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THE ANALYSIS OF BWR PRESSURE SUPPRESSION POOL DYNAMICS

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THE ANALYSIS OF BWR PRESSURE SUPPRESSION POOL DYNAMICS

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The design basis loss of coolant accident (LOCA) for light water nuclear reactors postulates a major break in a coolant line. Both the response of the reactor vessel and its mechanical system as well as the response of the pressure suppression containment system exterior to the pressure vessel are of primary interest following such an event. The ability to determine system response and the suitability of particular mechanical and structural design features in both cases is predicted on the completeness with which the dynamic environment created in the various compartments is treated.

In January of 1976, the Lawrence Livermore Laboratory (LLL) began a program for the NRC (RSR) [1] to provide a sample problem solution activity which treats by numerical analysis the air-steam-water system flow implied by a LOCA. As a basis and focal point for modeling, the program addressed itself to the pressure suppression pool dynamics representative of the Mark I BWR. A visual representation of the program activities to date is shown in Figure 1.

It has been made clear by the RSR that the purpose of this sample problem activity is to improve understanding of pressure suppression pool dynamics at early times. For the initial air-water problem activity a Laboratory production code, the Eulerian framed MAITAI, already on our time-shared CDC7600 [2] has been used.

The MAITAI computer code is a two-dimensional, multi-material Eulerian hydrodynamic code written in cylindrical coordinates. The code contains a

*This work was performed under the auspices of the U.S. Energy Research and Development Administration, under contract No. W-7405-Eng-48.

variety of equations-of-state including air and water. In addition, accompanying the code is an extensive package of graphics post-processers. A summary of MAITAI is shown in Figure 2.

With this code; 1) effective bubble growth phenomenology has been obtained in axisymmetric problems, (Figures 3-6) as well as in two-dimensional models of the three-dimensional torus with single and multiple downcomers (Figures 7-12), and 2) an engineering estimation of the effects of downcomer fill level has been obtained (Figures 13-16).

Recently we have undertaken to provide a benchmark experiment to provide code authentication. The experiment, compared to the Peachbottom BWR, exhibits a nominal scale factor of 38.4 and basically consist of a spherical flask containing a single downcomer. This was an air-only test with bubble dynamics photographed at 900 frames per second. The problem has a driving pressure (p_0) of two atmospheres and a wet well pressure (p_i) of one atmosphere. Details are given in Figures 17 to 20. We are currently in the process of normalizing the MAITAI code to this experiment.

In summary, substantial progress has been made into the understanding and calculational representation of suppression pool dynamics. With the benchmark experiment complete, plant particular analyses is close at hand.

REFERENCES

[1] Nuclear Regulatory Research Order No. 60-76-021, January 5, 1976.

[2] W. H. McMaster, "MAITAI: A Two-Dimensional Eulerian Hydrodynamic Code," UCRL in preparation, LLL, 1976.

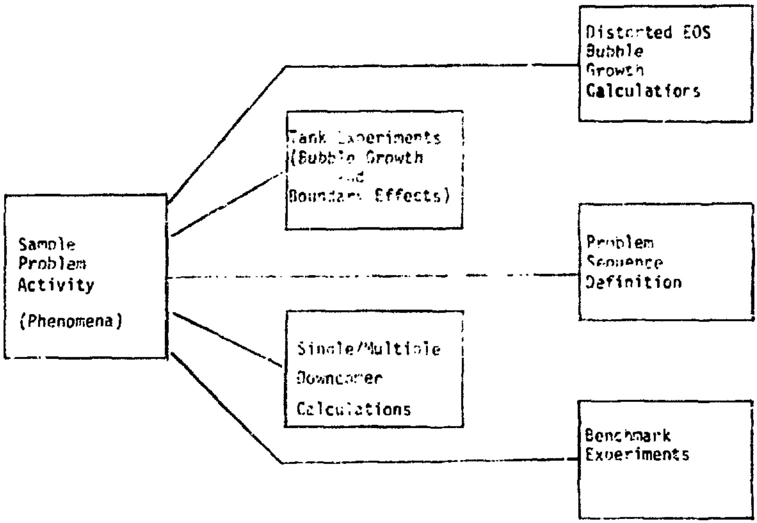

Figure 1. Sample Problem Activity

Figure 2. THE MAITAI CODE PACKAGE

MAITAI

- TWO-DIMENSIONAL EULERIAN IN CYLINDRICAL COORDINATES.
- MOMENTUM, MASS, ENERGY CONSERVATION
- INVISCID
- COMPRESSIBLE
- MULTIPLE MATERIAL (UP TO 5)
- NUMEROUS EQUATIONS-OF-STATE (INCLUDING AIR AND WATER)

GRAPHICS POST-PROCESSING

- PRESSURE AND DENSITY DOT PLOTS
- PRESSURE CONTOUR PLOTS
- VELOCITY VECTOR PLOTS
- POOL BOUNDARY LOAD SUMMARIES

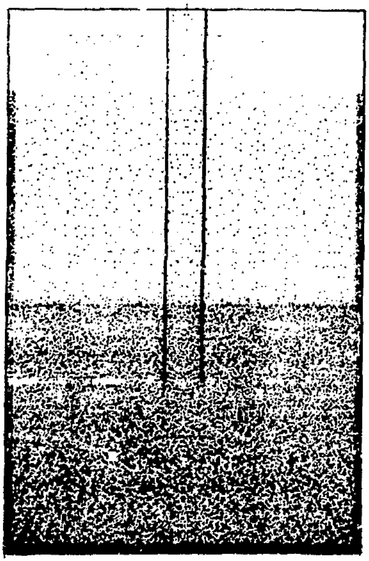

Figure 3. Axisymmetric Cylindrical Tank Problem at 0. ms

(Density Dot Plot)

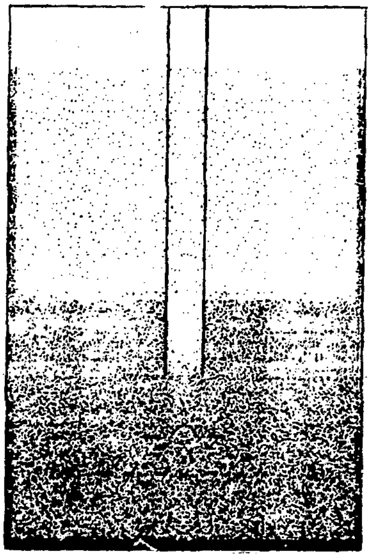

Figure 4. Axisymmetric Cylindrical Tank Problem at 1. ms

(Density Dot Plot)

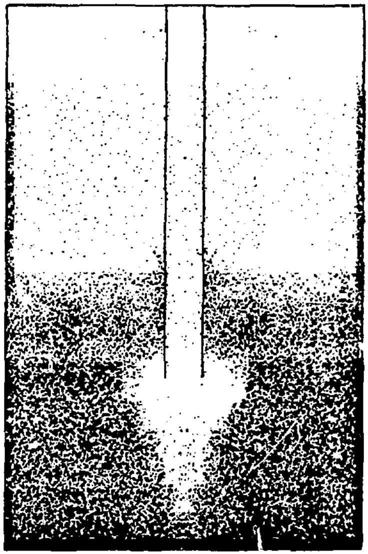

Figure 5. Axisymmetric Cylindrical Tank Problem at 2. ms

(Density Dot Plot)

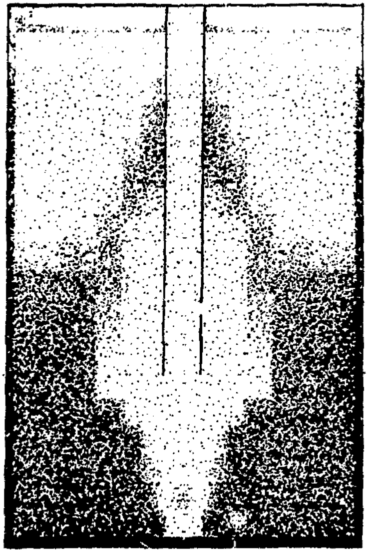

Figure 6. Axisymmetric Cylindrical Tank Problem at 3.5 ms

(Density Dot Plot)

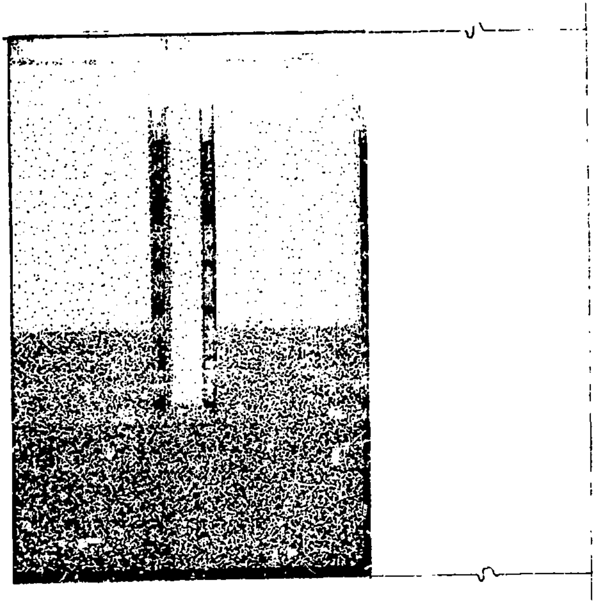

Figure 7. Off - Axis Single Downcomer Problem at 0. ms

(Density Dot Plot)

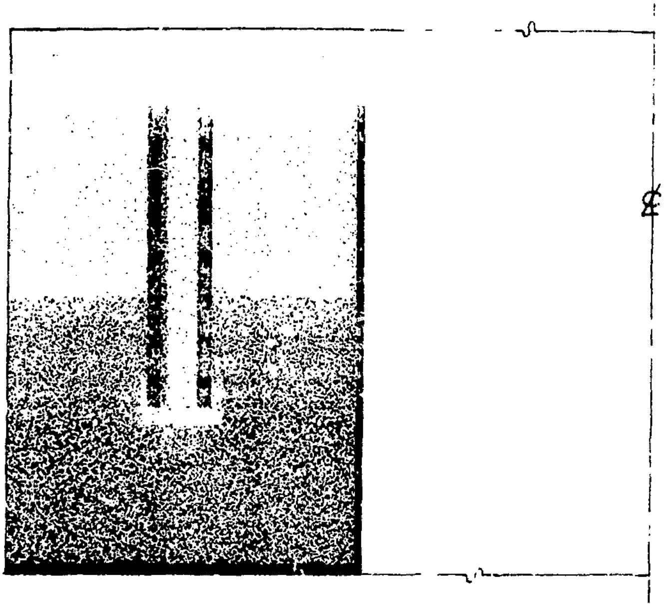

Figure 8. Off - Axis Single Downcomer Problem at 1. ms

(Density Dot Plot)

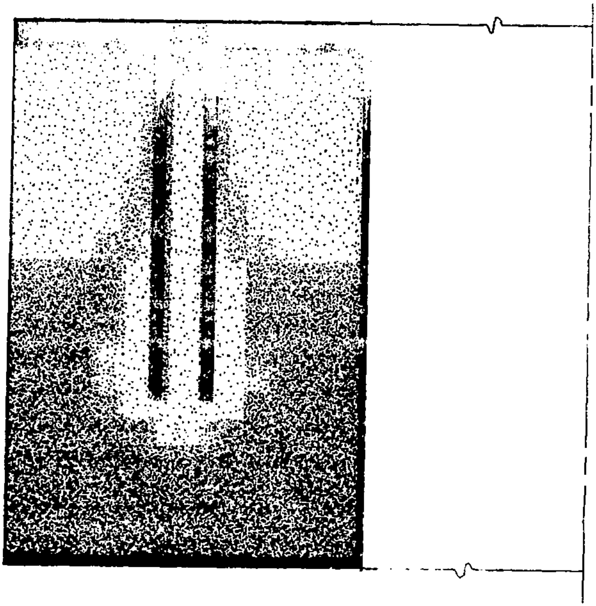

Figure 9. Off - Axis Single Downcomer Problem at 2. ms
(Density Dot Plot)

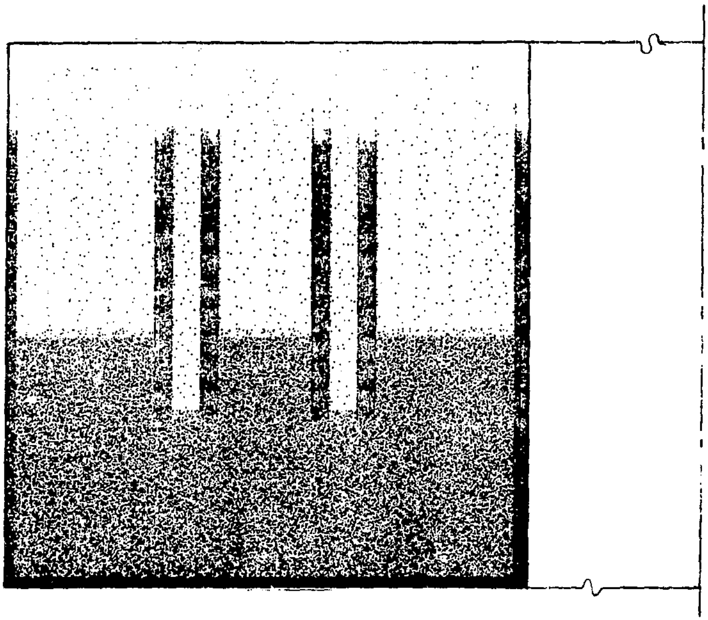

Figure 10. Off - Axis Double Downcomer Problem at 0. ms

(Density Dot Plot)

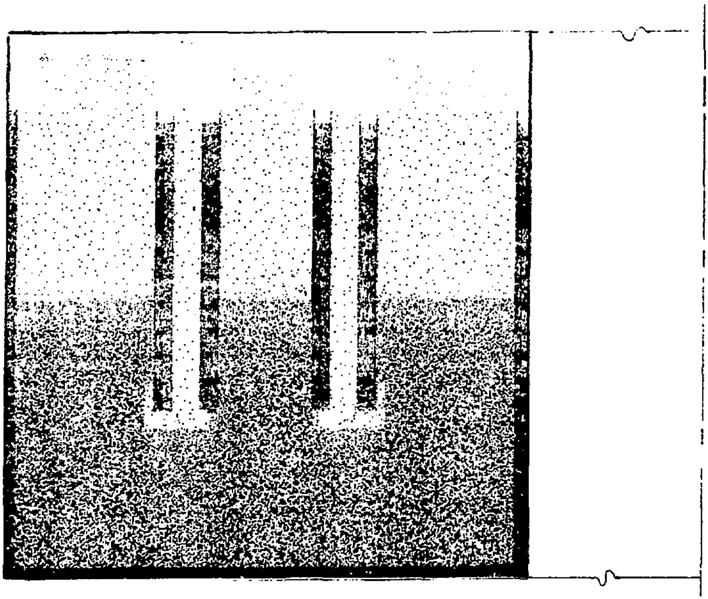

Figure 11. Off - Axis Double Downcomer Problem at 1. ms

(Density Dot Plot)

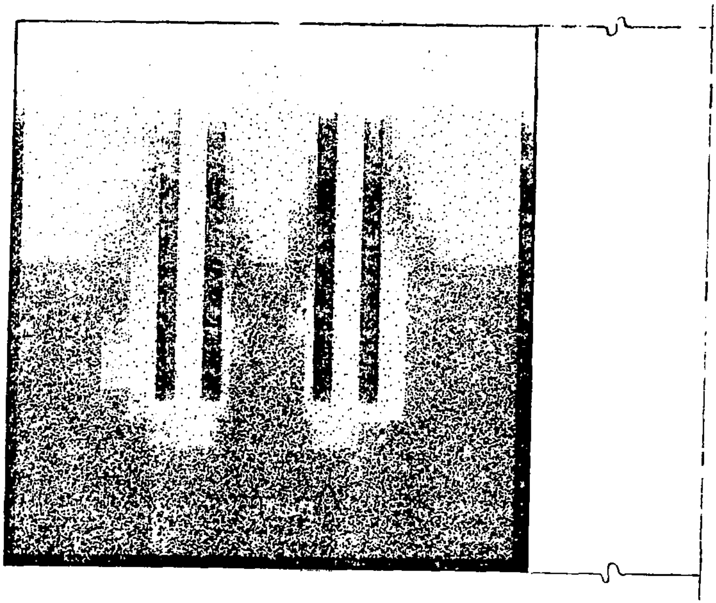

Figure 12. Off - Axis Double Downcomer Problem at 2. ms

(Density Dot Plot)

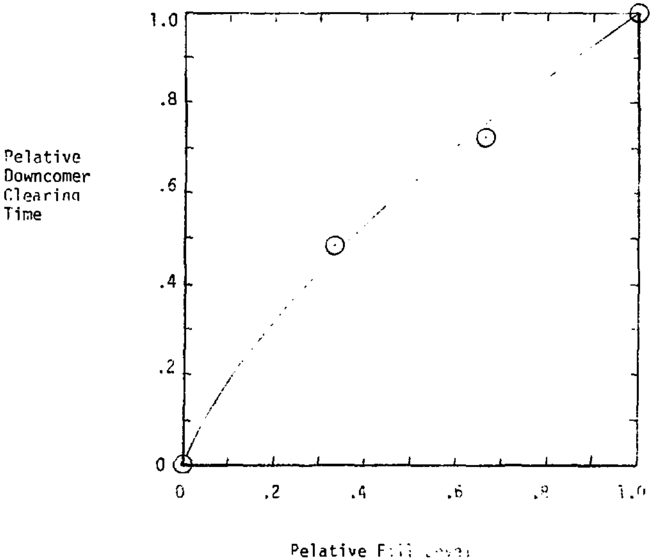

Figure 13. *Relative Downcomer Clearing Time as a Function of Fill Level*

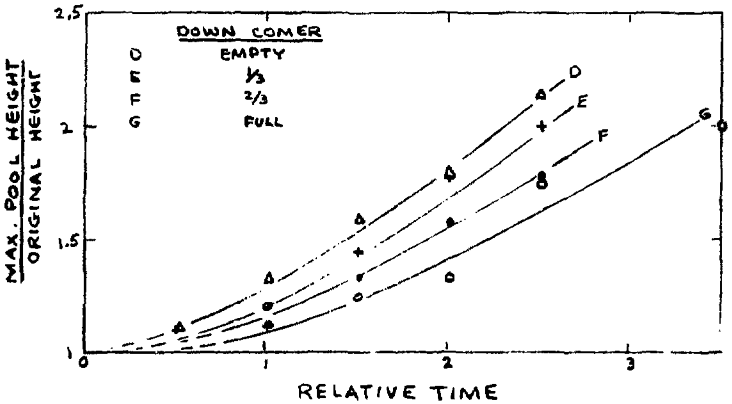

Figure 14. Relative Pool Swell as a Function of Fill Level

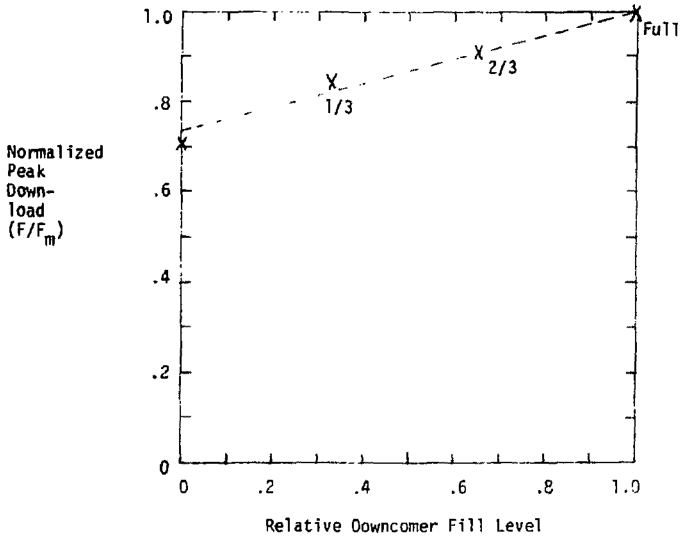

Figure 15. Normalized Peak Download as a Function of Fill Level

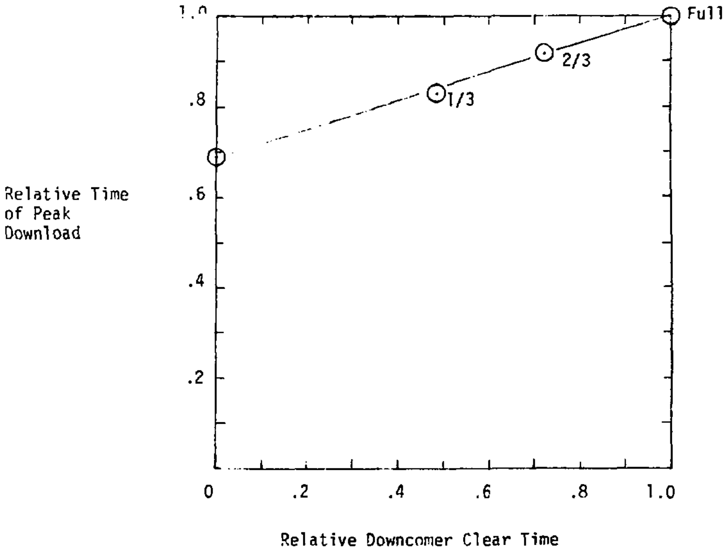

Figure 16. Time of Peak Download Vs. Vent Clear Time

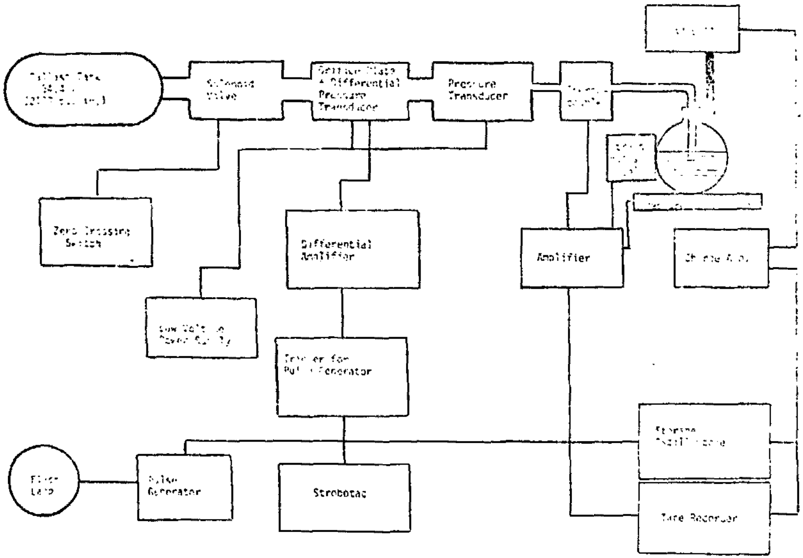

Figure 17. Schematic of Test Equipment (Benchmark Tests)

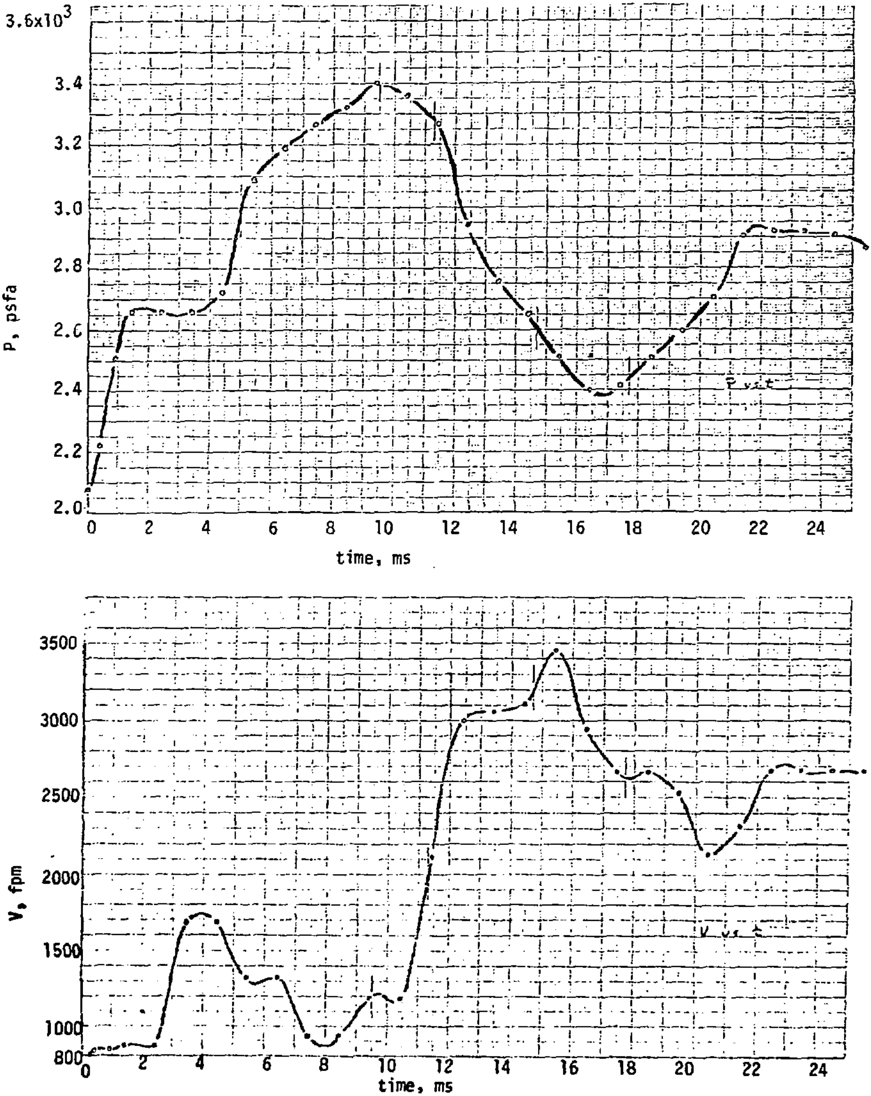

Figure 18 Pressure and Velocity of Air in Downcomer

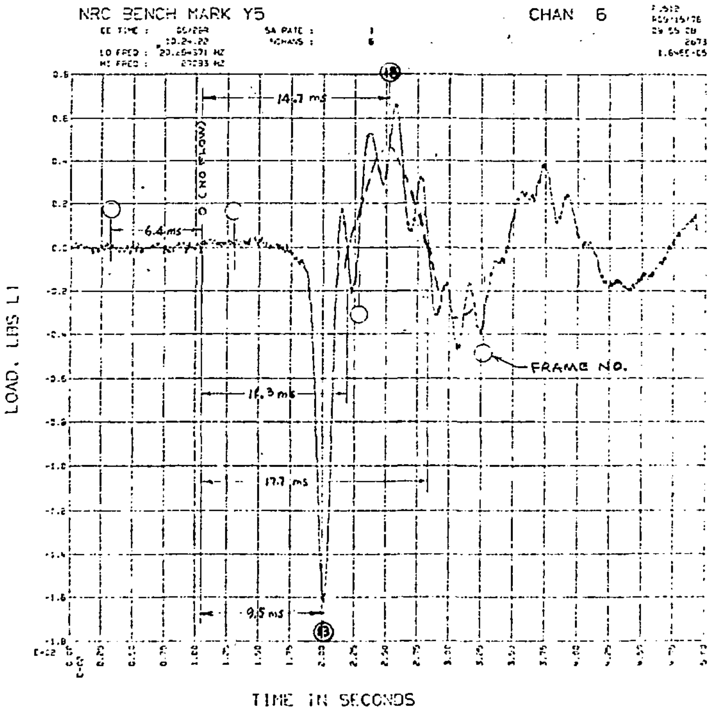

Figure 19. Load Trace

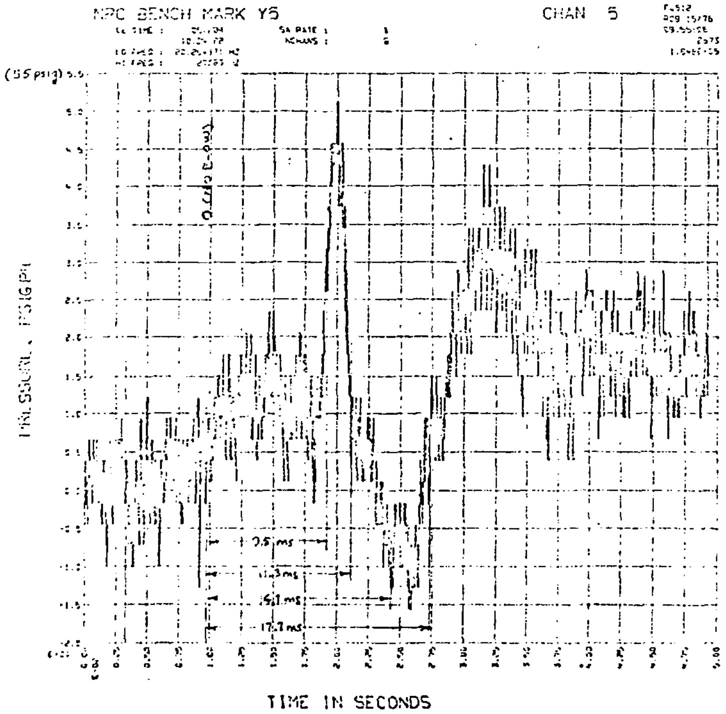

Figure 20. Pressure at the Bottom of the Flask