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NUCLEAR INSTRUMENT MODULE MAINTENANCE MANUAL

Part 1

CHAMBER VOLTAGE MONITOR AND TEST UNIT, ORNL MODEL Q-2601

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ABSTRACT

A Chamber Voltage Monitor and Test Unit, a special purpose module, was designed to supply signals for testing the response of parts of a reactor safety system utilizing ORNL modular reactor instrumentation, series Q-2600. The unit supplies a calibrated current ramp at two different rates for checking the response and approximate calibration of both neutron flux level and rate-of-change-of-flux-level trips and associated signal amplifiers, an adjustable steady-state test current, and a circuit which continuously monitors ion chamber polarizing voltage.

The circuit, application, maintenance procedures, and acceptance tests for the unit are described.

CONTENTS

1. DESCRIPTION

1.1 General

The Chamber Voltage Monitor and Test Unit, ORNL model Q-2601, is a special purpose module designed to supply certain signals for testing the response of parts of a safety system utilizing ORNL modular reactor instrumentation. The module provides a calibrated current ramp at two different rates to check the response and approximate calibration of both neutron flux level and rate-of-change-of-flux-level trips and associated signal amplifiers. An adjustable, steady-state current can be substituted for the ramps for more precise calibration. Switching is provided for increasing the effective sensitive volume of the safety channel ionization chamber for high-power system response checks. Also included is a circuit for monitoring the ion chamber undervoltage.

Most of the tests can be started remotely from the reactor console by relay circuits. Tests with the steady-state current and undervoltage monitor are intended primarily for calibration and trouble shooting and can be operated only from the front panel of the module.

1.2 Construction

The Chamber Voltage Monitor and Test Unit module is 2.83 in. wide, 4.72 in. high, and 11.90 in. deep. It is a standard "2 unit" plug-in module of the ORNL Modular Reactor Instrumentation series depicted on drawings Q-2600-1 through Q-2600-6.

1.3 Application

This module is intended to supply signals for both preoperational and on-line testing of a nuclear reactor safety system employing the ORNL modular reactor instrumentation series. It may be necessary to adjust the ramp and signal levels by changing soldered-in components to adapt the module for a particular application. The tests provided are (1) a slow current ramp for checking level trip circuits, (2) a fast current ramp for checking rate-of-change trip circuits, (3) a means of switching to parallel ion chamber sections for on-line level tests, (4) a calibrated adjustable current for calibration purposes, and (5) a continuous monitor of ion chamber polarizing voltage.

1.4 Specifications

1.4.1 Output Ramps

The basic ramp generator supplies a voltage ramp of 0 to +14 v with two ramp rates: 1 v/sec and 2.5 v/sec. The ramp voltage is applied to a suitable multiplier resistor to obtain the required current ramps. The output current is 0 to 46.7 μa (300 kilohms).

1.4.2 Output Current

The steady-state output current is 0 to 100 μa, which is adjustable with a 10-turn precision potentiometer on the front panel. The potentiometer is calibrated to be direct reading from 0 to 100, which corresponds to 0 to 100 μa. The current is applied only while the front-panel pushbutton control is depressed.

1.4.3 Add-On Chamber Section

Relay switching circuits are arranged to connect the signal lead of a special section of the safety system ionization chamber in parallel with the signal lead of the main sensitive volume of the chamber so as to increase its sensitivity. This provides a simple and direct test of the ability of the safety system to respond when the reactor is at fully rated power. To avoid charge buildup, the add-on section is grounded by the relay contacts when it is not in use.

1.4.4 Undervoltage Monitor

The circuit continuously monitors the polarizing voltage of the ionization chamber on a return lead from the chamber. When the chamber voltage is greater than 200 ± 10 v, a green "Normal" indicator lamp on the front panel is lighted. When the voltage, for any reason, drops below 200 ± 10 v, the circuit changes state and lights a red "Low" indicator lamp and a yellow "Latch" indicator lamp. When the voltage is restored, the "Low" indicator lamp is extinguished; the "Normal" light again comes on. The "Latch" light remains on until the front panel "Reset" pushbutton is depressed.

The relay that actuates the indicator lamps has additional contacts, single pole, double throw, for use in external circuits. An additional front-panel pushbutton labeled "Test" simulates a low-voltage condition to the monitor circuit without affecting the actual chamber voltage.

1.4.5 Power Requirements

The power requirements are +32 ± 4 v unregulated and +25 v ± 0.1% regulated.

1.4.6 Ambient Temperature Range

The ambient temperature range is 10 to 55° C.

1.5 Applicable Drawings and Specifications

The following list gives the drawing numbers (ORNL Instrumentation and Controls Division drawing numbers) and subtitles and the fabrication specification number for the Chamber Voltage Monitor and Test Unit:

1.	Q-2601-1	Circuit.
2.	Q-2601-2	Details.
3.	Q-2601-3	Metalphoto Panel.
4.	Q-2601-4	Printed Circuit Board.
5.	Q-2601-5	Assembly.
6.	Q-2601-6	Parts List.
7.	SF-238	Fabrication Specification.

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

1.	Q-2601-1	Assembly.
2.	Q-2600-2	Details.
3.	Q-2600-3	Details.
4.	Q-2600-4	Details.
5.	Q-2600-5	Details.
6.	Q-2600-6	Details.

2. THEORY OF OPERATION

2.1 General

The Chamber Voltage Monitor and Test Unit is a general purpose module designed to provide signals to test parts of a nuclear safety system using the Q-2600 series of modular reactor instrumentation. Application to a particular reactor will very likely require individual tailoring of the ramp rates and current levels produced by the circuit. The chamber voltage monitor may also require some adjustment of the alarm level.

2.2 Circuit Description

2.2.1 Ramp Generator

A linear voltage ramp is generated by charging a capacitor with a constant current. The base of transistor Q1 (Fig. 1) is held at a constant potential with respect to the +25 v supply by zener diode D1. This in turn causes the emitter voltage of Q1 to be constant across a fixed resistance R2, establishing constant emitter current. To a first approximation, transistor collector current is equal to emitter current regardless of collector voltage, until saturation is reached, that is, until the collector voltage equals the emitter voltage. Thus, the collector current of Q1 is constant and flows into capacitor C1.

In the standby condition, the capacitor is nearly short circuited by R21 through the contacts of relay K1. When K1 is energized, the contacts open and the capacitor begins to charge. The rate of charge, or the time slope of the voltage ramp, is determined by the magnitude of the current and the size of the capacitor. In this case

$$\frac{V}{t} = \frac{I}{C} = \frac{20 \times 10^{-6}}{20 \times 10^{-6}} = 1 \text{ v/sec.}$$

The voltage across C1 is sensed by a very high beta Darlington-pair emitter-follower Q2 and Q3.

When relay K2 is energized, R1 is switched in parallel with R2, increasing the charging current from 20 to 50 μa and the corresponding ramp rate from 1 to 2.5 v/sec.

R21 prevents contact damage when the contacts of K1 reclose across the charged capacitor C1.

2.2.2 Current Switching

The Flux Amplifier, ORNL model Q-2602, which is fed by the test signals from the test module, has 100% feedback to the input terminal so that there is no input voltage offset. This makes possible the use of voltage signals and suitable multiplier resistors to derive calibration current signals.

For steady-state calibration or checks, a voltage adjustable from 0 to 25 v by a front-panel Helipot can be applied through a 250-kilohm resistor to the amplifier input by depressing pushbutton S1. The corresponding current is 0 to 100 μa, and the Helipot dial labeled "Current Adjust" is read directly from 0 to 100 units.

The voltage ramp described in Sect. 2.2.1 can be applied through a 300-kilohm resistor R4 by energizing K1; this will result in a current ramp ranging from 0 to 46.7 μa. The ramp is initiated by a second contact of K1 which removes the short circuit from capacitor C1. When a pushbutton on the reactor console is depressed, K1 is energized. This range and ramp rate provide an operational check of the level safety system of the reactor. A rate test is accomplished by simultaneously energizing K1 and K2; this provides the same current range, but at a ramp rate 2.5 times faster.

The test currents are applied to the flux amplifier input by way of a second ionization-chamber signal lead which is separate all the way to the chamber plates, so that a test signal must travel to the chamber and back to the amplifier input. In this way a successful current test verifies that the chamber is connected to the amplifier.

2.2.3 Add-On Chamber Section

When relay K3 is energized, a second section of the safety ionization chamber is connected in parallel with the main section, increasing its sensitivity by approximately 50%. This provides an overall operational check of the safety system when the reactor is operating near full power. A normally closed contact of K3 keeps the add-on section normally grounded to avoid charge buildup during standby periods and to reduce switching transients. This test is useful only when substantial ion chamber current exists.

2.2.4 Chamber Voltage Monitor

In a manner similar to the signal lead, a separate high-voltage lead is returned from the plates of the ionization chamber. This voltage is continuously monitored by a circuit consisting of transistors Q4 through Q8. If the voltage, normally 250 v, is interrupted or reduced below approximately 200 v, an undervoltage alarm occurs.

The sensed voltage is reduced from 250 to 100 v at R8 by two zener diodes D2 and D3. The voltage is further reduced to 20 v at the base of Q4 by the dividing

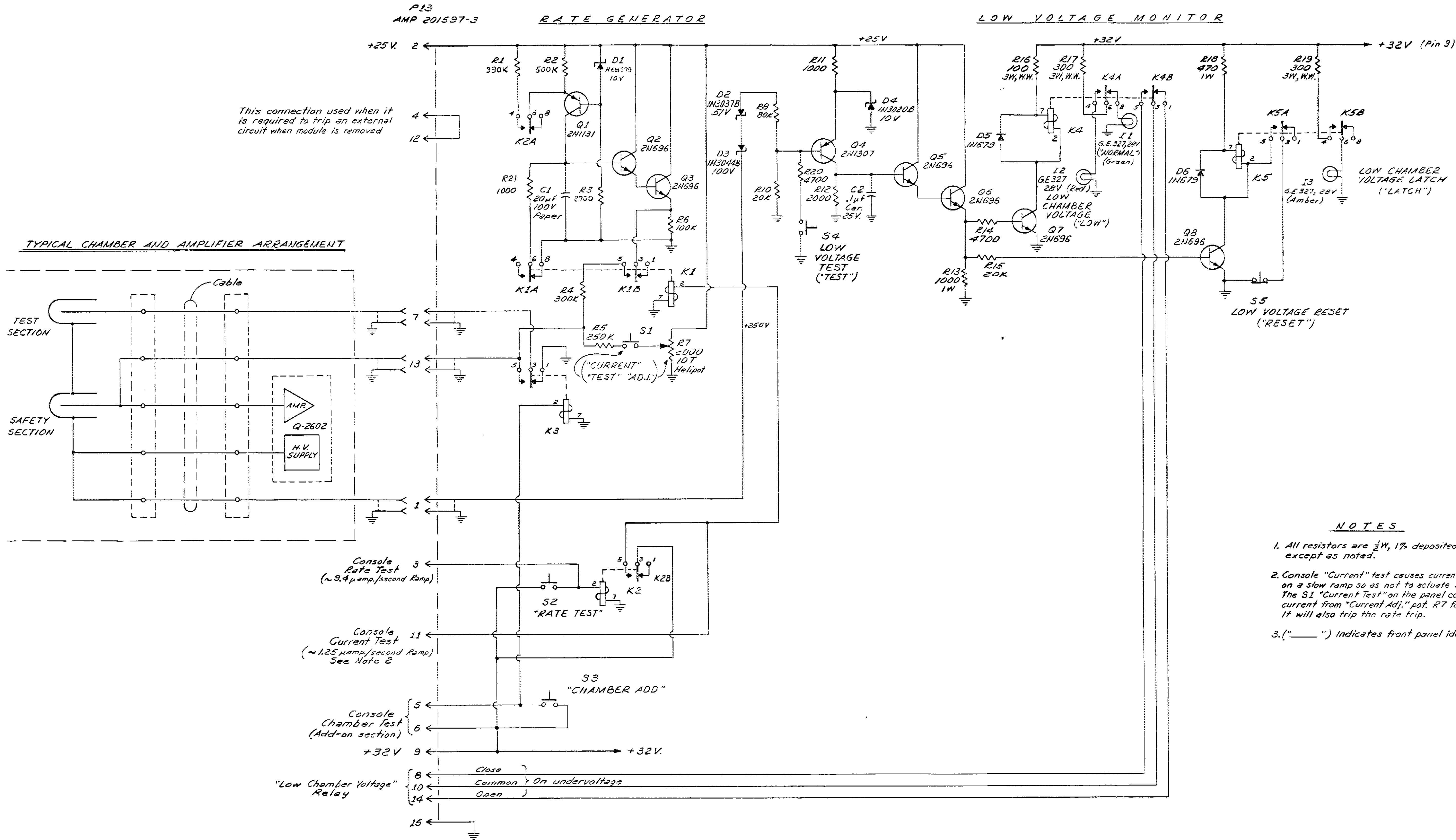

Fig. 1. Chamber Voltage Monitor and Test Unit, ORNL Model Q-2601.

NOTES

1. All resistors are $\frac{1}{2}$W, 1% deposited carbon except as noted.

2. Console "Current" test causes current to increase on a slow ramp so as not to actuate rate trip also. The S1 "Current Test" on the panel connects a steady current from "Current Adj." pot. R7 for calibration; it will also trip the rate trip.

3. ("____") Indicates front panel identifications.

action of R8 and R10. The emitter of Q4 is biased at 10 v so that the transistor is reverse biased and not conducting under normal conditions. The collector of Q4 is near ground potential so that the Darlington emitter-follower Q5 and Q6 and the relay drivers Q7 and Q8, driven by the emitter-follower output, are also not conducting. A normally closed contact of K4 energizes the green "Normal" lamp on the front panel.

When the input voltage drops below 200 v, the Q4 base voltage is reduced to below 10 v, and Q4 conducts. The collector voltage of Q4 increases to 10 v, turning on Q5, Q6, Q7, and Q8 and energizing both K4 and K5. K4 contacts extinguish the "Normal" lamp and lights the red "Low" chamber voltage lamp. A second set of K4 contacts controls external circuits. K5 seals itself in and remains energized, lighting the "Latch" lamp until the input voltage is restored and "Reset" button S2 is depressed. This enables the operators to identify a momentary chamber voltage fault.

A test of the voltage monitor circuit is accomplished by pressing "Test" pushbutton S1 on the front panel. This reduces the voltage at the base of Q4, simulating a low input condition without causing significant loading of the chamber voltage itself.

3. OPERATING INSTRUCTION

3.1 Installation

The Chamber Voltage Monitor and Test Unit is one of the ORNL modular reactor instrumentation series. Like 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

3.2.1 Panel Controls

Chamber Voltage Monitor. -- Three pilot lamps indicate the state of chamber voltage: the green "Normal" light is on when the voltage is more than 200 v, the red "Low" light is on when the voltage is less than 200 v, and the amber "Latch" light comes on when the voltage drops below 200 v and remains on until the "Reset" button is pressed. The "Test" button when depressed causes a simulated low voltage to test the monitor without disturbing the actual chamber voltage.

Current Test. -- When the "Current Test" button is depressed, a current adjustable from 0 to 100 μa by the "Current Adjust" potentiometer is applied to the flux amplifier input through the ionization chamber cables.

Rate Test. -- When the "Rate Test" button is depressed, a current ramp from 0 to 47 μa is applied to the flux amplifier input. The ramp rate is 25%/sec.

Chamber Add. -- When the "Chamber Add" button is depressed, the test section of the ionization chamber is connected in parallel with the main safety section, increasing the chamber by about 50%.

3.2.2 Remote Controls

Current ramps may be initiated remotely from the reactor console by energizing relay K1. Simultaneous actuation of K2 with K1 increases the ramp speed 2.5 times to provide a rate test. K3 controls the add-on chamber section.

3.3 Connections

All connections are made through the rear connector P13 when the module is inserted. A jumper between pins 4 and 12 is provided so that if the module is removed from a drawer a warning signal is given.

3.4 Operating Procedures

Those functions which are operated remotely from the reactor console will be described in the appropriate reactor operating procedures. The current ramps and chamber-add tests are initiated by depressing the proper pushbutton for the selected reactor mode.

The front panel "Current Test" is intended more as a trouble-shooting tool than as a routine test by reactor operators. It is the only test that applies a current which is accurately known at any instant and can be used to make steady-state checks of accuracy or gain.

4. MAINTENANCE INSTRUCTIONS

4.1 General

This module is designed to operate continuously with a minimum of maintenance and no adjustments. Should a failure occur, any part listed in the Replaceable Parts List, Sect. 5, may be replaced.

4.2 Periodic Maintenance

No periodic maintenance is expected to be required.

4.3 Calibration Procedures

There are no calibration procedures. Testing for proper performance is described in Sect. 6, Acceptance Tests.

5. REPLACEABLE PARTS LIST

A description and an ORNL Stores number for replaceable parts are given in Table 1. A complete parts list is given on ORNL drawing Q-2601-6.

Table 1. Replaceable Parts List

Part No.	ORNL Stores No.	Description
C1	06-812-6027	Capacitor, 20 μf, ±10%, 100 v dc w, 1.0 in. diam by 3-9/16 in. long, 1/2-28 thread mtg. stud, complete with No. 6-120C nut and No. 2-54B lockwasher, No. 118P 20691T25, Sprague Electric Co.
C2	06-802-0087	Capacitor, 0.1 μf, ±20%, 25 v dc w, monolithic, formulation C23, No. 3C21, Sprague Electric Co.
R7		Potentiometer, 2000 ohms, ±3%, linearity ±0.25%, 10 turn, 1.5 w at 40°C, 1/4 in. shaft, 3/8 × 22 bushing, Helipot model 7216R2KL.25.
R16	06-933-6230	Resistor, 100 ohms, 3 w, ww, axial leads, Ohmite code 7/16-A-54-F.
R17, R19	06-933-6250	Resistor, 300 ohms, 3 w, ww, axial leads, Ohmite code 7/16-A-54-F.
R18	06-932-2093	Resistor, 470 ohms, ±5%, 1 w, AB.

Table 1. (Continued)

Part No.	ORNL Stores No.	Description
R13, 21	06-932-2133	Resistor, 1000 ohms, ±5%, 1 w, AB.
R11	06-932-0097	Resistor, 1000 ohms, 1%, 1/2 w, carbon film, Stemag STAK.[1]
R12	06-932-0113	Resistor, 2000 ohms, 1%, 1/2 w, carbon film, Stemag STAK.[1]
R3	06-932-0121	Resistor, 2700 ohms, 1%, 1/2 w, carbon film, Stemag STAK.[1]
R14, 20	06-932-0131	Resistor, 4.7 kilohms, 1%, 1/2 w, carbon film, Stemag STAK.[1]
R10, 15	06-932-0155	Resistor, 20 kilohms, 1%, 1/2 w, carbon film, Stemag STAK.[1]
R8	06-932-0185	Resistor, 80 kilohms, 1%, 1/2 w, carbon film, Stemag STAK.[1]
R1	06-932-0187	Resistor, 330 kilohms, 1%, 1/2 w, carbon film, Stemag STAK.[1]
R6	06-932-0189	Resistor, 100 kilohms, 1%, 1/2 w, carbon film, Stemag STAK.[1]
R5	06-932-0205	Resistor, 250 kilohms, 1%, 1/2 w, carbon film, Stemag STAK.[1]
R4	06-932-0209	Resistor, 300 kilohms, 1%, 1/2 w, carbon film, Stemag STAK.[1]
R2	06-932-0225	Resistor, 500 kilohms, 1%, 1/2 w, carbon film, Stemag STAK.[1]
D5, 6	06-995-6160	Diode, rectifier, 200 v PIV, 140 v rms, type 1N679.

[1] All carbon film resistors, "Stemag," double high-temperature varnish coated. Vendor: H. E. Priester Corp., Scarsdale, N. Y. (ORNL supplied). Equivalent metal film resistors may be substituted.

Table 1. (Continued)

Part No.	ORNL Stores No.	Description
D1	06-995-7460	Diode, zener, 10 v, type HZ8379, 250 mw, Hughes.
D4	06-995-7094	Diode, zener, 10 v ±5%, 1 w, type 1N3020B, Motorola.
D2	06-995-7112	Diode, zener, 51 v, 1 w, type 1N3037B, Motorola.
D3	06-995-7118	Diode, zener, 100 v, 1 w, type 1N3044B, Motorola.
Q2, 3, 5, 6, 7, 8	06-996-1610	Transistor, silicon, NPN, type 2N696, Texas Instr.
Q1	06-996-1710	Transistor, silicon, PNP, type 2N1131, Texas Instr.
Q4	06-996-1960	Transistor, germanium, PNP, type 2N1307, Texas Instr.
	06-986-2111	Socket, transistor, 4 contact, Be-Cu gold-flashed contacts, for printed wiring boards, ELCO No. 3303.
K1, 2, 3, 4, 5	06-944-0669	Relay, dc, microminiature, dpdt, 3 amp at 228 v dc, contacts coil 26.5 v dc, type VRS2C675D-24, Elgin, Advance Electric Co.
I1, 2, 3	06-916-2576	Lamp, incandescent, 28 v at 40 ma, type 387, General Electric Co.

6. ACCEPTANCE TEST PROCEDURE

6.1 Test Equipment

The following test equipment is required:

1. Power supply, dc unregulated, 32 ± 4 v, up to 1 amp.

2. Power supply, dc regulated, 25 ± 0.1 v, regulation ±0.1%, up to 50 ma.

3. Voltmeter, dc, 0.5% accuracy, multirange.

4. Power supply, dc, 0 to 250 v adjustable, 10 ma.

6.2 Acceptance Test

6.2.1 Ramp Generator

1. Connect the 25-v dc supply positive to pin 2 and the negative to pin 15. Connect the 32-v dc supply positive to pin 9 and the negative to pin 15. Connect an accurate dc voltmeter to measure the ramp generator output on the emitter of Q3 with respect to HQ ground.

2. To initiate the slow ramp, energize relay K1 by shorting pin 11 to pin 9 and observe the linear increase of voltage on the meter. The voltage should rise from 0 to 14 ± 1 v in 14 ± 1 sec. The voltage should not rise higher than 15 v.

3. To initiate the fast ramp, energize K1 and K2 simultaneously by shorting pins 3 and 9 together or by pressing the "Rate Test" pushbutton. The voltage should rise from 0 to 14 ± 1 v in 5.6 ± 0.5 sec.

6.2.2 Voltage Monitor

1. Connect the 0- to 250-v supply positive to pin 1 and the negative to pin 15. Connect an accurate voltmeter across the 250-v supply terminals.

2. Increase the supply voltage to approximately 250 v and press the "Reset" button on the module front panel. Only the green "Normal" lamp should be lighted. Slowly decrease the supply voltage and observe the voltage when the red "Low" lamp just lights. The voltage should be 200 ± 10 v.

3. Increase the voltage to 250 v. The "Low" lamp should become extinguished and the "Normal" lamp should light. The "Latch" lamp should come on simultaneously with the "Low" lamp and should remain on until the "Reset" button is depressed.

4. Press the low-voltage "Test" button. The circuit should respond the same as if the voltage were reduced to less than 200 v.

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