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October 19, 1962

REFERENCE

WESTERN NEW YORK NUCLEAR RESEARCH CENTER REACTOR PROGRAM

- Experiment No. 6 - Coaxial Cables
- Experiment No. 7 - Electronic Tubes
- Experiment No. 8 - Electrical Insulating Coatings
- Experiment No. 9 - DC Impedance Converter (Nuvistor)
- Experiment No. 10 - Tetrode Pulse Preamplifier (Nuvistor)

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This memorandum was compiled and edited by Mr. H. P. Kalapaca, Control Equipment Design, Control Development, Westinghouse Astronuclear Laboratory. Detailed test procedures were prepared by the following individuals:

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WESTERN NEW YORK NUCLEAR RESEARCH CENTER REACTOR PROGRAM

1.0 General - The experiments described in this memorandum represent a continuation of the efforts begun in June 1962. As stated in WANL-TME-039, dated April 14, 1962, the purpose of these experiments is to perform initial screening of electronic components and circuit assemblies presently being considered for use in the NERVA reactor control system. Thus far, five experiments have been conducted at the WNY reactor consisting of tests on insulated wires and cables, resistors, capacitors, a pulse preamplifier, and two different DC preamplifier schemes. The present set of experiments are scheduled to be conducted during the time period October 29 - November 2, 1962. Future plans call for one additional test series on electronic components and circuits during December 1962. Subsequent tests will be carried out at the Nuclear Aerospace Research Facility (NARF) in Fort Worth, Texas and at the Plum Brook Reactor Facility.

2.0 Test Conditions

2.1 Physical Location - All of the experiments described in this memorandum except the coaxial cable test will be placed within the 3" x 3" x 30" aluminum capsules used in prior runs. Likewise, as before, all of the experiments will be located in the A3 experimental hole of the WNY reactor core. The coaxial cables will be placed within a 3" diameter stand-pipe which is described in detail in the Experiment No. 6 writeup.

2.2 Nuclear Environment - Measurements made during the last series of tests at the WNY Facility which involved placing bare and cadmium-covered cobalt and nickel foils in the interior of the test capsules (with the experiments in place) revealed the following neutron flux data:

$$\text{Fast neutron flux (E} > 2.9 \text{ MEV)} = 1.2 \times 10^{12} \text{ n/cm}^2\text{-sec}$$

$$\text{Thermal (cadmium difference) neutron flux} = 4 \times 10^{12} \text{ n/cm}^2\text{-sec}$$

These values agree very closely with independent measurements made by three other agencies in the same experimental hole.

The gamma dose information obtained with nitrous-oxide dosimeters (supplied and readout by the General Dynamics/Fort Worth Corporation) indicates that the gamma dose rate in the interior of the test capsules is slightly greater than 10^8 R/hr. This value still appears to be high by a factor of two. During the present test sequence, it is planned to measure the gamma intensities using a 4 cc graphite-electrode ionization chamber.

2.3 Test Duration - Four hours. This test duration will provide the following

integrated fluxes:

$$\text{Fast neutron (E} > 2.9 \text{ MEV)} = 1.7 \times 10^{16} \text{ n/cm}^2$$

$$\text{Thermal neutron (Cd difference)} = 5.8 \times 10^{16} \text{ n/cm}^2$$

$$\text{Gamma} = 2 \times 10^8 \text{ R } (1.7 \times 10^{10} \text{ ergs/gram - C)}$$

- 2.4 Temperature Control - As was the case in prior tests, the interior of the test capsule will be filled with dry helium gas and maintained at a static pressure of 15 psig throughout the pre-irradiation, irradiation, and post-irradiation test phases. Free convection of the helium gas will provide sufficient cooling in order to maintain component temperatures below their maximum rated values (approximately 125°C).

EXPERIMENT NO. 6 - COAXIAL CABLE TEST

- 1.0 Purpose of Test - It is the designed purpose of this test to measure radiation induced effects on cables directly affecting application to neutron detectors. Two basic measurements will be made. One will measure induced DC currents at an applied potential in the order of microvolts and the other will measure electrical noise content of leakage currents with a high DC voltage applied.
- 2.0 Test Justification - Tests of the type proposed have not been conducted previously. Test data available indicates a good probability that the cables selected for test will perform properly in the proposed NERVA applications. Testing to simulated application conditions is to be performed to verify the hypothesis. A "best" cable for the high voltage and electrometer signal applications will be determined.
- 3.0 Test Conditions - The cables tested will be subjected to the nuclear environment as described in the introduction. It is not intended, however, to test for integrated effects. Tests will be made at different levels as required to establish rate effects. Dosimetry checks will be made to establish exposure levels.

Cables will be mounted in a standpipe inserted in the reactor core. Cooling will be provided by air convection in the standpipe to the surrounding reactor coolant water. Thermocouples will be attached to the cables undergoing test to monitor temperatures.

4.0 Experiment Description

4.1 Cables to be Tested - The following cables will be tested in this experiment:

- a.) Westinghouse WX 4403 vacuum cable
- b.) Amphenol RG 149/U (polyethylene)
- c.) Amphenol 21-541 (low-noise polyethylene)
- d.) General cable RG-81 (magnesium oxide)
- e.) Raychem 32-195 (irradiated polyolefin)

4.2 Mechanical Arrangement - The cables to be tested will be installed in a standpipe for insertion in the reactor core. The cable ends will be sealed with potting compound before insertion in the standpipe and located in such a manner as to eliminate end effects.

4.3 Induced DC Leakage Currents - The test circuit of Figure 6-2 will be used

to measure DC leakage currents at low applied potentials. The same cables as tested for noise will be tested for leakage current. The operational amplifier will serve as a high gain feedback type linear microammeter. Offset will be carefully adjusted to a minute value with the amplifier balance control. This will minimize amplifier input current requirements and reduce with potential on the cable under tests to virtually zero volts (20 to 100 microvolts).

The range of the linear microammeter is adjustable over a wide range as determined by the feedback network of Figure 6-3. For best accuracy and minimum offset the amplifier output voltage will be maintained at 1 volt or less by selecting the proper range. Induced cable current will be determined by amplifier output voltage and the feedback resistor used.

$$(I = \frac{V_{out}}{R_F}).$$

- 4.4 High Voltage Noise Test - The experimental setup as shown in Figure 6-1 will be used in this experiment. A potential of 900 volts DC will be applied to the center conductor with both positive and negative polarities. Noise will be monitored (with and without terminating impedances on the cable input) with an oscilloscope and a preamplifier.

A series of high pass filters will be used to ascertain the frequency characteristic of the noise.

Cable leakage currents will be measured with an electrometer primarily to check for cable failures and to serve as a point of reference.

Photographs of oscilloscope traces will be used to record observed noise levels.

- 5.0 Test Description - The same cables will be tested for both noise and leakage current at low applied potentials. In that hysteresis effects of dielectric absorption would introduce errors if cables were alternately tested at high voltage and zero potential, the low voltage measurements will be completed first. After a cooldown period of about 24 hours the same cables will be retested at the same power levels for noise effects.

The testing will include pre-irradiation testing of each cable for noise of leakage current as described. The standpipe will then be placed in the core or with the reactor at zero power and cables again will be tested. The reactor power will then be increased in steps to a level of 10 KW, 100 KW and 1 MW with noise or leakage current measurements made at each level. Similarly, post-irradiation tests will be conducted after shutdown with the standpipe removed from the core and placed in a storage rack.

HIGH VOLTAGE NOISE MEASUREMENT
FIGURE 6-1

DC LEAKAGE CURRENT MEASUREMENT
FIGURE 6-2

ALL RESISTORS $\pm 5\%$

LINEAR FEEDBACK NETWORK
FIGURE 6-3

EXPERIMENT NO. 7 - ELECTRONIC TUBES

- 1.0 Purpose of Test - The purpose of the electronic tube test is to measure the effects of a radiation environment on the static characteristics of a variety of electronic tubes that may be used in the pulse and/or DC preamplifier designs being developed for NERVA nuclear instrumentation applications.
- 2.0 Test Justification - A review of prior radiation tests and information received from manufacturers indicates that RCA nuvistor electronic tubes, selected subminiature glass electronic tubes, and ceramic tubes are among the types that offer the greatest degree of radiation resistance. Except for the ceramic tubes, however, there is not sufficient radiation effects data at the combined dose rate and integrated dosage expected for the NERVA environment.
- 3.0 Experiment Description
 - 3.1 Tubes to be Tested - Table 7-1 itemizes the electronic tubes that will be tested during this experiment. Two tubes of each type will be tested. The tester is a Hickok Electrical Instrument Company transconductance tube checker, Model 539B with modified connections for additional measurements.
 - 3.2 Mechanical Arrangement - The tubes are mounted to 1/16 inch thick 1100-H14 aluminum alloy plates by means of tube shields and fuse clips. (See Figure 7-1) The Raytheon CK 5889 tubes are mounted with an International Electronic Research Corporation (IERC) tube shield type T3A-421. The Raytheon CK 5886 tubes are mounted with an IERC tube shield type T3A-423FB. The remaining Sylvania tubes on this plate (7963 and 6112) are mounted with the IERC tube shield type T3A-421. The second plate uses an IERC tube shield type T3A-431 to mount the Sylvania tubes 8185. The remaining tubes (RCA nuvistors 8056, 7895, 7586 and 7587) are mounted with fuse clips.

The T3A-421 tube shield is made of aluminum and beryllium-copper materials with a total weight of 2.1 grams. The T3A-431 and T3A-423FB shields are also made of the same materials but with a weight of 2.9 grams and 2.0 grams respectively. The spring assembly of these shields had a cadmium plated finish. However, by means of a chemical process the cadmium finish was removed leaving only the beryllium-copper.

The fuse clips, manufactured by Littlefuse are constructed of nickel-plated phosphor bronze. The tubes are mounted such that the shields and fuse clips have maximum contact with the aluminum plates in order to obtain optimum heat transfer.

The tube leads are wired with No. 20 AWG irradiated polyolefin (Raychem Corporation) insulated wire from the capsule to the monitoring equipment, except for grid leads which are wired with Raychem 42-178 coaxial cable.

- 3.3 Electrical Hook-Up - As previously stated the tubes will be tested with the Hickok transconductance tube tester. A plug-in adapter has been constructed to readily measure grid current, filament current, plate current and grid current. (See Figure 7-2)

Temperature measurements using copper-constantan thermocouples will be made at the following points:

- 1.) On the surface of a glass tube at the middle of the plate.
- 2.) On the surface of a nuvistor tube in the middle of the plate.
- 3.) On the surface of nuvistor tube at the top of the plate.
- 4.) On the surface of one of the aluminum mounting plates (near the mid-point).
- 5.) Ambient capsule gas temperature (measured about 1-1/2 inches above the surface near the mid-point).

- 4.0 Test Description - The tubes, located in the capsule, will be placed into a storage rack in the reactor pool for the pre-irradiation tests. The wires from the tubes will come through a conduit to the remotely located tube tester. All of the tubes will be wired to a standard eight pin octal plug. This plug will be inserted into the adapter which will in turn be plugged into the tube tester. (See Figure 7-3) With the tubes in the storage location, the following information will be obtained:

- a.) Short test
- b.) Leakage test (between given element and all other elements)
- c.) Transconductance
- d.) Plate current
- e.) Grid current
- f.) Filament current
- g.) Life test
- h.) Gas test

(A standby filament supply will provide filament heating for the tubes while they are not being tested. The filament supply is also an orderly method of keeping the tube sockets at hand.)

Upon completion of the pre-irradiation tests, the capsule will be placed into the core of the reactor and the reactor brought up to full power. At full power (1 megawatt) the same tests will be made as were made during pre-irradiation tests. When the reactor is shut down, the capsule will again be placed into the storage rack and then permitted to cool to ambient temperature. When the temperature has stabilized, post-irradiation data will be taken. Again, the same tests as were made in pre-irradiation will be made in post-irradiation.

TABLE 7 - I
ELECTRONIC TUBES TO BE TESTED

Tube Group	Manufacture	Tube Number	Tube Type	Characteristics	Size and Weight	Materials
1	Raytheon	CK5886	Subminiature Glass Bulb T - 2 x 3	Electrometer Pentode Fil. = 1.25V at 10 μ a Max. Plate Cur. = 300 ma Mu = 175; Gm = 175	$\frac{H}{1.5''} \times \frac{W}{.285''} \times \frac{L}{.4''}$ 2.6 grams	Note A
2	Raytheon	CK5889	Subminiature Glass Bulb T3	Pentode Fil. = 1.25V at 7.5 ma Max. Plate Cur. = 300 μ a Mu = 250; Gm = 10	$\frac{H}{1.75''} \times \frac{Dia.}{.400''}$ 2.65 grams	Note A
3	Sylvania	6112	Subminiature Glass Bulb T3	Dual Triode Fil. = 6.3V at 300 ma Max. Plate Cur. 3.3 ma Mu = 60 to 80; Gm = 1800	$\frac{H}{1.5''} \times \frac{Dia.}{.40''}$ 3.5 grams	Note A
4	RCA	<u>7586</u> A15212	Nuvistor Metal Shell	Triode Fil. = 6.3V at 140 ma Max. Plate Cur. = 20 ma Mu = 35; Gm = 10,000	$\frac{H}{.8} \times \frac{Dia.}{.5''}$ 1.9 grams	See Table 7 - II
5	RCA	<u>7587</u> A2702	Nuvistor Metal Shell	Tetrode Fil. = 6.3V at 150 ma Max. Plate Cur. = 20 ma Gm = 10,000	$\frac{H}{1.05''} \times \frac{Dia.}{.5''}$ 2.35 grams	See Table 7 - II
6	RCA	<u>7895</u> A15321	Nuvistor Metal Shell	Triode Fil. = 6.3V at 135 ma Max. Plate Cur. = 15 ma Mu = 64; Gm = 9500	$\frac{H}{.8''} \times \frac{Dia.}{.5''}$ 1.9 grams	Note B

TABLE 7 - I (Cont'd)

Tube Group	Manufacturer	Tube Number	Tube Type	Characteristics	Size and Weight	Materials
7	Sylvania	7963	Subminiature Glass Bulb T3	Dual Triode Fil. = 6.3V at 350 ma Max. Plate Cur. = 22 ma Mu = 40; Gm = 13,000	H 1.375" x .400" 4.0 grams	See Table 7 - III
8	RCA	8056 A15319	Nuvistor Metal Shell	Triode Fil. = 6.3V at 135 ma Max. Plate Cur. = 15 ma Mu = 12.5; Gm = 8000	H .8" x .440" 1.9 grams	Note B
9	Sylvania	8185	Subminiature Glass Bulb T3	Triode Fil. = 6.3V at 300 ma Max. Plate Cur. = 50 ma Mu = 42; Gm = 19,000	H 1.625" x .400" 4.4 grams	See Table 7 - III

NOTE A : No actual material list was available but because of the similarity of the tubes it is believed that the materials are essentially the same as types 7963 and 8185.

NOTE B : No actual material list was available but because of the similarity of the tubes it is believed that the materials are essentially the same as types 7586 and 7587.

TABLE - 7 - II

PARTS LIST FOR THE 7586 AND 7587*

Envelope	No. 52 Alloy (50% nickel, 50% iron)
Stem wafer	Forsterite ceramic
Anode	330 Grade Electronic Nickel
Element Support	Copper plated steel (SAE 1010)
Flanges	
Stem leads	Copper plated molybdenum
Grid	Copper plated molybdenum and nickel plated molybdenum
Cathode support sleeve	Nickel chromium alloy
Heater	Tungsten - Alumina coating
Cathode	High purity nickel; Barium-Strontium- Calcium Carbonate Coating
Seal Braze and Metallizer	Molybdenum Germanium copper alloy

The total material by weight is:

<u>Material</u>	<u>Weight in grams x 10⁻³</u>
Aluminum Oxide	3.5
Barium	0.22
Calcium	0.03
Chromium	0.8
Copper	59.8
Forsterite	338.5
No. 52 Alloy (50% Ni, 50% iron) (plus 0.5% Mn, 0.3% Si, 0.15% Cu, 0.06% C Trace of Cobalt)	1143.1
Germanium	6.54
Manganese	0.03
Molybdenum	131.5
Nickel	49.4
SAE 1010 Carbon range: 0.05 - 0.15% Manganese: 0.30 - 0.60% Phosphorus (max): 0.045% Sulphur (max): 0.055%	90.0
Strontium	0.27
Tungsten	3.5

* The parts list for type 7587 is identical with the addition of a top cap of the same material as the envelope above and a ceramic spacer, of the same material as the stem wafer above.

TABLE - 7 - III

MATERIALS LISTS FOR SYLVANIA FRAME GRID SUBMINIATURE TUBES 7963 AND 8185

<u>TUBE PART</u>	<u>MATERIAL</u>	<u>TUBE TYPE</u>
Heater Wire	Tungsten Coil	Both
Heater Wire Coating ⁵	Alundum	Both
Cathode Sleeve	220 Nickel	Both
Cathode Tab	Dotab (Nickel Alloy)	Both
Cathode Coating	Oxide Coating of Ba O/Sr O/Ca O	Both
Mica Spacers	Mica .006" to .011" Coated with Magnesium Oxide	Both
Stem Leads	.017" Dumet Wire Tinned Exterior to Glass	Both
Stem Glass	Corning Type 8161	Both
Bulb Glass	Corning Type 0120	Both
Plate	Carbonized, Nickel Plated Steel	Both
No. 1 Grid Side Rods	Molybdenum	Both
No. 2 Grid Straps	Molybdenum	Both
No. 1 Grid Laterals	Tungsten Wire	Both
Support Rods	Nickel Plated Steel	7963
Heater Connectors	Nickel Plated Steel	Both
No. 1 Grid Connector	Nickel	Both
Kemet Getter		7963
Rectangular Loop	Nickel	
Getter Bar	Iron Clad Barium	
Getter Material (Flushed)	Barium, Aluminum	
Stabil Getter		8185
Ring	Nickel or Nickel Plated Steel	
Getter Material (Flushed)	Barium, Aluminum, Nickel

ELECTRONIC TUBE ARRANGEMENT
FIGURE 7-1

PLUG IN ADAPTER
FIGURE 7-2

BLOCK DIAGRAM OF ELECTRONIC TUBE TEST

FIGURE 7-3

EXPERIMENT NO. 8 - ELECTRICAL INSULATING COATINGS

- 1.0 Purpose of Test - To measure the relative effectiveness of various electrical insulating coatings in reducing the shunting effect on high impedance circuits caused by the ionization of cooling gas in nuclear environments.
- 2.0 Justification - The effects of cooling gas ionization on circuit operation in a nuclear environment must be reduced or eliminated in order to make it possible to measure signal currents as low as 10^{-9} ampere which may be generated by the power range neutron detector at the lowest part of its range. Likewise, pulse circuits would benefit from a reduction in the gas ionization effects in that some of the restrictions on impedance levels could be minimized. Based on tests conducted at pulsed-reactor facilities, it appears that coating materials can have a substantial effect in reducing gas ionization problems. However, none of the prior test data are directly applicable to the radiation conditions which will be encountered during a NERVA mission. The insulation coatings selected for this test represent a cross section of materials that show definite promise of performing satisfactorily.
- 3.0 Experiment Description
 - 3.1 Insulating Coatings to be Tested - The following insulation coatings will be tested during this experiment:
 - Dow Corning 991 Varnish (50% solution of a silicone resin in xylene) - Unfilled
 - Dow Corning 991 Varnish - Filled with No. 325 mesh Synthamica No. 202 powder
 - General Electric RTV-60 Silicon Rubber Spray
 - GC Electronics Red Glyptal Insulation Varnish (alkyd base)
 - Minnesota Mining and Manufacturing Company "Scotchcast" No. 5 Epoxy Resin - Filled with alumina powder
 - Krylon Acrylic Resin Spray
 - 3.2 Mechanical Arrangement - The test lead is fastened with a machine screw to a $1/4''$ diameter x $1/2''$ long steatite standoff (Birnbach 441A) which in turn is fastened to a $13-1/2''$ x $2-5/8''$ aluminum test plate with a machine screw. The entire standoff with lead attached is given two coats of an insulating coating to minimize the danger of pin holes in the coating. Three similar posts are prepared for each insulating coating under test.

Also, four uncoated posts are provided for comparison purposes. Figure 8-1 shows the locations of the insulating coatings on the aluminum plate. Test leads are No. 20 gauge Raychem Corporation Rayolin N hook-up wire.

- 3.3 Electrical Hookup - The electrical hookup for this test is shown in Figure 8-2. The test consists of measuring the insulation resistance between the screws mounted on top of the insulators and the aluminum plate which is at ground potential. Individual wires connected to the different coated insulators will be individually connected to the measuring setup shown and readings taken.
- 4.0 Test Procedure - The insulation resistance will be measured at a 300 volt DC potential during pre-irradiation tests, at zero reactor power, 10 KW reactor power, 100 KW reactor power, 1 MW reactor power and post-irradiation. Except at the 1 MW reactor power level only one set of readings will be taken after which the reactor power will be increased to a higher level. After reactor power reaches the 1 MW level, readings will be taken at 1/2 hours intervals throughout the power run to measure the effect of integrated dosage.

Post-irradiation inspection for physical damage to the test coatings (after cooldown) will be performed for correlation with measured performance.

LOCATION OF INSULATING COATINGS
FIGURE 8-1

INSULATING COATING TEST - ELECTRICAL HOOKUP
FIGURE 8-2

EXPERIMENT NO. 9 - DC IMPEDANCE CONVERTER (NUVISTOR)

- 1.0 Purpose of Test - To measure the performance of a DC impedance converter circuit over a current range of 10^{-9} to 5×10^{-4} ampere in a radiation environment similar to that expected during a NERVA mission.
- 2.0 Justification - The Power Range neutron detector being developed for the NERVA reactor control system may generate currents as low as 10^{-9} ampere at the bottom part of its range. One approach that is being investigated with regard to transmitting this signal to control circuits located near the payload compartment is to use a DC preamplifier circuit directly coupled to the output of the neutron detector. Consequently, this circuit must be capable of operating properly in a radiation environment. The first experimental model of a DC preamplifier that was tested in a radiation environment (Experiment No. 5 - Western New York Nuclear Research Center Reactor Program) revealed that input currents from 10^{-9} to about 10^{-6} ampere could not be meaningfully measured in the radiation environments encountered with the WNY reactor operating at 1 MW. One of the sources of difficulty is believed to be due to the poor performance of the 7895 nuvistor electrometer tube. Since that time, an improved nuvistor electrometer tube (8056) has appeared on the market. Furthermore, due to the relative complexity of the DC preamplifier circuit tested, it was found to be very difficult to identify and account for all of the possible radiation effects mechanisms. As a result of these considerations, it was decided to test only that portion of the circuit which is felt to be the most critical, namely -- the log diode-electrometer tube circuit. Due to the simplicity of the circuit, there should be few, if any, side effects. Hence, it should be possible to isolate and identify all radiation induced effects with a high degree of confidence.
- 3.0 Experiment Description
 - 3.1 Circuit to be Tested - The circuit to be tested is shown in Figure 9-1. Only that portion shown within the dashed lines will be located in the radiation field. Basically, it is a simple impedance converter consisting of an electrometer, a log diode, and a cathode resistor and a capacitor around the log diode.
 - 3.2 Mechanical Arrangement - The irradiation models will be constructed along the lines of the first model except that all tubes will be mounted in fuse clips connected to the aluminum plate. Six 8056 nuvistor tubes have been filament-aged for 215 hours, and the final model tubes will be selected from these six. Two identical circuits will be mounted on one plate and tested simultaneously.
 - 3.3 Electrical Hookup - The test monitoring instrumentation is shown schematically in Figure 9-1. The input current will be supplied by the ion current

simulator described previously.

- 4.0 Test Procedure - The pre-irradiation, irradiation, and post-irradiation test procedures are essentially the same as those previously described for the nuvistor log diode preamplifier irradiation test (Ref. Experiment No. 5, WANL-TME-090).

Long and short term drift measurements were taken of the impedance converter circuit (Model No. 2E). These data are shown on Figure 9-2.

POWER RANGE PREAMPLIFIER #2E
 FIGURE 9-1

Figure 9-2 Model #2E 8056 Power Range Preamplifier,
Drift Measurements (Sheet 1 of 5)

Figure 9-2 Model #2E 8056 Power Range Preamplifier,
Drift Measurements (Sheet 2 of 5)

Figure 9-2 Model #2E 8056 Power Range Preamplifier,
Drift Measurements (Sheet 3 of 5)

Figure 9-2 Model #2E 8056 Power Range Preamplifier,
Drift Measurements (Sheet 4 of 5)

Figure 9-2 Model #2E 8056 Power Range Preamplifier,
Drift Measurements (Sheet 5 of 5)

EXPERIMENT NO. 10 - TETRODE PULSE PREAMPLIFIER (NUVISTOR)

- 1.0 Purpose of Test - The purpose of this test is to establish the feasibility of a nuvistorized tetrode pulse preamplifier for amplifying pulse voltages as small as 100 microvolts and transmitting them over as much as 100 feet of cable to a receiving point while the preamplifier is subjected to gamma and neutron radiation levels similar to those expected during a NERVA mission.
- 2.0 Justification - This test is one of a series of screening tests on various pulse preamplifier designs. The goal of such testing is to arrive at an optimum pulse preamplifier design for use with intermediate range neutron detector. The restart capability stipulated for the NERVA reactor requires that the intermediate range neutron detector and associated preamplifier be able to withstand the radiation environment associated with a NERVA mission without suffering any significant degradation in performance.
- 3.0 Experiment Description
 - 3.1 Circuit to be Tested - The preamplifier circuit to be tested together with its cable driver unit are shown in Figures 10-1 and 10-2 respectively.
 - 3.2 Mechanical Arrangement - The circuit components are mounted to a 13-1/2" x 2-5/8" aluminum test plate using steatite insulators, nickel-plated brass screws, and ordinary solder. Hook-up wires and coaxial cables are insulated with an irradiated polyolefin material (Raychem Corporation).
 - 3.3 Electrical Hookup - The instrumentation set-up for monitoring the performance of the preamp during all test phases is shown in Figure 10-3.
- 4.0 Test Procedure - Tests on the irradiation test model preamplifier will consist of a pre-irradiation test, a test during irradiation at various reactor power levels, and a post-irradiation test. Conclusions on the feasibility of the preamplifier will be based on the data accumulated from the above tests.
 - 4.1 Pre-Irradiation Test
 - 4.1.1 The purpose of this test will be to establish circuit performance baseline data, and to check circuit performance before and after installation in the test capsule.
 - 4.1.2 The circuit will be initially energized in free air, and connected to instruments as shown in Figure 10-3. Power supplies should be turned on in the following order.

1. Turn on filaments - allow time to heat
 2. Turn on plate voltage
 3. Turn on screen voltage
- 4.1.3 Observe values of all applied voltages and currents.
 - 4.1.4 Check temperature of tubes with thermocouples attached at lower part of tube. Temperatures should not exceed 150°C .
 - 4.1.5 Observe output of preamplifier on scope to assure output is pure tube noise. Measure peak to peak value of noise.
 - 4.1.6 Measure noise output with an R. F. voltmeter to derive the r.m.s. noise voltage referred to the input.
 - 4.1.7 Gain and Waveform Check - Apply square wave input signal (between ten and one hundred KC for convenience). Adjust generator amplitude and attenuator so that negative voltage pulse at the input grid is 10 MV.peak. Measure output voltage to derive gain figure rise time of both input and output pulses should be about 0.05 microseconds. Pulse width should be about 0.2 microseconds.
 - 4.1.8 Obtain correlation of square wave signal levels into cable with pulse voltage at grid so that pulse input voltage at the grid can be adjusted over the range of 100 microvolts to ten millivolts.
 - 4.1.9 Photograph representative noise levels and output signals.
 - 4.1.10 Following completion of the free air check, the preamplifier should be installed in the test capsule, which can then be filled with helium and sealed. Energize the preamplifier (allow 30 min. warmup) and make the following tests: determine circuit temperature.
 - 4.1.11 Record all temperature and instrumentation reading with pre-amplifier at room temperature.
 - 4.1.12 Increase ambient temperature so that the internal temperature of the capsule will rise in steps up to 150°C on the hottest tube. Record instrumentation readings at each step.
 - 4.1.13 Reduce ambient temperature to initial level and record instrumentation readings.

4.2 Irradiation Test - Performance of the preamplifier at various radiation levels and integrated flux values will be determined.

4.2.1 The instrumented capsule shall be placed in the cold reactor and the preamplifier circuit energized. Record capsule instrumentation readings and amplifier responses with the reactor in the shutdown condition. The reactor should then be raised to maximum radiation level in steps with instrumentation readings and circuit responses recorded during each step. The radiation should be held at maximum level until the preamplifier has been exposed to the required neutron and gamma dosage. Record instrument readings and circuit responses periodically during the time at maximum radiation level.

4.2.2 Upon completion of the dosage run, the reactor shall be shut down in steps, with capsule instrumentation and circuit response recorded during each step. The exact schedule of reactor operation to provide desired radiation levels and dosage will be determined prior to the test by WANL and A. S. & D.

4.3 Post-Irradiation Test - Following the irradiation test the capsule shall be removed from the reactor in a fully operating condition and placed in a suitable radiation cooling area. Capsule instrumentation and circuit responses shall be recorded during this operation. The amplifier circuit shall then be de-energized and removed from the capsule. The preamplifier shall be examined visually and electrically to determine radiation damage.

4.4 Evaluation - Information from the experiment shall be coordinated and arranged in a form usable for circuit evaluation. Gamma and neutron levels and dosage will be known at each step in the irradiation test so that circuit variations may be quantitatively correlated with radiation. Results of the temperature test in the preirradiation check will be integrated into the results. Circuit performance will be evaluated in terms of the nuclear test environment and NERVA radiation resistant design requirements, which the preamplifier should meet.

1. ALL TUBES ARE 7587/A2702 NUUVISTORS
2. ALL RESISTORS ARE IRC MOLDED METAL FILM, 1/2 WITH THE EXCEPTION OF R61,R11,R124,R166.
3. ALL CAPACITORS ARE CORNING GLASS TYPE, VALUES PF
4. R61,C11 AND C2 SIMULATE PULSE DETECTOR
5. TOTAL POWER DISSIPATION IS 8.0 WATTS

Figure 10-1 Nuvistor Tetrode Radiation Resistant Pulse Amplifier Circuit

1. ALL RESISTORS ARE IRC MOLDED METAL FILM
2. ALL CAPACITORS ARE CORNING GLASS TYPE
3. ALL FILAMENTS 6.3 VAC

Figure/O-2 Cable Driver Unit

Figure 10-3 Preamplifier Instrumentation for Astronuclear Irradiation Test