SERVICE NOTE

SUPERSEDES:

HP MODEL 8690A SWEEP OSCILLATORS

Serials Below 803-2061

Improved +275 V/-300 V Power Supplies

A new improved Low Voltage Power Supply Assembly, HP Part Number 08690-6043, is the recommended replacement for Low Voltage Power Supply Assemblies A5 and A6, HP Part Numbers 08690-6015 and 08690-6024. The new assembly has improved reliability and stability, and is directly interchangeable with the old power supply.

The entire new assembly, consisting of Boards A5 and A6, must be installed at the same time. Neither of the new assemblies will work with one of the old A5 or A6 Assemblies.

The following pages contain complete theory of operation, troubleshooting flow diagram, replaceable parts list, and schematics for the new power supply.

AFTER INSTALLING THE NEW POWER SUPPLY, ATTACH THIS SERVICE NOTE TO YOUR 8690A SWEEP OSCILLATOR OPERATING AND SERVICE MANUAL.

MS/mh/wo

4/68-4

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HEWLETT hp PACKARD

HEWLETT hp PACKARD LIMITED

INTER-OFFICE CORRESPONDENCE

FROM: Tom Clyde, South Queensferry. DATE 17th June, 1968.

TO: All Service Facilities SUBJECT: 8690A Signal Generator

Service Note P-08690-6043 issued by Microwave Division, also applies to 8690A's manufactured at South Queensferry. Our Serial Prefixes are different, however:-

Service Note	South Queensferry Prefix
P-08690A-6043	U803-00401 and below

Regards,

Tom

Printed in Scotland

GENERAL POWER SUPPLY OPERATING PRINCIPLES

All the dc operating voltages shown in Figure 4-2 of the 8690A Operating and Service Manual are electronically regulated. Some are obtained directly from regulated supplies, others are derived by voltage division from regulated supplies.

There are five transistor type regulators, two vacuum tube types supplying +275 volts and -300 volts, and three transistor types supplying +20, 12.6 and -6.3 volts. All of the regulators operate as follows. As shown in Figure 4-14 of the Operating and Service Manual, a regulating element (Series Regulator) is connected in series with the load and the dc power source (Rectifier). The resistance of the regulating element is made adjustable so that the voltage at its output will be adjustable. The resistance is adjusted by a control voltage; the higher the control voltage, the higher the output voltage. A sample of the Series Regulator output voltage is compared against a stable dc reference voltage by a Comparison Amplifier and the difference voltage is inverted and applied to the Series Regulator. As a result, any tendency for output voltage to change is immediately counteracted by the control voltage, and the supply output voltage remains constant.

Since the gain of the Comparison Amplifier determines the degree of regulation, it may be followed by an additional control, or driver, amplifier to improve regulation. The Comparison Amplifier is a differential type for temperature stability. The dc reference voltage used for comparison is obtained from voltage regulator electron tubes, from semiconductor voltage reference diodes, or by voltage division from another regulated power supply. When an adjustable power supply is used as the reference for another supply, changing its output level also changes the level of the supply for which it is the reference.

+275 AND -300V POWER SUPPLY TURN-ON SEQUENCE.

The following paragraphs describe the +275V power supply. A similar description applies to the -300V supply, with exceptions noted.

A5CR1, A5CR2 and A5CR3 form a voltage reference stick, and provide +180V to forward bias A5CR20. Current flows through A5R29 and A5R24, and then into the base of A6Q7. A5V1 will not conduct at first because filaments have not heated.

The resulting large A6Q7 base current (about 0.9 mA) causes A6Q7 to saturate. The high A8Q7 collector current robs base current from A6Q6 and shuts off series regulator A6Q10 by making A6Q5 and A6Q10 collector currents zero. This prevents current flow through the series regulator. Because A6Q10 is cut off, the impedance of the power supply is high and very little current flows through A5R34 into the +275V supply load.

Voltage at A6F1 (input to the +275V supply voltage limiter) is about 360V. Thus, current flows through A5R2, A6CR4, A6CR5, A6R6 and A6Q7. Initial +40V output voltage is established by voltage division between A5R2 and A6R6. The output voltage stays at about 40V magnitude (+ for +275V supply; - for -300V supply) until after A5V1 vacuum tube filaments have heated up. The output voltages track as they increase from the 40V level to the normal output levels.

A few seconds after turn-on, A5V1 conducts and shunts base current formerly available to A6Q7. A6Q7 collector current then decreases, allowing current to flow through the base of A6Q6. Series regulator A6Q10 then conducts only through the load impedance because the current path through A6CR5 and A6R6 is closed by limited A6Q7 base current.

The output voltage begins to rise as A6Q10 collector current flows into the load and charges C8B. When the output reaches +275V, A5V1 shunts just enough current away from the base of A6Q7 to control the output current, maintaining a constant voltage regardless of the load impedance. The initial conditions hold until A5V1 begins to conduct appreciable current and the power supply outputs increase in voltage toward a stable condition.

When the -300V supply output voltage increases more negative than -82V, A5V2 turns on to regulate the A5Q1 and A5Q2A base voltages at this level. When the output voltage is -300V, voltage at the center tap of A5R7 -300V ADJ is set to -82V and A5Q2A will take over control of the A6Q9 base current. This control establishes the stabilized -300V output voltage.

Since the voltage difference between A5V1 cathode and A5CR14 cathode is less than 10V, A5CR17 prevents current from passing through A5R16 and into A5R22 when a stable condition is reached. This minimizes +275V supply drift by reverse biasing A5CR15; i.e., there are no voltage variations across nonconducting A5CR15.

+275V AND -300V POWER SUPPLY INTERDEPENDENCE.

When the +275V supply output voltage exceeds +180V, A5CR21 conducts, A5CR20 is reverse biased, and A5V1 is supplied with a well regulated plate voltage. A5V1 can conduct the proper current only if the -300V supply voltage for A5R22, A5R23 and A5R26 is approximately correct. Thus, the +275V supply is dependent on the -300V supply for proper operation.

Further, the -300V supply needs correct bias current supply by the +275V supply. The -300V supply sequences through the following states as the output voltage increases from -40V to -300V.

At turn-on, some of the A5R15 (next to test loop B) current flows through the base of A6Q9, turning on A6Q9, A6Q8 and the -300V series regulator A6Q11. A6Q11 collector current passes through the -300V supply load impedance and develops an output voltage which is controlled by the relationship between A5R15, A5R16 and A5R22. Assuming that A6Q9 base current is negligible and that the voltage at A5CR14 cathode is always about 4.5 volts, the current flowing through A5R15 will also flow through A5R16 and A5R22 (A5V1 is off because filaments have not yet heated) and will develop a voltage at test point 1 about equal but of opposite polarity to the voltage at test point 2, because the resistive sum of A5R22 and A5R16 is about equal to A5R15. The two power supply outputs approximately track each other during turn-on because equal currents flowing through equal resistances yield equal voltages. The small base current required by A6Q6 to maintain tracking is controlled by the voltage at either end of the A5R15/A5R16/A5R22 resistor stick.

+275 AND -300V CURRENT LIMITERS.

The two current limiters are identical in function; the following paragraphs describe the +275V current limiter. The current limiters are similar to a bridge circuit. A5Q4 acts as a switch to shunt base current away from A6Q6 which drives the series regulator, thus turning off the current available to the load. The unique characteristic of the circuit is that the maximum current available to the load is roughly proportional to output voltage.

Under normal operating conditions A5Q4 is turned off and the series regulator can have as much base current as it needs. If the load resistance begins to decrease so that the load current increases, A6Q10 emitter voltage increases due to the increase of voltage across A5R34. A5Q4 base voltage also increases and eventually exceeds A5Q4 emitter voltage. This turns on A5Q4, unbalances the bridge and provides a current path from the base of A6Q6 to the emitter of A5Q4, limiting the base current available to A6Q6.

Once A5Q4 collector current starts to flow, the output voltage decreases as series regulator A6Q10 base current is limited. A6Q7 will cut off as the feedback circuit tries to restore the output voltage, but the resulting extra base current available for the base of A6Q6 will be limited by the amount of A5Q4 collector current. With this limiting, the output voltage is no longer controlled by the feedback circuit, but is instead controlled by the current limiting circuit.

+275V AND -300V VOLTAGE LIMITERS.

The two voltage limiters are identical in function; the following paragraphs describe the +275V voltage limiter. The +275V voltage limiting circuit works in conjunction with the +275V current limiter to control voltage and current levels during all phases of turn-on, normal operation, and short circuit operation.

Under normal operating conditions, A5Q4 emitter (+275V output) is at +275V so that the voltage difference between this point and the collectors of A6Q1 and A6Q3 is about 125V. (Maximum voltage at A6Q3 is +400V at high line.) With only 125V available, A6CR1 and A6CR2 will not conduct so that A6Q1 and A6Q3 will saturate. In this state, the voltage drop between the A6Q1/A6Q3 collectors and the collector of A6Q10 is nearly zero. Thus, the A6Q10 series regulator collector to emitter voltage is a maximum of 125V; a safe level for collector currents in excess of 200 mA.

If the +275V supply load resistance should suddenly decrease to zero, A6Q10 emitter voltage will be about zero. A maximum of +400V at A6F1 will drop across A6R1/A6R2/A6CR1/A6R15/A6CR2. A6CR1 and A6CR2 together drop approximately +140V, leaving 260V drop across A6R1 and A6R2. Disregarding A6Q1 base current, A6Q10 collector voltage level is then about 270V, i.e., the collector voltage of A6Q10 is about the same as the voltage at the junction of A6R1 and A6R2. In this state, series regulator A6Q10 collector to emitter voltage will be about 270V. This is a safe level because the current limiter limits the current through A6Q10. A6CR1/A6CR2 and A6R1/A6R2 values are such that for any combination of load current and output voltage, the voltage across A6Q3 collector to emitter will be large enough to limit the series regulator power dissipation within safe limits.

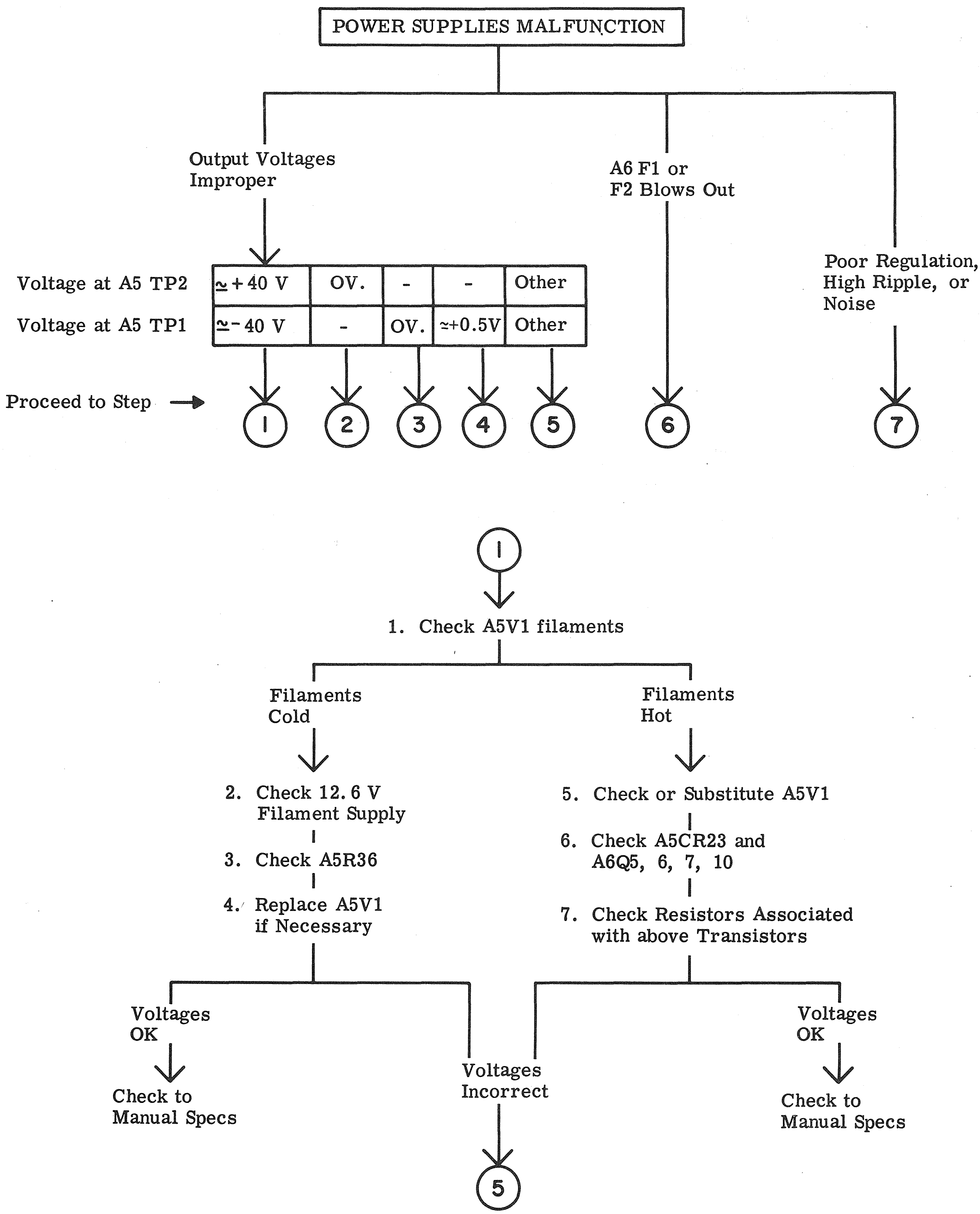


Figure 5-16. +275V and -300V Power Supply Troubleshooting Flow

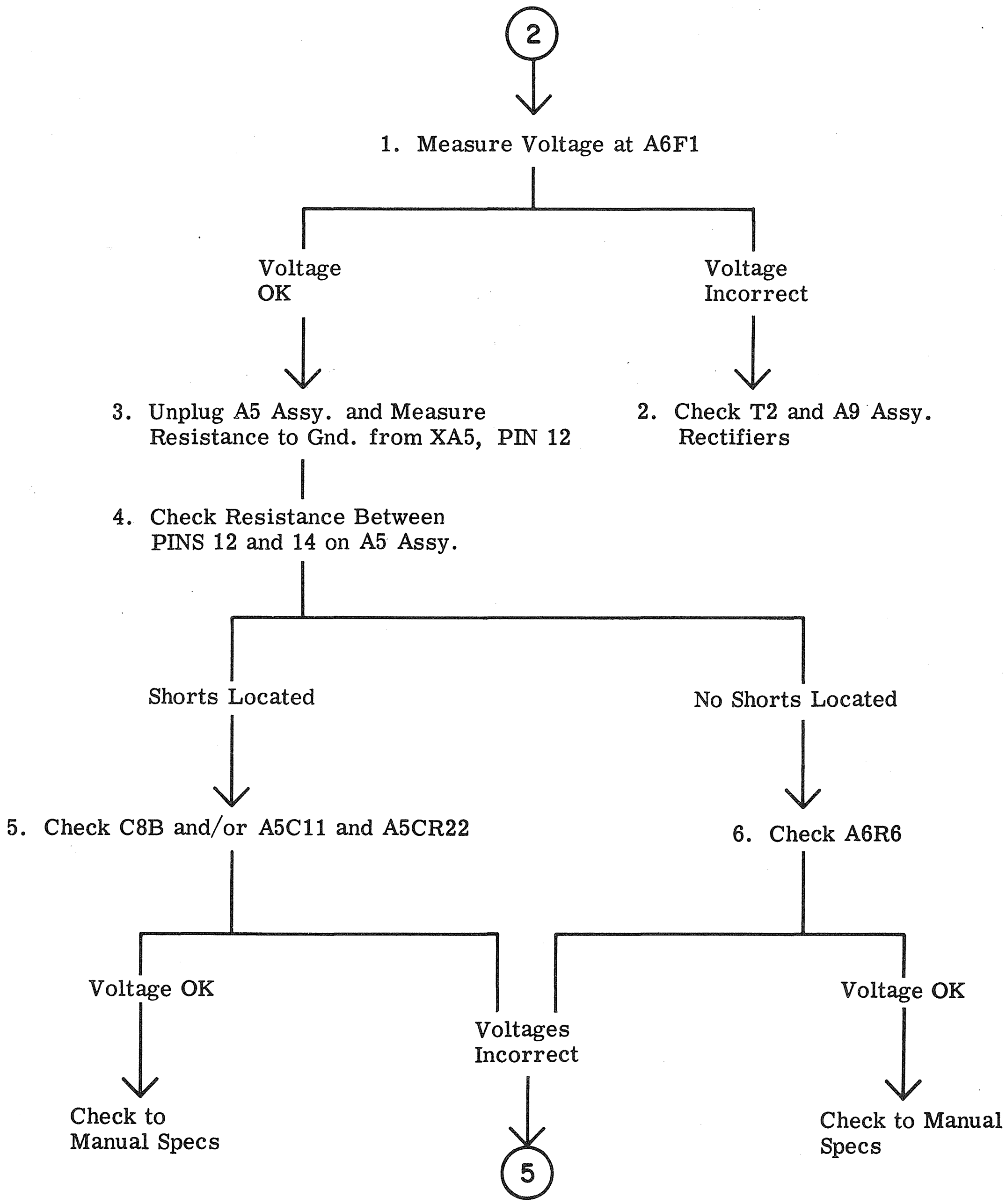


Figure 5-16. +275V and -300V Power Supply Troubleshooting Flow (Continued)

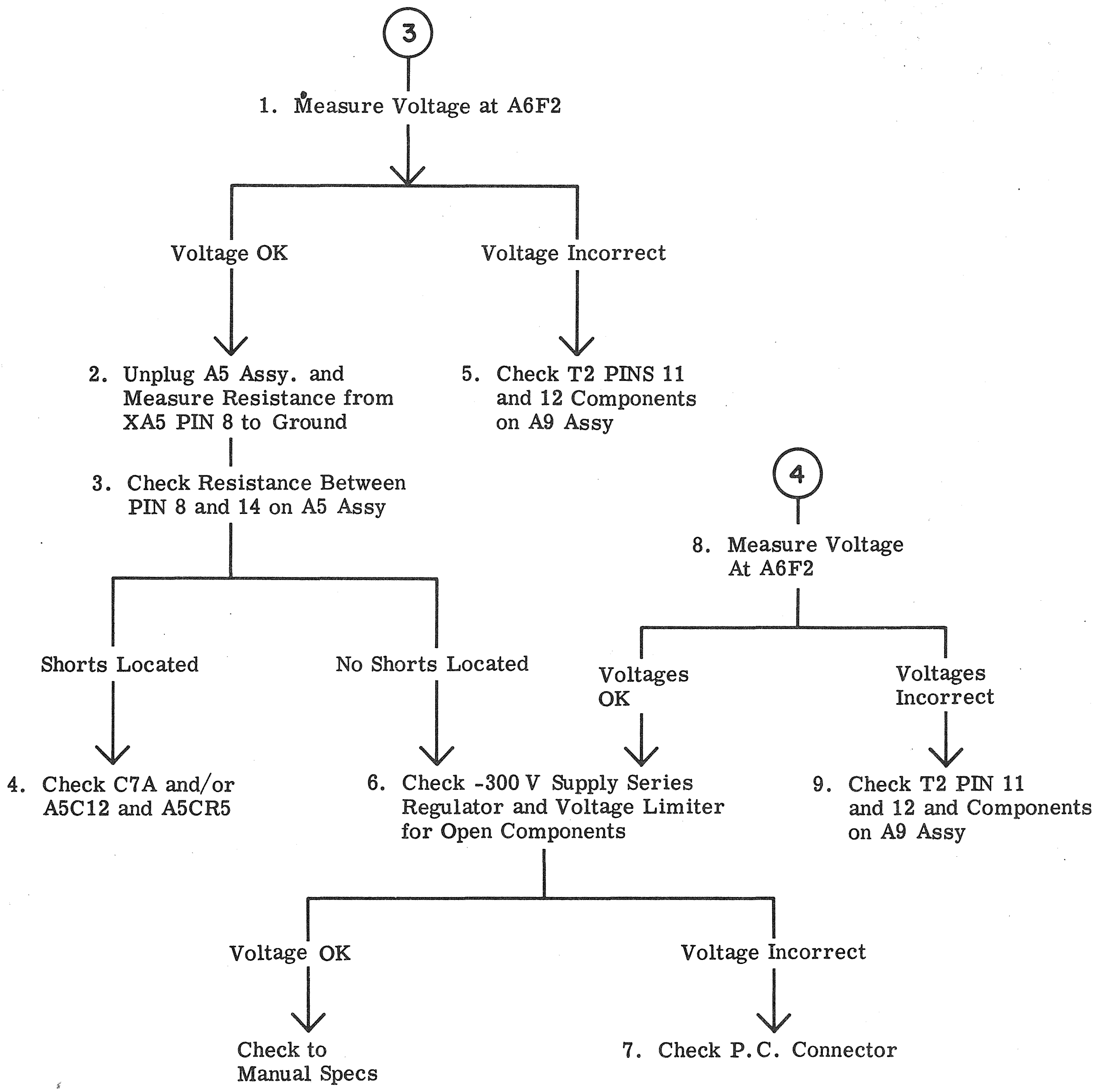


Figure 5-16. +275V and -300V Power Supply Troubleshooting Flow (Continued)

5

1. Remove RF Unit and All Plug-In P.C. Boards Except A5, A6, and A14

Supplies Function Properly with Load Removed

2. Check A6Q5-11 for Low Gain

Supplies Malfunction

3. Move Test Loop B from Test Point #2 to Test Point #3

-300 V Supply Voltage OK

4. Trouble is in +275 V Supply. Check Diodes and Transistors with Ohmmeter. Check Current Limiter

5. Check Other Components with Ohmmeter

6. Return Test Loop B to Test Point 2

-300 V Supply Voltage Incorrect

7. Return Test Loop B to Test Point 2

8. Check D.C. Voltages at A5V2 Cathode and A5CR4 Anode. Check Current Limiter

Voltages OK

9. Check A5CR8, 9, A5Q2 and A6Q2, 4, 8, 9, 11 with Ohmmeter

10. Check Resistors and Capacitors Associated with Above Components

Voltages Incorrect

11. Replace Faulty Component

Figure 5-16. +275V and -300V Power Supply Troubleshooting Flow (Continued)

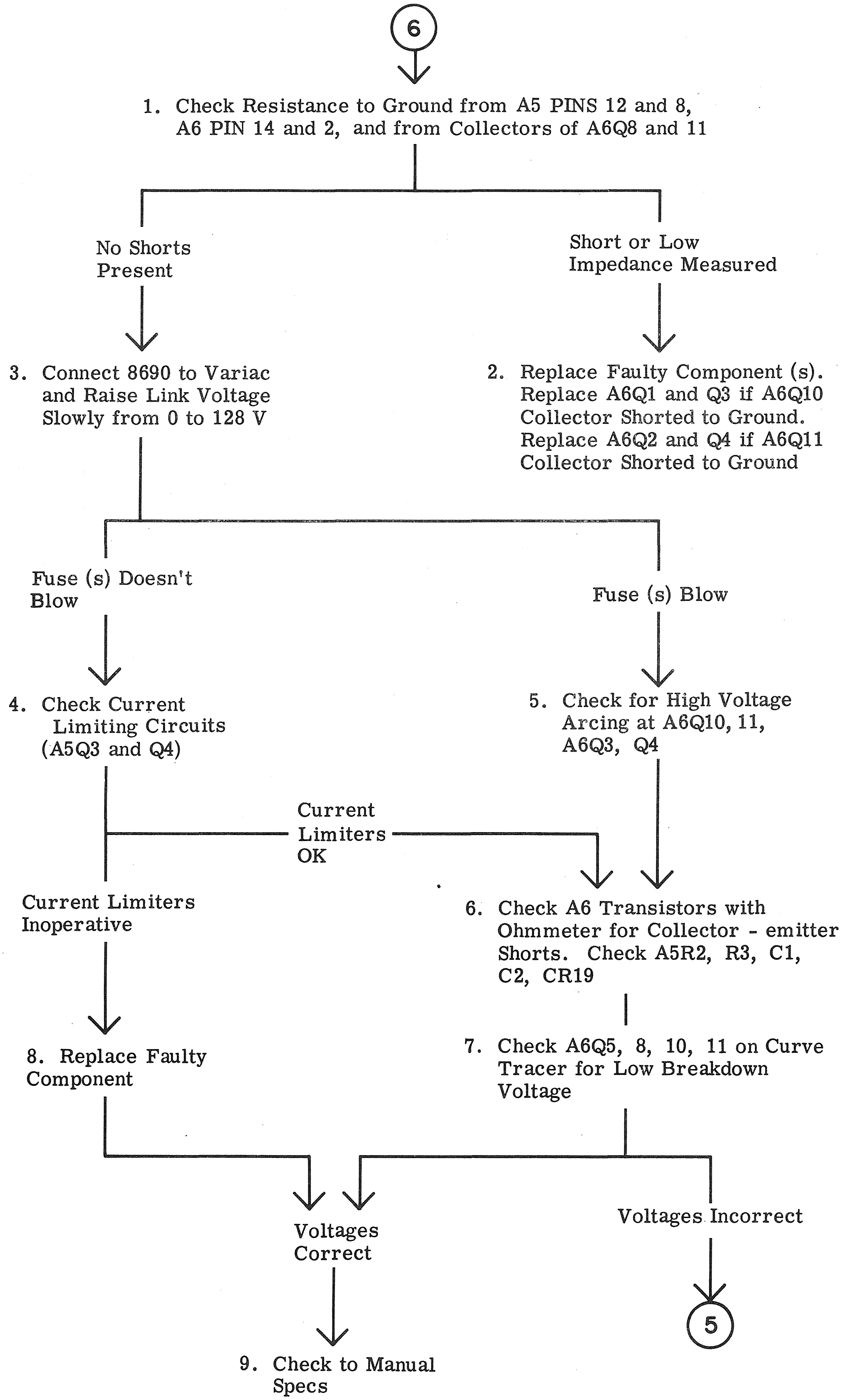


Figure 5-16. +275V and -300V Power Supply Troubleshooting Flow (Continued)

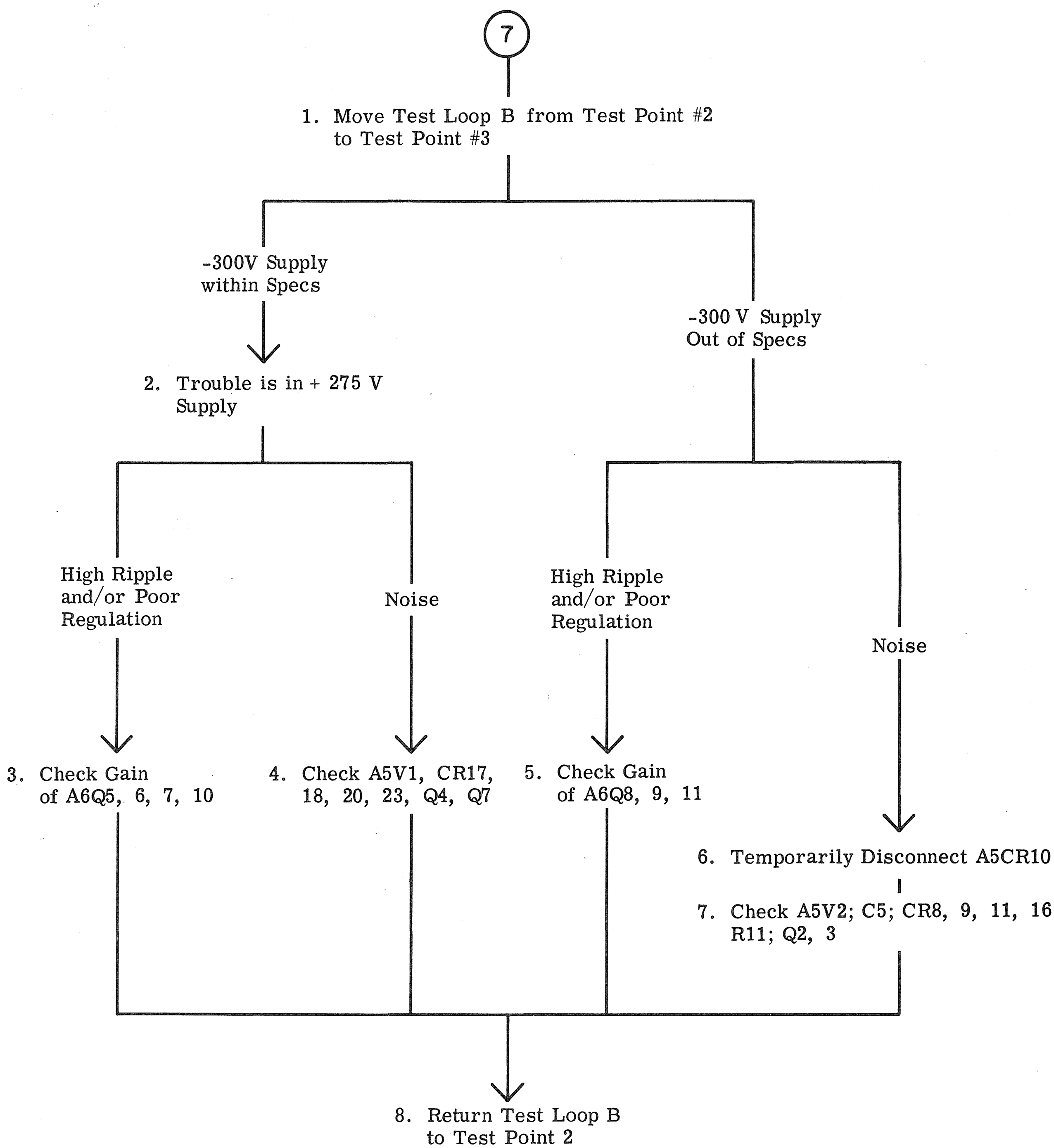


Figure 5-16. +275V and -300V Power Supply Troubleshooting Flow (Continued)

Table 6-1. Reference Designation Index (Cont.)

Reference Designation	Part No.	Description #	Note
A5	08690-6033	BOARD ASSY:LOW VOLTAGE POWER SUPPLY	
A5C1	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
A5C2	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
A5C3	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
A5C4	0150-0121	C:FXD CER 0.1UF +80%-20% 50VDCW	
A5C5	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
A5C6	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
A5C7	0160-2199	C:FXD MICA 30 PF 5%	
A5C8	0160-2218	C:FXD MICA 1000 PF 5%	
A5C9	0160-0174	C:FXD CER 0.47 UF +80-20% 25VDCW	
A5C10	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
A5C11	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
A5C12	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
A5CR1	1902-0176	DIODE BREAKDOWN:47.5V 1W	
A5CR2	1902-0176	DIODE BREAKDOWN:47.5V 1W	
A5CR3	1902-0197	DIODE BREAKDOWN:SILICON 82.5V 5%	
A5CR4	1902-0025	DIODE,BREAKDOWN:10.0V 5% 400 MW	
A5CR5	1901-0029	DIODE:SILICON 600 PIV	
A5CR6	1902-3369	DIODE BREAKDOWN:61.9V 400MW	
A5CR7	1902-3369	DIODE BREAKDOWN:61.9V 400MW	
A5CR8	1901-0033	DIODE:SILICON 100MA 180WV	
A5CR9	1901-0033	DIODE:SILICON 100MA 180WV	
A5CR10	1902-3428	DIODE BREAKDOWN:SILICON 100V 5%	
A5CR11	1901-0033	DIODE:SILICON 100MA 180WV	
A5CR12	1902-3290	DIODE BREAKDOWN:SILICON 31.6V 5%	
A5CR13	1901-0033	DIODE:SILICON 100MA 180WV	
A5CR14	1901-0033	DIODE:SILICON 100MA 180WV	
A5CR15	1901-0033	DIODE:SILICON 100MA 180WV	
A5CR16	1901-0029	DIODE:SILICON 600 PIV	
A5CR17	1902-0025	DIODE,BREAKDOWN:10.0V 5% 400 MW	
A5CR18	1901-0029	DIODE:SILICON 600 PIV	
A5CR19	1901-0029	DIODE:SILICON 600 PIV	
A5CR20	1901-0029	DIODE:SILICON 600 PIV	
A5CR21	1901-0029	DIODE:SILICON 600 PIV	
A5CR22	1901-0029	DIODE:SILICON 600 PIV	
A5CR23	1901-0033	DIODE:SILICON 100MA 180WV	
A5Q1	1854-0022	TRANSISTOR:NPN SILICON	
A5Q2	1854-0221	TRANSISTOR DUAL:SILICON NPN	

 # See introduction to this section for ordering information

Table 6-1. Reference Designation Index (Cont.)

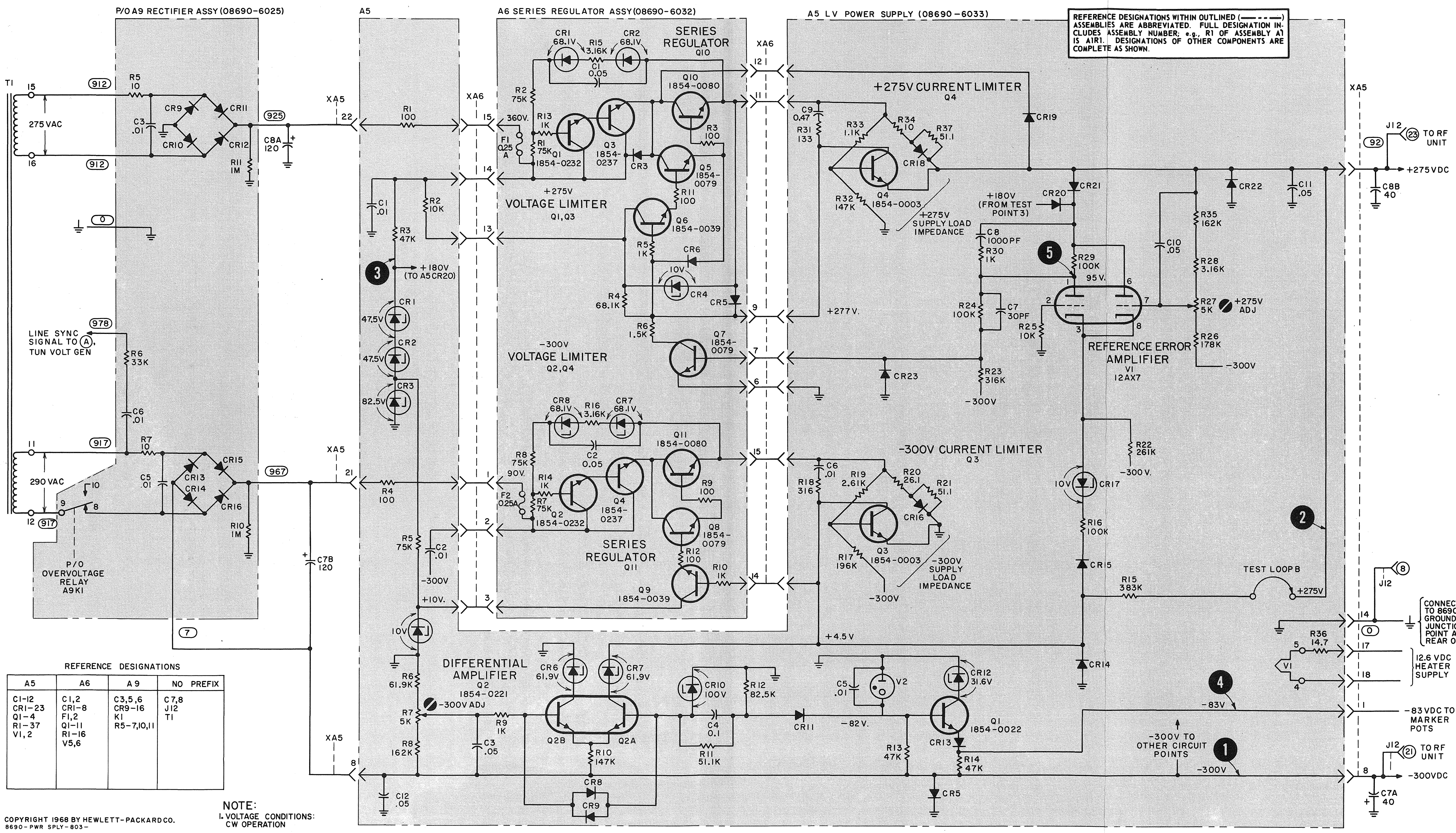
Reference Designation	Part No.	Description #	Note
A5Q3	1854-0003	TRANSISTOR:NPN SILICON	
A5Q4	1854-0003	TRANSISTOR:NPN SILICON	
A5R1	0812-0018	R:FXD WW 100 OHM 3% 5W	
A5R2	0819-0027	R:FXD WW 10K OHM 5% 20W	
A5R3	0764-0031	R:FXD MET OX 47K OHM 5% 2W	
A5R4	0812-0018	R:FXD WW 100 OHM 3% 5W	
A5R5	0757-0856	R:FXD MET FLM 75.0K OHM 1% 1/2W	
A5R6	0757-0460	R:FXD MET FLM 61.9K OHM 1% 1/8W	
A5R7	2100-1760	R:VAR WW 5K OHM 10% LIN 1/2W	
A5R8	0757-0130	R:FXD MET FLM 162K OHM 1% 1/2W	
A5R9	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A5R10	0698-3175	R:FXD MET FLM 147K OHM 1% 1/2W	
A5R11	0757-0458	R:FXD MET FLM 51.1K OHM 1% 1/8W	
A5R12	0757-0463	R:FXD MET FLM 82.5K OHM 1% 1/8W	
A5R13	0764-0031	R:FXD MET OX 47K OHM 5% 2W	
A5R14	0764-0031	R:FXD MET OX 47K OHM 5% 2W	
A5R15	0757-0133	R:FXD MET FLM 383K OHM 2% 1/2W	
A5R16	0757-0465	R:FXD MET FLM 100K OHM 1% 1/8W	
A5R17	0757-0063	R:FXD MET FLM 196K OHM 1% 1/2W	
A5R18	0698-3444	R:FXD MET FLM 316 OHM 1% 1/8W	
A5R19	0698-0085	R:FXD MET FLM 2.61K OHM 1% 1/8W	
A5R20	0757-0003	R:FXD MET FLM 26.1 OHM 1% 1/2W	
A5R21	0757-0394	R:FXD MET FLM 51.1 OHM 1% 1/8W	
A5R22	0757-0064	R:FXD MET FLM 261K OHM 1% 1/2W	
A5R23	0698-3425	R:FXD MET FLM 316K OHM 1% 1/2W	
A5R24	0757-0465	R:FXD MET FLM 100K OHM 1% 1/8W	
A5R25	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	
A5R26	0757-0129	R:FXD MET FLM 178K OHM 2% 1/2W	
A5R27	2100-1760	R:VAR WW 5K OHM 10% LIN 1/2W	
A5R28	0757-0279	R:FXD MET FLM 3.16K OHM 1% 1/8W	
A5R29	0757-0367	R:FXD MET FLM 100K OHM 1% 1/2W	
A5R30	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A5R31	0698-3437	R:FXD MET FLM 133 OHM 1% 1/8W	
A5R32	0698-3175	R:FXD MET FLM 147K OHM 1% 1/2W	
A5R33	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A5R34	0757-0984	R:FXD MET FLM 10.0 OHM 1% 1/2W	
A5R35	0757-0130	R:FXD MET FLM 162K OHM 1% 1/2W	
A5R36	0698-3388	R:FXD MET FLM 14.7 OHM 1% 1/2W	
A5R37	0757-0394	R:FXD MET FLM 51.1 OHM 1% 1/8W	
A5V1	1932-0030	ELECTRON TUBE:12AX7	
A5V2	1940-0013	ELECTRON TUBE:82.0 +/- 1V	
A6	08690-6032	BOARD ASSY:REGULATOR	
A6C1	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	

 # See introduction to this section for ordering information

Table 6-1. Reference Designation Index (Cont.)

Reference Designation	ⓗ Part No.	Description #	Note
A6C2	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
A6CR1	1902-3381	DIODE BREAKDOWN:68.1V 400MW	
A6CR2	1902-3381	DIODE BREAKDOWN:68.1V 400MW	
A6CR3	1901-0029	DIODE:SILICON 600 PIV	
A6CR4	1902-0554	DIODE BREAKDOWN:10V 1W	
A6CR5	1901-0033	DIODE:SILICON 100MA 180WV	
A6CR6	1901-0033	DIODE:SILICON 100MA 180WV	
A6CR7	1902-3381	DIODE BREAKDOWN:68.1V 400MW	
A6CR8	1902-3381	DIODE BREAKDOWN:68.1V 400MW	
A6F1	2110-0004	FUSE:CARTRIDGE 1/4 AMP 250V	
A6F2	2110-0004	FUSE:CARTRIDGE 1/4 AMP 250V	
A6Q1	1854-0232	TRANSISTOR:SILICON NPN	
A6Q2	1854-0232	TRANSISTOR:SILICON NPN	
A6Q3	1854-0237	TRANSISTOR:SILICON NPN 2N3738	
A6Q4	1854-0237	TRANSISTOR:SILICON NPN 2N3738	
A6Q5	1854-0079	TRANSISTOR:SILICON 2N3439	
A6Q6	1854-0039	TRANSISTOR:SILICON 2N3053	
A6Q7	1854-0079	TRANSISTOR:SILICON 2N3439	
A6Q8	1854-0079	TRANSISTOR:SILICON 2N3439	
A6Q9	1854-0039	TRANSISTOR:SILICON 2N3053	
A6Q10	1854-0080	TRANSISTOR:SILICON	
A6Q11	1854-0080	TRANSISTOR:SILICON	
A6R1	0757-0856	R:FXD MET FLM 75.0K OHM 1% 1/2W	
A6R2	0757-0856	R:FXD MET FLM 75.0K OHM 1% 1/2W	
A6R3	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A6R4	0757-0461	R:FXD MET FLM 68.1K OHM 1% 1/8W	
A6R5	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A6R6	0811-0005	R:FXD WW 1500 OHM 1% 5W	
A6R7	0757-0856	R:FXD MET FLM 75.0K OHM 1% 1/2W	
A6R8	0757-0856	R:FXD MET FLM 75.0K OHM 1% 1/2W	
A6R9	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A6R10	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A6R11	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A6R12	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A6R13	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A6R14	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A6R15	0757-0279	R:FXD MET FLM 3.16K OHM 1% 1/8W	
A6R16	0757-0279	R:FXD MET FLM 3.16K OHM 1% 1/8W	

 # See introduction to this section for ordering information



REFERENCE DESIGNATIONS

A5	A6	A9	NO PREFIX
C1-12 CR1-23 Q1-4 R1-37 V1,2	C1,2 CR1-8 F1,2 Q1-11 R1-16 V5,6	C3,5,6 CR9-16 K1 R5-7,10,11	C7,8 J12 T1

8690-PWR SPLY-803-

NOTE:
1. VOLTAGE CONDITIONS: CW OPERATION