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NUCLEAR INSTRUMENT MODULE MAINTENANCE MANUAL

PART 17

FISSION CHAMBER AND PREAMPLIFIER DC POWER SUPPLY, ORNL MODEL Q-2617-5

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ABSTRACT

The Fission Chamber and Preamplifier DC Power Supply provides three regulated output voltages from an unregulated input supply of -32 ±4 v dc for use with the Fission Chamber and Preamplifier Assembly, ORNL model Q-2617-1. The three outputs are: +300 v dc for polarization of the fission chamber, +110 v dc for the preamplifier anode supply, and -22 v dc for the preamplifier vacuum tube heaters and for biasing. The supply is fabricated in a standard "three-unit" plug-in module of the ORNL Modular Reactor Instrumentation Series.

This report describes the circuit, applications, maintenance procedures, and acceptance tests for the power supply.

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1. DESCRIPTION

1.1 General

The Fission Chamber and Preamplifier DC Power Supply provides three regulated output voltages from an unregulated input supply of -32 ± 4 v for use with a Fission Chamber and Preamplifier Assembly, ORNL model Q-2617-1. The three outputs are (1) +300 v for polarization of the fission chamber, (2) +110 v for the preamplifier anode supply, and (3) -22 v for the preamplifier vacuum tube heaters and for biasing.

The -22 v is derived directly from the -32 v battery supply through a series regulator and a current-limiting circuit. The other two voltages, +300 v and +100 v, are developed by a dc-to-dc converter with a series preregulator.

1.2 Construction

The Fission Chamber and Preamplifier DC Power Supply is contained in a module 4.25 in. wide, 4.72 in. high, and 11.90 in. deep. It is a standard "three-unit" plug-in module of the ORNL Modular Reactor Instrumentation Series depicted on drawings Q-2600-1 through Q-2600-5.

The circuits are on two printed circuit boards mounted parallel to each other and enclosed in a perforated metal shield to reduce electrical radiation and coupling to other modules. Adjustments and test points are accessible through the shield from the top of the module.

1.3 Application

The module is intended to supply all required voltages to the Fission Chamber and Preamplifier Assembly, which has come to be known as the "snake." Because the snake is an unrepairable, potted assembly, the power supply is designed to limit currents and voltages so as to protect both the snake and the power supply against damage from almost any conceivable combination of crossed connections or short circuits.

1.4 Specifications

1.4.1 <u>General</u>

1. Power required: -32 ± 4 v dc, 0.5 amp max.

2. Ambient temperature range: 0 to 55°C.

1.4.2 -22 v Supply

1. Output voltage range: -20 to -24 v dc.
2. Output current range: 200 to 400 ma
3. Voltage regulation: ± 1%.
4. Current limiting: Adjustable to limit the output current to not greater than 110% of normal operating current from normal to short circuit.

1.4.3 +300 v Supply

1. Output voltage: +300 ± 15 v dc.
2. Output current: 0 to 100 μa.
3. Current limiting: 3 ma max, any load.
4. Noise and ripple: 100 mv max.

1.4.4 +110 v Supply

1. Output voltage: +110 ± 10 v dc.
2. Output current: 0 to 15 ma.
3. Current limiting: 100 ma max, any load.
4. Noise and ripple: 10 mv max.

1.5 Applicable Drawings

The following list gives the drawing numbers (ORNL Instrumentation and Controls Division drawing numbers) and fabrication specification number and subtitles for the Fission Chamber and Preamplifier DC Power Supply:

1. Q-2617-5-1 Circuit.
2. Q-2617-5-2 Details.
3. Q-2617-5-3 Metalphoto Panel.
4. Q-2617-5-4 Printed Circuit Board
5. Q-2617-5-5 Assembly.

6. Q-2617-5-6 Parts List.

7. Q-2617-5-7 Details.

8. SF-248 Fabrication Specification.

The following list gives the drawing numbers and subtitles for the Plug-In Chassis System:

1. Q-2600-1 Assembly.

2. Q-2600-2 Details.

3. Q-2600-3 Details.

4. Q-2600-4 Details.

5. Q-2600-5 Details.

2. THEORY OF OPERATION

2.1 General

The Fission Chamber and Preamplifier DC Power Supply is made up of two basic circuits. For the higher voltages a preregulator and a dc-to-dc converter are used. For the heater and bias supply, a current-limiting circuit is used in conjunction with a conventional series regulator.

2.2 Circuit Description of the -22 v Supply

The -22 v supply consists of a voltage regulator (Q8, Q9, Q10) and a current-limiting circuit (Q7, D12, D13), as shown in Fig. 1. The limiting circuit protects the series heater string of the preamplifier from damage when any of several possible fault conditions occur.

The action of the limiting circuit is similar to that of a constant-current circuit. The base voltage of Q7 is held constant at +2 v with respect to the -32 v supply by the two Zener diodes D12 and D13. The breakdown voltages of the diodes are 12 v and 10 v respectively, but they are connected in opposition so that the reference voltage is the difference in the two voltages. This arrangement yields a sharper knee and a stiffer reference voltage than a single low-voltage diode. The emitter voltage is different from the base voltage only by V_{be}, the base-emitter voltage drop of the transistor, which is fairly constant. Thus, the emitter voltage is constant across a fixed resistance R22 and R26, yielding a constant current in the emitter of Q7, provided that the collector-emitter voltage is large enough to keep the transistor out of saturation. When "normal" output current is flowing (less than the limit current),

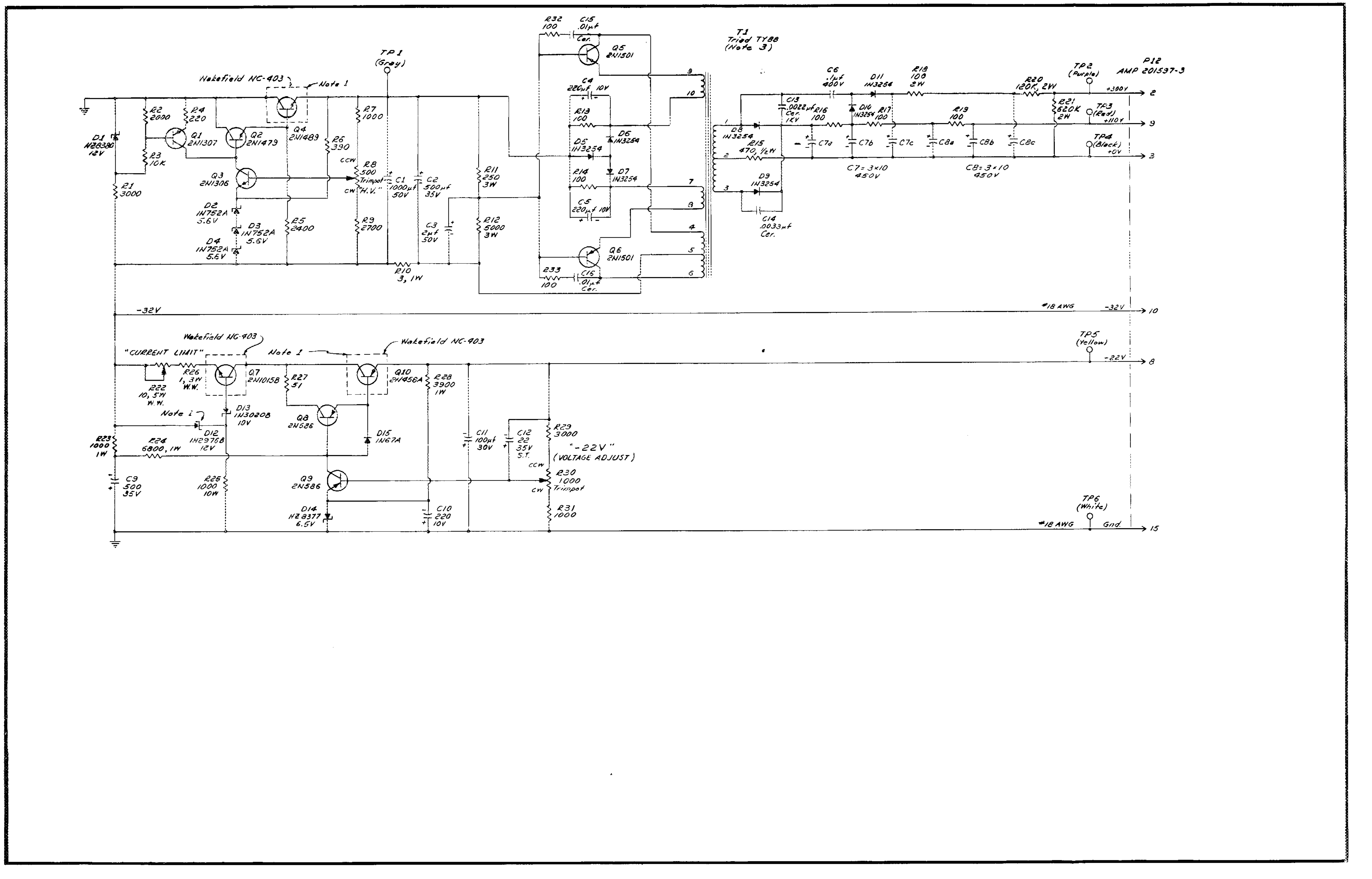

Fig. 1. Fission Chamber and Preamplifier DC Power Supply Circuit

the voltage at the collector of Q7 is less than 2 v more positive than the -32 v supply, and Q7 is saturated. In this condition, Q7 simply acts as a series resistor and does not control the output current. It is only when the output current tends to increase above normal that Q7 comes out of saturation and limits the output current to

$$I_{limit} = \frac{V_z - V_{be}}{R26 + R22},$$

where V_z is the difference in the breakdown voltages of D12 and D13 and V_{be} is the forward base-emitter voltage drop of Q7.

The voltage regulator consists of Q8, Q9, and Q10. The output voltage is sensed by the base of Q9 and compared with the voltage of reference diode D14 in the emitter of Q9. The amplified difference on the collector of Q9 is applied to the base of Q8. Q8 provides current gain only to drive the base of the output transistor Q10. The regulated output voltage appears between the emitter of Q10 and ground. Diode D15 is used to protect Q8 from turn-on transients.

The output voltage is adjusted with Trimpot R30. The current at which the circuit limits is set with the "Current Limit" potentiometer R22.

2.3 Circuit Description of the +300 v and +110 v Supplies

The supply is designed to operate from a nominal 32-v station battery with a terminal voltage variation from 28 to 36 v dc. This wide variation makes necessary a voltage preregulation, which consists of transistors Q1, Q2, Q3, and Q4.

The preregulator output voltage is sensed by resistors R7, R8, and R9 and applied to the base of amplifier stage Q3. A reference voltage (16.8 v) generated by Zener diode string D2, D3, and D4 is applied to the emitter of Q3. The amplified difference appears at the collector of Q3 and is applied to driver Q2 and pass transistor Q4. A constant collector current is provided for Q3 by transistor Q1, Zener diode D1, and the associated network.

The preregulator output (test point TPI) is filtered by C1, C2, and R27, and is applied to the dc-to-dc converter.

Q5, Q6, T1, and the associated circuitry comprise a free-running square-wave oscillator inverter. Networks C15-R32 and C16-R33 round the edges of the square wave somewhat to avoid the generation of sharp, high-frequency spikes, which may be coupled to other circuits. The 110-v output is obtained from a full-wave rectifier and filter and the 300-v output from a voltage tripler. The supply can be short circuited without damage. Most transistor inverters when overloaded will stop oscillating.

The oscillator transistors can be damaged unless their nonoscillating current is limited to a safe value. Current limiting by series resistance in a primary lead is undesirable because of power waste and because the inverter will have poor load regulation. On the other hand, biasing such that the transistor current goes to zero in the nonoscillating condition will not allow oscillations to start when the short is removed. The current-limiting scheme used here consists of a combination of clamping and series-emitter resistance to set the current to a predetermined value. R11 and R12 bias the bases of Q5 and Q6 into conduction. R13 and R14 limit the transistor currents in the nonoscillating condition to a little less than the oscillating currents. The voltage drop across these resistors is less than the value that causes appreciable current flow through D5, D6, and D7 until oscillation begins. In the oscillating condition, the drops across R13 and R14 respectively are limited by the diodes to 1.4 v. The low dynamic resistance of the diodes assures a stable, nonoscillating current value.

3. OPERATING INSTRUCTIONS

3.1 Installation

The Fission Chamber and Preamplifier DC Power Supply is a module in the ORNL Modular Reactor Instrumentation Series. Like the other modules in this series, it has standard connectors and dimensions and has a pin- and hole-code on the rear plate so that the module will not be inserted in a wrong location in a drawer. The module is installed by placing it in its proper location, inserting the module firmly, and tightening the thumb screw. The module may be plugged in with power on without damage.

3.2 Operating Controls

There are three adjustment controls located on the top of the module. These are HV, -22 v, and Current Limit adjustments. Also accessible on the top of the module are several test points for measuring the output voltages.

3.3 Connections

All normal connections are made through the rear connector P12 when the module is inserted.

3.4 Operating Procedures

During initial installation or after repair or reinstallation of either the power supply module or the associated preamplifier assembly, the output voltages and current limiting should be checked and readjusted if necessary.

3.4.1 HV Adjustment

HV adjustment should be made only under load (preamplifier assembly connected to system), because the +110 v and +300 v outputs are not load regulated. R8 (HV adjustment) should be adjusted until the voltage between TP3 (red) and TP4 (black) measures +110 ± 2 v. After this adjustment has been made, the +300 v output should be checked by measuring from TP2 (purple) to TP4 (black). The voltage should be +300 ± 15 v. There is no separate adjustment for the +300 v since this voltage is not critical.

3.4.2 Current Limit Adjustment

The following procedure should be followed when adjusting the current limit control located on the top of the module:

1. Turn the current limit control R22 fully counterclockwise.

2. Insert a 0- to 500-ma ammeter between TP5 (yellow-minus) and TP6 (white-plus). Observe the polarity.

3. With normal input voltage, adjust the current limiting potentiometer R22 until the ammeter indicates 340 ± 5 ma.

4. Insert a 75-ohm, 25-w rheostat adjusted for maximum resistance in series with the ammeter (disconnect the preamplifier load).

5. Adjust the -22 v adjustment potentiometer R30 until -22 ± 0.5 v is indicated between TP5 (yellow) and TP6 (white).

6. Slowly decrease the resistance of the 75-ohm, 25-w rheostat and observe when the voltage between TP5 and TP6 first changes from -22 v. This change should occur when the current is greater than 290 ma. If a voltage change occurs when the current is less than 290 ma, repeat the current-limiting adjustment procedure, steps 3 to 6.

3.5 Precautions

To assure proper protection for the fission chamber and preamplifier assembly, the current-limiting adjustment procedure should be carefully carried out each time a change, repair, or substitution is made in the dc power supply module.

4. MAINTENANCE INSTRUCTIONS

4.1 General

This module is designed to operate continuously with a minimum of maintenance and adjustment. Voltage and current limiting adjustments and voltage test points are accessible from the top of the drawer with the module inserted and the circuits energized. Should a failure occur, any part listed in the Replaceable Parts List, Sect. 5, may be replaced.

4.2 Periodic Maintenance

Measurement and readjustment of the output voltages and current limiting should not be required more frequently than once every 3 to 6 months of normal continuous service. The outputs should be checked and readjusted as necessary if any changes are made in the fission chamber and preamplifier assembly.

4.3 Calibration

No calibration procedures are required except for normal adjustment described under Operating Procedures, Sect. 3.4, and Acceptance Testing, Sect. 6.

4.4 Transistor Voltage Chart

The voltages of all transistors are listed in Table 1.

Table 1. Transistor Voltage Chart[1]

Transistor	Emitter	Base	Collector
Q1	-0.85	-1.0	-6.9
Q2	-7.5	-6.9	0.0
Q3	-15.5	-15.5	-6.9
Q4	-8.2	-7.5	0.0
Q5	-9.4 dc/50 ac[2]	-6.7	-32.0 dc/25.3 ac[2]
Q6	-9.4 dc/50 ac[2]	-6.7	-32.0 dc/25.3 ac[2]
Q7	-31.0	-31.0	-31.0
Q8	-22.0	-22.5	-31.0
Q9	-6.5	-6.6	-22.3
Q10	-22.0	-22.0	-31.0

[1]All dc voltages were measured with respect to ground (pin 15 of P12 or TP6-white) with a 20,000-ohm/v voltmeter (Triplett 630). All ac voltages were measured with a 5000-ohm/v meter, Triplett 630.

[2]The frequency was approximately 8 kc square wave.

5. REPLACEABLE PARTS LIST

A description and ORNL Stores number for all replaceable parts are given in Table 2.

Table 2. Replaceable Parts List

Part No.	ORNL Stores No.	Description
T1		Transformer, epoxy molded, toroidal, 28 v dc, input 250/125 v dc output, Triad type TY-88.
C1		Capacitor, 1000 mf, -10 to +100%, 50 v dc w, -10 to +85°C operating temperature, type PSD, Callins Industries, Inc.
C2, C9		Capacitor, 500 mf, -10 to +100%, 35 v dc w, -10 to +85°C operating temperature, type PSD, Callins Industries, Inc.
C11		Capacitor, 100 mf, -10 to +100%, 30 v dc w, -10 to +85°C operating temperature, type PSS, 0.500 in. diam by 1.500 in. high, Callins Industries, Inc.
C7, C8	06-804-0745	Capacitor, 10-10-10-mf, -10 to +50%, 450 v dc w, Mallory No. P375.8.
C4, C5, C10	06-816-3040	Capacitor, 220 mf, ±10%, 10 v dc w, tantalum clear plastic insulating sleeve, Sprague No. 150D227X9010S2.
C12	06-816-3260	Capacitor, 22 mf, ±10%, 35 v dc w, tantalum clear plastic insulating sleeve, Sprague No. 150D226X9035R2.
C3	06-804-3700	Capacitor, 2 mf, -10 +100%, 50 v dc w, clear plastic insulating sleeve, Sprague No. 40D187A2.
C13	06-802-0395	Capacitor, 0.0022 mf, ±20%, 1000 v dc w, ceramic, disc, formulation 40, Sprague No. 20C162.
C14	06-802-0400	Capacitor, 0.0033 mf, ±20%, 1000 v dc w, ceramic, disc, formulation 40, Sprague No. 29C260.

Table 2 (continued)

Part No.	ORNL Stores No.	Description
C15, C16	06-802-0420	Capacitor, 0.01 mf, ±20%, 500 v dc w, ceramic, disc, formulation 40, Sprague No. 33C70.
C6	06-810-2805	Capacitor, 0.1 mf, ±20%, 400 v dc w, vitamin "Q", Sprague No. 191P10404S4, with clear plastic insulating sleeve.
R8	06-930-8206	Potentiometer, trimmer, 500 ohms, ±10%, 1-12 w, conductive glass resistance element, "Helitrim" series 53, with printed circuit pins, Helipot Div.
R30	06-930-8208	Potentiometer, trimmer, 1000 ohms, ±10%, 1-1/2 w, conductive glass resistance element, "Helitrim" series 53, with printed circuit pins, Helipot Div.
R22		Potentiometer, 10 ohms, ±10%, 5 w at 35°C, ww, Mallory No. VW10.
R25	06-936-1980	Resistor, 1000 ohms, ±10%, 10 w, ww, Ohmite "Brown Devil."
R26	06-933-6110	Resistor, 1 ohm, ±5%, 3 w, ww, axial lead, Ohmite Code 7/16-A-54-F.
R11		Resistor, 250 ohms, ±5%, 3 w, ww, axial leads, Ohmite Code 7/16-A-54-F.
R12	06-933-6300	Resistor, 5000 ohms, ±5%, 3 w, ww, axial leads, Ohmite Code 7/16-A-54-F.
R18		Resistor, 100 ohms, ±5%, 2 w, A-B.
R20		Resistor, 120 kilohms, ±5%, 2 w, A-B.
R21		Resistor, 620 kilohms, ±5%, 2 w, A-B.
R10		Resistor, 3 ohms, ±5%, 1 w, A-B.
R23		Resistor, 1000 ohms, ±5%, 1 w, A-B.
R28		Resistor, 3900 ohms, ±5%, 1 w, A-B.
R24		Resistor, 6800 ohms, ±5%, 1 w, A-B.
R27		Resistor, 51 ohms, ±5%, 1/2 w, A-B.

Table 2 (continued)

Part No.	ORNL Stores No.	Description
R13, R14, R32, R33, R16, R17, R19		Resistor, 100 ohms, ±5%, 1/2 w, A-B.
R4		Resistor, 220 ohms, ±5%, 1/2 w, A-B.
R6		Resistor, 390 ohms, ±5%, 1/2 w, AB.
R31, R7		Resistor, 1000 ohms, ±5%, 1/2 w, A-B.
R2		Resistor, 2000 ohms, ±5%, 1/2 w, A-B.
R5		Resistor, 2400 ohms, ±5%, 1/2 w, A-B.
R9		Resistor, 2700 ohms, ±5%, 1/2 w, A-B.
R1, R29		Resistor, 3000 ohms, ±5%, 1/2 w, A-B.
R3		Resistor, 10 kilohms, ±5%, 1/2 w, A-B.
R15		Resistor, 470 ohms, ±5%, 1/2 w, A-B.
D15	06-995-5280	Diode, crystal, germanium, 1N67A, Hughes.
D2, D3, D4	06-995-6230	Diode, zener, 5.6 v, ±5%, 400 mw, type 1N752A, Motorola.
D13	06-995-7094	Diode, zener, 10.0 v, ±5%, 1 w, type 1N3020B, Motorola.
D12	06-995-7064	Diode, zener, 12.1 v, ±5%, 10 w, type 1N2976B, Motorola.
D14		Diode, zener, 6.5 v, ±5%, 250 mw, Hughes Aircraft Co. No. HZ-8377.
D1	06-995-7910	Diode, zener, 12.0 v, ±5%, 250 mw, Hughes Aircraft Co. No. HZ-8380.
D5, D6, D7, D8, D9, D10, D11	06-995-7124	Rectifier, silicon, type 1N3254, clear plastic insulating sleeve, RCA.
Q1	06-996-1960	Transistor, germanium, PNP, type 2N1307, Texas Instruments.
Q3	06-996-1940	Transistor, germanium, NPN, type 2N1306, Texas Instruments.

Table 2 (continued)

Part No.	ORNL Stores No.	Description
Q10	06-996-1220	Transistor, germanium, PNP, type 2N458A, Texas Instruments.
Q8, Q9	06-996-1400	Transistor, germanium, PNP, type 2N586, RCA.
Q2	06-996-1985	Transistor, silicon, NPN, type 2N1479, RCA.
Q4	06-996-1986	Transistor, silicon, NPN, type 2N1489, Silicon Transistor Corp.
Q5, Q6	06-996-1990	Transistor, germanium, PNP, type 2N1501, Honeywell.
Q7	06-996-1990	Transistor, germanium, NPN, type 2N1015B, Silicon Transistor Corp.

6. ACCEPTANCE TEST PROCEDURE

6.1 Test Equipment

The following test equipment is required:

1. Digital voltmeter, Cubic type V-71 or equal.
2. Decade power resistor box.
3. 0-50 v, 0.5 amp regulated power supply.
4. 0-500 ma ammeter.
5. 75-ohm, 25-w rheostat.

6.2 Adjustment Procedure

1. Adjust the current limiting potentiometer R22 to its extreme counterclockwise position.

2. Connect a 0- to 500-ma ammeter between TP5 (yellow-minus) and TP6 (white-plus). Observe the polarity.

3. Connect the -32 v terminal from a bench power supply between pin 10 and pin 15 (ground) of connector P12.

4. Readjust R22 until the ammeter indicates 340 ± 5 ma short circuit current.

5. Connect a 75-ohm, 25-w rheostat adjusted for maximum resistance in series with the ammeter.

6. Adjust the -22 v adjustment potentiometer R30 until -22 ± 0.5 v is indicated between TP5 (yellow) and TP6 (white).

7. Slowly decrease the resistance of the 75-ohm rheostat and observe when the voltage between TP5 and TP6 first changes from -22 v. This change should occur when the current is between 290 and 340 ma. If the voltage change occurs outside this current range, steps 4 through 7 should be repeated.

6.3 Acceptance Test

6.3.1 Output Voltage Range (-22 v)

1. Connect -32 v to the input, pin 10 and pin 15 (ground).

2. Connect a power decade resistance box adjusted for 85 ohms to the -22 v output pin 8 and pin 15. Measure the output voltage with a digital voltmeter.

3. Adjust the -22 v adjustment potentiometer R30 over its full range and measure the output voltage change. The voltage should be adjustable over the range of -20 to -24 v or greater.

6.3.2 Output Current Range

1. Reset the output voltage to -22 v.

2. Short circuit the output through a 0- to 500-ma ammeter.

3. Adjust the "Current Limit" control R22 over its full range. The current should change from less than 200 ma to more than 400 ma.

6.3.3 Voltage Regulation

1. Reset the current limit to 340 ma.

2. With a 75-ohm load, vary the -32 v input supply plus and minus 1 v and measure the output voltage change with a digital voltmeter. The total change should be less than 100 mv.

3. Reset the input to -32 v and adjust the load to 60 ohms. The load change from 75 to 60 ohms should change the output voltage less than 100 mv.

6.3.4 Current Limiting

1. Readjust the current limit control R22 and the "-22 v"; adjust R30 properly according to the procedure of Sect. 6.2.

2. Decrease the load resistance from 75 ohms until the output voltage just begins to change. Measure the load current.

3. Short circuit the load resistance and again measure the load current. The difference between the two measured currents should be no more than 30 ma.

4. With a 75-ohm load, measure the voltage drop across R22 and R26 in series. This voltage should be less than 3 v.

6.3.5 High Voltage Output

1. Connect a 7500-ohm load to the +110 v output, pin 9 to pin 3 (ground), and a 10-megohm load to the +300 v output, pin 2 to pin 3.

2. Measure the +110 v output TP3 (red) to TP4 (black) while adjusting the HV control R8 over its entire range. The voltage should vary from less than 105 v to more than 115 v. The corresponding range of preregulator output voltage TP1 (gray) to TP6 (white) is approximately -22 to -26 v.

3. Readjust the HV control until TP3 (red) measures +110 v.

4. Measure the +300 v output TP2 (purple) to TP4 (black). The voltage should be +300 ± 15 v.

5. While observing the voltage from TP3 to TP4, short circuit the +110 v output, pin 9 to pin 3. The voltage should drop to zero and return almost immediately when the short is removed.

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