LOFT TECHNICAL REPORT LTR 141-65
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PRELIMINARY REPORT ON BATTELLE NORTHWEST LIQUID LEVEL PROBES (LLP)

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LOFT PROGRAM

TITLE PRELIMINARY REPORT ON BATTELLE NORTHWEST LIQUID LEVEL PROBES (LLP)	REPORT NO. LTR 141-65
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ABSTRACT

The Battelle Northwest Liquid Level Probe was evaluated for possible use in the LOFT Blowdown Suppression Tank. The results from the test indicate that the probe will measure the liquid level to ± ¼ inch, over a range of 50 inches. The next step is to test the functionability of the probe under simulated LOFT-Blowdown Suppression Tank operating conditions.

SUMMARY

The range of the Battelle LLP is 50 inches (127 cm). It can measure depth changes with an accuracy of 2% at the rate of 80 inches/sec without difficulty. The response time is 300 msec. (λ 10 to 90%). This will allow the change in volume of the fluid in the LOFT suppression tank to be calculated to within ± 10%. The LLP can be adapted for use in the LOFT suppression tank as a means of measuring the mass transfer and mass flow rates.

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1.0 Introduction

The purpose of this report is to present the results of tests performed to determine the feasibility of using the liquid level probes (LLP) obtained from Battelle Northwest in the LOFT suppression tank. The liquid level probes are proposed as a means of measuring the total mass transfer and the mass flow rate in the suppression tank during a LOCE. The range, accuracy, and response of the liquid level probe is described in subsequent sections of this report.

2.0 Description of Liquid Level Probe

The LLP is a float/switch sensor consisting of a vertical stainless steel tube (Figure 1) containing an array of magnetically operated dry reed switches which connect a common lead to the junction of 100 equal series resistors, constituting a 100-step potentiometer (Figure 2).[1] The magnetic reed switches are spaced at 1/2 inch (12.7 mm) intervals giving a range of 50 inches (127 cm). The switches are actuated by a magnet within a free-moving toroidal float which encircles the tube containing the switch and resistor arrays. As the float moves up or down the tube from one position to the next, the residual field is sufficient to hold the first switch closed until after the second switch has closed, preventing an open-cicuit condition. The tube also contains an identical, but untapped,100 resistor reference array which is used for temperature compensation.

These sensors can be installed vertically in the suppression tank in an on-axis location, through penetrations at the top of the tank. Signal conditioning circuitry would be located in TAN 630,Room 219. Cable length should cause no problems since the reference and "working" string resistor leads will be the same length.

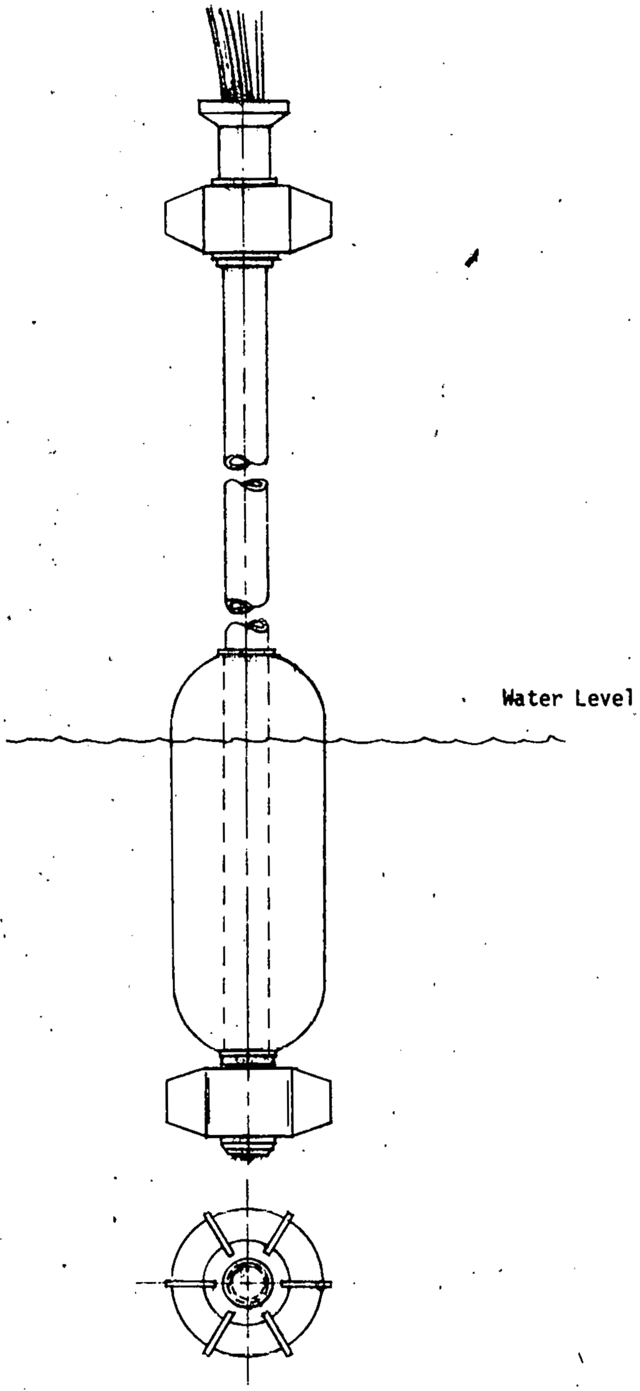
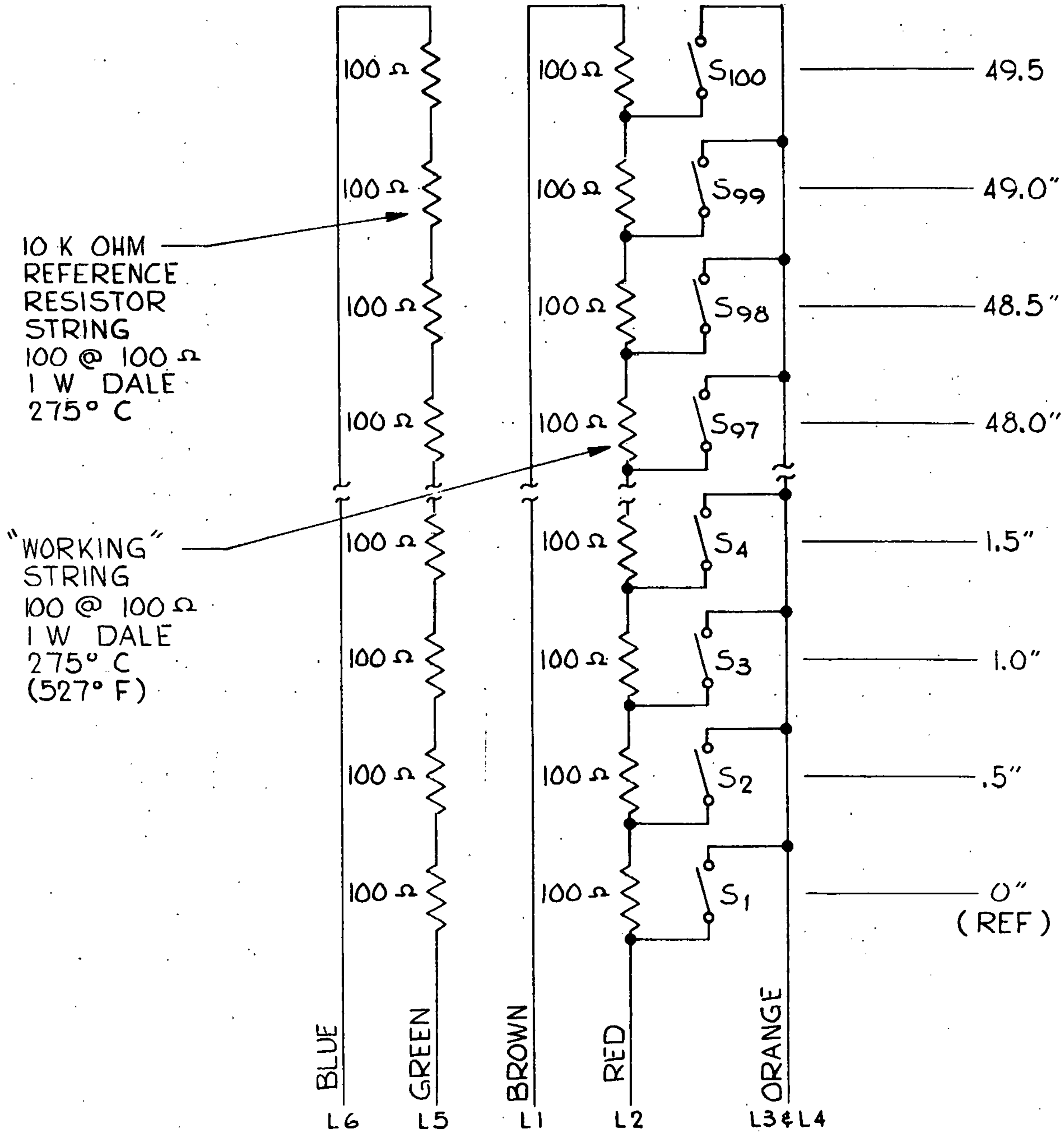


Figure 1 LIQUID LEVEL PROBE



F/S PROBE RESISTOR ARRAY & SWITCH SPACING

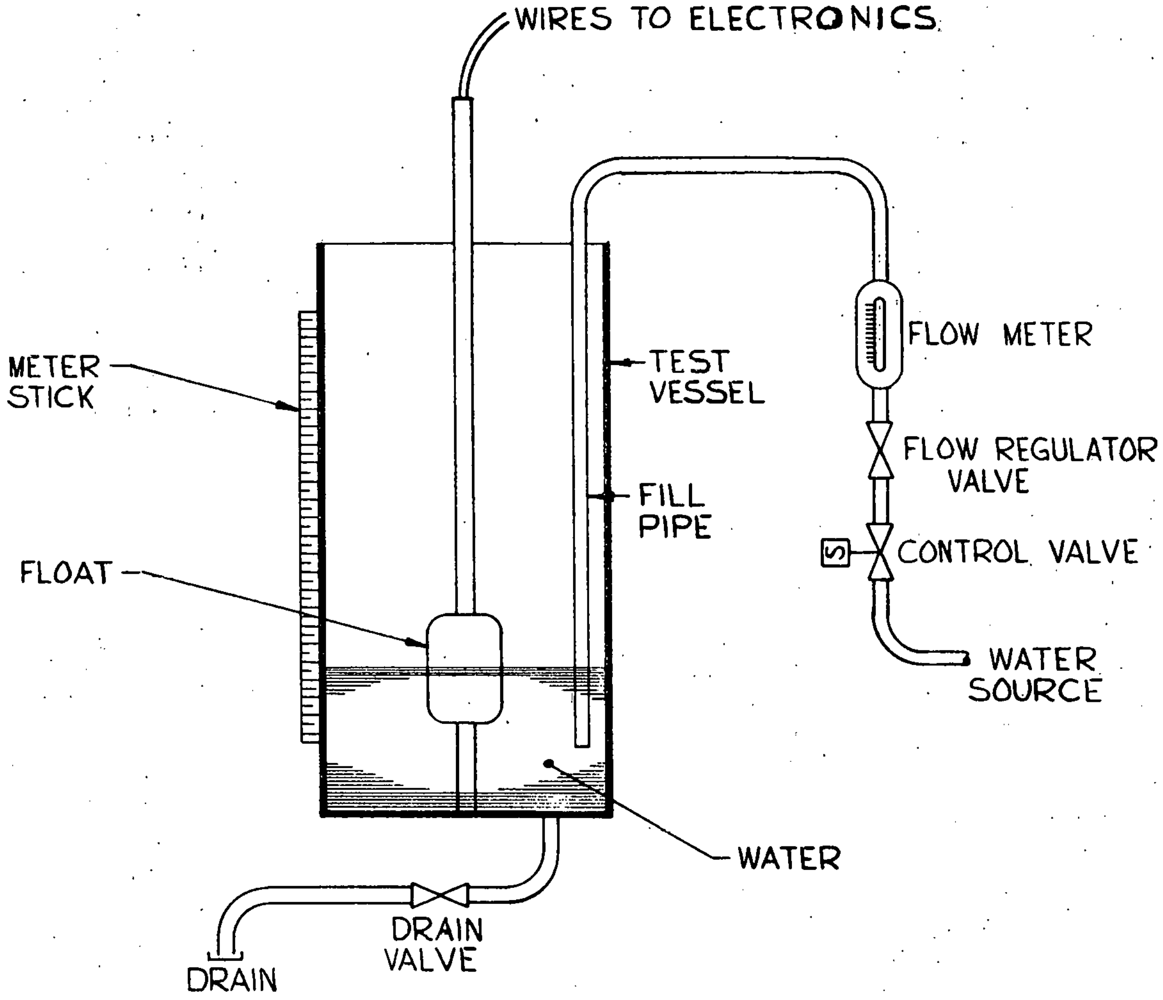
FIGURE 2

3.0 Description of Test and Test Results

3.1 Accuracy and Fluid Velocity Test

The accuracy and fluid velocity test were conducted to confirm the LLP's ability to measure changes in liquid levels and the rate of change of these levels. Based on data taken in earlier LOFT blowdown experiments (L1-2), it was determined that the expected depth changes would range from 4 to 8 inches (101.6 to 203.2 mm) at velocities of 0.5 in/sec (12.7 mm/sec) to 2.0 in/sec (50.8 mm/sec)[2]. These tests were performed with the LLP centered vertically in a glass test vessel, using water as the fluid. The inside diameter of the test vessel was 6 inches and the net flow area was 24.6 in^2 (158.7 cm^2). Water entering at the rate of 2 gal/min (7.57 l/min) gives a water velocity of 0.313 in/sec (7.95 mm/sec) in the test vessel. Figure 3 illustrates the experimental test unit. These tests were performed by the Development and Evaluation Laboratory at the Auxiliary Reactor Area Test Facilities.

The accuracy of the LLP was checked by recording the beginning and ending water levels as measured by the LLP and by recording the beginning and ending water levels as measured by a yardstick affixed to the side of the test vessel. The changing water depth and the time required for these changes were recorded on a strip chart recorder connected to the output of the LLP as water was emitted to the test vessel at predetermined rates. The velocity of the water in the test vessel was also determined by measuring the time required for the water to pass points of known separation with a stop watch. The accuracy was found to be ± 10%,worst case. Typically the accuracy is ± 5%. The results of the test are summarized in Table A.



LIQUID LEVEL PROBE TEST ARRANGEMENT

FIGURE 3

TABLE A

LIQUID LEVEL PROBE

SUMMARIZED TEST RESULTS

Flow Vel. in/sec (mm/sec)	Accuracy: Probe Beginning Level in. (mm)	Probe Ending Level in. (mm)	Probe Δh in. (mm)	Yardstick Beginning Level in. (mm)	Yardstick Ending Level in. (mm)	Yardstick Δh in. (mm)	Velocity: Average Velocity in/sec (mm/sec)	Integrated Velocity in/sec (mm/sec)	Deviation %	Timed Velocity STD in/sec (mm/sec)
.35* (8.89)	43 (1092.2)	27.5 (698.5)	15.5 (393.7)	6 3/4 (171.45)	22 (558.8)	15 1/4 (387.35)	0.343 (8.71)	0.342 (8.69)	0.59	0.34 (8.64)
1.00 (25.4)	465 (1181.1)	23.5 (596.9)	23 (589.2)	3 (76.2)	26 1/4 (666.75)	23 1/4 (590.55)	1.07 (27.18)	1.08 (27.43)	0.53	1.09 (27.69)
1.70 (43.18)	46.5 (1181.1)	22.5 (571.5)	24 (609.6)	3 (76.2)	27 1/2 (698.5)	24 1/2 (622.3)	1.72 (43.69)	1.71 (43.93)	0.58	1.72 (43.69)
2.00 (50.8)	47 (1193.8)	23 (584.2)	24 (609.6)	2 7/8 (73.03)	26 5/8 (676.28)	23 3/4 (603.25)	2.03 (51.56)	2.04 (51.82)	0	2.04 (51.82)

*established by using a calibrated flowmeter

	Using Yardstick as Standard -Accuracy	Deviation (Using watch and measurement as reference)
.35 (8.89)	2%	0.59%
1.00 (25.4)	1%	0.53
1.70 (43.18)	2%	0.58
2.00 (50.8)	1%	0

3.2 Response Test

The response of the LLP was measured by allowing the float to fall under the acceleration of gravity into approximately 15 inches (38 mm) of water. The water served as a cushion to prevent damage to the float. The results given in Table B were taken from strip chart recording of the fall of the float. The LLP will measure rates of 75 in/sec (1.9 m/sec) to 80 in/sec (2 m/sec) without difficulty.

4.0 Uncertainty Analysis

4.1 Worst Case

This analysis is based on an assumed depth change of 5.0 in (127 mm) and a beginning depth of 52.0 in (1320.8 mm)[3]. The probe can measure the depth to plus 0.5 in (12.7 mm) and minus 0 inches.

This gives four possible combinations of depth and volume. These combinations are:

	Depth Range inches (mm)	Volume ft^3 (liters)	% Error in Vol
1.	52.0 - 57.0 (1320.8 - 1447.8)	146.168 (4139.0)	0
2.	52.0 - 57.5 (1320.8 - 1460.5)	160.7898 (4552.9)	10
3.	52.5 - 57.5 (1333.5 - 1460.5)	146.168 (4139.0)	0
4.	52.5 - 57.0 (1333.5 - 1447.8)	131.5512 (3725.1)	10

Thus, at the worst, the volume in the suppression tank will be known to within ± 10%.

TABLE B

FREE FALL RESULTS

	Distance in (mm)	Calculated* Fall Time msec	Measured Fall Time msec	Response			Vel. in/sec (mm/sec)
				$T_{1/e}$ msec	T 10 to 90% msec	Frequency Hz	
Run I	36 (914.4)	431	480	360	300	1.17	75 (1905)
Run II	37 (939.8)	437	460	337.5	315	1.11	80.4 (2042.16)

* ignore drag, friction, and V_o

4.2 Usual Case

Typically the magnet will cause the next switch in the string to close when the fluid level is approximately one quarter inch below the indicated level; that is, at 52.00 read 52.0
52.25 read 52.5
52.50 read 52.5
52.75 read 53.0
53.00 read 53.0.

Thus, the height of the fluid in the suppression tank is measured to ± ¼ inch (6.4 mm) and yields a volume with an error of ± 5%.

5.0 Conclusions and Recommendations

These liquid level probes are capable of measuring the changes in liquid level in the suppression tank. If turbulence in the tank is severe the rate of change may be difficult to measure unless further development, such as surrounding the float with a pipe with holes in the bottom and the top, is undertaken to keep the float from bouncing. Also, if any accuracy better than ± 5% is desired, a second generation of probes should be designed to measure smaller changes in fluid depth but if the accuracy of the liquid level probe is acceptable, then install as is.

Therefore the following is recommended:

1. Estimate the cost to install
2. Compare with alternative float method (See Appendix B)
3. Test functionability under simulated LOFT - Blowdown Suppression Tank operating conditions:
    a. Vibration .
    b. Bubble Test.

6.0 References

1. U. L. Upson, Float/Switch Liquid Level Gauge, (March, 1976).
2. G. M. Millar, Experiment Data Report for LOFT Nonnuclear Test L1-3A, TREE-NUREG-1027, (December 1976).
3. H. C. Robinson, LTR 20-57, March 1976.
4. J. R. Dixon, Blowdown Loop Total Mass Calculations, LDR-112-4006, (August 1976).

APPENDIX A

GRAPHS

A-1
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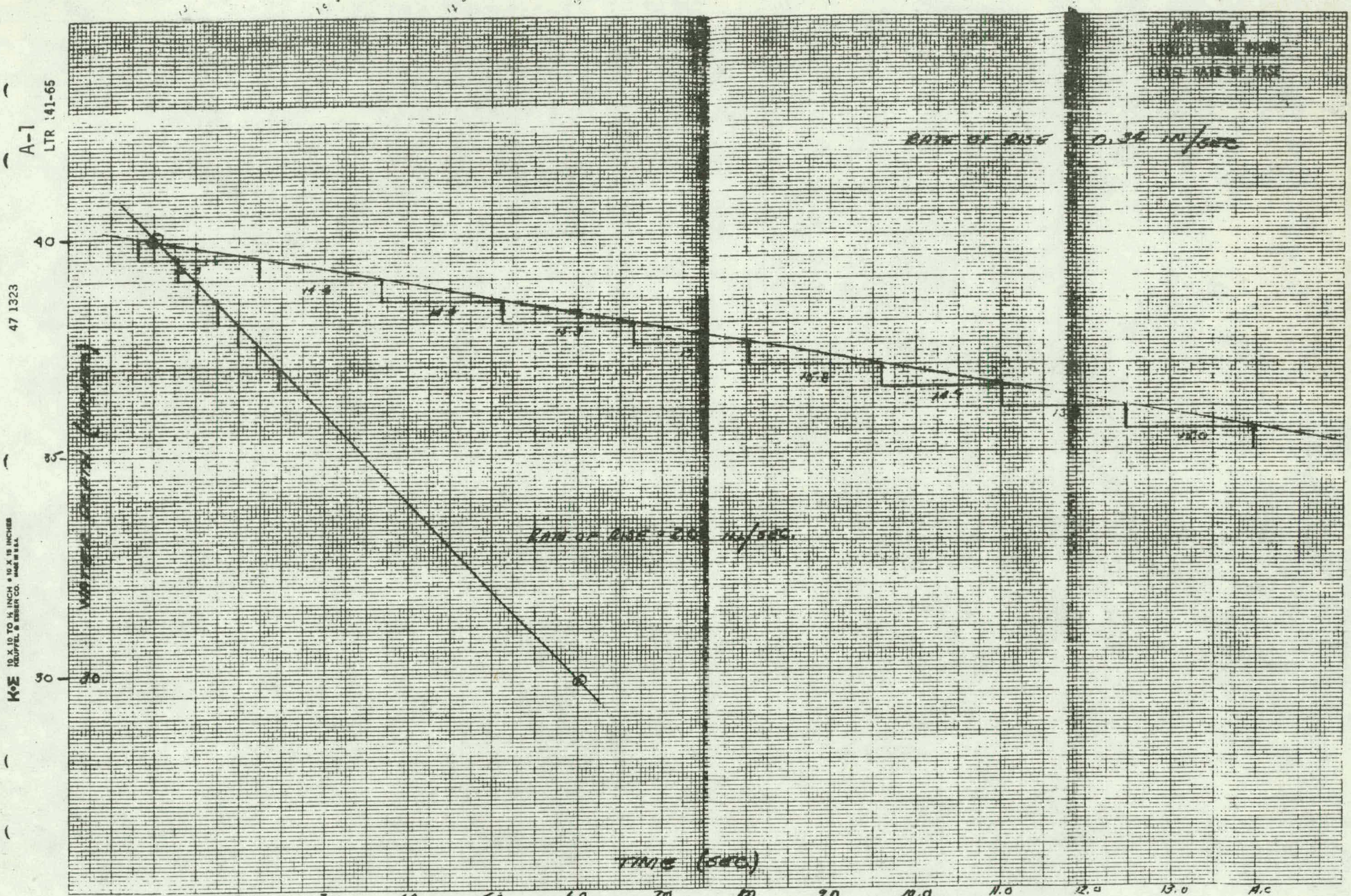
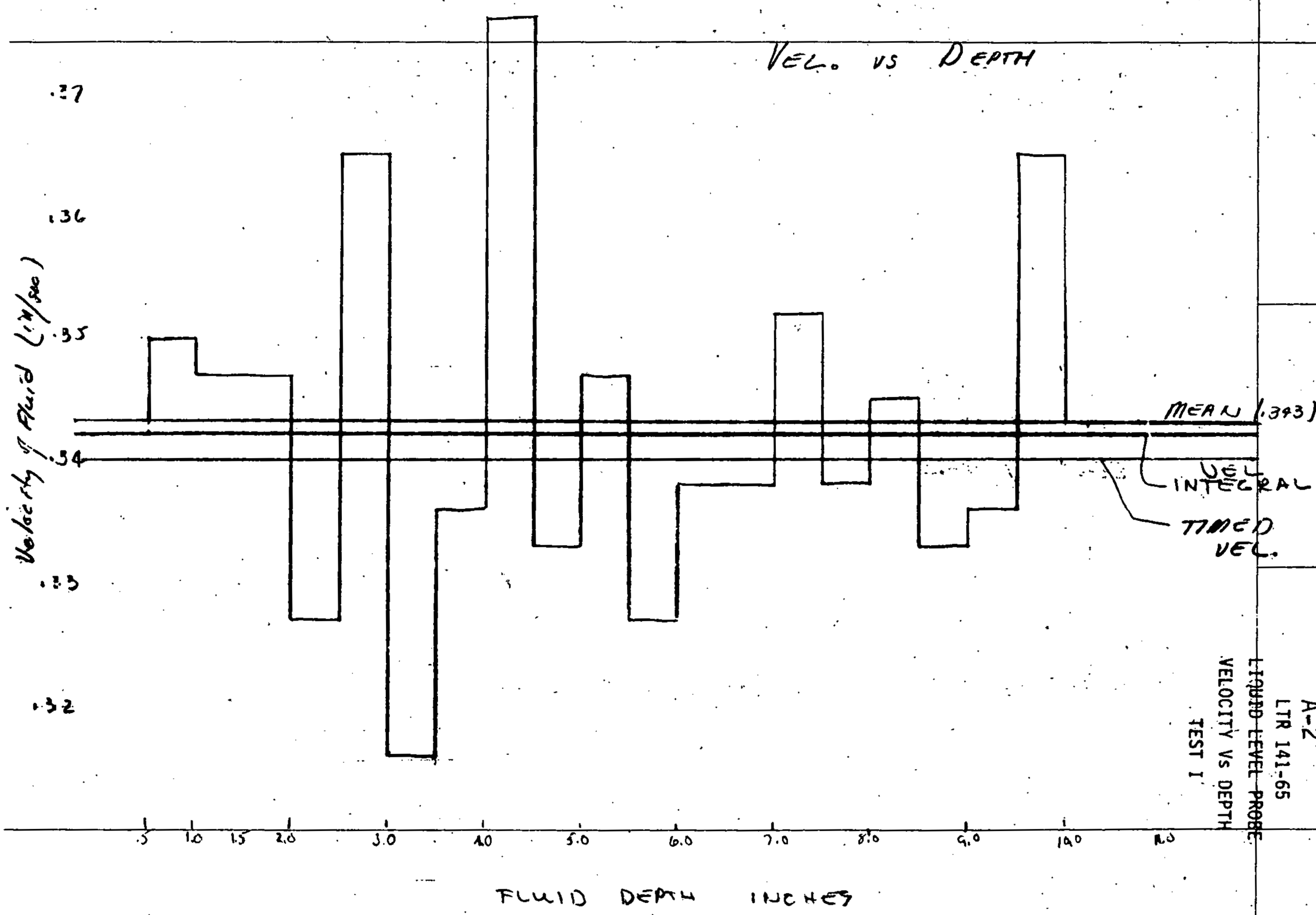

RATE OF RISE = 0.34 IN/SEC
RATE OF RISE = 2.0 IN/SEC
WATER DEPTH (INCHES)
TIME (SEC)
40
35
30
.5
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0



A-2
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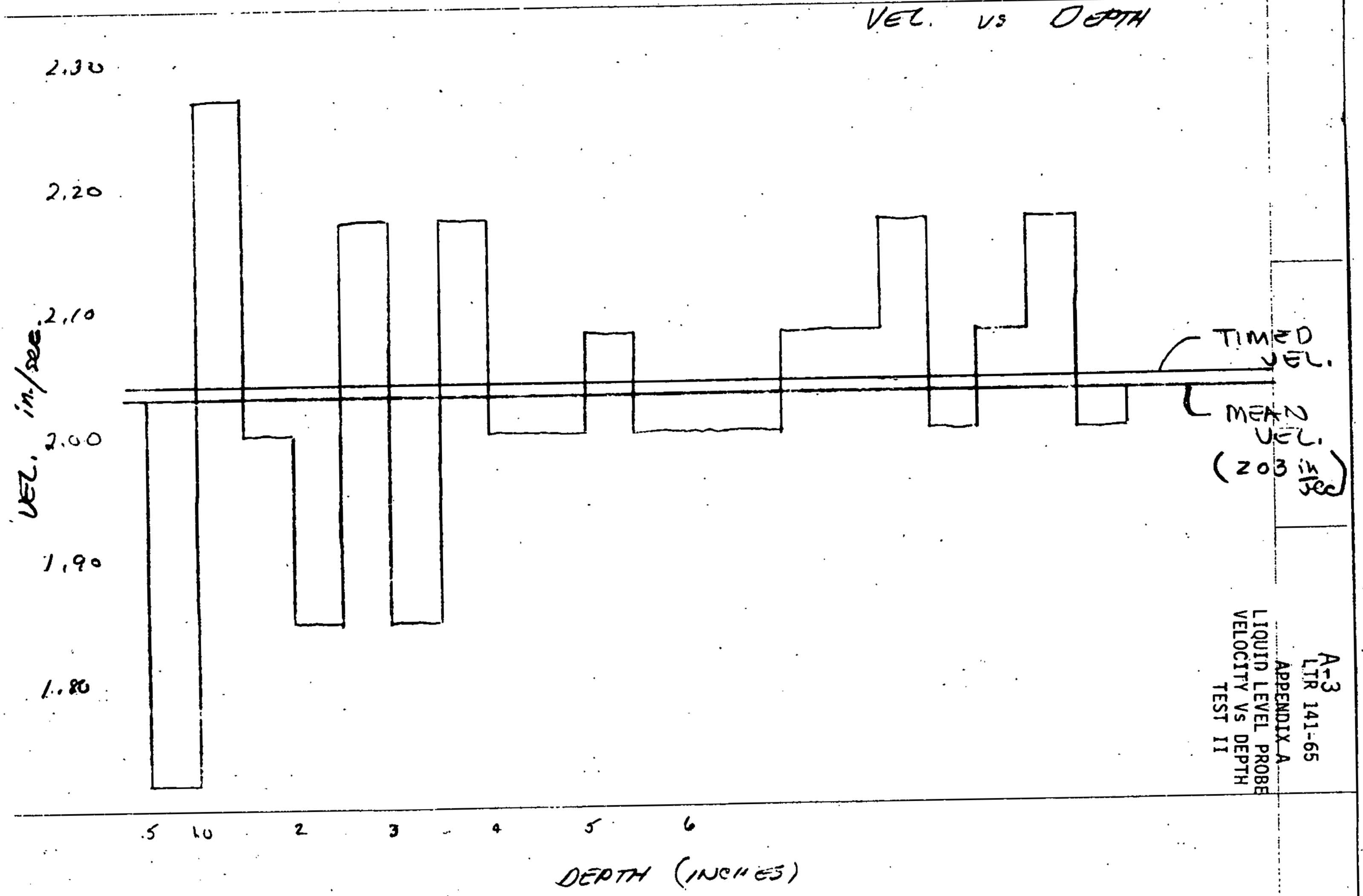
LIQUID LEVEL PROBE
VELOCITY Vs DEPTH
TEST I



A-3
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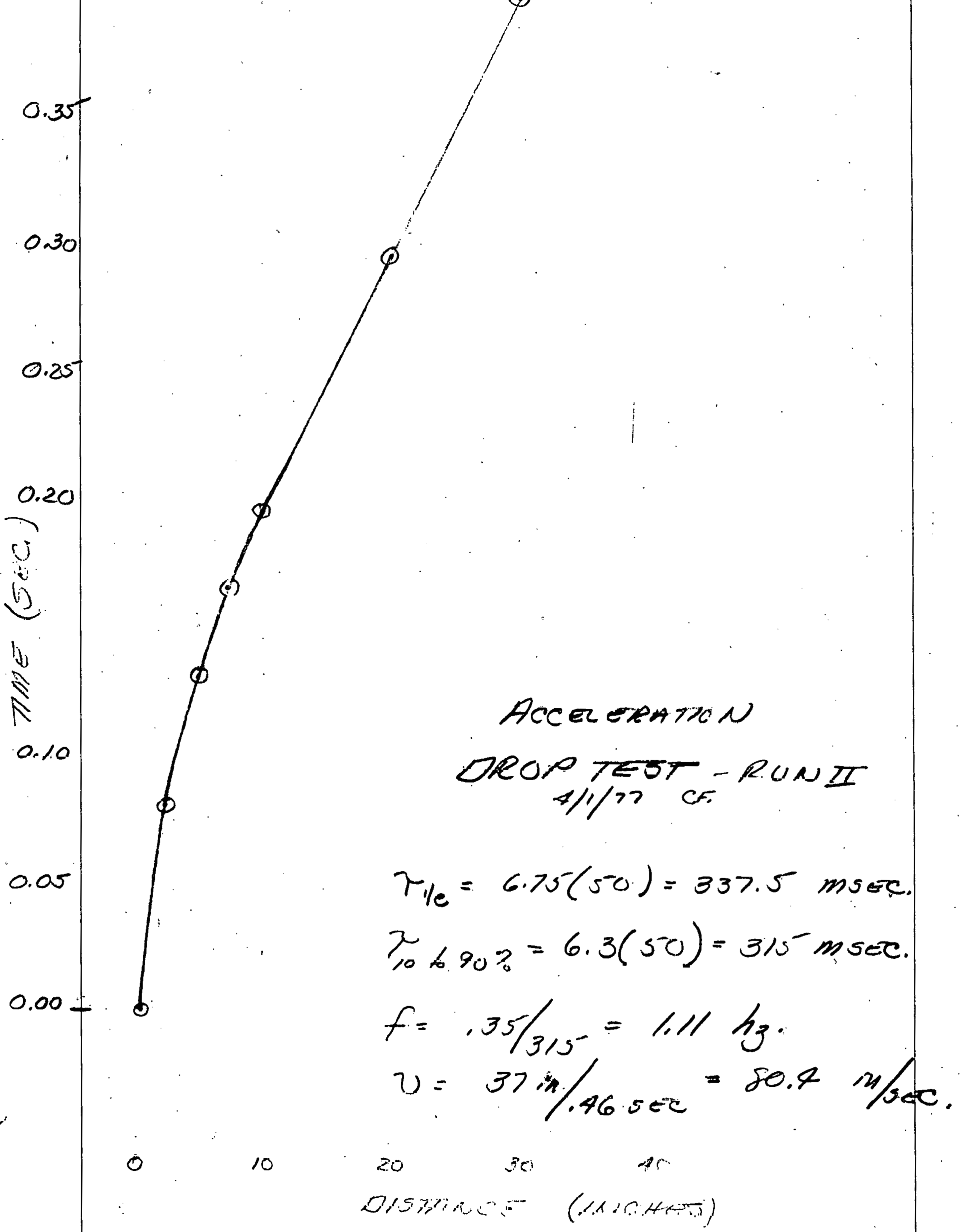
APPENDIX A
LIQUID LEVEL PROBE
VELOCITY Vs DEPTH
TEST II

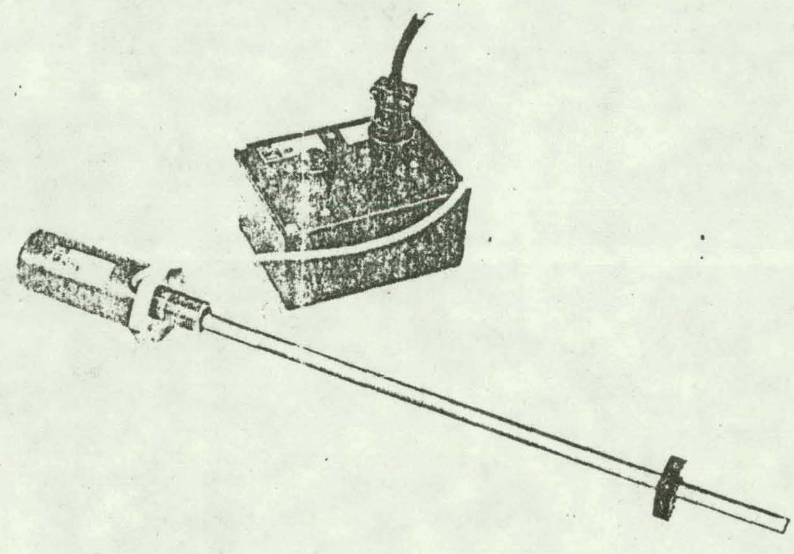
APPENDIX A
LIQUID LEVEL PROBE
ACCELERATION

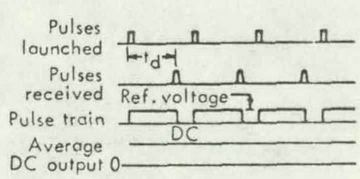


APPENDIX B

TEMPSONICS, INC. PROBE

APPENDIX B
TEMPSONICS, INC. PROBE





The magnetrostrictive transducer
This device developed by Tempsonics, Inc., Plainview, NY uses an electrical analog of an echo to measure distance. A magnet is attached to the object whose displacement is to be measured. The magnet rides a tube containing a special ferromagnetic (magnetostrictive) wire. A pulse launched by a transmitter/receiver travels the wire at a controlled speed and rate. The interaction of pulse current through the wire and magnetic field from the magnet causes the pulse to be reflected. The pulse returns to a fixed reference point. The transmitted and returned signal trigger the beginning and end of a pulse width output.

The pulse train generated can gate a precision quartz clock for a count or digital output. One can also filter it to derive a dc voltage for an analog output.

The system features precision of ±0.05 percent with a repeatability of ±0.01 percent. Its range can go to 12 feet or greater. The unit can withstand high pressures and can be used in hydraulic actuators. Other uses include die casting machines, atomic reactor rod controls and sawmill machinery. □