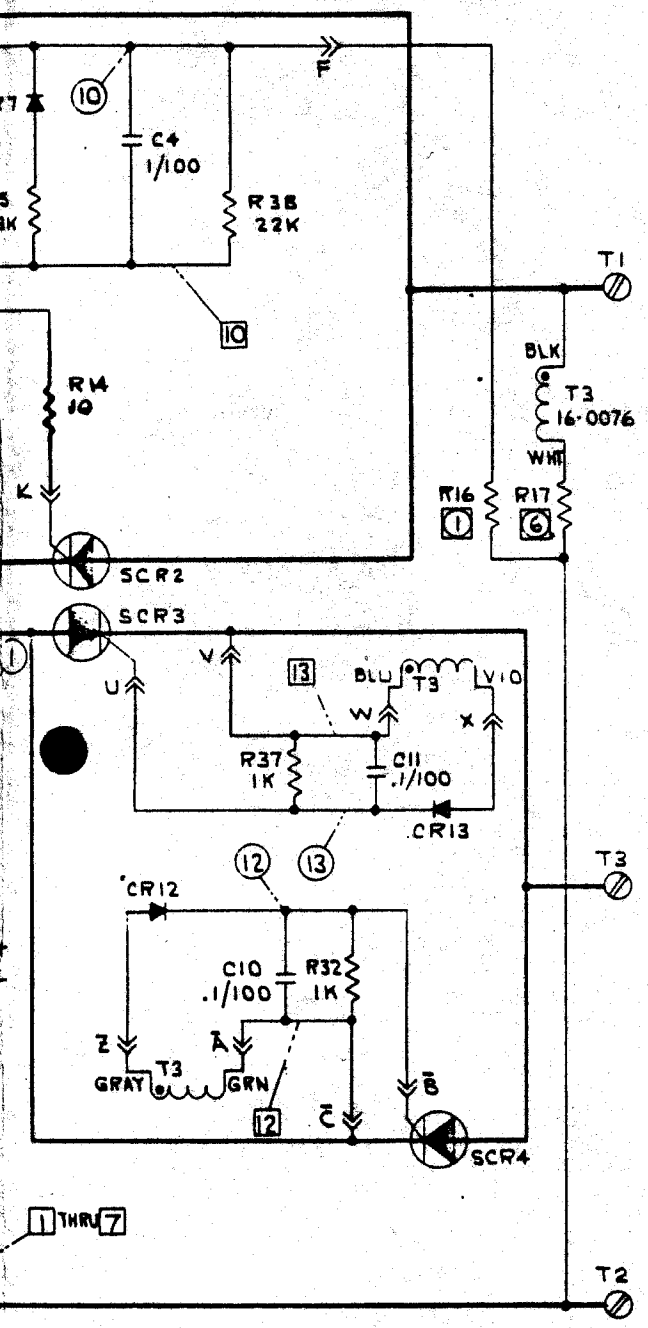
6 R17; 208/240V, 5K/10W; 480V, 10K/10W; 600V, 12K/10W.
5 T1 TO BE 16-0083 FOR 208/240V, 16-0085 FOR 480V, 16-0086 FOR 600V.
4. ALL RESISTORS ARE ½W EXCEPT R1, FUSIBLE & R44 (¼W)
3. ALL DIODES ARE 15-1035.
2. LAST USED REF DESIG; R44, C12, CR15, SCR4, Q9
1 R16; 208/240V, 50K/25W; 480V, 100K/25W; 600V, 100K/25W.

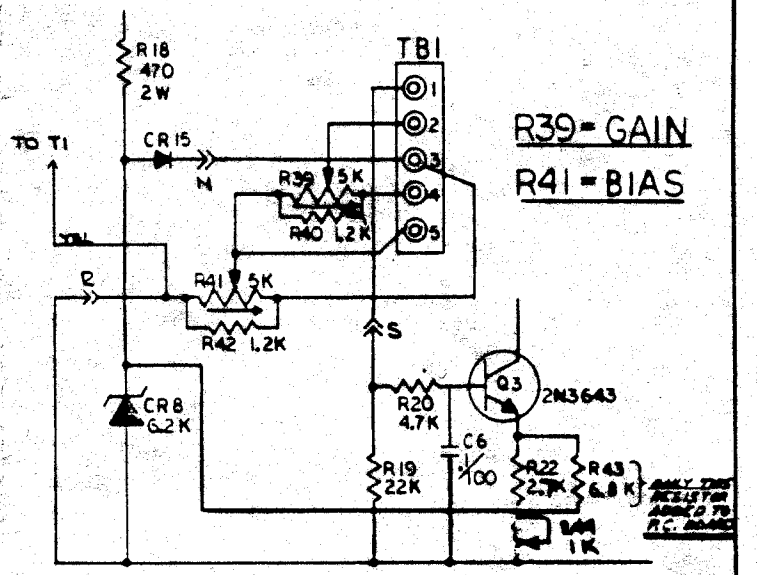
NOTES: UNLESS OTHERWISE INDICATED.

LEGEND FOR BE
SCOPE REFER
PROBE REFER

T UNITS WITH SCR'S REQUIRING A 200MA GATE DRIVE CURRENT ADD C5 (1MF/10 221 TO 820 OHMS. (AMPLITUDE OF VO C1, NORMALLY 12V±1.2V, WILL CHANGE

REV	DESCRIPTION	BY	DATE
A	SEE ECN # 1285	R.S.	12-3-69
B	SEE ECN # 1306	[illegible]	1-13-70
C	SEE ECN # 1316	R.S.	1-30-70
D	SEE ECN # 1327	R.S.	2-10-70
E	# 1517	[illegible]	[illegible]
F	1520	[illegible]	[illegible]
G	SEE ECN # 1535	[illegible]	21 MAY '71
H	ECN 1538 R22 WAS 3.3K	[illegible]	[illegible]
I	ECN 1573 R18 WAS 390 [illegible]	[illegible]	[illegible]
K	R22 WAS 3.3K ECN 1606	[illegible]	[illegible]
L	R27 WAS R21 (GREEN) ECN 1618	[illegible]	22 NOV 71
M	TRANSISTOR CHANGE ECN 1618	[illegible]	[illegible]
N	ADD CONFIGURATION 1719 FOR BIAS & GAIN SK. CHG	J.L.	18 JAN 72
P	ECN PIN NOS CKT NO CHNG. PER ECN 1758	[illegible]	[illegible]
Q	NOTE 5, NOTE 7 PER ECN 1783	[illegible]	[illegible]
S	R32 WAS 2.7K PER ECN 1788	[illegible]	[illegible]
T	ECN 2036 ADD POT R22 WAS 2.7K	DM	5-1-72





DETAIL A
FOR BIAS & GAIN
CONFIGURATION

02-0163 T

LEGEND FOR BENCH TEST
- ☐ SCOPE REFERENCE GND.
- ○ PROBE REFERENCE

SCR'S REQUIRING A 200MA OR GREATER CURRENT ADD C5 (1MF/100V) & CHANGE R[illegible]. (AMPLITUDE OF VOLTAGE ACROSS [illegible] 12V ± 1.2V, WILL CHANGE TO 21V ± 2.1V)

QTY	REF DESIG	PART NUMBER	DESCRIPTION	VENDOR

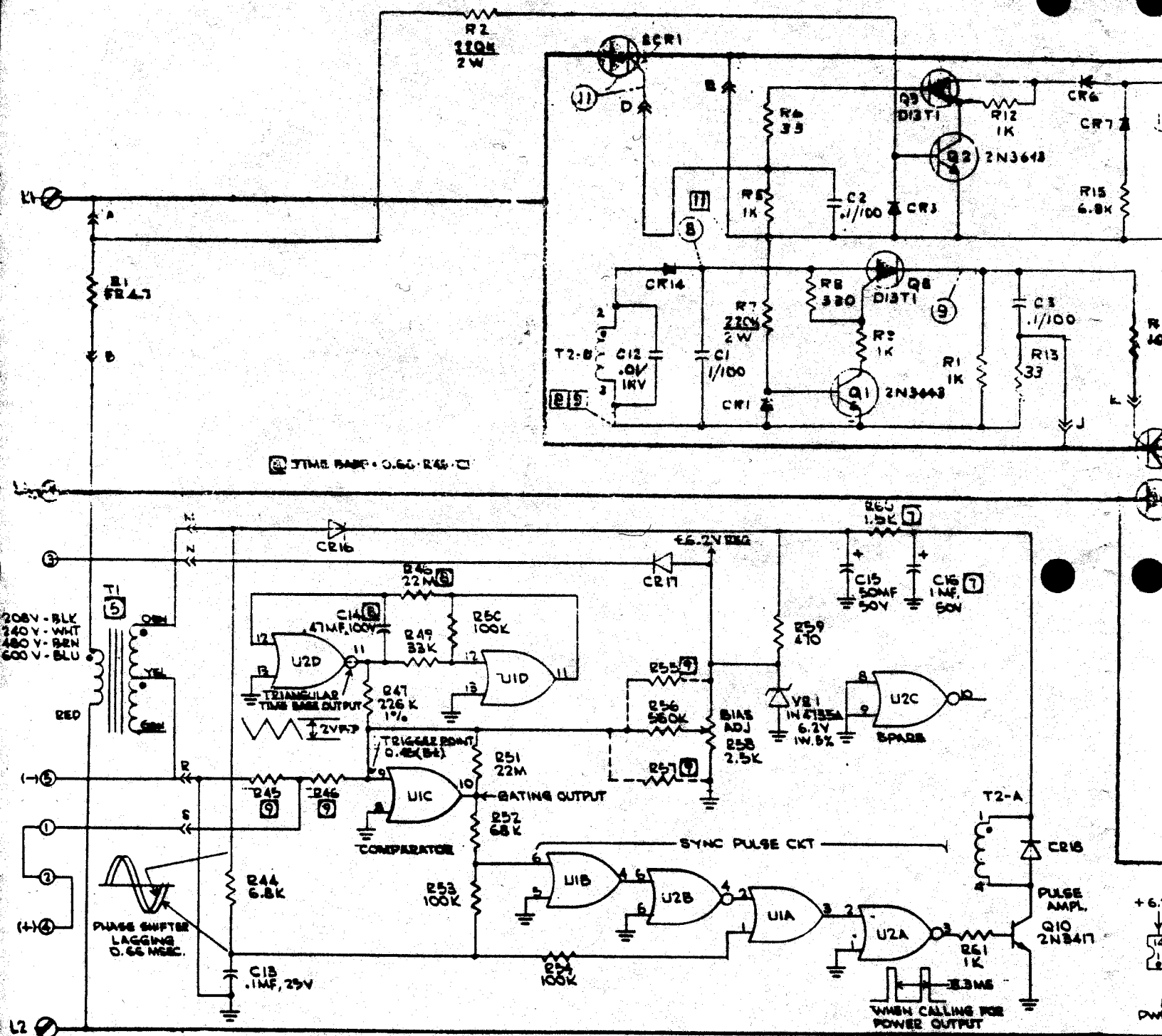
SCHEMATIC DIAGRAM
BPAC-3 (FOR SN 21800 & UP)

UNLESS OTHERWISE SPECIFIED
FRACTIONS = 1/32
DECIMALS = .015
ANGLES = 2°
HOLE DIA = .005

DRAWN BY [illegible] 9-12-69
CHECKED BY [illegible] 6-1-70
APPROVED BY [illegible] 7-1-70

SIZE NONE
DRAWING NO. 02-0163
REV T
SHEET 1 OF 1

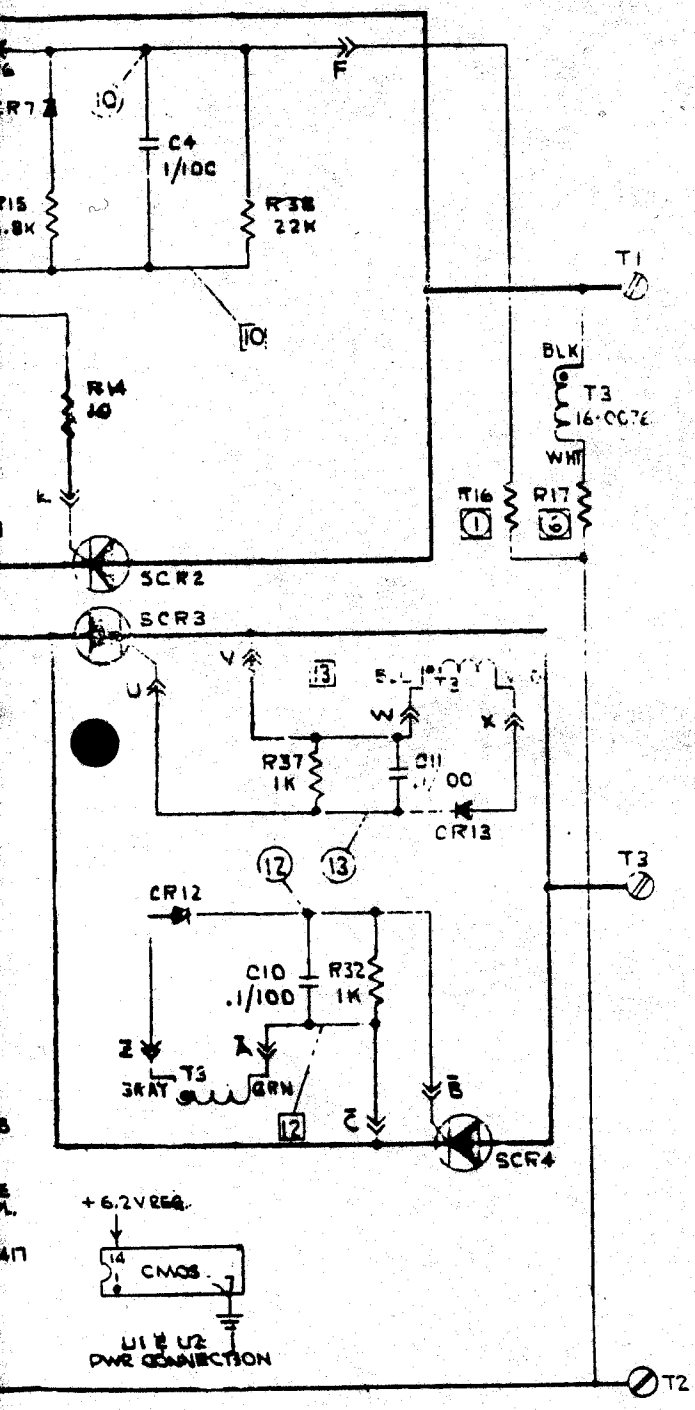
NEXT ASSY



[6] R 7; 208/240V, 56, 10W; 480V, 10K/10W; 600V, 12K/10W.
[5] T1 TO BE 16-0083 FOR 208/240V, 16-0085 FOR 480V, 16-0086 FOR 600V.
4. ALL RESISTORS ARE ½W EXCEPT R1, FUSIBLE
3. ALL DIODES ARE 18-1035.
2. LAST USED REF DESIG; R61, C18, CR18, SCR4, Q10
[1] R16; 208/240V, 50K/25W; 480V, 100K/25W; 600V, 100K/25W
NOTES: UNLESS OTHERWISE INDICATED.

[7] MINIMUM WITH ... GATE DRIVE CURRENT ... R6C TO 680 OHMS ... INCREASED ...

REVISIONS				
SHEET	LTR	DESCRIPTION	DATE	APPROVED



INPUT RANGE - VALUES						
RANGE	E_{IN}	E46 (R_{GN})	E45 (R_{BK})	R56	R57	R55
250 SLIDE WIRE 0-5V	22K	560K	22K	560K	—	—
0-16V	1K	1.8M	1K	560K	—	—
3-10V	22K	820K	22K	560K	560K	—
5-7V	22K	270K	22K	560K	80K	—
5-16V	22K	560K	22K	560K	330K	—
6-9V	22K	330K	22K	560K	220K	—
0-5MA	1K	560K	1K	560K	—	—
1-5MA	1K	430K	1K	560K	—	—
3-7MA	1.5K	1.6M	1.5K	560K	—	—
4-20MA	270	470K	270	560K	—	—
4-20MA	1K	1.8M	1K	560K	—	—

02-0460

LEGEND FOR BENCH TEST
- SCR# REFERENCE GND.
- PROBE REFERENCE

QTY	REF DESIG	PART NUMBER	DESCRIPTION	ITEM NO.
		FINISH		
		MATERIAL		

Loyola controls inc. FIRST IN SCR POWER CONTROLS

BPAC-3-H, SCHEMATIC (SLO-CYCLE)

UNLESS OTHERWISE SPECIFIED
2 PLACES ± .030
3 PLACES ± .010
ANGLES ± 2°

DRAWN BY Hallett DATE 2/MAY/76
CHECKED BY DATE
APPROVED BY DATE

SCALE NONE
DRAWING NO. 02-0460 REV
SHEET OF

NEXT ASSY