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LOFT/UTILITY TECHNOLOGY TRANSFER MEETING

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LOFT Experimental Transducers for Mass Flow and Liquid Level Detection

by

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LOFT Experimental Transducers for Mass Flow and Liquid Level Detection

Instrumentation that is installed on LOFT is comprised of two different types: process and experimental. Process instrumentation is designed to NRC requirements and is used for plant control while the primary function of the experimental measurement system is to provide measurements necessary for verification of codes and plant performance. Some of the experimental instruments may have application to LPWR's. The measurements that will be discussed in this presentation are those used for mass flow and liquid level.

The various mass flowrate instrumentation is designed to measure flow from natural circulation to high flow with void fraction from 0 to 100%. The best method,for two phase flow, has been the gamma densitometer and drag disk. Natural circulation has been measured using pulse neutron activation (PNA) and low flow turbines. Both have only been moderately successful.

The need for a vessel liquid level measurement was clearly illustrated at TMI. LOFT uses discrete conductivity probes to evaluate the liquid level in the core, upper and lower plenums, and the downcomer. These measurements have been extremely valuable in evaluating LOFT tests. The LOFT conductivity Liquid level transducer probably is not directly applicable to LPWRs due to reliability and data interpretation problems. The original LOFT liquid level transducer design was for measuring exactly that, liquid level. Experience since then indicates that a liquid level transducer would be more valuable if it could also measure void fraction. Future designs for liquid level measurements should seriously consider this.

A study was performed that evaluated the ability of instrumentation, other than the conductivity liquid level transducers, to measure liquid level in the reactor vessel. Transducers evaluated were: cladding and fluid thermocouples, self powered neutron detectors, differential pressure transducers, and power and intermediate range ion chambers. Data from two large and one small break test were used for the evaluation. The results indicated that qualitative liquid level information could be obtained from all the above measurements. However, there are limitations such as: response time, reliability, and ease of obtaining and presenting quantitative information on a real time basis. Also, voiding and refilling of the reactor vessel occurred in 50 seconds for the large break tests analyzed, therefore, it is not clear that the conclusions drawn are applicable beyond that time.

Of the transducers currently installed in LOFT, excluding the liquid level transducer, the SPND and thermocouples show the most promise for the time frame investigated.

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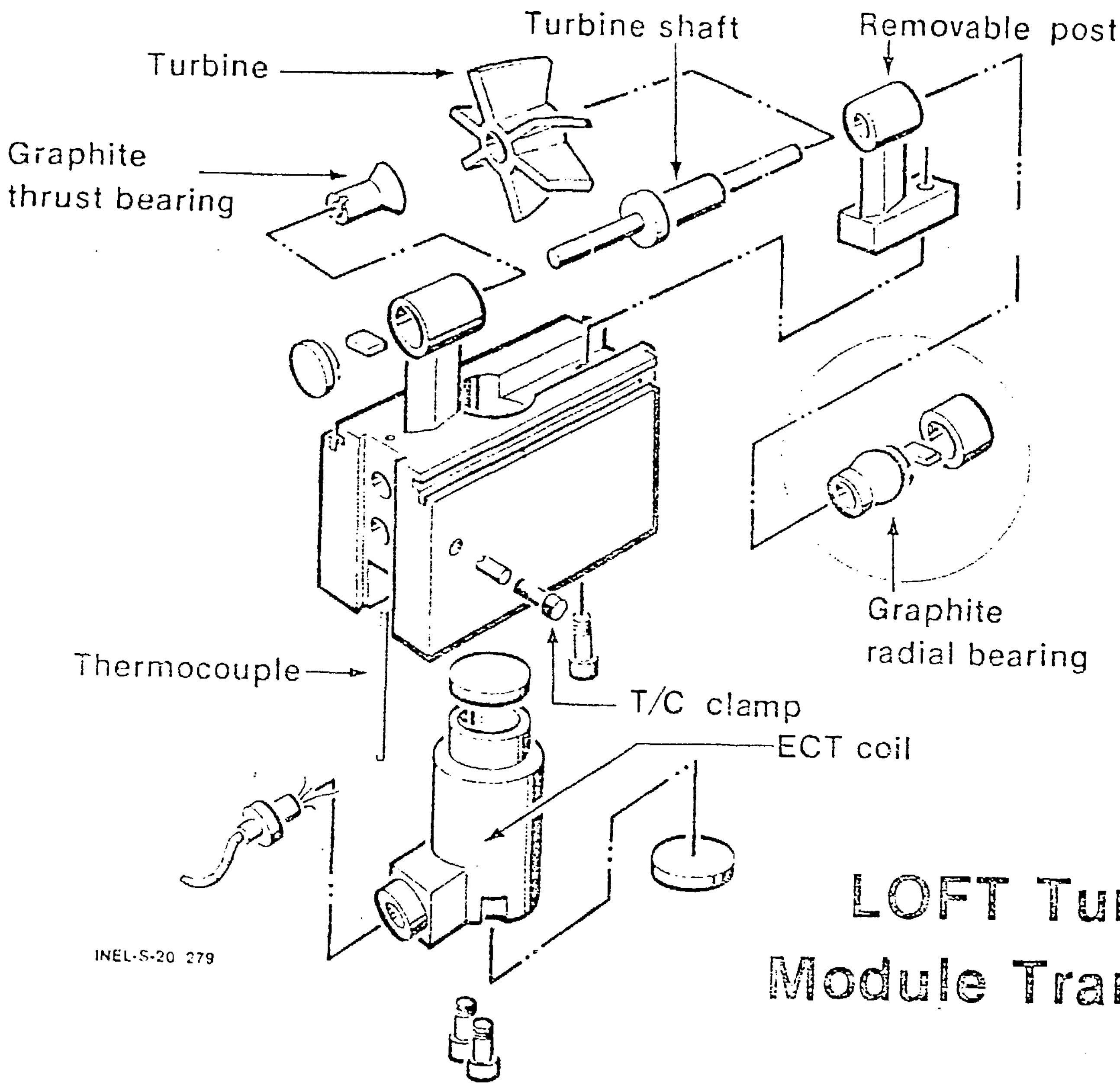
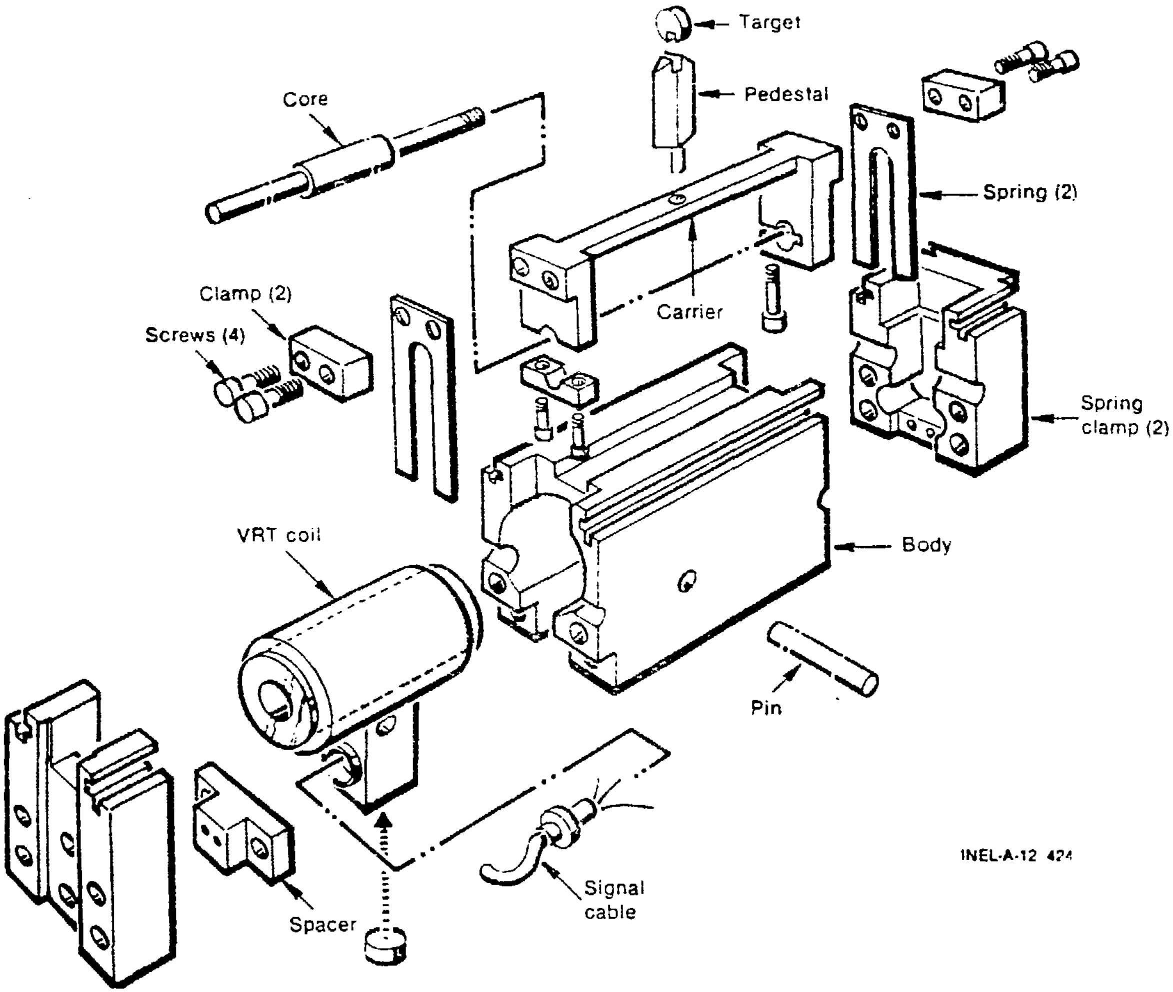
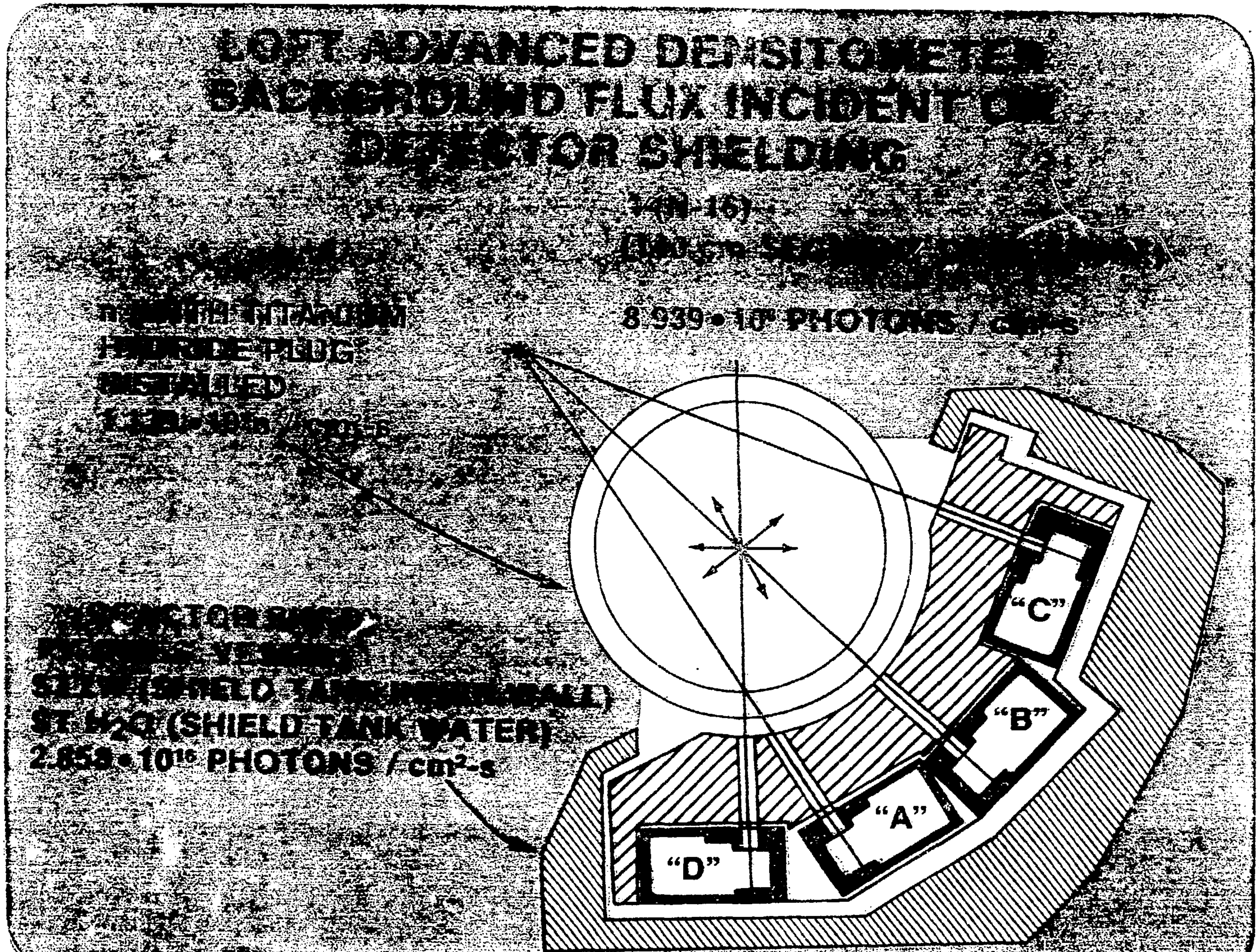
A heated thermocouple, used in PBF, was also considered. This technique is the most adaptable to LPWRs, both from a retrofit and new construction viewpoint.



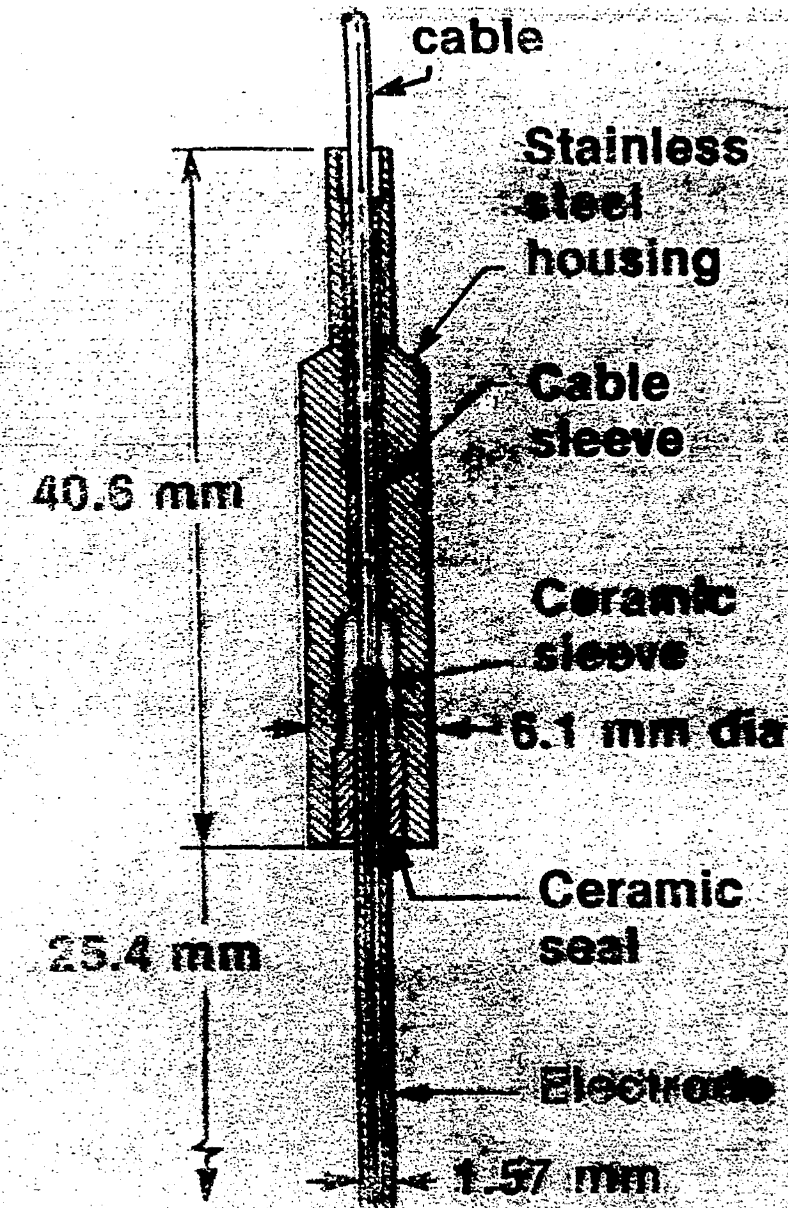
LOFT Turbine Module Transducer

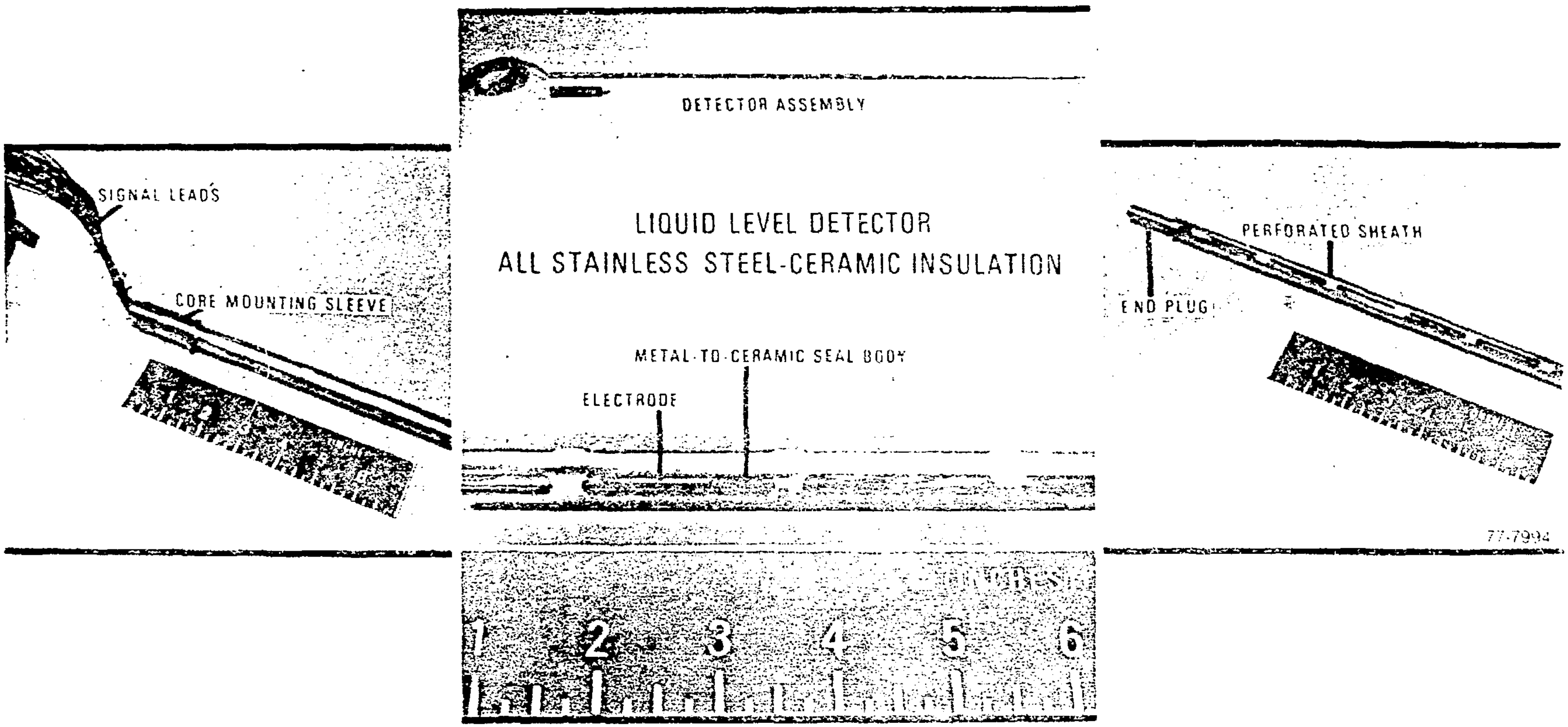


Exploded view of drag disc.


LOFT ADVANCED DENSITOMETER
BACKGROUND FLUX INCIDENT ON
DETECTOR SHIELDING
TITANIUM
HYDRIDE PLUG
INSTALLED
PHOTONS / cm²-s
(SHIELD TANK WATER)
2.858 • 10¹⁶ PHOTONS / cm²-s
"C"
"B"
"A"
"D"

LLT Electrode





Liquid level probe assembly.

Equation for Level from ΔP

$$\text{Liquid level} = \frac{\rho_1}{\rho_2} H_1 - \frac{\Delta P}{g \rho_2}$$

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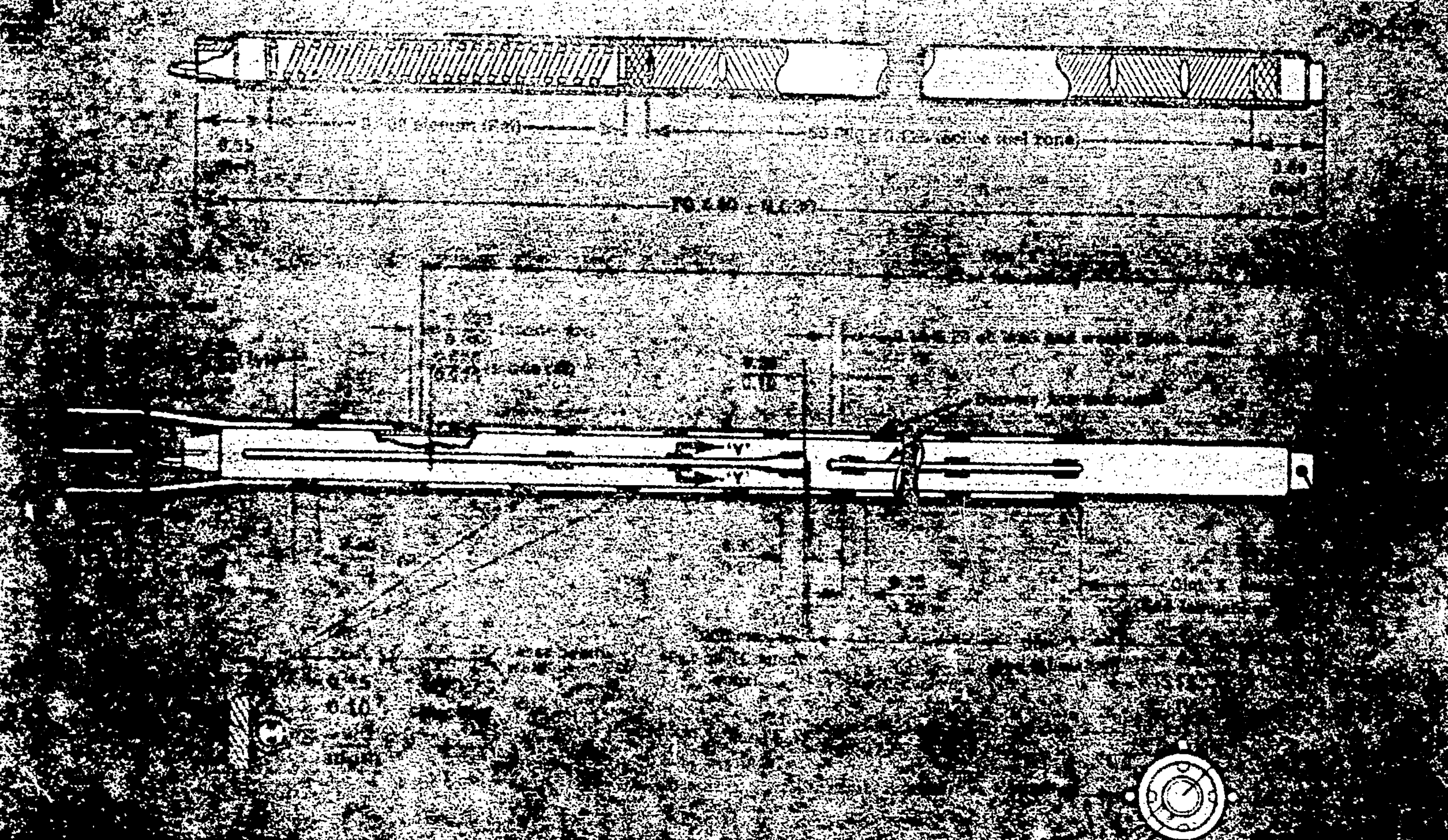
LOFT Fuel Rod
Clad Thermocouples



[illegible]	No. T/C	'X' - Distance from bottom of fuel rod to button of T/C																
		2.0	8.0	11.0	15.0	21.0	24.0	26.0	28.0	30.0	32.0	34.5	37.0	39.0	45.0	49.0	54.0	62.0
[illegible]	[illegible]						III		IV		I		II					
[illegible]	[illegible]	III			IV							I				II		
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[illegible]	[illegible]			[illegible]						III					IV			I

Subcooled Meter Equation

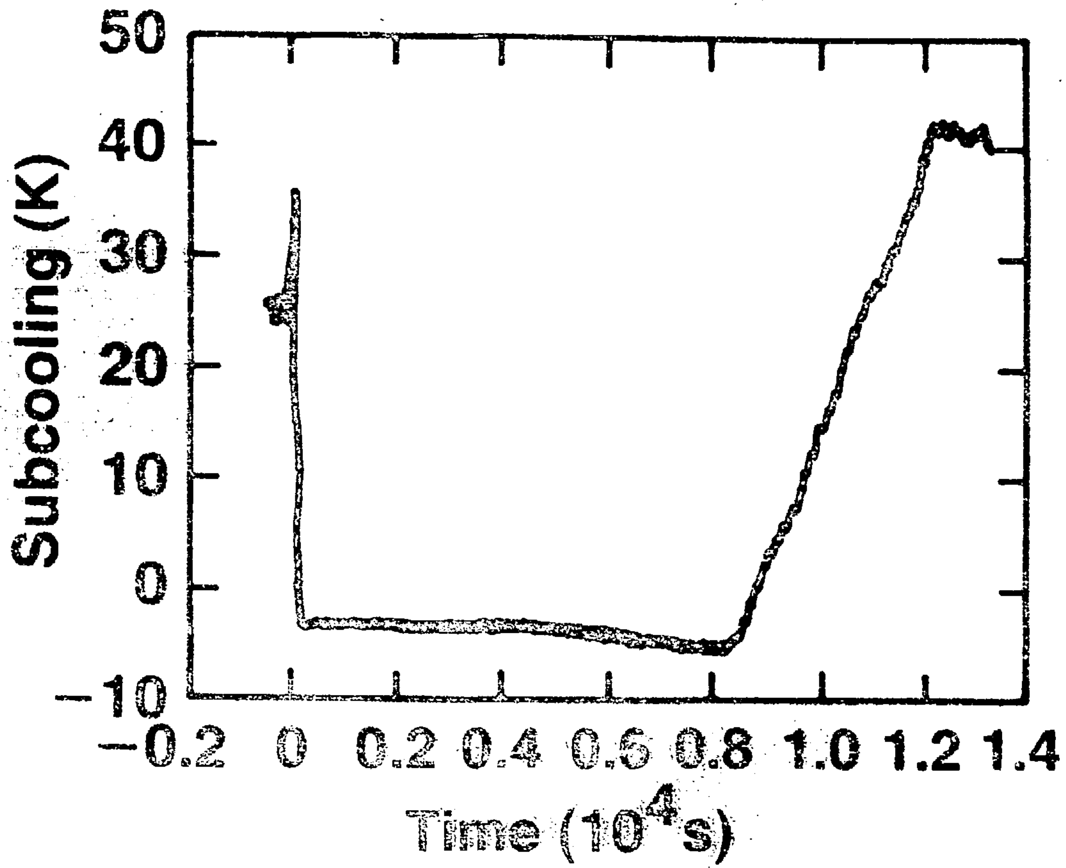
Degrees Subcooling = $T_{actual} - T_{sat}$

where:

T_{actual} = Temperature from thermocouple or RTD

T_{sat} = Temperature from steam tables using absolute pressure

L3-2 Subcooled Meter Data



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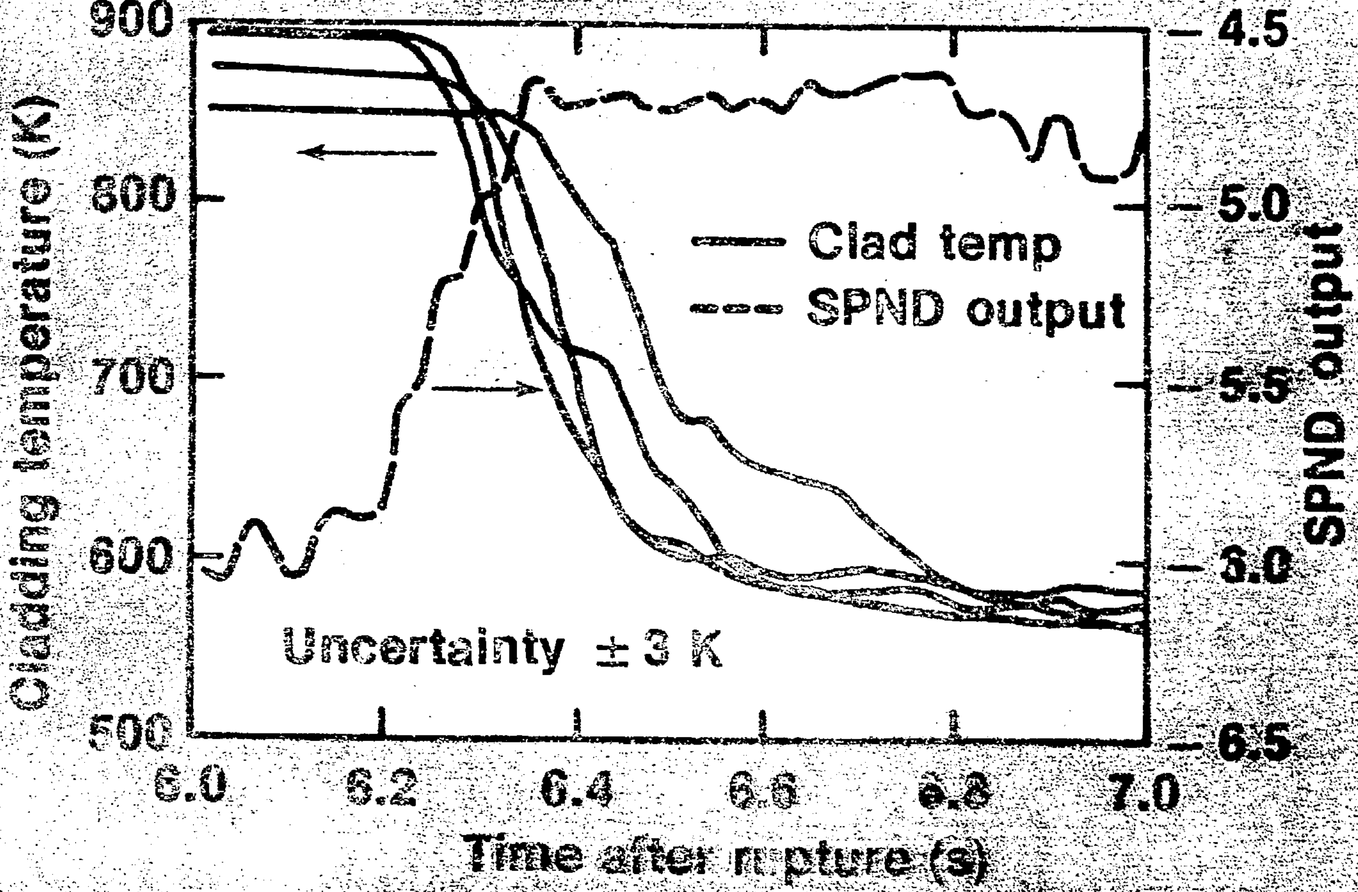
L2-3 Cladding Temperature vs SPND Output



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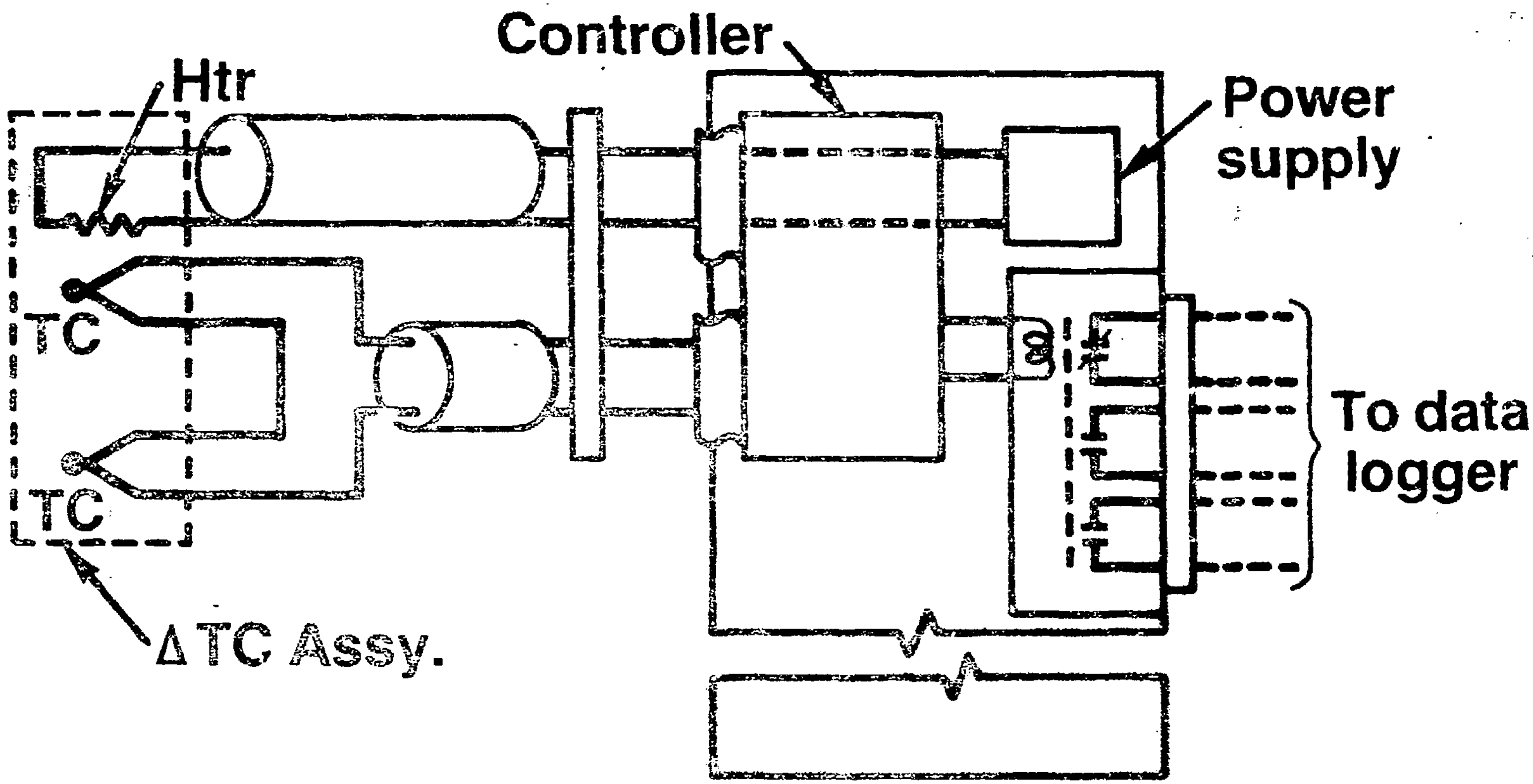
PBF Heated Thermocouple Liquid Level Detector



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