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DUAL CHANNEL
DC AMPLIFIER
MODEL 150-2000
IM-150-2000-1

INSTRUCTION MANUAL

**HEWLETT
PACKARD**



**SANBORN
DIVISION**

SANBORN DUAL CHANNEL DC AMPLIFIER

MODEL 150-2000

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3. OPERATION: GENERAL PROCEDURES

There are three basic procedures in operating the Dual Channel DC Amplifier:

- STARTING: This includes the warmup period and connecting the signal. See paragraph 4.
- CALIBRATION: An accurate recording depends on proper calibration. The standard procedure is given. See paragraph 5.
- OPERATION: After starting and calibrating, the operation is straight-forward. See paragraph 6.

4. OPERATION: STARTING THE DUAL CHANNEL DC AMPLIFIER

1. Set each RANGE switch to OFF and each POWER switch to ON. Allow 5 minutes warmup for best stability.
2. Connect each signal with Amphenol 2-contact plug, Sanborn No. 10B2-1FW. Terminal 1 is the signal terminal, and terminal 2 is ground. Note that the signal source impedance must be small in comparison with 1.15 megohms if the source impedance is to be neglected.

5. OPERATION: CALIBRATING THE DUAL CHANNEL DC AMPLIFIER

1. After warmup, make available an accurately measured d-c calibration voltage between two volts and 200 volts as convenient, from a source having the same impedance as the signals to be recorded, if this impedance is not negligible with respect to 1.15 megohms.
2. Set the RANGE VOLTS/CM switch to approximately half the calibration voltage.
3. Apply the calibration voltage, and adjust the GAIN control for a deflection represented by the formula:

$$\text{Deflection} = \frac{\text{Calibration voltage}}{\text{RANGE setting}}$$

6. OPERATION: RECORDING WITH THE DUAL CHANNEL DC AMPLIFIER

1. After warmup and calibration, set the RANGE switch to OFF and set the stylus base-line with the POSITION control. If the signal has both positive and negative values, set the stylus near mid-scale. If the signal is of one polarity only, set the stylus near one edge of the recording chart.
2. Now turn the RANGE switch to the right until the signal gives a reasonable stylus deflection, and start the Recorder in motion. Set the STYLUS TEMP control for the best definition. Normally a slight increase in temperature improves the definition when recording high frequencies. Writing the RANGE setting and paper speed on the chart avoids confusion when interpreting the record later on.

7. MAINTENANCE: ADJUSTING THE DAMPING CONTROL

This adjustment may be required after extended operation, or after a tube or other component is replaced.

1. Apply a square voltage pulse to the input with a voltage supply, potentiometer, and switch circuit.
2. Adjust the potentiometer and the RANGE switch for one centimeter of deflection when the signal pulse circuit is closed.
3. Adjust the DAMPING control for the best possible square wave on the recording.

11. MAINTENANCE: INDICATOR DATA

<u>Symbol</u>	<u>Type</u>	<u>Function</u>	<u>Sanborn No.</u>
I 2001	NE-51	Indicates that primary power is applied to the Dual Channel DC Amplifier.	30B-1

12. MAINTENANCE: PLUG-IN CAPACITOR DATA

<u>Symbol</u>	<u>Type</u>	<u>Function</u>	<u>Sanborn No.</u>
C2005, A, B, C	20/20/10 Mfd. 450 volt insu- lated can.	Section A: filter for +360 volt plate supply to V2003, V2004. Section B: filter for +360 volt plate supply to V2006, V2007. Section C: not used.	572-217
C2006 A, B, C	20/20/10 Mfd. 450 volt insu- lated can.	Sections A and C: filter for -3.5 volt supply to POSITION controls. Section B: filter for +270 volt plate supply to V2002, V2005.	572-217
C2007 A, B, C	20/20/10 Mfd. 450 volt insu- lated can.	Sections A, B, and C: filter for -270 volt supply to cathode return of V2002, V2005.	572-217

13. MAINTENANCE: SIGNAL CONNECTOR DATA

<u>Description</u>	<u>Sanborn No.</u>
Amphenol 2-contact plug, mates with INPUT socket.	10B2-1FW

14. MAINTENANCE: NAME PLATE LOCATION

In case of maintenance problems beyond the scope of this manual, contact Sanborn Company or your nearest Industrial Representative. Give the serial number on the nameplate of your Dual Channel DC Amplifier. This name plate is on the rear chassis wall, and is visible by opening the rear door of the cabinet.

SANBORN COMPANY
 175 WYMAN STREET
 WALTHAM 54, MASS.
 TEL: TW-4-6300
 MARCH 9, 1960

REPLACEMENT PARTS LIST
 RPL-150-2000-2

SANBORN DUAL CHANNEL DC AMPLIFIER
 MODEL 150-2000

RESISTORS

<u>SYMBOL</u>	<u>VALUE(ohms)</u>	<u>TOL(± %)</u>	<u>WATTS</u>	<u>SANBORN NO.</u>	<u>REMARKS</u>
R2001	1.3K	5	30	53A-132J	Wire Wound
R2002	1.3K	5	30	53A-132J	Wire Wound
R2003	15K	5	1	51D-153J	Composition
R2004	1.2 Meg	5	$\frac{1}{2}$	50A-125J	Composition
R2005	10K	5	$\frac{1}{2}$	50A-103J	Composition
R2006	10K	5	$\frac{1}{2}$	50A-103J	Composition
R2007	1.2 Meg	5	$\frac{1}{2}$	50A-125J	Composition
R2008	1.2 Meg	5	$\frac{1}{2}$	50A-125J	Composition
R2009	12 Meg	5	$\frac{1}{2}$	50A-126J	Composition
R2010	400	5	10	53A-401J	Wire Wound
R2011	400	5	10	53A-401J	Wire Wound
R2012	27K	5	1	51D-273J	Composition
R2013	68K	5	1	51D-683J	Composition
R2014	47K	5	1	51D-473J	Composition
R2015	4.7K	5	$\frac{1}{2}$	50A-472J	Composition
R2016	4.7K	5	$\frac{1}{2}$	50A-472J	Composition
R2017	.1 Meg	5	2	52C-104J	Composition
R2018	1.2 Meg	5	$\frac{1}{2}$	50A-125J	Composition
R2019	10K	5	$\frac{1}{2}$	50A-103J	Composition
R2020	10K	5	$\frac{1}{2}$	50A-103J	Composition
R2021	1.2 Meg	5	$\frac{1}{2}$	50A-125J	Composition
R2022	1.2 Meg	5	$\frac{1}{2}$	50A-125J	Composition

SANBORN DUAL CHANNEL DC AMPLIFIER

MODEL 150-2000

ELECTRICAL PARTS LIST--SCHEMATIC 150-2000-C1 SUB. 5RESISTORS (Cont.)

<u>SYMBOL</u>	<u>VALUE (Ohms)</u>	<u>TOL. (± %)</u>	<u>WATTS</u>	<u>SANBORN NO.</u>	<u>REMARKS</u>
R2023	12 Meg	5	$\frac{1}{2}$	50A-125J	Composition
R2024	2.5 Meg	1	$\frac{1}{2}$	50J-255G	Composition
R2025	1.5 Meg	1	$\frac{1}{2}$	50J-155G	Composition
R2026	.5 Meg	1	$\frac{1}{4}$	50H-504G	Composition
R2027	.25 Meg	1	$\frac{1}{4}$	50H-254G	Composition
R2028	.15 Meg	1	$\frac{1}{4}$	50H-154G	Composition
R2029	50K	1	$\frac{1}{4}$	50H-503G	Composition
R2030	50K	1	$\frac{1}{4}$	50H-503G	Composition
R2031	2.5 Meg	1	$\frac{1}{2}$	50J-255G	Composition
R2032	1.5 Meg	1	$\frac{1}{2}$	50J-155G	Composition
R2033	.5 Meg	1	$\frac{1}{4}$	50H-504G	Composition
R2034	.25 Meg	1	$\frac{1}{4}$	50H-254G	Composition
R2035	.15 Meg	1	$\frac{1}{4}$	50H-154G	Composition
R2036	50K	1	$\frac{1}{4}$	50H-503G	Composition
R2037	50K	1	$\frac{1}{4}$	50H-503G	Composition
R2038	.25 Meg	20	$\frac{1}{2}$	56A-39	Hi-torque Linear Taper
R2039	10K	20	$\frac{1}{2}$	56A-37	Linear Taper
R2040	2.5 Meg	20	2	56A-56	Linear Taper
R2041	1.5 Meg	5	$\frac{1}{2}$	50AB-155J	Composition
R2042	1.5 Meg	5	$\frac{1}{2}$	50AB-155J	Composition
R2043	2.5 Meg	20	2	56A-56	Linear Taper

SANBORN DUAL CHANNEL DC AMPLIFIER

MODEL 150-2000

ELECTRICAL PARTS LIST--SCHEMATIC 150-2000-C1 SUB. 5TUBES (cont.)

<u>SYMBOL</u>	<u>DESCRIPTION</u>	<u>SANBORN NO.</u>
V2003	Type 6V6GT	68A-4
V2004	Type 6V6GT	68A-4
V2005	Type 6SL7GT, Aged, Tested & Selected	69A-6
V2006	Type 6V6GT	68A-4
V2007	Type 6V6GT	68A-4

MISCELLANEOUS

E2001	8-Contact Terminal Strip	64G-2
F2001	1 $\frac{1}{4}$ Amp. Slo. Blo. Fuse	26B-14
I2001	Neon Bulb	30B-1
J2001	12-Pin Jones Connector	10C12-2MX
J2002	Octal Socket	10H8-2FX
J2003	11-Pin MIP Socket	10B11-2FX
J2004	Octal Socket	10H8-2FX
J2005	Octal Socket	10H8-2FX
J2006	2-Contact Amphenol Connector	10B2-2MX
J2007	2-Contact Amphenol Connector	10B2-2MX
P2002	8-Contact Plug	10B8-1MWA
P2003	11-Contact Plug (with cap & cable clamp)	10B11-2MW
P2004	8-Contact Plug (with cap & cable clamp)	10B8-3MW
P2005	8-Contact Plug (with cap & cable clamp)	10B8-3MW

SANBORN DUAL CHANNEL DC AMPLIFIER

MODEL 150-2000

ELECTRICAL PARTS LIST--SCHEMATIC 150-2000-C1 SUB. 5MISCELLANEOUS (cont.)

<u>SYMBOL</u>	<u>DESCRIPTION</u>	<u>SANBORN NO.</u>
S2001	SPST Toggle Switch	62D-15A
S2002	1-Deck, 8-Position Wafer Switch	62B-16
S2003	1-Deck, 8-Position Wafer Switch	62B-16
T2001	Regulated Power Transformer	66B-23
T2002	Filament Transformer	66B-5
Y2001	Selenium Rectifier	16B-7
C2001	.879 - .909 mfd Capacitor (Red Dot)	8B-44A
	.847 - .878 mfd Capacitor (Yellow Dot)	8B-44B
	.816 - .846 mfd Capacitor (White Dot)	8B-44C

These Capacitors are supplied with 66B-23 Transformers. When used for Replacement the color code on the capacitor must match color code on mating transformer.

MAINTENANCE MANUAL
for
SANBORN DUAL CHANNEL DC AMPLIFIER
MODEL 150-2000

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DUAL CHANNEL DC AMPLIFIER	
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SANBORN COMPANY
Waltham, Mass.
November, 1957
MM-150-2000-1

SYSTEM TROUBLE CHECK

SANBORN 150 SYSTEM

RECORDER

DUAL CHANNEL DC AMPLIFIER

Save time by first finding where the fault is, by following these steps in sequence

1. IS THERE ACTUALLY A FAULT?

Check the operator's technique - try the measurements again - see that the operator isn't trying something the system isn't built for - check line voltage and frequency.

2. IS THE FAULT IN THE GALVANOMETER?

Power OFF: Check that there is no roughness when moving writing arm with finger.

Power OFF: Measure galvanometer coil resistance at galvanometer cap. Should be in vicinity of 3200 ohms.

Power ON: Measure voltage across galvanometer coil at the galvanometer cap. Check that 32 volts change in this voltage gives approximately 10 millimeters of stylus deflection (12.5 divisions on narrow Permapap).

3. IS THE FAULT IN THE DUAL CHANNEL DC AMPLIFIER?

Connect a low test voltage into one channel of the instrument and then into the other channel. (Voltage from a 1.5 volt flashlight battery is suggested.) If either channel is defective, and the other channel is normal, check tubes in the defective channel. If both channels are defective or dead, check rectifier Y200 and the fuse F2001.

4. DID THESE STEPS POINT OUT THE TROUBLE?

By now, you should have made a start at localizing the source of trouble. If not, the trouble may be system-wide, or may be impossible to track down by this method. What to do: use the Trouble Shooting Chart and Check Charts.

TROUBLE SHOOTING CHART
 SANBORN DUAL CHANNEL DC AMPLIFIER
 MODEL 150-2000

This chart assumes that the fault has been traced to the Dual Channel DC Amplifier.

SYMPTOM	POSSIBLE CAUSE	CHECK
Fuse blows each time instrument turned on.	Defective tube	Check V2001
	Defective condenser	Check plug-in condensers C2006, C2007, also C2001
	Defective transformer	Check T2001, T2002
	Wrong size fuse	Must be 1.25 A Slo-Blo
Does not work; tubes do not light	Blown fuse	Check F2001
	Loose connectors	Check that power connectors P2002, P2003 at chassis top and rear are firmly in place
Tubes light, but no operation all channels	Defective tube	Check V2001
	Loose connectors	Check that signal circuit connectors into J2004 and J2005 are firmly in place
No operation one channel only, other channel normal	Defective tube	Check tubes in defective channel
	Loose connector	Check that signal circuit connector into J2004 or J2005 is firmly in place
	Open resistor	Check R2001 or R2002, R2010, R2011
POSITION control will not move stylus over entire recording channel	Defective tube	Check tubes in defective channel(s), including rectifier V2001
	Defective condenser	Check C2011
	Matched resistor pairs out of tolerance	Check matched resistors
	No negative bias voltage	Check Y2001, R2005, C2007A,B

SYMPTOM	POSSIBLE CAUSE	CHECK
Stylus stays at one side of recording channel while instrument on	Defective tube	Check tubes in defective channel(s)
	Leaky condenser	Check all mica condensers
	Signal overload	If stylus returns to normal with ATTENUATOR at OFF, trouble probably coming in from outside the instrument
Erratic stylus motion	Intermittent tube	Check all tubes
	Intermittent rectifier	Check Y2001
	Loose tube, plug-in, or connector	Press in tightly
	Erratic signal	Check signal with meter and oscilloscope
	Intermittent circuit element	Check with meter and oscilloscope for intermittent circuit element
Low sensitivity	Defective tube	Check all tubes
	Improper operation	Check operating technique
Non-linear	Defective tube	Check all tubes
	No negative bias voltage	Check Y2001, R2003, C2007A,
	Mica condenser	Check mica condensers - leakage across or through them can alter grid bias
	Low line voltage	Check that line voltage is within limits
	Defective circuit element, giving incorrect circuit voltages	Quick check: measure for approximately 130 volts at 6V6 grids for quick check of proper operating voltages
	Signal	Signal having high-frequency components or fast pulses may not show on the recording, but still drive tubes into non-linear region

SYMPTOM	POSSIBLE CAUSE	CHECK
Drift	Drifting tube	Check all tubes
	May be drift of Permapaper	See Recorder Trouble Shooting Chart
	Drifting signal	Check with meter and oscilloscope. See if baseline drift with ATTENUATOR at OFF
	Line voltage or frequency	Drifting widely or outside limits can cause drift. Check with meter
	Inadequate warmup	Warm up at least the stated five minutes required
	Drift in high-frequency signal component	High-frequency components can overload the grids and still not show on the record as a signal. This causes a non-linearity, which can appear as a drift if the high-frequency component drifts. Check with meter and oscilloscope
Unsatisfactory frequency or transient (overshoot) response, or cannot adjust damping control(s)	Defective tube	Check all tubes
	Improper adjustment	Re-adjust
	Leakage	Leakage across (or through) R2009-C2004 or R2023-C2010. If dirty, clean with carbon tetrachloride or equivalent
Unsatisfactory control of trace density	See the Recorder Trouble Shooting Chart	
Noise, microphonics, or hum	Defective tube	Check all tubes
	Defective component	Check circuit with oscilloscope to find source of interference
	Noisy signal	Check signal with oscilloscope. See if baseline becomes clear with ATTENUATOR at OFF.
	Loose input plug or connector	Plug in firmly
	Open shield connection, or ground loop	Check input circuit cabling

Quick check: For a quick check on operation, set POSITION to mid-scale and measure from grid (terminal 5) to ground of each 6V6 stage. Should be approximately 130 volts. to indicate normal operation of entire channel. (Test at 115 volt line.) Then measure from terminal 5 of one 6V6 to terminal 5 of the other 6V6 in the same channel; should not be more than a few volts, to show normal operation.

PERIODIC MAINTENANCE

SANBORN DUAL CHANNEL DC AMPLIFIER

MODEL 150-2000

This is recommended every 500 hours of operation, or every 3 to 6 months, as determined by experience.

1. Replace the 6V6GT tubes in each channel - V2003, V2004, V2006, V2007. Use a commercial tube replacement, or use Sanborn replacement no. 68A-4.
2. Replace the 5R4GY tube in the power supply - V2001. Use a commercial tube replacement, or use Sanborn replacement no. 68A-43.
3. Inspect above-chassis for loose tube, controls, plug-in components, and connectors.
4. Inspect below-chassis for loose resistors, condensers, terminal boards, etc.
5. Look for evidence of overheated components - check visually and by smell for burnt insulation, transformers, resistors, condensers, etc.
6. Look for frayed or burned-away insulation.
7. Check for dents, panel scratches, corrosion, and other mechanical abuse.
8. Blow out dust and dirt with an air hose.
9. Go through the steps of the Check Chart.

CHECK CHART

1. Warm up Dual Channel DC Amplifier at least five minutes. Line voltage at 115 volts. Perform following tests on each channel of the instrument.
2. Check that POSITION control will move stylus across entire recording channel. Set stylus 20 divisions above bottom of chart.
3. Insert signal from 1.5 volt flashlight battery and series switch. Set RANGE switch to 1 VOLT/CM and GAIN control full right. Check for at least 17 mm. stylus deflection (21 divisions with narrow-channel Permapaper). Set GAIN for 15 divisions deflection.
4. Intermittently operate switch and adjust DAMPING control for best possible square wave on the recording. Leading edge of square wave should have fast rise, with no overshoot.
5. Insert signal from audio oscillator, with Dual Channel DC Amplifier channel set to 10 divisions peak-to-peak recording. Response should be as shown on characteristic curve in Instruction Manual.

VOLTAGE AND RESISTANCE CHART
 SANBORN DUAL CHANNEL DC AMPLIFIER
 MODEL 150-2000

TUBE	1	2	3	4	5	6	7	8	9
V2001		30K* +385V		3.5K (4 to 6) 800VAC		3.5K (6 to 4) 800VAC		30K* +385V	
V2002		700K +130V	1.6M .22V	3K -3.5V	850K +130V	1.6M .22V	2.9VAC	2.9VAC	
V2003		3.4VAC	90K* 3.7VAC +360V	90K* 3.7VAC +360V	1M +130V		45K* 3.4VAC	6K	
V2004		3.5VAC	100K* 3.9VAC +360V	100K* 3.9VAC +360V	1.2M +130V		45K* 3.4VAC	6K	
V2005		1M +130V	1.4M .12V	3K -3.5V	1M 2VAC +130V	1.4M .12V	2.9VAC	2.9VAC	
V2006		45K 3.4VAC	100K* 3.6VAC +360V	100K* 3.6VAC +360V	1.3M 2VAC +130V		45K* 3.4VAC	6K	
V2007		45K 3.4VAC	100K* 3.2VAC +360V	100K* 3.2VAC +360V	1.4M +130V		45K* 3.4VAC	6K	

Readings taken with H. P. Model 410B VTVM.

A 1.5K 30W resistor across pins 3-4, 5-4, 6-7, 8-7 of jack 2001 to simulate galvanometers.

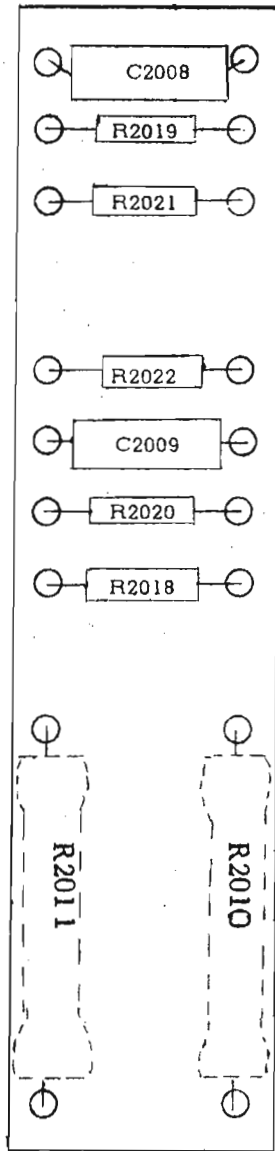
VOLTAGE READINGS

- POWER ON
- NO SIGNAL
- ATTENUATOR OFF
- POSITION CENTER
- DAMPING CENTER
- MEASURE FROM EACH TUBE SOCKET TERMINAL TO GROUND

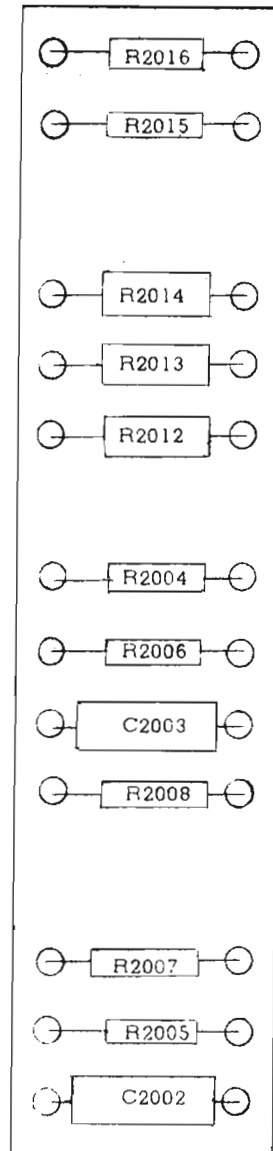
RESISTANCE READINGS:

- POWER OFF
- NO SIGNAL
- ATTENUATOR OFF
- POSITION FULL CLOCKWISE
- DAMPING FULL COUNTERCLOCKWISE
- MEASURE EACH TUBE SOCKET TERMINAL TO GROUND
- *CHARGING CAPACITOR

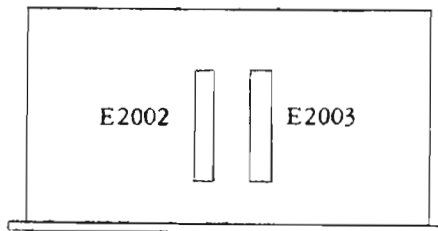
SANBORN DUAL CHANNEL DC AMPLIFIER MODEL 150-2000



E2002

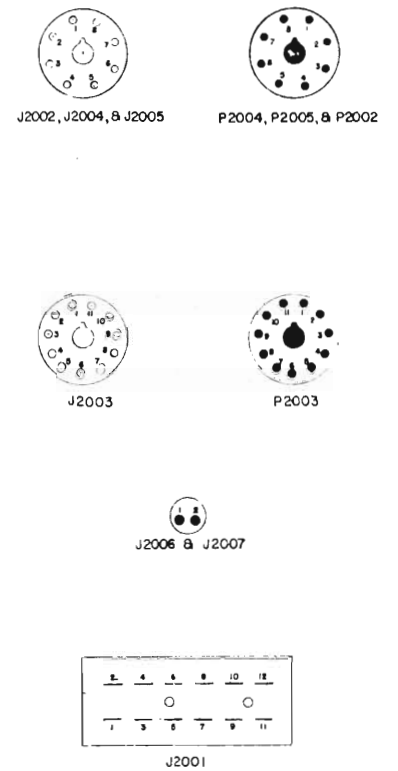
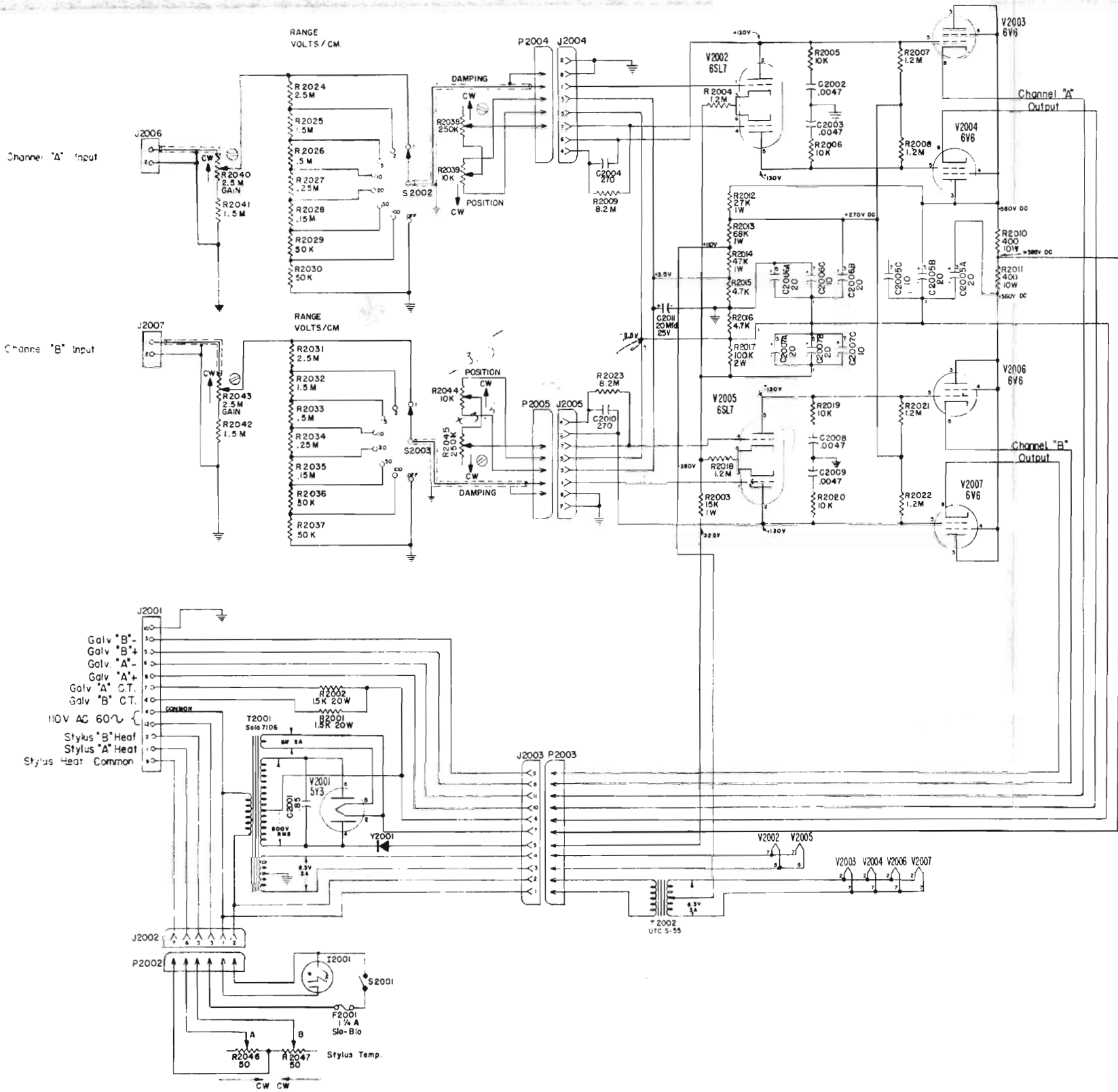


E2003



BOTTOM VIEW OF CHASSIS

COMPONENT LOCATION ON RESISTOR BOARDS



- ALL POLARITY AND PHASE INDICATIONS ARE AS SHOWN. IF NOT SHOWN, ASSUME POSITIVE OR NEGATIVE AS INDICATED BY THE SYMBOL.
- REMOVE ALL BURRS
- NOTES
- ⊥ Denotes chassis ground.
 - All 20, 10, 2, & 1W resistors as well as R2009, R2023, R2004, R2007, R2008, R2018, R2021, & R2022 are 5% tolerances.
 - Resistors R2024 thru R2037 are 1% composition.
 - C2004 & C2010 are 5% Capacitors.
 - All voltages measured with respect to chassis ground.