Radiation Center Oregon State University Corvallis, Oregon 97331 (503) 754-2341

August 17, 1979

Division of Operating Reactors
Operating Reactors Branch #4
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Attention: Mr. Robert W. Reid, Branch Chief

Reference: Oregon State University TRIGA Reactor, License No. R-106, Docket No. 50-243

Gentlemen:

We are enclosing the additional information you requested in your letter of July 20, 1979. This additional information is related to the amendment to our Technical Specifications which we submitted April .6, 1979.

We have discussed our request for proposed change number '5, as stated in our letter to you dated April 16, 1979, with your Mr. Vissing, and we have decided to withdraw our request for this change at this time.

We are still hopeful that we can complete the electronic modifications to our console before the fall term classes begin. If we receive approval for these amendments by September 15, this could be accomplished. We greatly appreciate all the help and cooperation you can give us in this regard. Please let us know if you have any other questions or if additional information is needed.

Sincerely,

C. H. Wang
Reactor Administrator

C. V. Smith
Vice President for Administ ation

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CHW/ef
Enc.
cc Oregon Department of Energy
Region V, U.S. Nuclear Regulatory Commission

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782 288

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STATE OF OREGON)
)ss
COUNTY OF BENTON)

C. H. Wang and C. V. Smith, being first duly sworn on oath, depose and say that they have affixed their signatures to the letter above in their official capacities as Reactor Administrator and Vice President for Administration of Oregon State University, respectively; that they have signed this letter supplying additional information in support of the application for an amendment to the Technical Specifications of the OSTR Operating License No. R-106; that in accordance with the provisions of Part 50, Chapter 1, Title 10 of the Code of Federal Regulations, they are attaching this affidavit; that the facts set forth in the within letter are true to their best information and belief.

C. H. Wang
Reactor Administrator

C. V. Smith
Vice President for Administration

Subscribed and sworn to before me, a Notary Public, in and for the County of Benton, State of Oregon, this 20th day of August, A.D. 1979.

Irene L. Sears
Notary Public of Oregon

December 6, 1982
My Commission Expires

782 289

RESPONSE TO

NRC REQUEST FOR ADDITIONAL INFORMATION

DATED JULY 20, 1979

OREGON STATE UNIVERSITY TRIGA REACTOR

LICENSE NO. R-106

DOCKET NO. 50-243

AUGUST 17, 1979

General Note: Figures 1, 2, and 3, submitted on April 16, 1979, have been revised as Figures 1-R, 2-R, and 3-R, respectively. The new revised figures replace the original figures.

1. The new linear "safety power level" channel and the existing percent power channel will indeed use separate ion chambers. The existing percent power channel will use the same ion chamber and circuitry that is now installed. The new safety channel will use the ion chamber that is presently being used as the linear channel. The compensating voltage for this existing ion chamber will not be used; it will function as an uncompensated ion chamber. See Figure 5 for the locations of the two chambers. The lower left chamber (in Figure 5) represents the existing percent power chamber and the upper left represents the new safety channel chamber.

2. (Also see the answer to question 3, as these are directly related.) We only have two realistic options with regard to the console electronics in question: we can continue to use the existing system, or we can replace it with a new system. We stated, on p. 2 of the Justification sent to NRC on April 16, 1979, that the new system "should be more reliable, since it is newer and utilizes all solid-state modular construction with integrated circuitry." We should have emphasized the age factor, as this is probably the most important. The existing system is almost 13 years old, and it seems reasonable to assume that its continued operation would not prove to be as reliable as that of a new system.

   The instrumentation manufacturer (General Atomic Co.) has determined that the mean time between failures (MTBF) for one of our new proposed safety channels is about 10,000 hours. We don't have an MTBF for the present system to compare to this. With the present system, however, we have experienced three electronic system failures in the past 12 years, during which time the console electronics operated about 15,000 hours. It thus appears to us that the reliability of the new system is at least as good or better than that of the present system.

   Our statement on reliability should say, therefore, that reliability will not be decreased when the new system is installed, that the

782 290

reliability will probably increase somewhat, and that the expected MTBF for the new system is about 10,000 hours.

3. Our instrument package was operated for a burn-in period of about 100 hours at room temperature by the manufacturer (General Atomic Co.) prior to shipment to OSU. This was, according to GA, about twice the time normally used for burn-in. In addition, the instrument package was operated for a burn-in period of one week (170 hours) at room temperature by OSU after its arrival here. Thus, the total burn-in period experienced by this instrumentation has been about 270 hours. No failures have been detected during this total burn-in period.

The following information regarding the reliability of our instrument package has been supplied by the manufacturer:

> All instrument components are high quality industrial grade and/or meet military specifications. All active components are solid state devices for high reliability and reduced size. Integrated circuits are used extensively where appropriate, and printed circuit boards are of high temperature and fire-resistant material. Components are de-rated for improved reliability, and circuit reliability analyses are made for all modules involved in the reactor safety system. Recommended testing intervals are based on the predicted mean time between failures. Overall system reliability is enhanced by the use of plug-in circuit boards or modules, thus reducing the mean time to repair.
>
> The more recent design improvements in the General Atomic research reactor instrument system include consideration of the recent ERDA criteria for reactor safety systems and the RDT standards. Circuits in the safety system have undergone reliability and failure mode analysis and are the same as those used in GA Electronic Systems power reactor instrumentation.
>
> Upon completion, modules undergo a Quality Assurance inspection and test, in addition to the normal Quality Assurance inspection and spot testing of incoming components used in the construction of these modules. After fabrication of the instrumentation system, the system is tested with simulated inputs to verify proper operation and to insure that there are no undesirable interactions between the circuits. Critical nuclear channels are tested in a reactor before delivery to the customer. The console is operated for an extended "burn-in" period to allow location and replacement of any temperature-sensitive or weak components. Failures in the electronic modules during a total operating period of several hundred thousand hours have been exceedingly low, and most of them experienced have been failures induced by human error or by failure of an external sensor or device.

782 291

4. The new calibration circuits for the log and linear power and period channels are similar to the existing calibration circuits in that they generate test signals to the channel electronics for checking proper circuit alignment. The new calibration circuit uses a high stability quartz-controlled oscillator, producing a 2 MHz signal which is then digitally divided. The various pulse frequencies and widths are selected by the PERIOD/LOG TEST switch. A pulse of height 0.8V and width of 1 microseconds at frequencies of 100 Hz, 10 KHz, and 200 KHz is used to calibrate the low-range (count rate) circuits. A pulse width of 5 microseconds at 10 KHz and of three varying heights (.3V, .9V, and 10V) is used to calibrate the high range (Campbelling) circuit.

   The calibrate circuit diagrams, shown in Fig. 2-R, are simplified schematics representing a more complex system. The one calibrate position shown in the log circuit (Fig. 2-R) actually represents six different calibrate positions (positions 1 through 6 in Table 1). These provide six different calibration signals for both the wide-range log and wide range linear channels. The one calibrate position shown in the period circuit (Fig. 2-R) represents two separate period calibration signals (calibrate #1 and #2 positions in Table 1). In addition, the period trip setting is checked with the PERIOD/LOG TEST switch in the operate position and the PERIOD TRIP TEST switch turned on (see Table 1).

   The new calibrate (PERIOD/LOG TEST switch) switch is not spring-loaded as the existing switches are. To preclude leaving the calibrate switch in a calibrate position, the switch is connected to the source and 1 kW interlocks (see Table 1).

4a. Initial adjustments were first made at the factory by the instrument vendor (General Atomic Co.) prior to shipping the instruments to OSU. The vendor sent detailed procedures for calibrating and adjusting the new instrumentation. These are listed in the General Atomic Co. publication: "Left-Hand Console Drawer - Installation, Operation, and Maintenance Manual - Prepared for Oregon State University," #E-115-759 (Rev.), Jan. 1979. This manual gives specific details for aligning the channel electronics before installation and also after the components are installed. These alignments will determine the final calibration settings, as indicated in columns 3, 4 and 5 of Table 1. These final calibration settings are only shown as approximate values in Table 1; the final values will have to be determined after the detector and instrument package have been installed as the detector cable length will affect the calibration signal.

4b. Once the instrumentation and detectors have been installed and initially adjusted and aligned the final calibration points given in columns 3, 4 and 5 of Table 1 will have been established. Then, prior to startup each day, the wide range log and linear and period channels will be checked to verify proper response at these nine different positions: two period test points, the period trip point, and six different test points for both the log and linear channels.

Table 1

PERIOD/LOG TEST Switch Position	PERIOD TRIP TEST Switch & Potentiometer Position	EXPECTED RESPONSE			Linear Range Switch Position	Source & 1 kW Interlocks
		Period Meter (Seconds)	Log Meter & Recorder (%)	Linear Recorder		
Operate	Off	← OPERATIONAL INPUTS →			Depends On Power Level	Not Active
Calib. #1	Off	10 Sec	NA	NA	NA	Active
Calib. #2	Off	3 Sec	NA	NA	NA	Active
Operate	On & Turn To Trip Point	Increasing To Trip Point (3 Sec)	1×10^{-2} & Increase	NA	NA	Active
Position #1	Off	∞	$\sim 5 \times 10^{-6}$	~ .05 W	0.1 W	Active
Position #2	Off	∞	$\sim 5 \times 10^{-4}$	~ 5 W	10 W	Active
Position #3	Off	∞	$\sim 1 \times 10^{-2}$	~ 100 W	100 W	Active
Position #4	Off	∞	$\sim 2 \times 10^{-2}$	~ 200 W	300 W	Active
Position #5	Off	∞	$\sim 2 \times 10^{-1}$	~ 2 kW	3 kW	Active
Position #6	Off	∞	~ 20	~ 200 kW	300 kW	Active

782 293

5. Your understanding is correct--the new fission chamber is larger than the existing one. The new fission chamber will be located adjacent to the existing fission chamber. The new fission chamber will be placed into the existing log ion chamber shroud, which will accept the physical size of the new chamber. The existing log ion chamber will be removed and stored. See Figure 4 for the present detector locations and Figure 5 for the proposed detector locations.

   The new fission chamber will "see" essentially the same quadrant of the core as the old fission chamber, and source-fuel-detector geometry will be almost identical for either chamber. Any detector shadowing will be essentially the same as the existing fission and log chambers experience now, and this has not proven to be a noticeable effect or problem at all.

6. Figure 6 shows the operating ranges of the proposed instrumentation channels.

7. Our existing power supply arrangement consists of one high voltage supply unit and one low voltage supply unit for the four nuclear instrument channels.

   The proposed change will add two high voltage supply units (models HV-6) and two low voltage supply units. The proposed change will then provide our system with a total of three high voltage supply units and three low voltage supply units. See Table 2 for details of the present and proposed systems.

8. The new pulsing logic is virtually identical to the existing pulsing logic. A description of each follows:

   A. Existing Pulsing Logic.

      1. When the mode switch is placed in the pulse position:

         a. the percent power chamber is switched from the percent power circuit to the nv circuit.

         b. the linear channel signal is removed from the linear recorder and the nv circuit output is switched to the linear recorder for display.

         c. the log channel signal is removed from the log recorder and the fuel element temperature is switched to the log recorder for display.

         d. the period circuit input is grounded.

         e. the high voltage on the log and linear chambers is switched off.

         f. the pulse preparation relay (K-5) energizes and closes one set of contacts in the pulse relay (K-2) circuit.

      2. When the linear channel range switch is placed in the "1 MW-pulse" position, this closes another set of contacts in the pulsing relay (K-2) circuit.

782 294

<u>Table 2</u>

	Nuclear Channel	High Voltage Supply	Low Voltage Supply	Loss of High Voltage Protection
A. PRESENT SYSTEM	Linear	Existing HV Supply (designated HV-E)	Existing LV Supply (designated LV-E)	Yes: scram and annunciator
	Log	"	"	"
	Percent Power	"	"	"
	Startup (fission chamber)	"	"	"
B. PROPOSED SYSTEM	Percent Power	HV-E	LV-E	Yes: scram and annunciator
	Wide-range Log	HV-6A (new HV supply)	LV-1 (new LV supply)	"
	Wide-range Linear	"	"	"
	Safety	HV-6B (new HV supply)	LV-2 (new LV supply)	"

782 295

3. When the pulsing "FIRE" button is depressed this closes the final set of contacts in the pulsing relay (K-2) circuit and energizes the pulsing relay (K-2), which initiates the pulse.

B. New Pulsing Logic:

1. When the mode switch is placed in the pulse position:
   a. existing percent power chamber is switched from the percent power circuit to the existing nv circuit.
   b. the new wide range linear channel signal is removed from the linear recorder and the nv circuit output is switched to the linear recorder for display.
   c. the new wide range log channel signal is removed from the log recorder and the fuel element temperature is switched to the log recorder for display.
   d. the period circuit input is grounded.
   e. the new safety channel circuit is grounded.
   f. the pulse preparation relay (K-5) energizes and closes one set of contacts in the pulse relay (K-2) circuit.
2. When the new wide range linear "range" switch is placed in the "1 MW-pulse" position, this closes another set of contacts in the pulsing relay (K-2) circuit.
3. When the pulsing "FIRE" button is depressed, this closes the final set of contacts in the pulsing relay (K-2) circuit and energizes the pulsing relay (K-2), which initiates the pulse.

9. Our new instrumentation system would consist of three nuclear safety channels (percent power channel, safety channel, and wide range log channel via the period circuit). Our present system also consists of three, not four, nuclear safety channels (percent power channel, linear channel, and log channel via the period circuit). Thus, no reduction in the number of nuclear safety channels is proposed. We <u>do</u> propose to reduce the number of nuclear detectors from four to three, but the detector to be removed (the fission chamber-startup channel) is not a safety channel; it has no scram capabilities or functions now.

10. The fuel element temperature is the most important parameter from a safety standpoint in a TRIGA reactor. Our present system has four safety channels to provide automatic protection to assure that the reactor can be shut down before the safety limit on the fuel temperature will be exceeded. These present channels are the fuel element temperature, the linear power, the percent power, and the log power via the period circuit. The new proposed instrumentation also has four channels to provide such protection. These are the fuel element temperature, the percent power, the safety power channel, and the wide range log power via the period circuit.

Since our reactor is a pulsing reactor, the highest fuel element temperatures occur during a large reactivity pulse, not during steady-state operation at full licensed power (1 MW). During a \$2.35 pulse reactivity insertion, the peak measured fuel temperature is about 410°C, corresponding to a temperature rise of about ΔT = 390°C from ambient temperature. This measured temperature is still about 100°C below our limiting safety system setting (LSSS) for fuel temperature (510°C), which in itself has a large safety margin before the fuel temperature safety limit (1150°C) is reached. Thus, if the LSSS were reached, the predicted maximum fuel temperature at any point in the core would still only be 950°C, about 200°C below the safety limit.

The event postulated in this question does remove one of our four safety channels designed to limit fuel temperature. The three other safety channels would still be effective, however. Our analysis of this event indicates that the reactor would scram at about 110% of full-power (i.e., at 1.1 MW) and the scram would be initiated either by the percent power or the safety power channel. The fuel temperature would increase about 10-40°C above the ambient temperature existing prior to the event. The fuel temperature rise will depend on the initial power level (and temperature) existing before the event occurred, hence the variation from 10-40°C.

The measured fuel temperature never approaches the LSSS of 510°C, and hence the 110% of full-power scrams would be the effective shutdown mode, not the fuel element temperature scram. The safety limit for fuel element temperature is obviously not exceeded in this event.

The event postulated in this question, although dramatic, is not nearly as significant with regard to fuel temperature rise as a routine pulse. During this postulated event: the reactivity insertion rates are not nearly as rapid as during a pulse; the corresponding reactor periods, although short, are not nearly as short as during a pulse; and the fuel element heat transfer is not as adiabatic as during a pulse. All of these factors produce a fuel temperature rise which is less than the rise following a pulse of the same reactivity magnitude.

11. The loss of high voltage to the log-linear channel will cause a scram. Figure 2 has been modified (see Figure 2-R) to reflect this.

12. Figures 1 and 2 have been replaced by Figures 1-R and 2-R, respectively. These new figures show that the 1 KW interlock signal is derived from the wide range log amplifier. Figure 2 was correct with respect to the 1 KW interlock and Figure 1 was in error. Figure 1 should not have read, "1 KW pulse interlock." It should have read, "pulse interlock." The pulse interlock, shown in Figure 1-R, is effective when the range switch is in

782 207

the "1 MW-pulse" position. The reactor is interlocked such that both the range switch and the mode switch must be in the pulse positions before the pulsing relay (K-2) can be energized. Figure 2-R has also been corrected to show that the period channel is grounded out in both the pulse and square wave modes.

13. The crucial component in an overpower situation for each of the new instrumentation channels is the high voltage power supply (model HV-6), and the possibility of a "fold-over" situation occurring is more likely in the wide range linear and log channels than in the safety channel. By "fold-over," we are referring to a situation where the output, rather than increasing linearly with input, actually begins to decrease, and some time is required for the system to recover from this condition and return to proper linear operation. Fold-over begins to occur in the HV-6 high voltage supply when its output current exceeds 5 ma.

The safety channel uses an ion chamber and is set for a current output of about 3×10^{-4} ma at 1 MW. The chamber would put out about 1 ma during a pulse of 4000 MW. The amplifier in this channel can accept inputs up to 2 ma without fold-over or saturation. Thus the safety channel detector, high voltage supply, and amplifier can readily accept a 2 MW (200% full-power) over-power condition without saturation or fold-over.

The wide range linear and log channels use a fission chamber, with a current output of about 1.45 ma at 1 MW. At 2 MW (200% full-power), the amplifiers in these channels may become slightly non-linear, but they would not exhibit fold-over or saturation. At about 350% full-power, the high-voltage supply current would be about 5 ma and fold-over would begin to occur in the high-voltage supply.

Thus a 200% full-power condition should not produce saturation or fold-over in any of the proposed new instrumentation channels. These channels, of course, only have readouts up to about 110% of full power, so the indicating meters and recorders would be over-ranged at 200% full-power and no meaningful readouts would be obtained in this situation.

14. (Also see the answer to question 10 as these are directly related.)

Your understanding is correct: our present linear power channel trips at 110% of each range whereas the new safety power channel trips at 110% of full-power (i.e., at 1.1 MW).

During the event postulated in question 10, we have shown that this channel (or the percent power channel) still provides adequate protection with regard to fuel element temperature, our most important parameter. Other similar reactivity excusion accidents could be postulated, but they too would be less significant with regard to fuel temperature rise than a large routine pulse, for the reasons mentioned in the answer to question 10. And during

the pulse mode, this safety power channel (or the present linear power channel) is not required as a reactor safety channel. Hence it doesn't matter whether it trips at 110% of each range or 110% of full-power.

Thus, we feel confident that this new safety power channel will indeed provide adequate protection and prevent the fuel temperature safety limit from being exceeded.

782 209

WIDE RANGE LINEAR CHANNEL

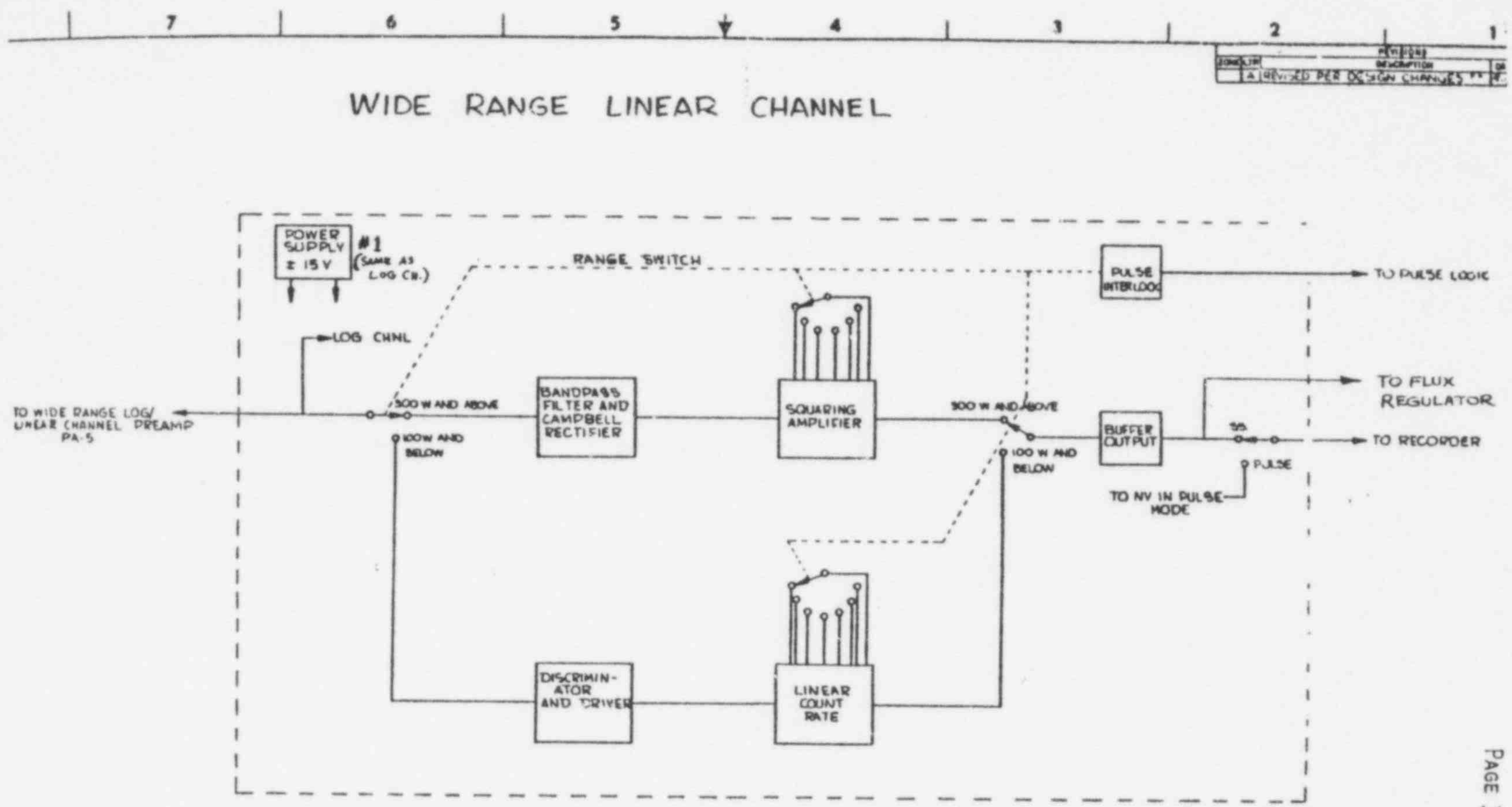

FIGURE 1-R

POOR ORIGINAL

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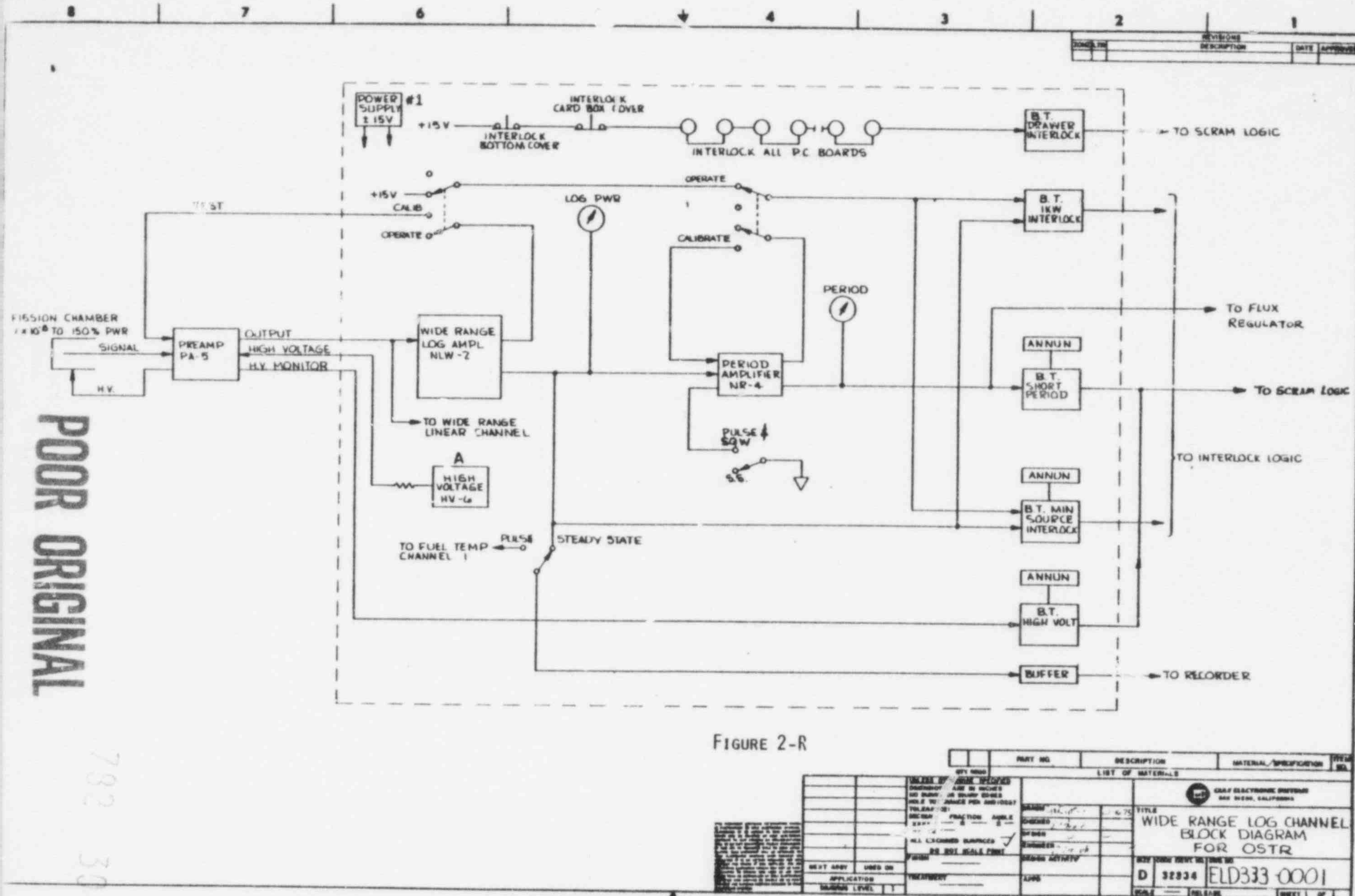

FIGURE 2-R

PART NO.	DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.	
LIST OF MATERIALS				

WIDE RANGE LOG CHANNEL BLOCK DIAGRAM FOR OSTR

D 32334 ELD333-0001

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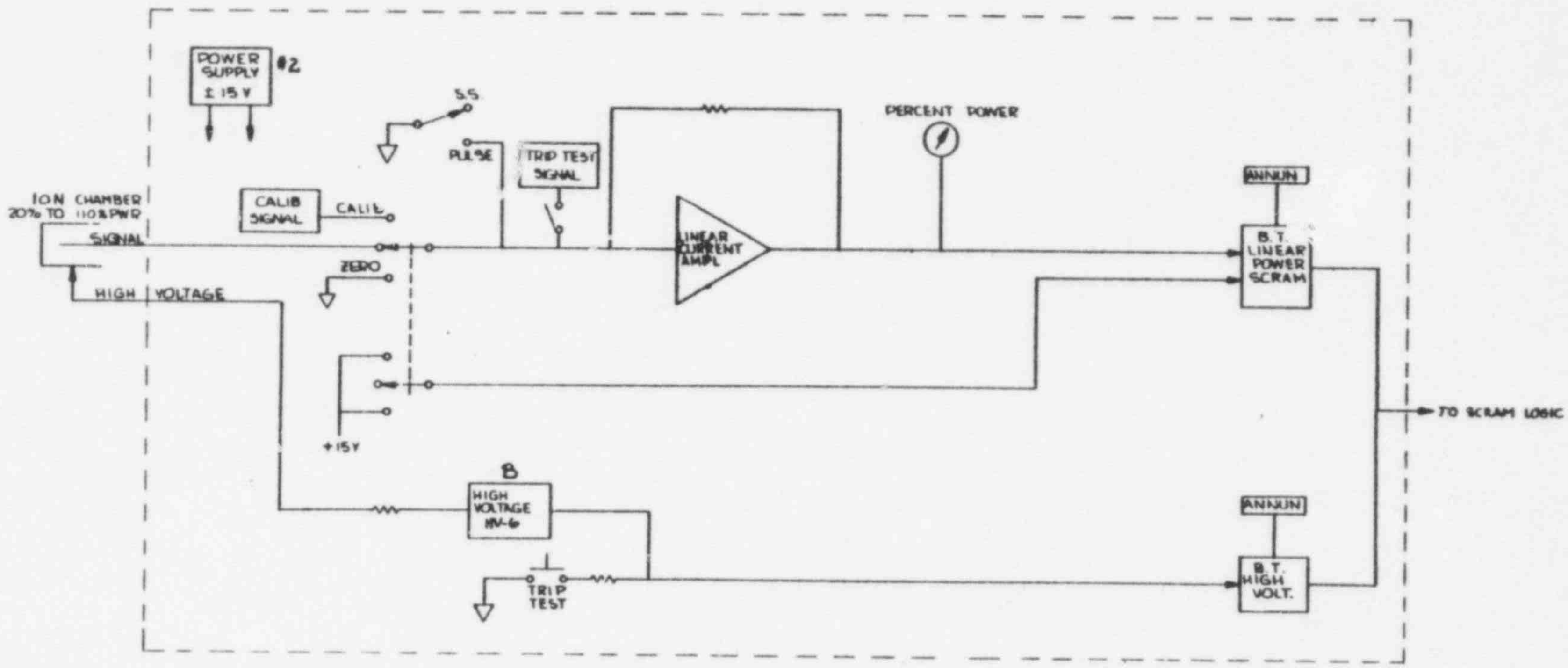

FIGURE 3-R

OSTR SAFETY CHANNEL BLOCK DIAGRAM

D 32334 ELD333-0003

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FIGURE 4

PRESENT NUCLEAR DETECTOR LOCATIONS

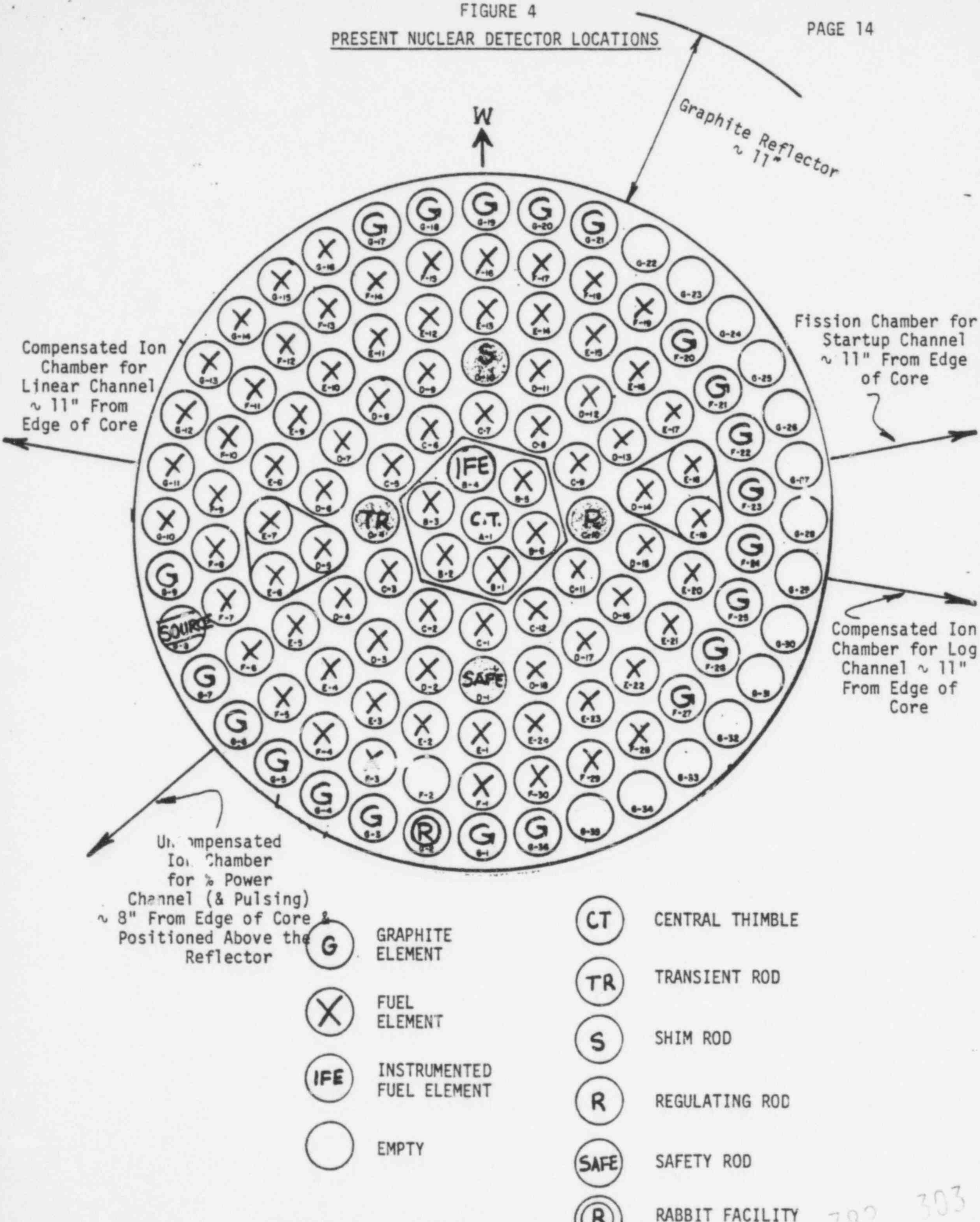

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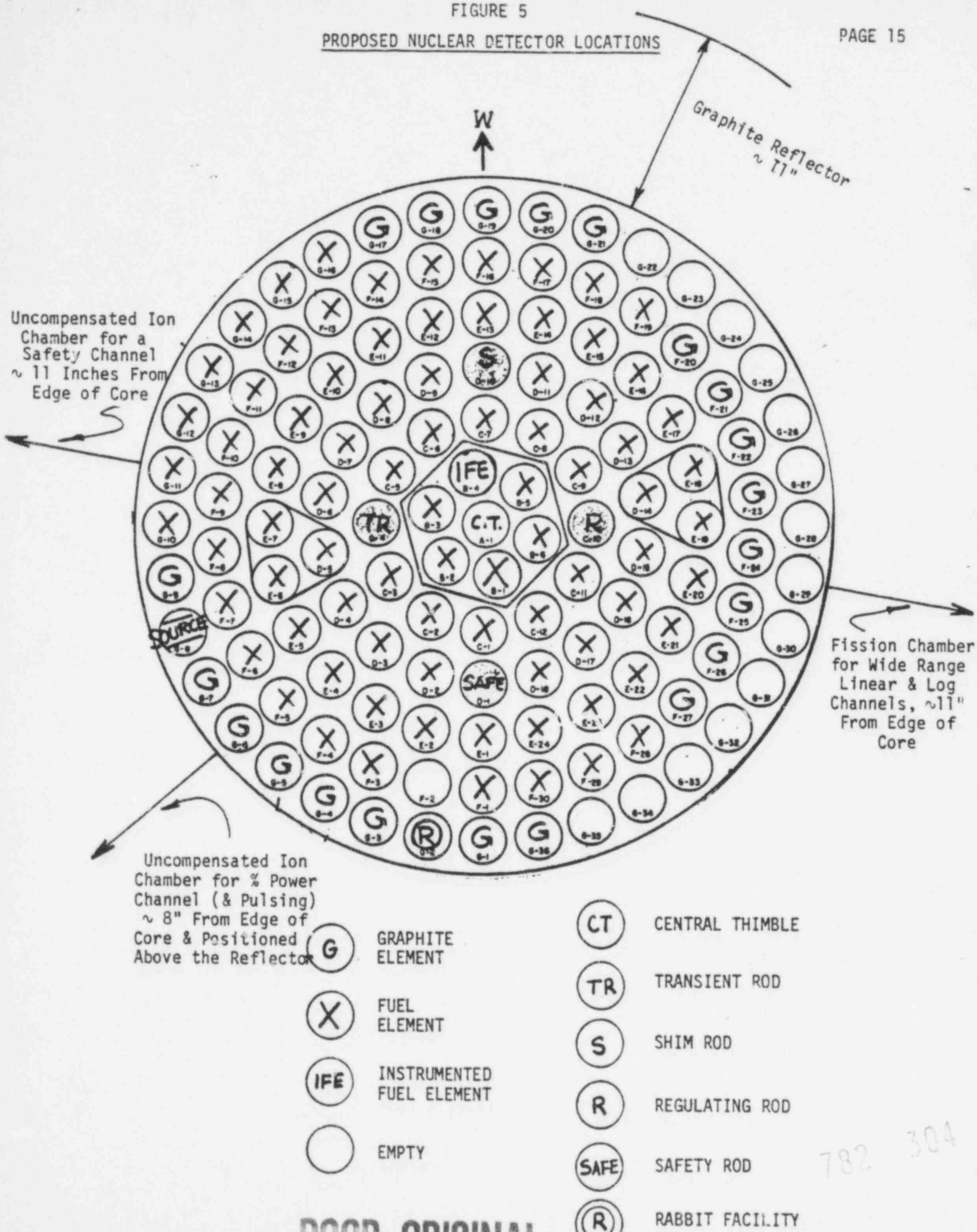
FIGURE 5

PROPOSED NUCLEAR DETECTOR LOCATIONS



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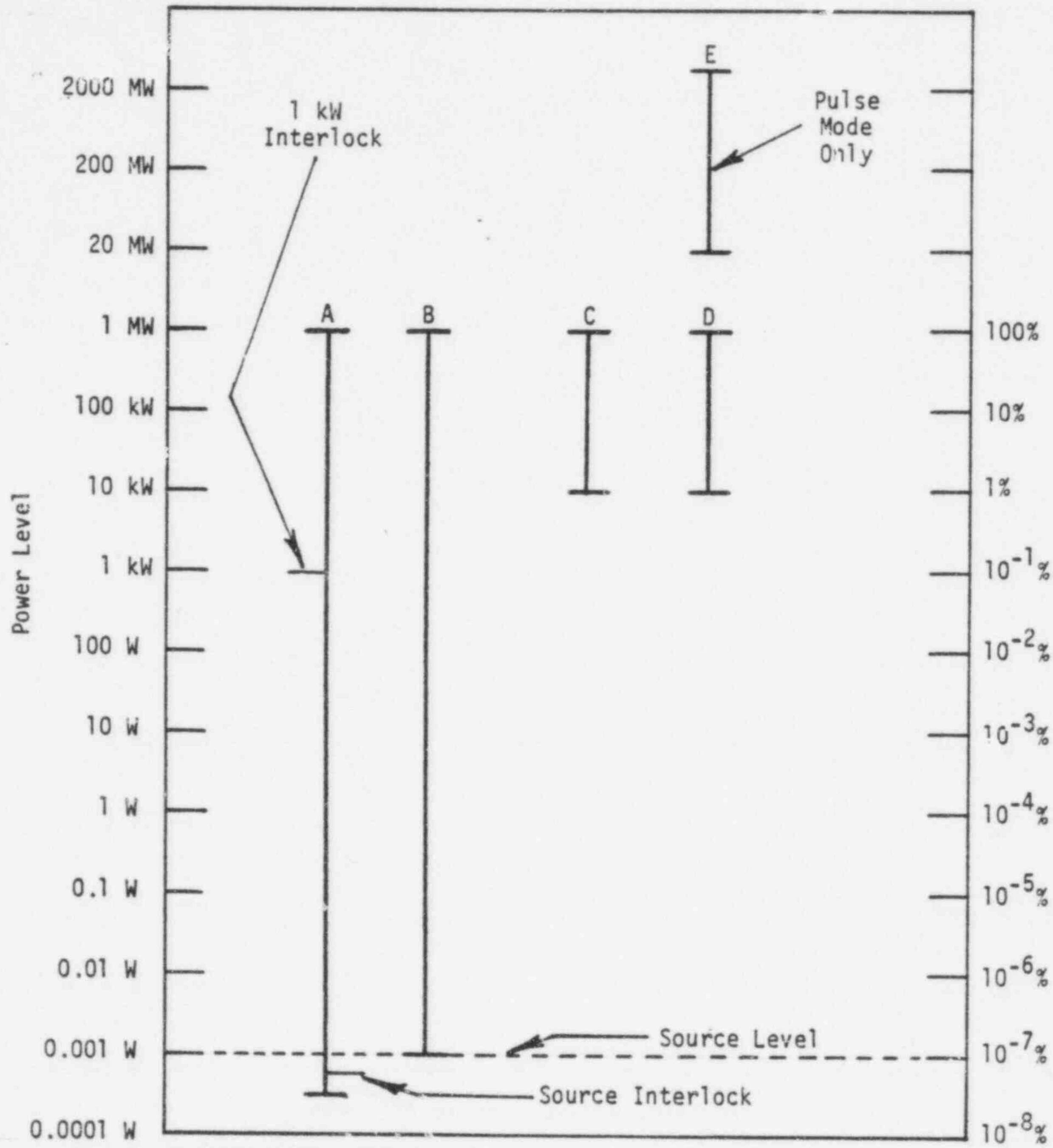
POOR ORIGINAL



A = Wide Range Log Channel
B = Wide Range Linear Channel } Same Fission Chamber
C = Percent Power Channel — Uncompensated Ion Chamber
D = Safety Channel
E = Pulse Mode NV Channel } Same Uncompensated Ion Chamber

Fig. 6 Typical Channel and Detector Operating Ranges

782 305