The Citation Sixteen

Professional Stereophonic Power Amplifier

Technical Manual

WARNING

These technical instructions are for use by qualified service personnel only. To avoid electric shock, do not perform any servicing other than that contained in the operating instructions unless qualified to do so.

harman/kardon

CITATION SIXTEEN SPECIFICATIONS

POWER OUTPUT:	**150 WATTS MIN. RMS PER CHANNEL, BOTH CHANNELS DRIVEN INTO 8 OHMS FROM 20Hz to 20kHz, WITH LESS THAN 0.05% THD**
Power Bandwidth:	From 0.5Hz to 110kHz at less than 0.1% THD into 8 ohms, both channels driven simultaneously at 75 watts per channel
Frequency Response:	From 0.5Hz to 120kHz, both channels driven simultaneously at 1 watt per channel, into 8 ohms
Square Wave Rise Time:	Better than 3 microseconds
Slew Rate:	Greater than 30V/μsec
Total Harmonic Distortion:	Less than 0.05% from 1 watt to 150 watts RMS, both channels driven simultaneously into 8 ohms from 0.5Hz to 20kHz
Intermodulation Distortion:	Less than 0.05% at from 0.015 watts to 150 watts
Hum and Noise:	Better than 100dB below 150 watts
Damping Factor:	300:1
Input Impedance:	22k ohms
Input Sensitivity:	1.25 volts for 150 watts
Phase Shift:	Less than 0.5 degrees at 20Hz, less than 12 degrees at 20kHz
Inputs:	One RCA type input terminal per channel
Outputs:	Instrument type binding posts. Accepts speakers from 4 to 16 ohms
Dimensions:	9 1/8" H x 19 1/8" W x 13 9/16" D (complete with metal cage) (23.2 cm H x 48.6 cm W x 34.4 cm D)
Weight:	55 pounds

TECHNICAL DESCRIPTION

CHASSIS WIRING

a. The chassis is twin powered and contains two independent power supplies. Each supply delivers two voltages, ±60VDC to power the output stages and driver boards and ±12VDC for the LED displays.

b. There are two heat sink assemblies, and each one consists of eight TO-3 power output transistors (Q13, 14, 15, 17, 18, 19, 20, 21), two TO-3 drivers (Q11, 12), and one V_{BE} multiplier (Q16). The 0.5 ohm, 5 watt emitter resistors are provided to improve current sharing between the transistors, and R35 is added to complement R34 in the measurement of output current in the current foldback circuit.

c. Output network L1, C1, R1, R2 provides the shaping required for good square wave response. L1 is a large air core inductor which isolates the feedback circuit from the effects of capacitive loads at high frequencies and which passes the output current with little loss and does not contribute to distortion, as is the case with iron core toroids.

d. Switches SW2 and SW3 are also mounted on the chassis. They provide the switching functions for the LED display, their function is explained in Section 3 (LED Display).

DRIVER BOARD

The driver board provides circuits for gain and drive and also includes circuitry used in current foldback which protects the amplifier from damage due to short circuits and overloads at the output.

The drive circuit is distinguished by its symmetry. Note that Q1 driving the upper half and Q2 driving the lower half are both connected to the I.C. output. These are class A stages each biased at about 1 m.a., but they are complementary in that Q1 is NPN and Q2 is PNP. Thus, when the I.C. output rises, Q1 collector current increases but Q2 collector current decreases by about the same amount. This change is amplified through Q5 and Q9 for the top and Q6, Q10 for the bottom. The important end result of this is that the upper and lower circuits are symmetrical and complementary. This differs from circuits employing a single class A driver with its associated load resistance, which is either a resistor or a transistor current source. For large output swings the single class A driver has no trouble in pulling the output down because it can be turned on hard and can sink the base current of the large drivers as well as any capacitor currents. Getting the output to rise is another matter, however, and the single class A driver can't handle it very well. The best it can do is to turn off and allow the rise from full negative to full positive to be controlled by the time constant of the load resistor and the circuit capacity. As an example, if Q5 were to be replaced by the conventional load resistor or current source, the rise time would be governed by the time to charge the shaping capacitor C21 from 0 volts to approximately +100 volts. As it is, Q5 acts the same as Q6 and actively pulls the output up. It is for this reason that the Citation 16 can slew at 30V/μsec as compared to the 8 or 10V/μsec rates of other amplifiers.

Slew rate is an important parameter because it determines the length of time that an amplifier is in saturation when it experiences a step voltage at the input. Note that the true input to the amplifier is not the input signal alone, but is the difference between the input signal and the fed back voltage from the output. This would be the voltage from Pin 9 to Pin 8 on IC1 and is called the error voltage. It is the error voltage that drives the amplifier. If the preamplifier which is connected to the Citation 16 delivers a full-scale step input with a 1μsec rise time (which it can do), and the power amplifier output can only slew at 8V/μsec, the output rise time would be 12.5μsec for full output. Amplifiers go into saturation when the error voltage exceeds a few millivolts, thus the unit would be saturated for approximately 11μsec while the output was trying to catch up to the input. With a 30V/μsec slew rate this time is reduced to about 2μsec. For step inputs that are less than full-scale the performance improves and at a one-half full-scale input the output follows the input with no saturation, i.e. with a 50 volt p-p square wave output there is no saturation in the Citation 16.

The circuit has two feedback loops, one is an overall loop that feeds the output back to the input via R7 and R8, and sets the input sensitivity at 1.25 volts. R7 and R8 are metal film resistors because composition resistors operating at the Citation 16 output level are non-linear and result in unacceptable levels of distortion. There is also an inner loop from the output back to Q1 and Q5. The upper half gain is controlled by R22 and R12, while the lower half is controlled by R23 and R13. This gain is set for approximately 20 which establishes a 5 volt p-p level at the I.C. output for full power. Q5 and Q6 are the high gain elements in this loop, and require about 50mV p-p for the 100 volt p-p maximum output. The loop is shaped by capacitor C21 which provides a corner frequency at about 8kHz.

In addition to providing the balanced input stage that assures a low offset at the output, the I.C. also augments the loop gain by a factor of at least 6500. Because some offset is possible, a null adjustment is provided by pot VR1. R3, a precision resistor is included to provide for bridge mode operation, which is discussed later.

Transistors Q3, Q4, Q7, Q8 are used in the current foldback protective scheme. The circuit is designed so that the amplifier will deliver the 11.1 ampere peak current required for a 250 watt output at 4 ohm load, but delivers progressively less current as the load impedance is reduced from 4 ohms to zero ohms at which impedance the current is limited to approximately 8 amperes. This limiting is accomplished by Q7 and Q8 which pull base current from Q9 and Q10. Q3 and Q4 are auxiliary limiters to protect Q5 and Q6. If they were not in the circuit Q5 and Q6 would overdissipate when Q7 and Q8 were driven into saturation.

LED BOARD

The LED circuit is a peak reading device that provides a visual indication of the output level. The circuit, with SW2 the load impedance switch in the 4 ohm position, gives a true indication for 4 ohm loads and has a full-scale range of 4 watts. As shown in the diagram, there are 8 lamps which will all be on for a 4 watt output level. As the level drops the lamps turn off in sequence until the lowest lamp is lit for a power level 30dB below full-scale.

The addition of R4 provides an input divider which permits the circuit to be used for 8 ohm loads. This divider is necessary because it takes more voltage to deliver 4 watts to 8 ohms than to 4 ohms. The 2-position impedance selector switch SW2 on the front panel is used to switch R4 in or out. Operating voltages and levels are shown on the following table:

dB Level	Lamp Color	Power Level (Watts)	Peak Volts 4 Ohms	Peak Volts 8 Ohms
0	Red	4.	5.65	8.
–3	Red	2.	4.00	5.65
–6	Yellow	1.	2.82	4.00
–9	Yellow	.5	2.00	2.82
–12	Green	.25	1.414	2.00
–18	Green	.0625	.707	1.00
–24	Green	.0156	.354	.500
–30	Green	.0039	.177	.250

Circuit operation is based on breaking down the base emitter diode of transistors Q2–Q9. This requires that approximately 1.1 volts be developed at all bases except Q6 which requires 0.5 volts. This is because Q6 is a single transistor and all the rest are Darlingtons'. In its simplest form, the amplifier output would be connected to the bus that ties resistors R9, 10, 11, 12 and 13 together. R9 and R7 would divide 5.65 volts down to 1.1 volts, R10 and R18 would divide 4.00 volts down to 1.1 volts, etc.

The difficulty with this is that the lamps have a dim glow because they only light for the peak of the sine wave. Thus, it is necessary to provide Q1, R3, and C1 for peak detection and elimination of lamp flicker. It is also obvious that the low level lamp drivers could not be broken down by the low voltages equivalent to –18, –24, and –30dB. For this reason, IC1 was added to provide a gain of 10 to these devices. The range selector switch SW3 mounted on the front panel provides for full-scale inputs of 4 watts, 16 watts, 64 watts, and 160 watts.

BRIDGE MODE

CAUTION

To prevent electric shock and for continued protection against fire hazard the "bridge mode" modifications must be made by qualified service personnel.

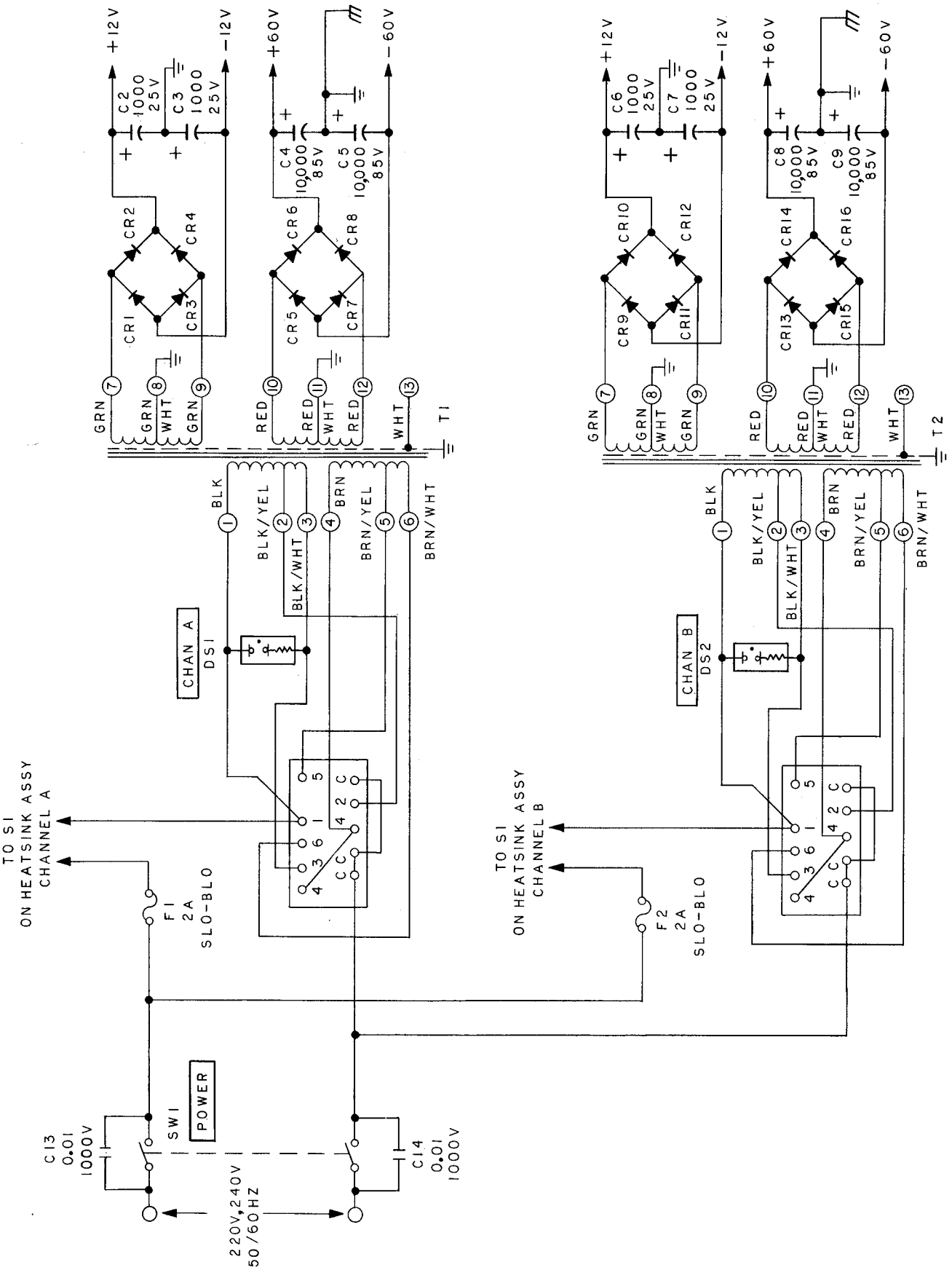
In the bridge mode, Channel A (left) is driven by the input signal and operates in the conventional way, i.e. it has a gain of +28 so that a 1.25 volt input produces a 35 volt output that is in phase with the input. Channel B (right) is configured differently, however. The gain of this channel is changed to –1 so that a 35 volt input produces an output of 35 volts that is 180° out of phase with the input. If the output of Channel A is fed to the input of the modified Channel B we have the desired result for bridge operation – two outputs that are equal in amplitude but opposite in phase. The mode of operation is established by the location of two patching cables.

There is a short cable that patches points on the Channel B driver board; this is called "the short jumper." There is a longer jumper that patches from Channel A driver to Channel B driver board; this is called "the long jumper." Jumper information for the two modes of operation is, as follows:

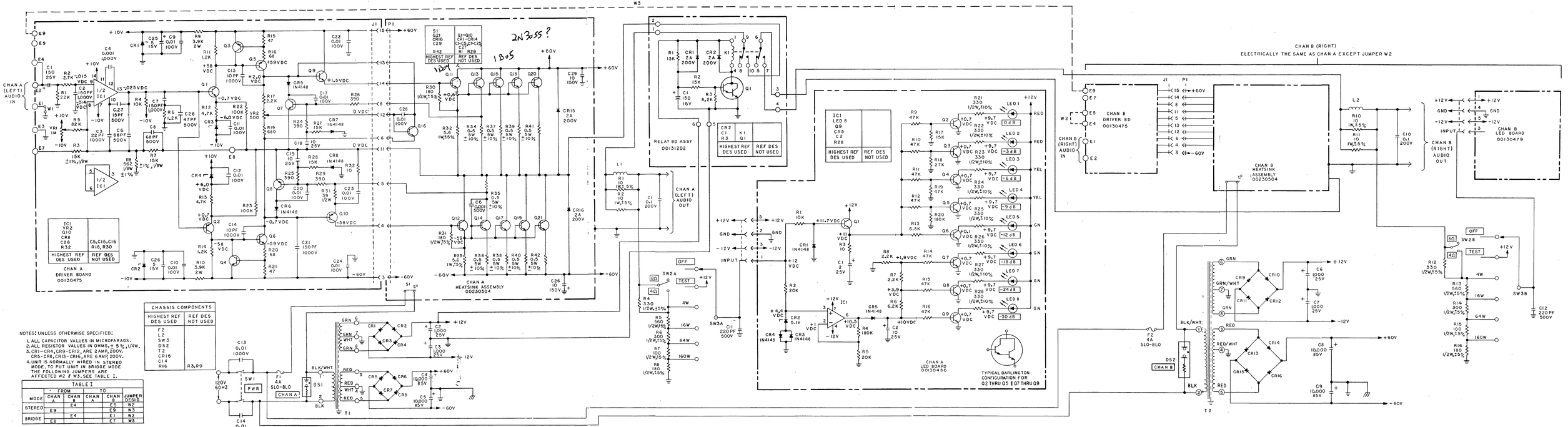
MODE	SHORT JUMPER	LONG JUMPER
Stereo	E4 to E5	E9 on Channel A to E9 on Channel B
Bridge	E4 to E1	E8 on Channel A to E7 on Channel B

For bridge mode the signal is to be connected to the left input.

MULTI VOLTAGE SCHEMATIC DIAGRAM



REGULAR VOLTAGE SCHEMATIC DIAGRAM



IC1 VR2 Q10 CR8 C28 R32	C5,C15,C16 R18,R30
HIGHEST REF DES USED	REF DES NOT USED

S1 C21 CR16 C29 R42	Q1-Q10 CR1-CR14 C1-C3,C9-C25 C27 R1 R29
HIGHEST REF DES USED	REF DES NOT USED

CR2 C1 R3	K1 Q1
HIGHEST REF DES USED	REF DES NOT USED

IC1 LED 8 Q9 CR5 C2 R28	
HIGHEST REF DES USED	REF DES NOT USED

CHASSIS COMPONENTS	
HIGHEST REF DES USED	REF DES NOT USED
F2 L2 SW3 DS2 T2 CR16 C14 R16	R3,R9

NOTES: UNLESS OTHERWISE SPECIFIED:

1. ALL CAPACITOR VALUES IN MICROFARADS.
2. ALL RESISTOR VALUES IN OHMS, ± 5%, 1/4W.
3. CR1-CR4, CR9-CR12 ARE 2AMP, 200V. CR5-CR8, CR13-CR16, ARE 6 AMP, 200V.
4. UNIT IS NORMALLY WIRED IN STEREO MODE. TO PUT UNIT IN BRIDGE MODE THE FOLLOWING JUMPERS ARE AFFECTED W2 & W3. SEE TABLE I.

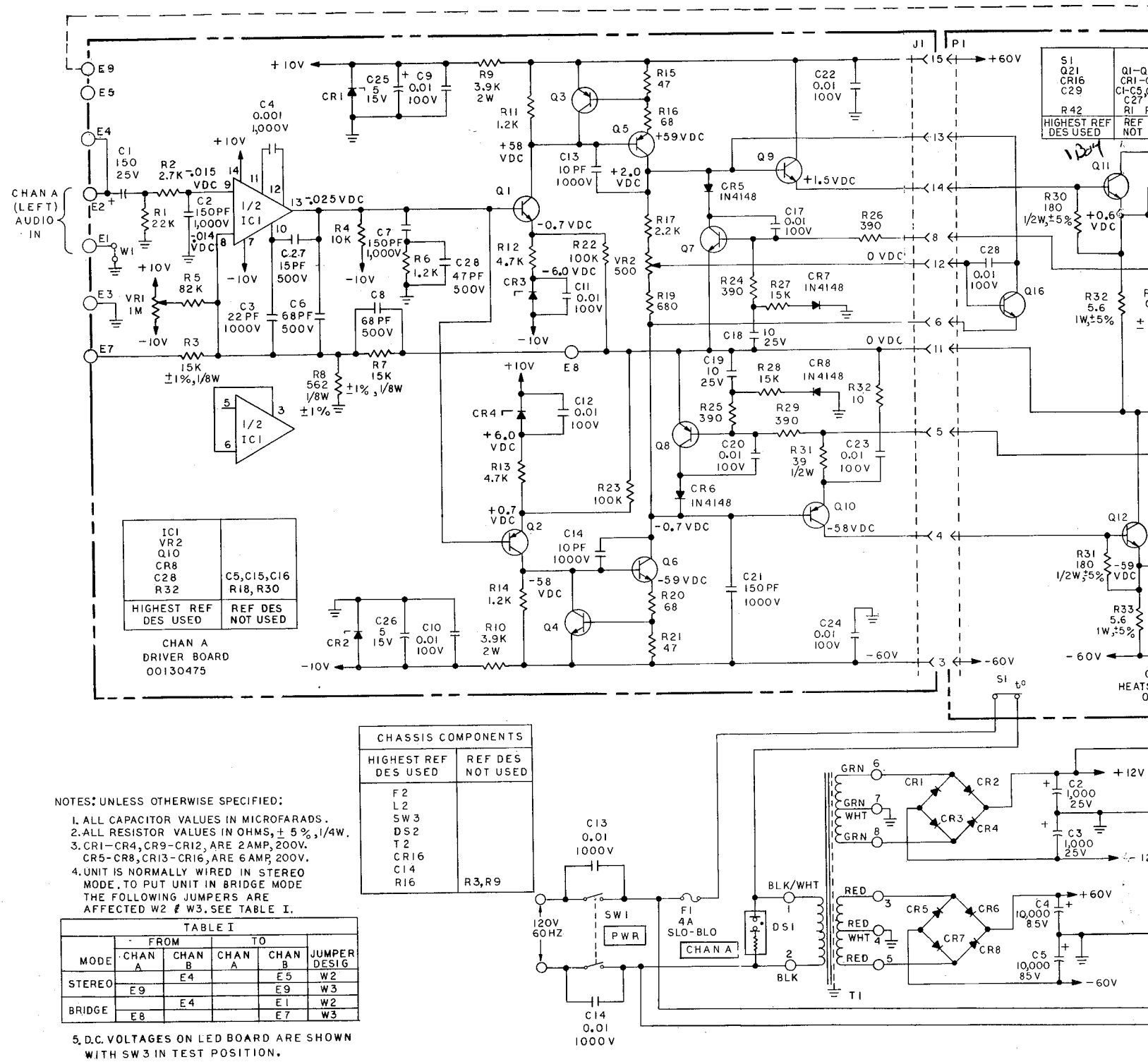
TABLE I

MODE	FROM CHAN A	FROM CHAN B	TO CHAN A	TO CHAN B	JUMPER DESIG.
STEREO	E9			E5	W2
				E9	W3
BRIDGE		E4		E1	W2
	E8			E7	W3

5. D.C. VOLTAGES ON LED BOARD ARE SHOWN WITH SW3 IN TEST POSITION.

CAUTION: WHEN ORDERING PARTS REFER TO PARTS LIST FOR H/K PART NO. IF NOT AVAILABLE USE REF DES AND ASSEMBLY USED ON. IE CR1 CHAN A DRIVER BOARD CR1 CHASSIS CR1 CHAN A LED BOARD

REGULAR VOLTAGE SCHEMATIC DIAGRAM



CHASSIS COMPONENTS	
HIGHEST REF DES USED	REF DES NOT USED
F2	
L2	
SW3	
DS2	
T2	
CR16	
C14	
R16	R3,R9

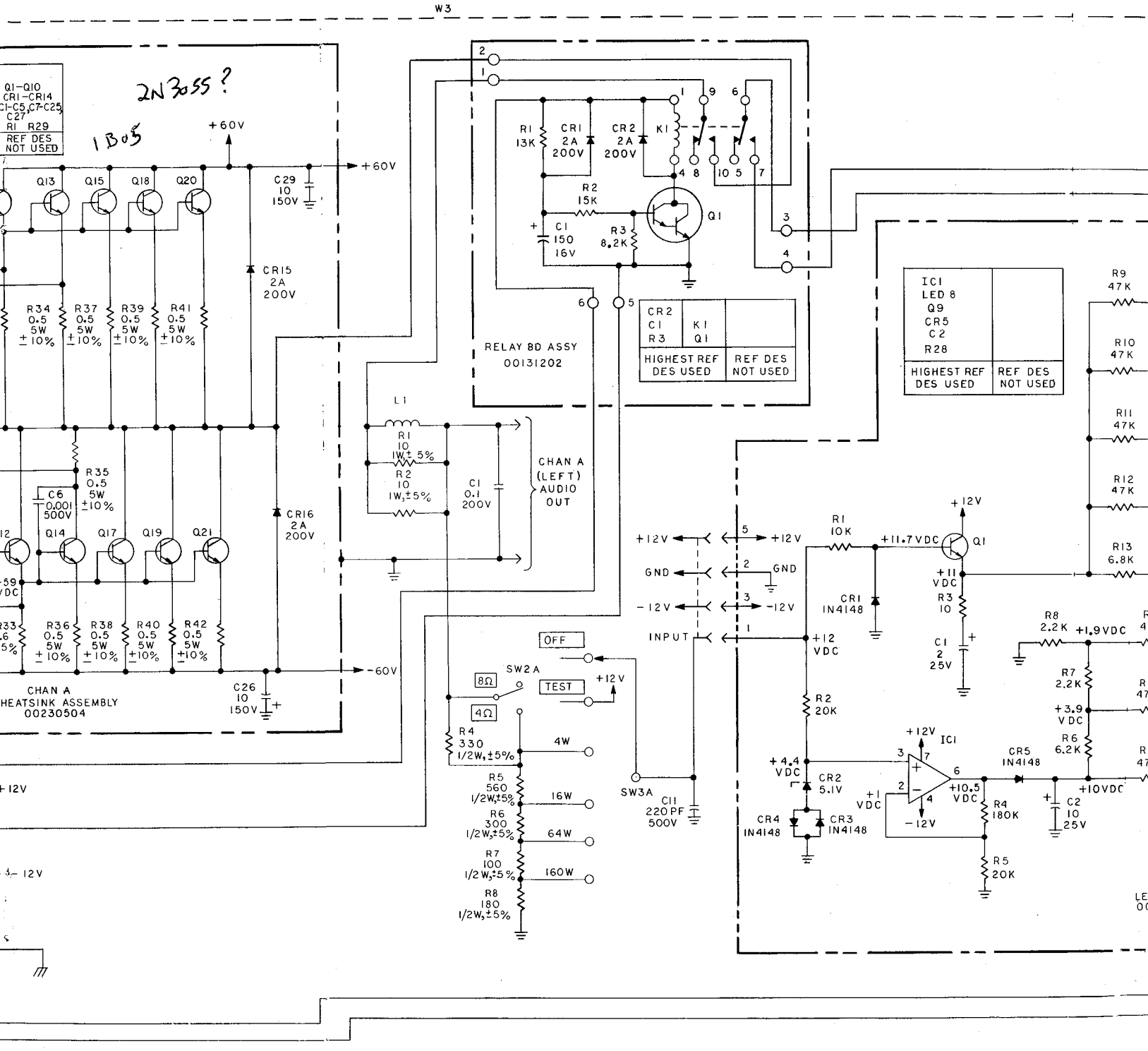
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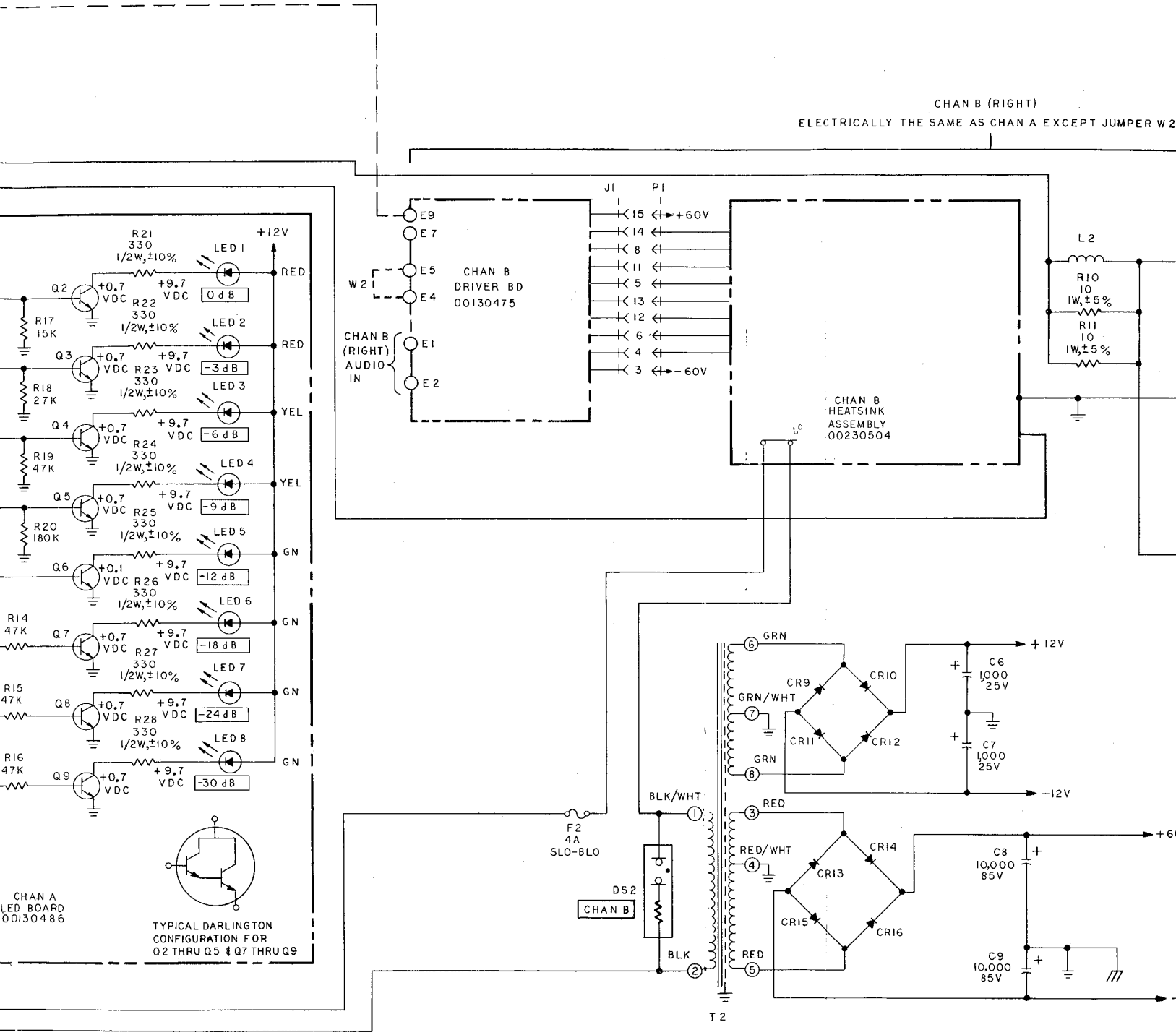
TABLE I

MODE	FROM CHAN A	FROM CHAN B	TO CHAN A	TO CHAN B	JUMPER DESIG
STEREO	E9	E4		E5	W2
				E9	W3
BRIDGE	E8	E4		E1	W2
				E7	W3

5. D.C. VOLTAGES ON LED BOARD ARE SHOWN WITH SW3 IN TEST POSITION.



CAUTION: WHEN ORDERING PAR
H/K PART NO. IF NOT
ASSEMBLY USED ON.



RTS REFER TO PARTS LIST FOR
T AVAILABLE USE REF DES AND
. IE CR1 CHAN A DRIVER BOARD
CR1 CHASSIS
CR1 CHAN A LED BOARD

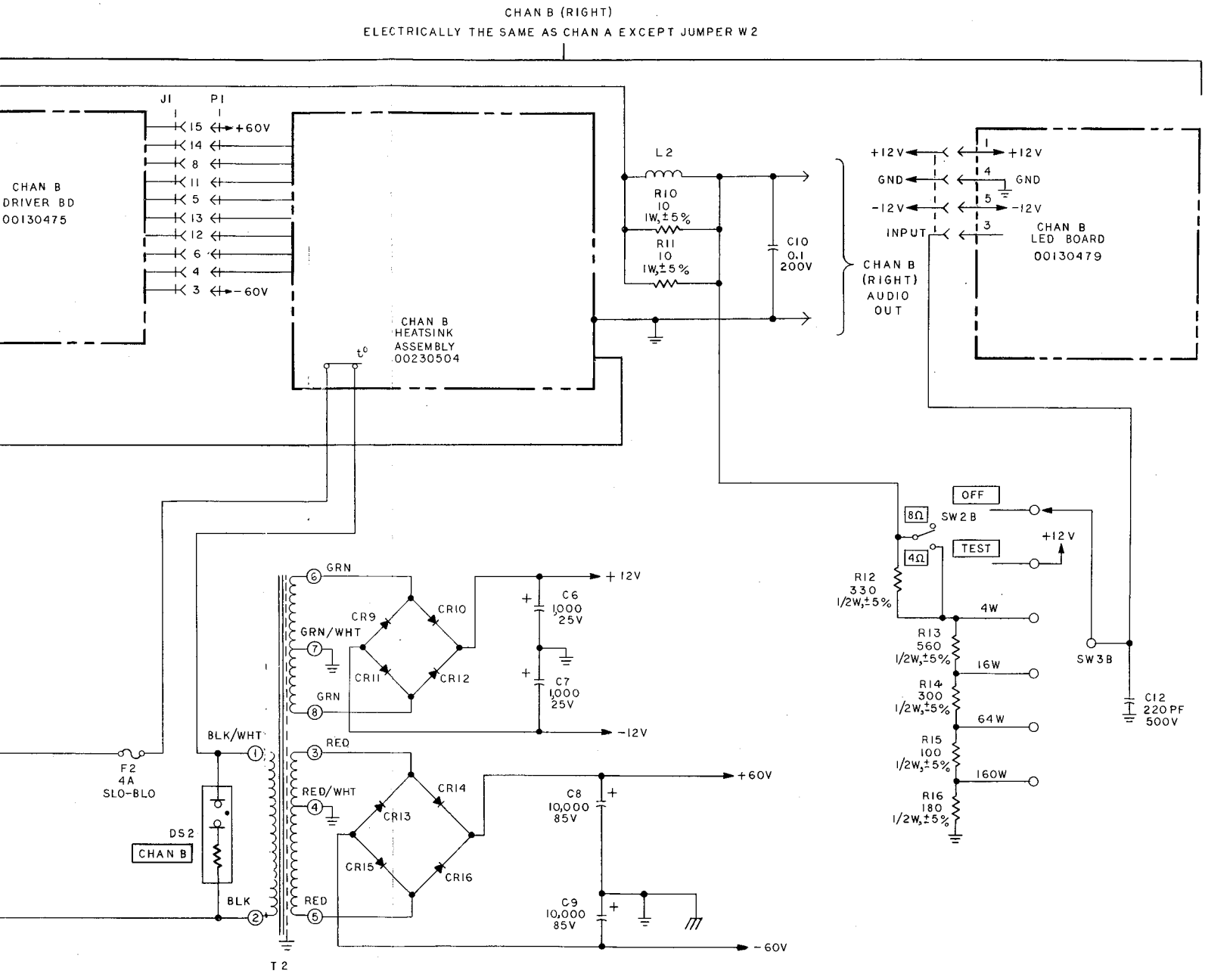
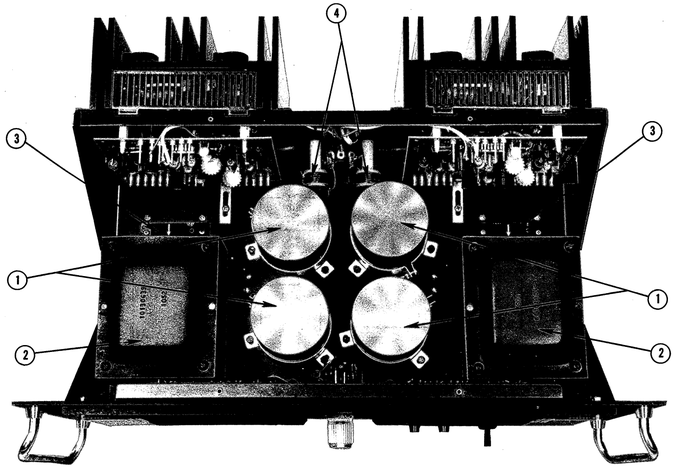

CHAN B (RIGHT)
ELECTRICALLY THE SAME AS CHAN A EXCEPT JUMPER W2
J1
P1
15
14
8
11
5
13
12
6
4
3
+60V
-60V
CHAN B
DRIVER BD
00130475
CHAN B
HEATSINK
ASSEMBLY
00230504
t°
L2
R10
10
1W, ±5%
R11
10
1W, ±5%
C10
0.1
200V
+12V
GND
-12V
INPUT
CHAN B
(RIGHT)
AUDIO
OUT
CHAN B
LED BOARD
00130479
OFF
8Ω
SW2B
4Ω
TEST
+12V
R12
330
1/2W, ±5%
4W
R13
560
1/2W, ±5%
16W
R14
300
1/2W, ±5%
64W
R15
100
1/2W, ±5%
160W
R16
180
1/2W, ±5%
SW3B
C12
220 PF
500V
GRN
GRN/WHT
GRN
CR9
CR10
CR11
CR12
C6
1,000
25V
C7
1,000
25V
+12V
-12V
BLK/WHT
RED
RED/WHT
BLK
RED
CR13
CR14
CR15
CR16
C8
10,000
85V
C9
10,000
85V
+60V
-60V
F2
4A
SLO-BLO
DS2
CHAN B
T2

FIGURE I



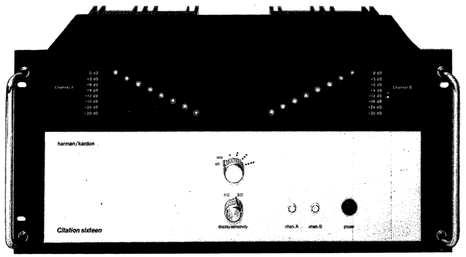
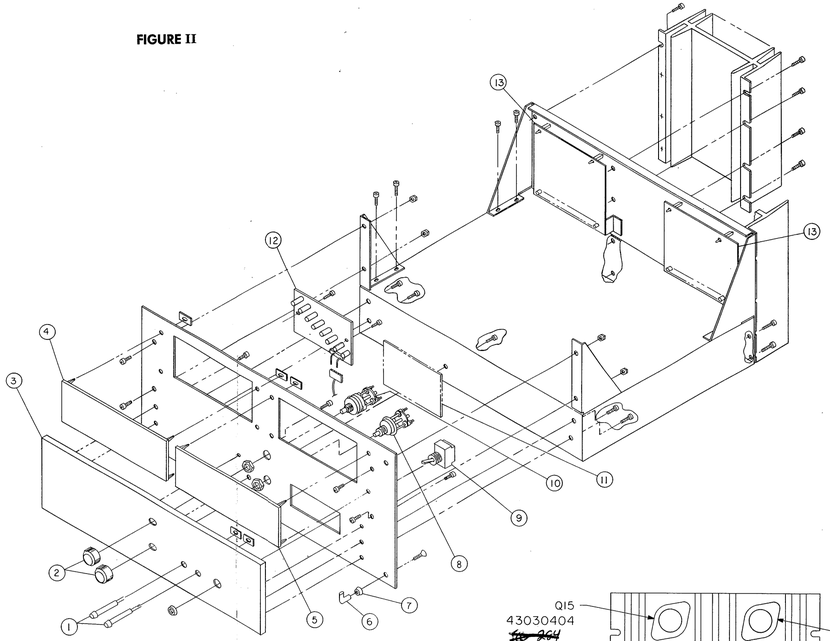
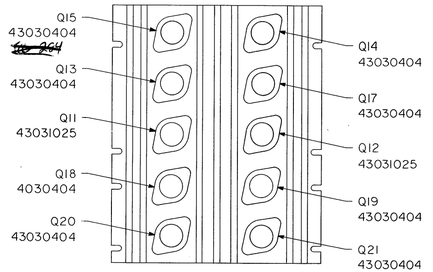


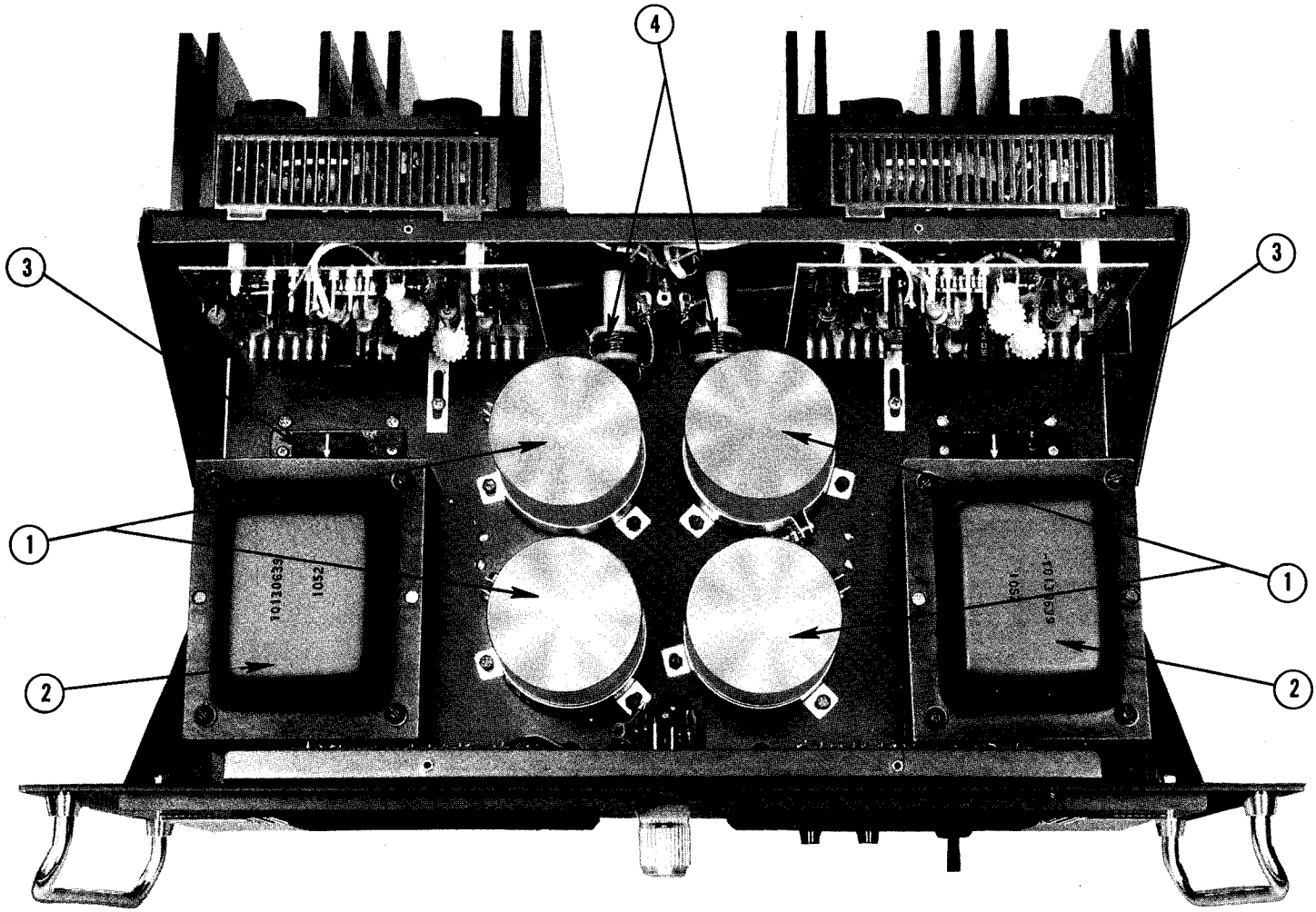
FIGURE II





REAR VIEW
HEATSINK ASSEMBLY 00230504
CHANNEL A OR B

FIGURE I


4
3
3
1
1
2
2

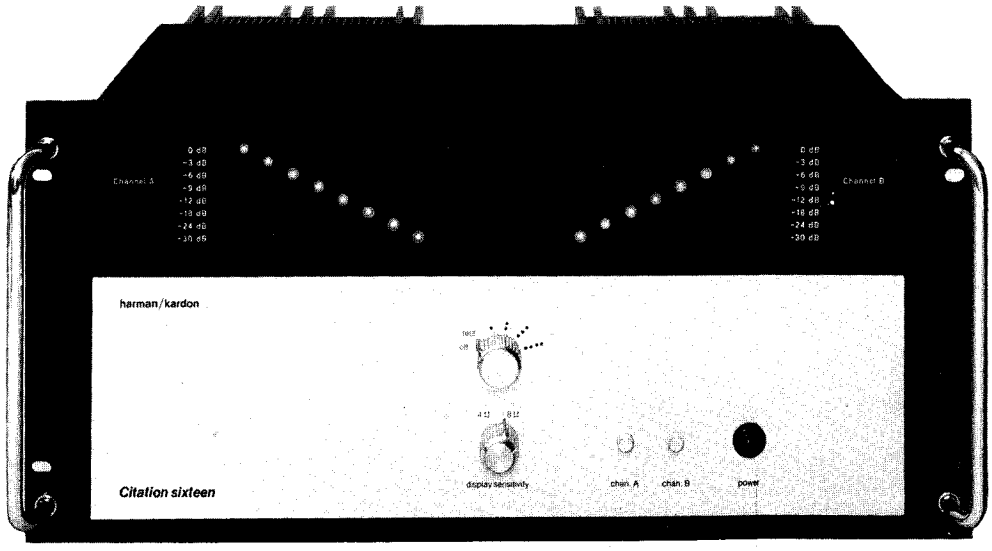
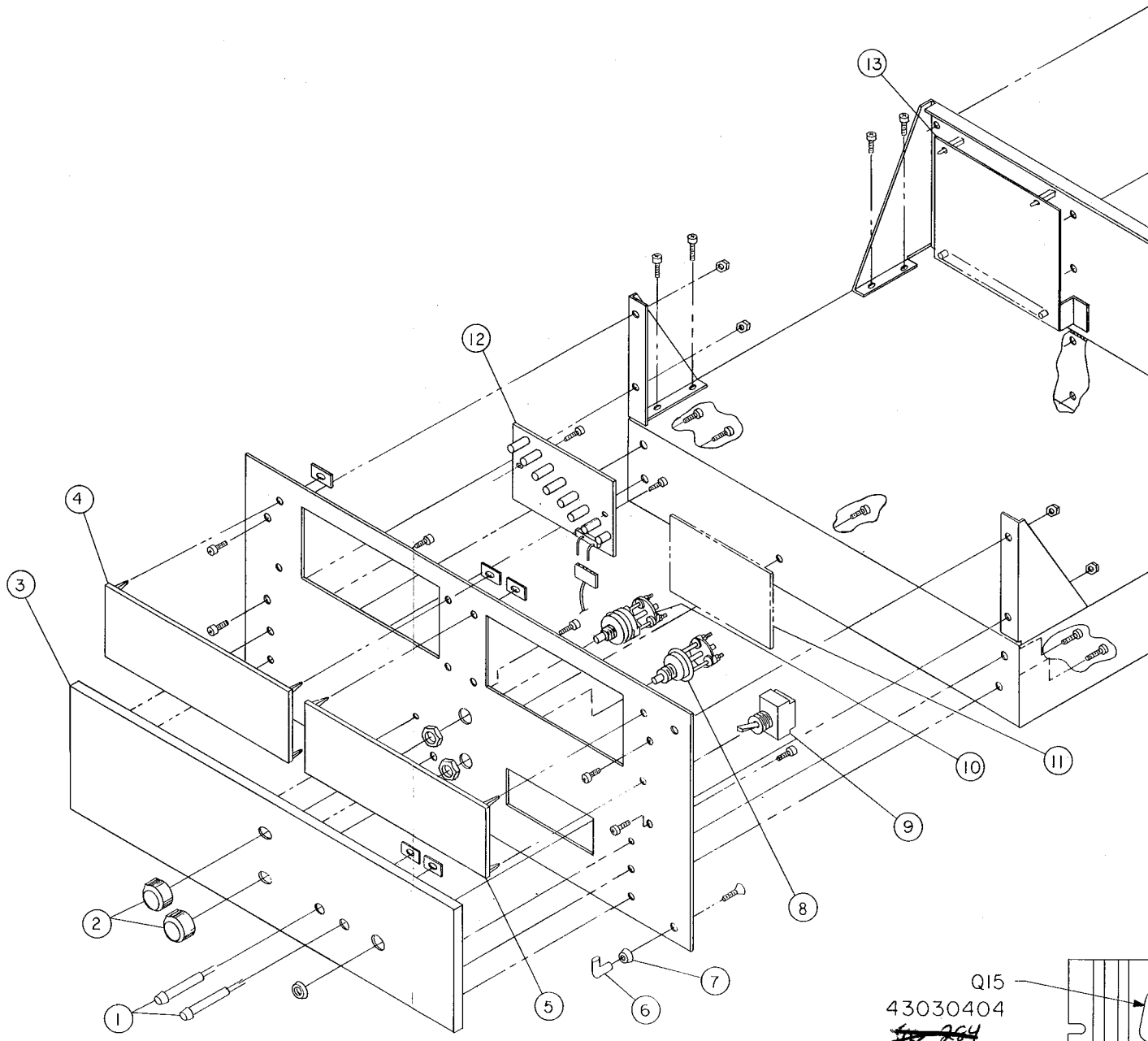
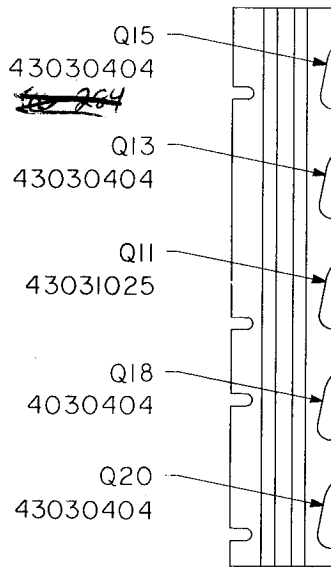
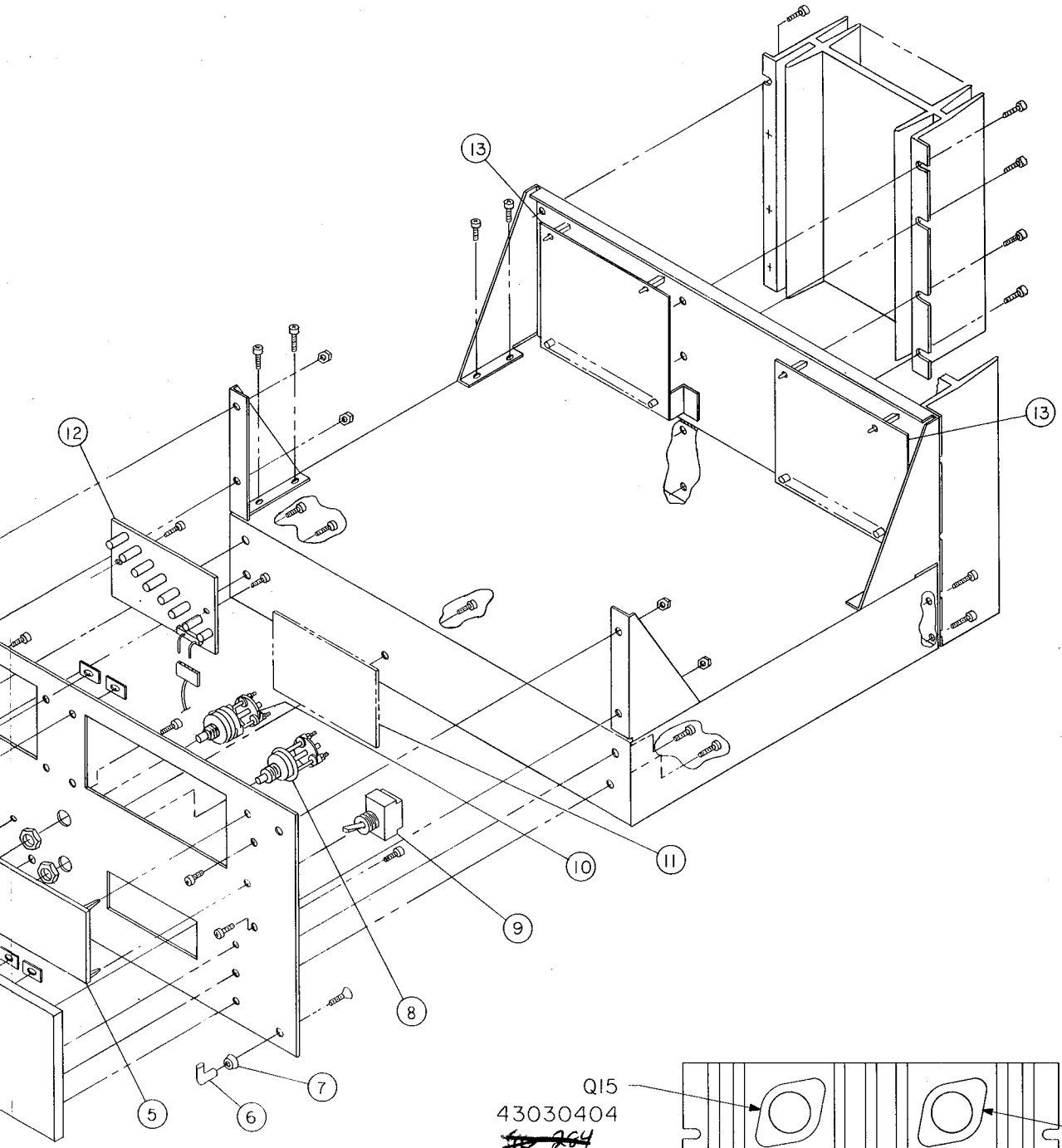

Channel A
Channel B
harman/kardon
Citation sixteen
display sensitivity
chan. A
chan. B
power

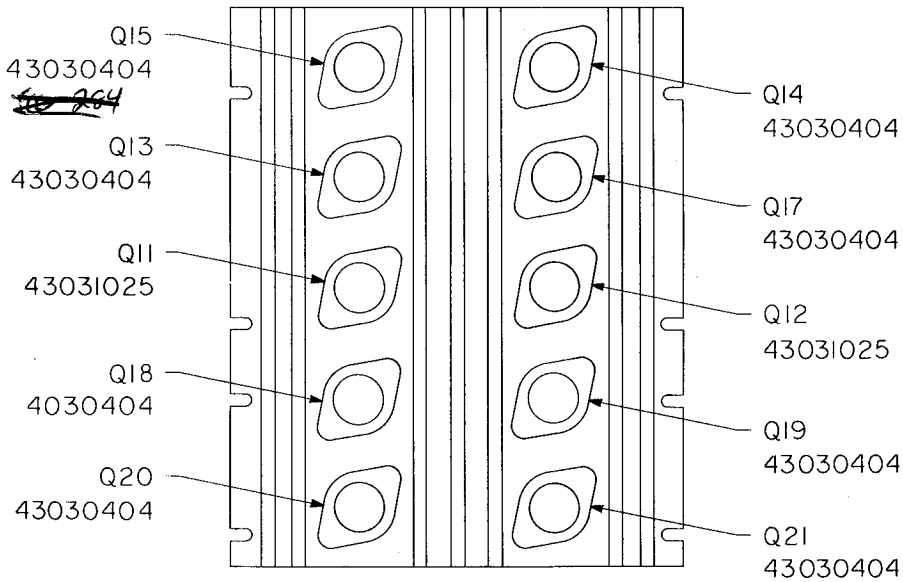
FIGURE II





REAR VIEW
HEATSINK ASSEMBLY 00230504
CHANNEL A OR B





REAR VIEW
HEATSINK ASSEMBLY 00230504
CHANNEL A OR B

MAIN CHASSIS PARTS LIST

FIG. NO.	REF. DES.	H/K PART NO.	DESCRIPTION
I-1	C4,5,8,9	31130322	Capacitor, Lytic, 10000UF, 85V
I-2	T1,2	10130339	Transformer, Power
I-4	L1,2	12030402	Output Inductor
II-1	DS1,2	47626247	Pilot Light Assy. (Neon) Red
II-2		63228028	Knob
II-3		63030453	Panel, Dress
II-4		63030449-1	Panel, LED Dress
II-5		63030449-2	Panel, LED Dress
II-6		62130377	Handle
II-7		62130466	Ferrule, Handle
II-8	SW2	24030338	Switch, Impedance Selector
II-9	SW1	26030342	Switch, Power, DPST
II-10	SW3	24030337	Display Range Sensitivity Switch
II-11		00130479	LED Display, Channel "B" Assy.
II-12		00130486	LED Display, Channel "A" Assy.
II-13		00130475	Driver Board Assy.
Ref.		60129981	Cover, Bottom
Ref.		62029267	Feet, Mtg, 3/4 High
Ref.		60129979	Cover, Wraparound
Ref.	CR5-8,13-16	41630450*	Rectifier, Silicon, MR752
Ref.	CR1-4,9-12	41029089*	Rectifier, Silicon, 2A, 200V
Ref.	C2,3,6,7	31521625	Capacitor, Lytic, 1000UF, 25V
Ref.		65430392	Post, Binding
Ref.		65427001	Fuseholder w/Hardware
Ref.	F1,2	45023101*	Fuse, Slo Blo 4 Amp. (Buss MDX)
Ref.		65430464	Strain Relief (Heyco SR-6N3-4)
Ref.		53030340	Line Cord

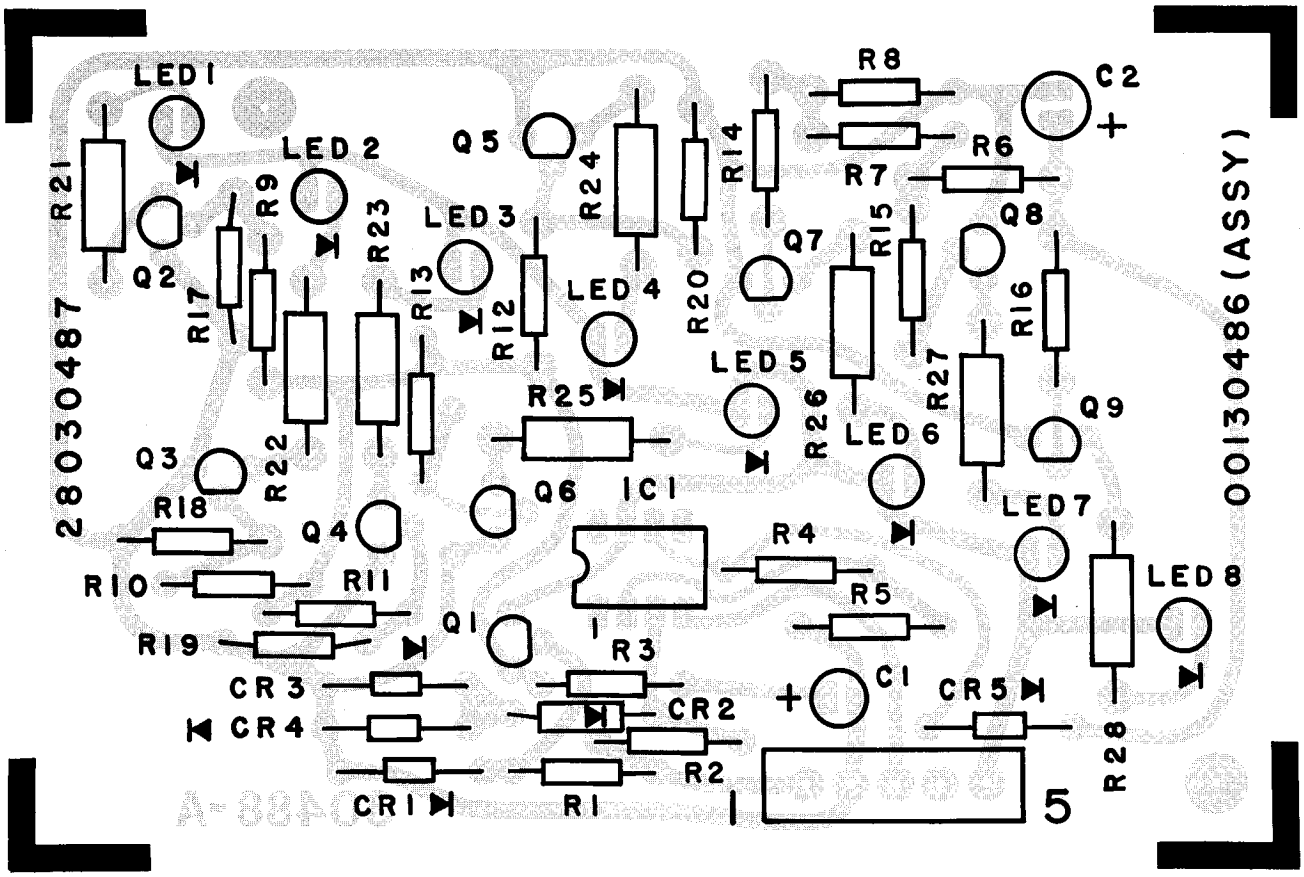
HEATSINK ASSEMBLY

Ref.	Q16	43025972*	Transistor, NPN, GP
Ref.		67029563	Clip, Transistor
Ref.	SW1	45530336	Terminal Cutout
Ref.	C26,29	31530452	Capacitor, 10UF, 150V
Ref.	CR13,14	41029089*	Diode, Silicon, 2A, 200V
Ref.	Q13-15, 17-21	43030404*	Transistor (RCA 1B05)
Ref.	Q13-15, 17-21	43032928*	Transistor (RCA 1B04) Alternate Replacement Part for 43030404
Ref.		66030343	Socket, Transistor TO-3
Ref.		61630380	Cover, Insulating TO-3
Ref.		85520110	Washer, Mica TO-3
Ref.		60130413	Cover, Heatsink
Ref.	Q11,12	43031025*	Transistor

EXPORT

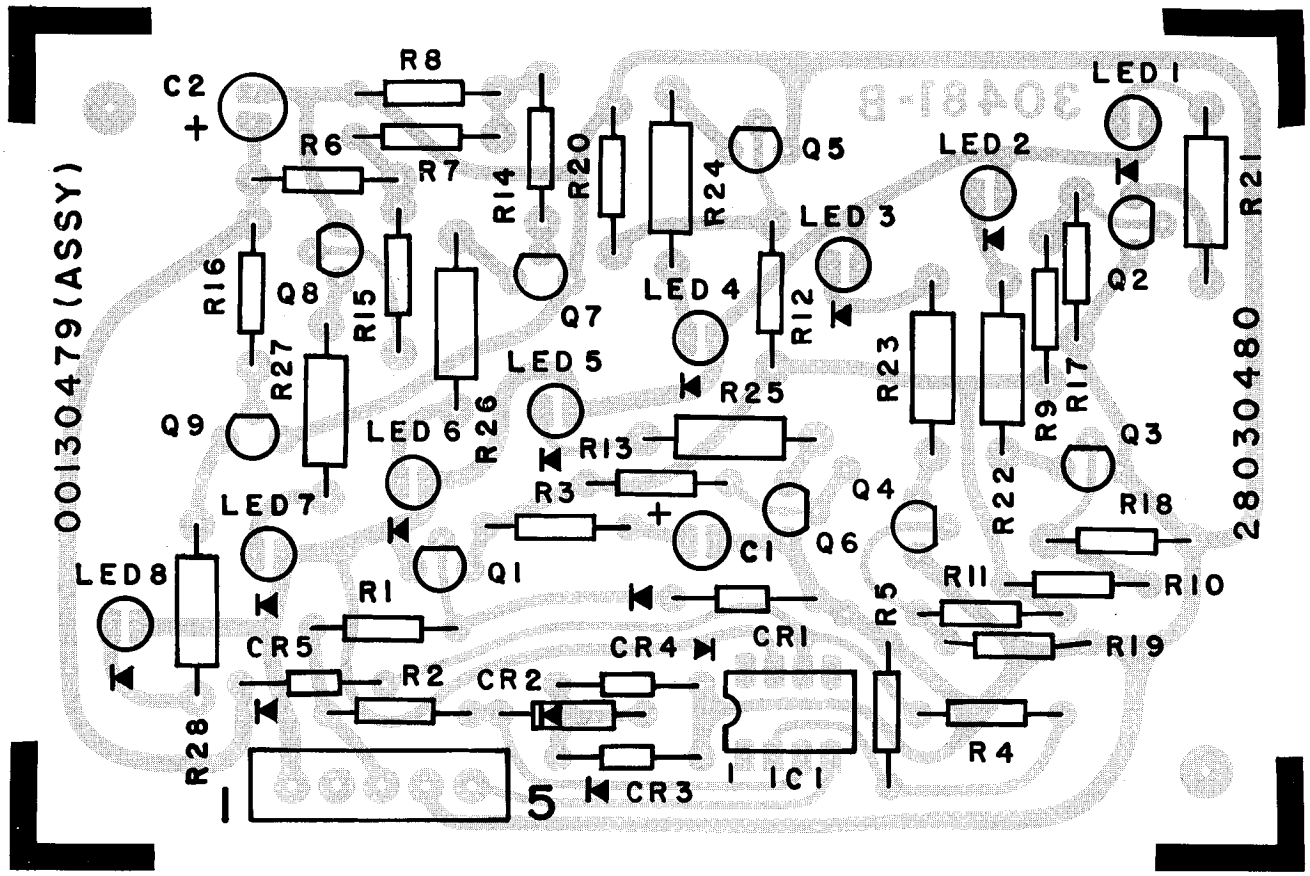
I-2	T1,2	10130639	Transformer, Power
I-3		65427580	Voltage Selector Connector Set
Ref.	F1,2	45022346	Fuse, 2A, Type MDL
Ref.		65430519	Fuseholder

LED BOARD CHANNEL A



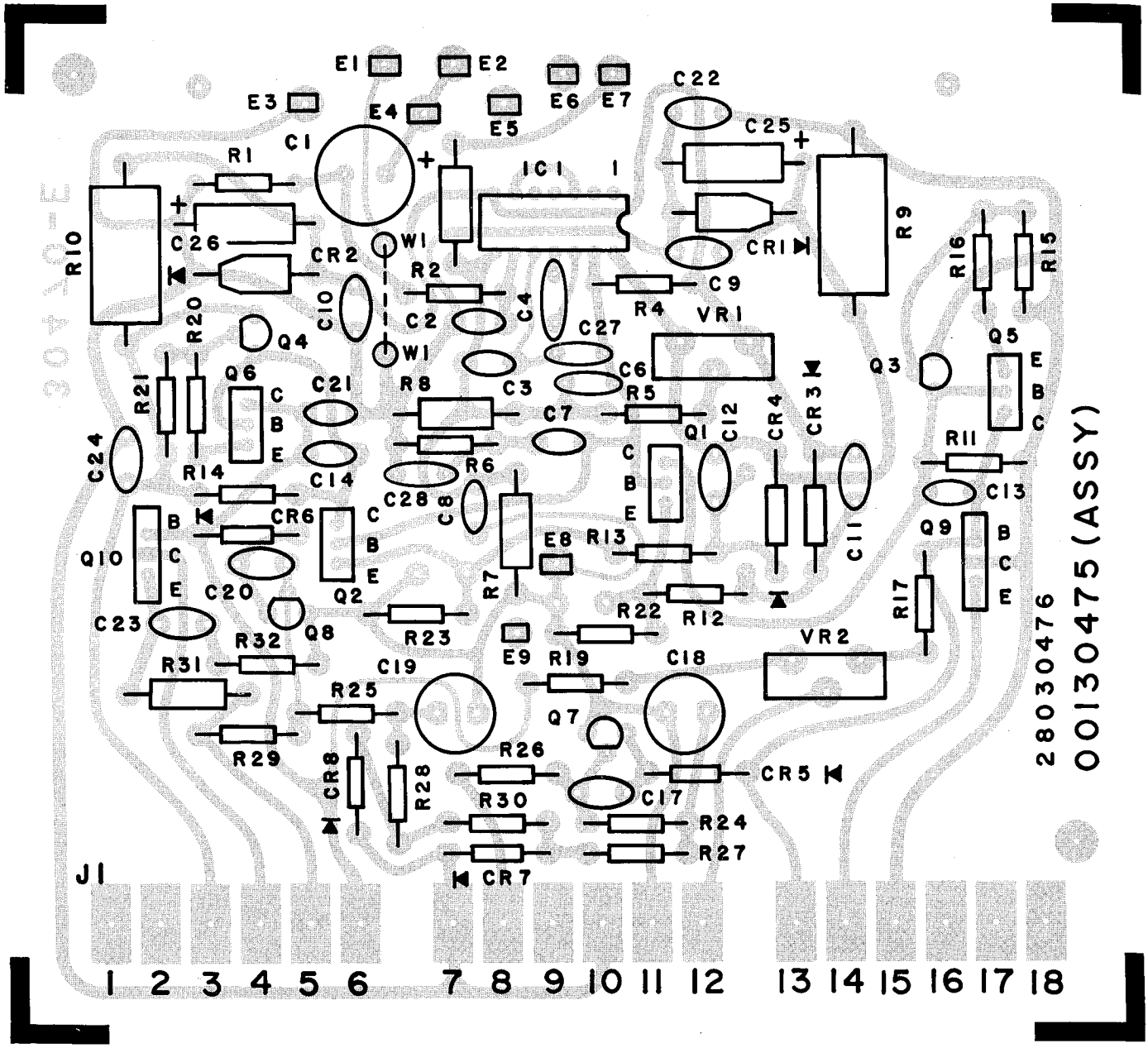
CIRCUIT REF. NO.	H/K PART NO.	DESCRIPTION
	00130486	P.C. Board Assy., Led Display Chan. "A"
CAPACITOR, LYTIC IEC		
C1	31827111	2UF, 35V, PA
C2	31819176	10UF, 25V, PB
DIODE		
CR1,3,4,5	41629897*	IN4148
CR2	42030498*	Zener 5.1V, 0.4W, 10% MOT MZ500-9
INTEGRATED CIRCUIT		
IC1	43130636*	Operational Ampl. MC1741C
TRANSISTOR		
Q1,6	43025972*	NPN GP
Q2-5,7,8,9	43029832*	MPS-A13
LAMP SOLID STATE		
LED1,2	46730574*	LED, Red
LED3,4	46730575*	LED, Yellow
LED5-8	46730576*	LED, Green

LED BOARD CHANNEL B



CIRCUIT REF. NO.	H/K PART NO.	DESCRIPTION
	00130479	P.C. Board Assy., Led Display Chan. "B"
CAPACITOR, LYTIC IEC		
C1	31827111	2UF, 35V, PA
C2	31819176	10UF, 25V, PB
DIODE		
CR1,3,4,5	41629897 *	IN4148
CR2	42030498 *	Zener 5.1V, 0.4W, 10% MOT MZ500-9
INTEGRATED CIRCUIT		
IC1	43130636 *	Operational Ampl. MC1741C
TRANSISTOR		
Q1,6	43025972 *	NPN GP
Q2-5,7,8,9	43029832 *	MPS-A13
LAMP SOLID STATE		
LED1,2	46730574 *	LED, Red
LED3,4	46730575 *	LED, Yellow
LED5-8	46730576 *	LED, Green

DRIVER BOARD CHANNEL A & B



DRIVER BOARD CHANNEL A & B

CIRCUIT REF. NO.	H/K PART NO.	DESCRIPTION
	00130475	P.C. Board Assy., Driver
CAPACITOR, LYTIC IEC		
C1	31830496	150UF, 25V, PJ
C18, C19	31830497	10UF, 25V, PND
C25, C26	31518818	5UF, 15V, TA
DIODE		
CR1, CR2	42020737*	Zener 10V, 1W, 10%
CR3, CR4	42030498*	Zener 5.1V, 0.4W, 10%, MOT MZ500-9
CR5-CR8	41629897*	IN4148
TRANSISTOR		
Q1, Q6	43030406*	NPN MOT MPS U10
Q2, Q5	43030407*	PNP MOT MPS U60
Q3, Q8	43027722*	PNP GP
Q4, Q7	43025972*	NPN GP
Q9	43030408*	NPN MOT MJE340
Q10	43030409*	PNP MOT MJE350
INTEGRATED CIRCUIT		
IC1	43130410*	Operational Ampl. UA739PC
RESISTOR, METAL FILM		
R3, R7	35111533	15KΩ, 1/8W, 1% Type M20D DALE
R8	35130659	56Ω, 1/8W, 1% Type M20D DALE
RESISTOR, VAR PIHER PT15YM		
VR1	21630493	IMΩ
VR2	21629833	500Ω

ALIGNMENT PROCEDURE ADJUSTMENTS

There are only two adjustments, the null pot VR1 and the idling current pot VR2. Both of these adjustments are to be made with no signals and no load. VR1 should be set so that the output of the amplifier is less than ±10 millivolts D.C.

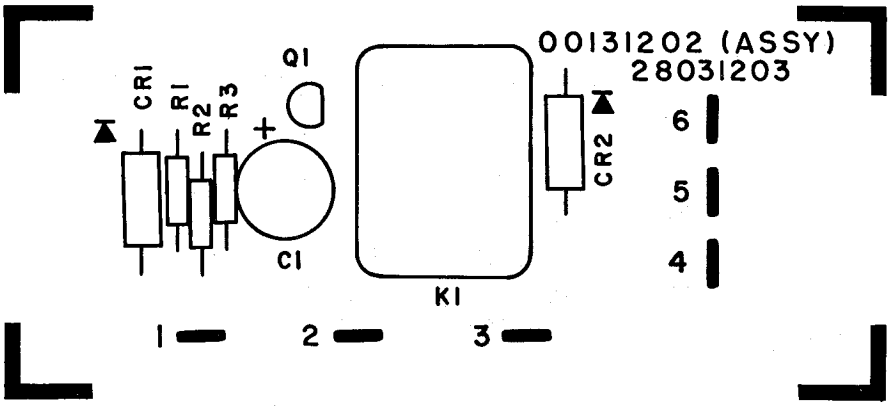
VR2 should be set for about 10 millivolts D.C. across one of the 0.5 ohm emitter resistors when the set is cold.

The easiest way to do this is to put one meter lead on the emitter of the upper left-hand output device on the heat sink and the other lead to the output terminal.

Both adjustments should be finalized after the amplifier has been operating for about 15 minutes with no signal and no load.

RCA 411 - 413 Driver

RELAY BOARD



CIRCUIT REF. NO.	H/K PART NO.	DESCRIPTION
	00131202	P.C. Board Assy. Relay Board
CAPACITOR, LYTIC IEC		
C1	31840006	150UF, 16V
DIODE		
CR1, 2	41029089*	Silicon Pwr. 2A 200V
TRANSISTOR		
Q1	43029832*	MPS-A13
RELAY		
K1	13031208	Potter Brumfield, R10-E2-W2-V185

NOTE TO WARRANTY STATIONS: Items marked with asterisk (*) are recommended spare parts stock. Printed circuit board assembly numbers are shown for reference only. Harman/Kardon does not normally supply assembled printed circuit boards.

NOTE: To speed handling of your order be sure to include both the model and serial numbers, in addition to the quantity, part number and part description of the items ordered. Orders from independent dealers, independent servicemen, and retail customers will be shipped on a cash in advance basis. Harman/Kardon reserves the right to substitute equivalent parts for those originally installed in this chassis. All parts should be ordered from Harman/Kardon, 55 Ames Court, Plainview, L.I., N.Y. 11803, Att: Parts Department.

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