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	KEWB TRANSIENT INSTRUMENTATION	PAGE 1 OF 9

TO: J. W. Flora

COPIES TO: H. Donohue* S. P. Harris* J. A. Brinkman* D. P. Gamble* R. K. Stitt* E. E. Motta* E. L. Gardner* M. E. Remley* C. E. Dixon*

SUBJECT: Prompt Radiation Effects on Cables and Linear Power Instrumentation Channels

CONTENTS:

I STATEMENT OF PROBLEM

SECTION I - CABLE EXPERIMENTS

In the course of experiments to test pressure transducers for instantaneous radiation sensitivity in the KEWB reactor, large radiation-induced voltages (the order of a volt) were observed during transients of approximately 500 Mw peak power. Maximum neutron fluxes involved were 5×10^{15} n/cm^2/sec. It was suspected that a part of this voltage was generated in the cable and the remainder in the piezoelectric transducer. To check this point, a series of tests on several types of cables alone, and on a bare wire pair was made in and near the central exposure facility of the KEWB reactor. Measurement of cable insulation resistance during the radiation bursts was made in three cases.

II. SUMMARY OF RESULTS

Radiation-induced signals were detected in the following types of cables: Microdot (type 50-3804), MgO insulated McGraw-Edison (for high temperature service), MgO insulated dual thermocouple leads, RG-62/U, RG-8/U, and Twinax (Belden 8227). Ordinary #22 gauge stranded hook-up wire was also found susceptible to radiation. These signals were the order of a few tenths to several volts peak across 1 megohm at maximum radiation intensity. In some cases, the signals follow the reactor power curve closely, as shown in Figure 1; in others they appear to be the sum of two opposing effects. In the hook-up wire tests an 800 ohm Shallcross wire-wound resistor joined the ends of the wires at the center of the exposure facility. In this test the maximum radiation-induced signal was 22.5 mv.

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In additional experiments to investigate the nature of radiation-induced voltages in cables, a 5 ft. length of RG19/U cable was inserted into the center of the exposure facility. This is heavy cable with 1/4" solid copper center conductor and polyethylene insulation 0.33" thick. The shield is copper braid and the end of the center conductor was covered with polyethylene. In this test the maximum radiation-induced signal at the peak of a transient in KEWB was + 60 volts. This is the largest radiation-induced voltage observed by us so far. A-90V. bias on this cable produced a relatively small effect (see Table I).

Another experiment was with a concentric rod, 1/4" diameter, and cylinder 3/4" diameter, air insulated. When the center rod was copper, the cylinder was aluminum and vice versa. With a copper rod and an aluminum cylinder a + 1.6 volt signal was obtained. With the materials interchanged, a - 1.2 volt signal was obtained. The shapes of the curves obtained for signal versus time were somewhat different and the times of peak signal differed.

In a test for loss of insulation resistance, a 9 volt bias was applied to one wire of a bare copper pair. During the peak of a transient the full 9 volts were seen at the oscilloscope input, which is a 1 megohm resistance, indicating a leakage resistance between the wires which is low compared to 1 megohm. The voltage observed with no bias occurs because of the grounded aluminum central tube liner. A similar test indicated a 1.8 megohm leakage resistance for the Microdot cable and 0.28 megohm for the McGraw-Edison cable. A portion of this could occur across the air gap at the end of the cable. The results of the cable tests are tabulated in Table I.

III. METHOD, DESCRIPTION OF EQUIPMENT, SAMPLE CALCULATIONS

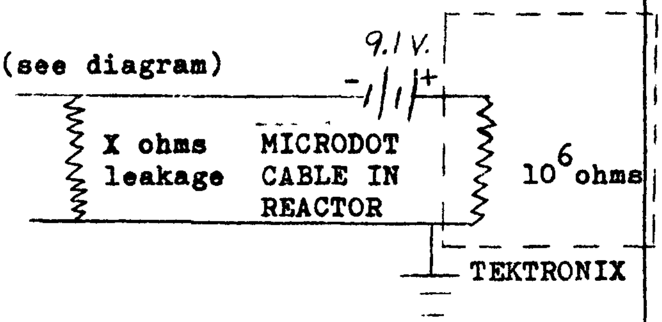
The method used to detect the radiation-induced voltages was to observe directly the voltage output of the cables being tested using a Tektronix oscilloscope. In most cases, the end of the cable, placed at the center of the exposure facility or near the reactor, was left open. The exception was the hook-up wire cable which terminated in an 800 ohm wire-wound resistor and was connected to a Kintel amplifier which was then connected to the oscilloscope. For the bare copper wire pair, two 1/8" copper rods were supported on porcelain insulators outside the reactor and the two rods were long enough to reach into the center of the reactor without additional support.

The Tektronix oscilloscope was triggered externally by the output of a thyratron which was fired by a signal from the log N power channel #8 early during the rising portion of a KEWB transient. The thyratron could also be fired by manually applying an independent triggering signal to check that no spurious voltages were being picked up by the cables. A sweep speed of 5 milliseconds per centimeter was used in all cases. As Table I shows, the radiation signals from the cables are generally quite well synchronized with reactor power. A portion of the thyratron signal is supplied to a galvanometer in the oscillograph used routinely to record reactor power. The signal obtained from hook-up wire (Figure 1) was compared with the power versus time curve for the transient and the two were found to agree very well. This is not the case for all cables, however, since the voltage appears to originate from more than one source.

The transient conductivity of insulators under irradiation has been explained[1] on the basis of carriers (electrons) produced in the insulator by gamma rays and recoil protons. The carriers generated can exceed the normal concentration by many orders of magnitude. The mean trapping time for carriers is very short ($\sim 10^{-10}$ sec) so that the equilibrium density at any instant is small. Effects can also be observed at the surface of metals.[1] Excitation of electrons to energies greater than the work function can liberate them from the metal surface. This effect is the same as the photoelectric effect and can produce small voltages.

Calculation of Leakage Resistance of Microdot Cable at Peak Reactor Power.

A voltage of + 4.6 v is observed (see diagram) at the Tektronix. When there is no bias, + 1.3 v is observed.



$$\begin{array}{r} 4.6 \\ -1.3 \\ \hline 3.3 \end{array} \text{ v across } 10^6 \text{ ohms}$$

$$I = \frac{E}{R} = \frac{3.3}{10^6} = 3.3 \text{ microamps drawn if there were no radiation voltage.}$$

$$X = \frac{9.1-3.3}{3.3\times10^6} = \frac{5.8}{3.3\times10^{-6}}$$

$$X = 1.8 \times 10^6 \text{ ohms leakage resistance of cable.}$$

SECTION II - RADIATION SUSCEPTIBILITY OF LINEAR POWER RECORDING SYSTEMS

I. STATEMENT OF PROBLEM

Currents caused by radiation effects in cables and electrometer preamplifier chassis could introduce errors in the reactor power data. Experimental observations of the response of these systems were made to determine the magnitude of their radiation sensitivity.

II. SUMMARY OF RESULTS AND RECOMMENDATIONS

The results show no observable radiation effects under the conditions of present use. They indicate, however, that care must be used in the application of cables to avoid such effects.

III. METHOD USED, DESCRIPTION OF EQUIPMENT, SAMPLE CALCULATIONS

The reactor power is measured by four linear recording systems. Each system includes an ionization chamber and polarizing batteries, an electrometer pre-amplifier, a galvanometer drive amplifier, a galvanometer, and interconnecting cables. The major difference between the systems is the relative neutron field strength at each ionization chamber. The four systems are grouped in pairs to provide self-monitoring. The locations of the ionization chambers of the linear power systems in the reactor room are shown in Figure 2. During the radiation sensitivity tests on these systems, one pair (channels 24 and 26) was used, as it normally is, and the other pair (channels 4 and 6) was altered to detect radiation-induced responses in various components of its circuits.

During the radiation sensitivity tests on various cables only those channels noted were altered. The other channels were connected as in normal use. The area enclosed by the dotted line in Figure 2 was used for the tests, which are summarized in Table II. Unless otherwise noted, the cables used are type RG-62/U fitted with BNC connectors.

The radiation induced cable current necessary to produce a 0.06 inch galvanometer deflection in channel 6 during transient #SPH79 may be calculated as follows:

$$I = \frac{D_g S_g R_g}{R_r G_p G_d},$$

where

D_g is the galvanometer deflection,

S_g is the galvanometer sensitivity expressed in amperes per inch deflection (0.01 amperes per 1 inch).

R_r is the galvanometer circuit resistance (1000 ohms).

R_r is the electrometer preamp range resistor value.

G_p is the preamp voltage gain (0.9).

G_d is the galvanometer driver amplifier voltage gain.

Taking the values of D_g, R_r, and G_d from Table II, we find that the current produced in the three foot length of Microdot cable was

$$I = \frac{0.06 \times .01 \times 1000}{10^6 \times 0.9 \times 20} = 3.3 \times 10^{-8} \text{ amperes}$$

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Since the same current would produce the 0.3 inch deflection in channel 6 during transient #80 it can be concluded that the current was again generated in the Microdot cable since it remained constant and the input cable length and the location of the electrometer were changed.

IV. REFERENCES

1. "Electrical Effects of High Intensity Ionizing Radiation on non-Metals" by V. A. J. Van Lint and P. H. Miller, Jr., Paper 54, Third Semi-annual Radiation Effects Symposium, NR-51, Volume 5, Atlanta, Georgia, 10/58.

2. "Study of Radiation Effects on Electrical Insulation" by J. F. Hansen and M. L. Shatzen, Paper 55, Third Semi-annual Radiation Effects Symposium, NR-51, Volume 5, Atlanta, Georgia.

3. "Radiation Effects Activities in ANP Programs", BMI-REIC-58-4-30 (Secret).

4. NARF Progress Report for February 1 through July 31, 1958, NARF-58-38 P (Confidential).

5. "The Conductivity Change in Good Insulators During γ- Irradiation. The Conductivity of Teflon" by Sumner Mayburg, WAPD-RM-122.

TABLE I

RADIATION EFFECTS EXPERIMENTS ON CABLES IN KEWB

Cable Description	Time - (Scope trigger to peak radiation Signal)	Time - (Scope Trigger to Peak Reactor Power)	Reactor Peak Power	Picture No. and Date	Bias	Radiation Signal (Maximum)
RG 19/U	19.0 ms	20.0 ms	360 Mw	7A 3-2-59	none	+ 60 v
RG 19/U	18.5	18.0	362	2A 3-2-59	-90v	+ 53 v
RG 19/U	16.3	17.9	363	4A 3-2-59	none	+ 8.0v*
TWINAX:Cu wire	16.0	17.3	362	4B 2-26-59	none	-1.3,+0.3v
Tinned wire	16.0	17.3	362	4B 2-26-59	none	-1.3,+0.1v
Hook-up wire	18.5	17.7	365	8B 2-26-59	none	+3.6 v
Hook-up wire	20.5	20.9	432	1 10-3-58	none	+22.5 mv**
Bare Cu wires	25	22.0	525	4A 10-20-58	none	+1.3v***
Bare Cu wires	24	20.6	560	2A 10-21-58	+9.1v	+10.2 v
Bare Cu wires	16.5	20.6	532	3A 10-21-58	-9.1v	-7.2 v
Microdot 50-3804	24	22.0	525	4A 10-20-58	none	+1.3 v
Microdot 50-3804	23	20.6	560	2A 10-21-58	+9.1v	+4.6 v
Microdot 50-3804	15	20.6	532	3A 10-21-58	-9.1v	-2.9 v
Microdot 50-3804	25.5	23.8	513	4A 10-21-58	none	+1.5 v
McGraw-Edison	21	22	525	4B 10-20-58	none	+0.6 v
McGraw-Edison	20	20.6	532	3B 10-21-58	none	+0.65 v
McGraw-Edison	21	23.8	513	4B 10-21-58	+9.1v	+7.7 v
RG 62/U	17.5	14.0	596	3 10-30-58	none	+4 v

* Across 91×10^3 ohm resistance
** with 800 ohm wire-wound resistance on end
*** Presence of grounded aluminum liner in central exposure facility gave this effect

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TABLE II

CIRCUIT DATA

Transient No.	Channel No.	Range Resistor	Connection Notes	Driver Amplifier Gain	Observed Effect
SPH 76	4	10^6 ohms	Battery disconnected from ion chamber	20	No Signal
	6	10^6 ohms	Battery disconnected from ion chamber	20	No Signal
SPH 77	4	10^6 ohms	Signal cable between electrometer and ionization chamber was disconnected at ionization chamber (both channels)	20	No Signal
	6	10^6 ohms	Signal cable between electrometer and ionization chamber was disconnected at ionization chamber (both channels)	20	No Signal
SPH 78	24		Signal cable between electrometer and driver amplifier was disconnected from electrometer and placed on the reactor room floor 3 ft. away from and parallel to the north face of the secondary inclosure.	20	1.5" negative deflection
SPH 79	24	--	Same as SPH 78	20	Same
	6	10^6	a 3 ft. length of Microdot cable was placed near the reactor. It was connected to the input of the electrometer by means of 1 ft length of RG-62/U cable	20	0.06 inch positive deflection
SPH 80	6	$5x10^6$	a 3 ft length of Microdot cable was connected to the electrometer input by means of an 8 ft. long RG-62/U cable	20	0.3 inch positive deflection

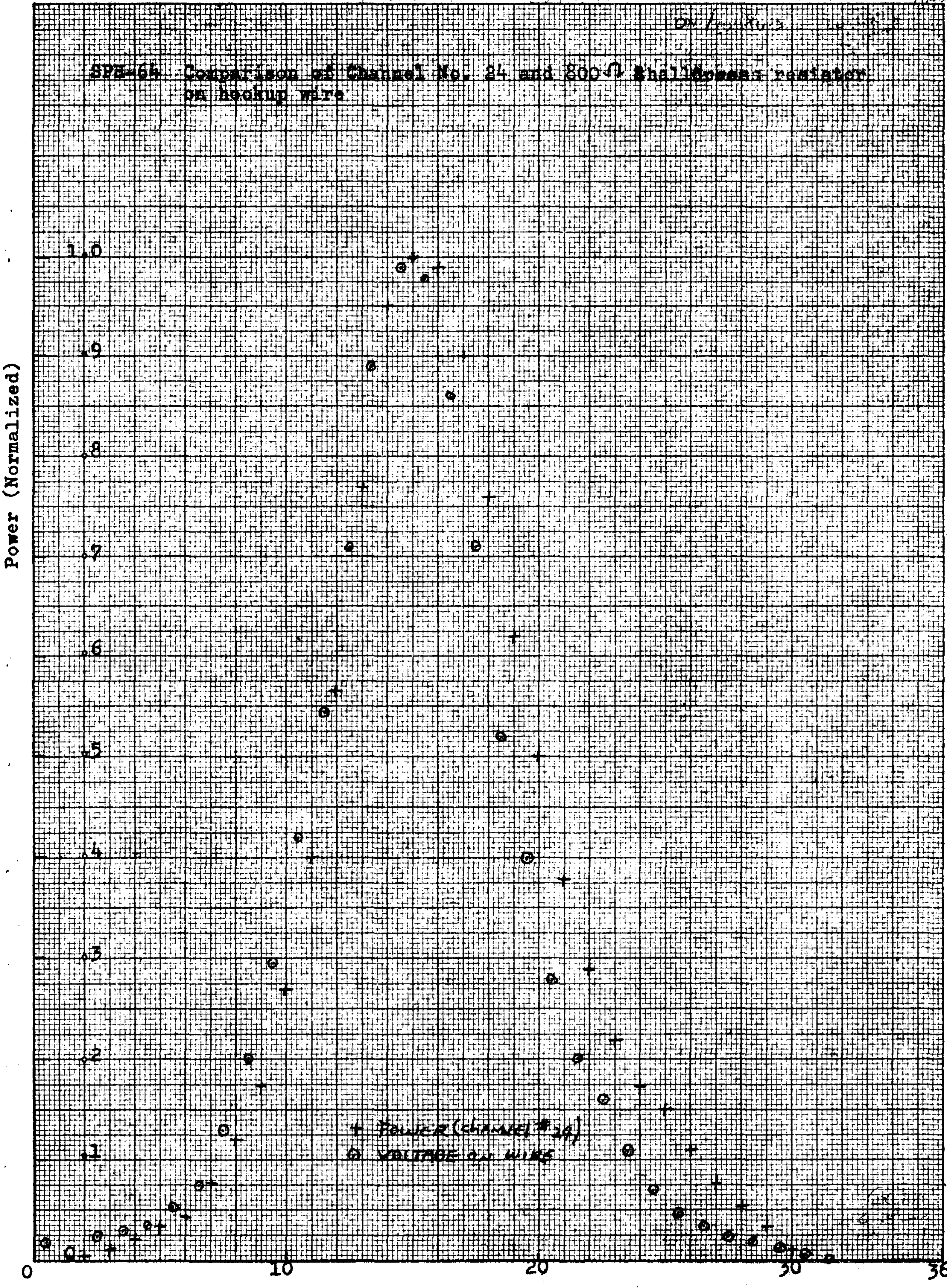

FIGURE 1 Time (ms) OLS 9

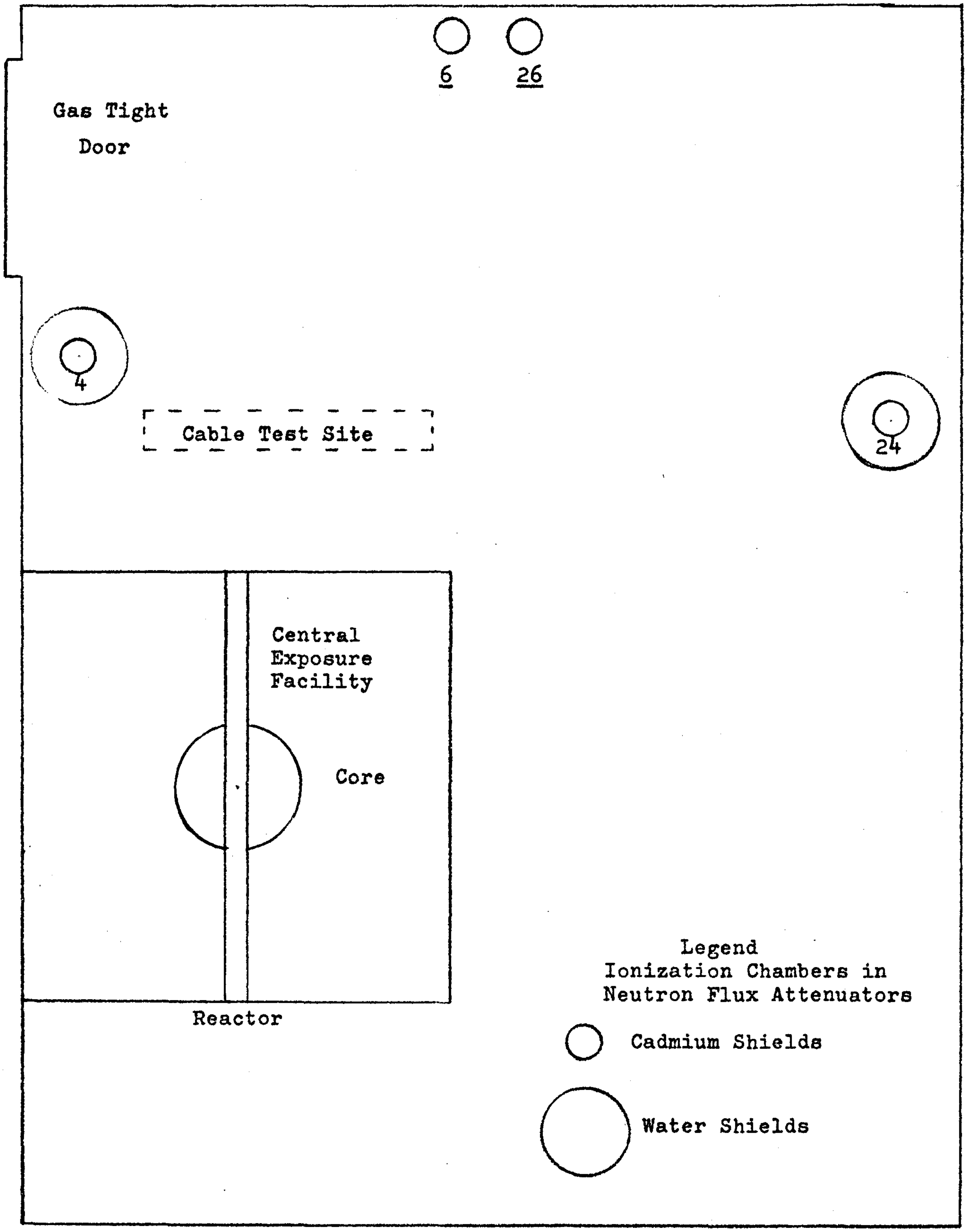

FIGURE 2 Reactor Room Floor Plan